The
Pacific
Institute
for the Mathematical Sciences

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ANNUAL REPORT

1997 − 1998

Foreword

For the last two years, the mathematical scientists of the Pacific Institute have worked tirelessly to build a unique institution within the Canadian mathematical sciences community and to secure funding to insure its continued existence. The outlook is indeed positive: it is now clear that PIMS is here to stay as an integral part of the Canadian scientific and international mathematical community.

Since the beginning of its operations in 1996, PIMS has unified the community of mathematical scientists in Western Canada, and engendered a many-fold increase in organized activity in mathematical research, industrial collaboration, education and public outreach. During its first year, PIMS sponsored numerous scientific activities of high quality, at all five sites and elsewhere, involving over a thousand scientists and students. PIMS provided postdoctoral opportunities, which did not previously exist, for more than twenty-five highly qualified young mathematical scientists. Its distributed nature has proven to be effective in creating a synergy involving hundreds of scientists and scholars in Western Canada, who had previously worked in relative isolation. Its broad regional base has allowed it to develop a productive dialogue among university scientists, local industry and the governments in Alberta and BC.

- **An adaptive structure:** PIMS has developed an innovative distributed structure sharing resources among the five university sites together with a flexible program structure and use of technology such as video-conferencing, interactive web-objects and other on-line research and computational tools. An NSERC 1996 site visit committee consisting of a top international team of scientists and engineers wrote in its report *"The Site Visit Team is convinced that given the goals, the demography of the two Western Provinces, and the existence of mathematical strengths at five different universities, the distributed institute concept— a network—is likely to be much more effective than would the establishment of a single-site institute"*. Many of PIMS' programs could not have been organized without the combined resources of all five member universities.

- **Interdisciplinary programs:** PIMS has developed innovative scientific programs such as shorter and varied thematic periods and proactive outreach to other disciplines. In its planned thematic programs, emphasis has been put on emerging areas and those at the interface of different disciplines: *Mathematical Economics and Finance* in 1998, *Mathematical Biology* in 1999 *Combinatorial optimization* in 2000 and *Computational challenges in industrial problems* in 2001. In

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the planning stages are also thematic programs in *Constructive and Experimental Mathematics* and *Knot Theory*. PIMS was carefully scrutinized by NSERC before it received its interim funding. The above cited international panel also wrote in its report *"To summarize, the quality and nature of the scientific programs proposed by PIMS is excellent, based on great scientific strength and appropriate structure"*.

- **Training of highly qualified personnel:** An important mission of PIMS is to provide new opportunities for outstanding young mathematical scientists to develop their skills. This year, twenty eight postdoctoral fellowships will be created by PIMS in collaboration with its industrial partners and its affiliated departments. Support programmes for graduate students at member institutions is also provided: Participation in high-level scientific activities, training camps in industrial mathematics as well as recruitment programs.

- **Technology-based maths projects:** PIMS has an extensive research program on the application of new technologies for research and training in the mathematical sciences: As an illustration, we cite the Polymath Development Project at SFU for developing on-line Java-based resources for the mathematical community, the Fluid dynamics Laboratory at U. Alberta for performing numerical simulations and other mathematical experiments dealing with environmental and industrial problems and the Sunsite at UBC which is being developed in collaboration with Sun Microsystems.

- **Innovative industrial programs:** PIMS industrial outreach activities include the traditional support for Industrial Postdoctoral Fellows and for industrial workshops and mini-courses. More innovative are the bi-annual Industrial Problem Solving Workshops, the on-going Industrial Working Seminars and the recruitment of highly qualified mathematicians to act as Industrial facilitators to insure a continuous interaction between PIMS scientists and their industrial partners.

- **A proactive involvement in math. education:** PIMS initiates educational activities at all levels, from grades K-12 to university level. In the schools, these activities include, for example, involvement in stimulating and training through workshops for teachers, alternative math. events 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.

- **Links to Pacific Northwest universities and to Pacific Rim countries:** PI_{ms} 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 will be hosting 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.

PI$_{ms}$ is committed to support the *Pacific Northwest Seminars Series* which 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. PIMS is supporting these grass-root organizations while promoting the formation of similar organizations in other fields.

- **Involvement of Federal and Western Provincial Governments and Industry:** NSERC has recognized the national importance of PIMS by providing interim funding and by allowing it equal access, along with the Centre de Recherches Mathematiques and the Fields Institute, to the NSERC envelope for maths institutes. NSERC's support for PIMS was instrumental in securing funding from the BC provincial government (who used the above cited NSERC peer-review of PIMS as the basis for their decision) and is an essential ingredient of the pending application for funding to the Alberta Science Research Authority. This support is currently augmented by Western Canadian universities and the non-academic sector which supports its industrial programs.

- **A Network of Centers of Excellence:** In collaboration with the Fields Institute and the Centre de Recherche Mathematiques, PIMS is in the process of developing a NCE in the Mathematical Sciences: MITACS (short for "Mathematics of Information Technology and Complex Systems") was created to bring together leading 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.

- **National Partneships:** Finally, PIMS is working closely with the Fields Institute and the CRM to coordinate the activities of mathematical scientists at a national level including: Integrated thematic programs, proposed joint scientific review panel and cross appointments on boards, development of a national education panel and co-operation on industrial partnership programs. We view this as a first step towards the development of a single, truly national mathematical institution to unite all Canadian mathematical scientists and coordinate overall direction on a national scale.

That PIMS is already at this mature stage of its development is testimony to the strength of its vision and the dedication of dozens of distinguished scientists. Through their volunteer efforts, we are developing the Canadian scientific infrastructure and creating exciting opportunities for the following generations of mathematical scientists.

Nassif Ghoussoub, Director

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Chapter 1

About the Pacific Institute for the Math. Sciences

The emergence in Western Canada, over the last twenty years, of a world–class Mathematical Science Community has paralleled the dramatic economic development of Alberta and British Columbia. The foundation of the *Pacific Institute for the Mathematical Sciences* reflects this westward shift. The PIMS, a needed counterpart to the *Fields Institute* in Ontario and the *Centre de Recherches Mathematiques* in Montreal, is based on scientists in more than fifteen departments in the seven largest BC and Alberta Universities. It is already in interim operation with continuing financing from:

- Simon Fraser University, The University of Alberta, The University of British Columbia, The University of Calgary, The University of Victoria, and the University of Lethbridge;

- the Natural Sciences and Engineering Research Council of Canada; and

- the British Columbia Science and Information Technology Agency.

Purpose

The mission of the *Pacific Institute for the Mathematical Sciences* (PIMS) is to promote all aspects of mathematics by coordinating and facilitating the activities of the mathematical scientists in Alberta and British Columbia and by linking them more closely with mathematical scientists in the rest of Canada and the world. This is being achieved by:

- Strengthening ties and collaboration between the mathematical scientists in the academic community and those in the industrial and business sector;

- Enhancing education and training in the mathematical sciences, and broadening communication of mathematical ideas;

- Creating strong mathematical partnerships and links within Canada and organizations in other countries, with a focus on the nations of the Pacific Rim; and

- Promoting research in the mathematics sciences.

Activities of PIMS

Industry: Together with industrial partners PIMS is committed to arranging and coordinating a variety of activities such as working groups and seminars, industrial problem solving workshops, cooperative fellowships and projects, industrial certificate programmes, and graduate student internship programmes.

Education and Outreach: PIMS is committed to the initiation of mathematical educational activities at all levels, from grades K-12 to university undergraduate and graduate programs. In the schools, these activities include workshops for students, their parents and their teachers, training and upgrading programmes in mathematics and its applications as well as sponsoring and initiating math fairs and clubs. In universities, PIMS is sponsoring national conferences for undergraduate students, training camps for mathematics competitions. Support programmes for graduate students at member institutions is also provided.

Advancement of mathematics:
PIMS will continue to promote the advancement of all aspects of mathematics through colloquium series, conferences, workshops, thematic periods and graduate level summer schools. It is also committed to creating opportunities for the new generations of mathematical scientists by providing support and training through its postdoctoral programs.

Composition of PIMS

The Pacific Institute for the mathematical sciences is a partnership between:

- 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 and the Government of Canada through the Natural Sciences and Engineering Research Council.[1]

- A large group of math teachers and educators in Alberta and British Columbia as well as a growing number of math-using industrial and government researchers.

More than 200 scientists are currently working on PIMS activities, and represent a broad spectrum of research disciplines including mathematics, statistics and computer science; and, also physical, chemical and life sciences; medical science; finance; management; and computer, electrical, chemical, geomatics and mechanical engineering. The target partners and customers include scientists and engineers in Alberta and British Columbia universities, graduate students at these institutions, college instructors, elementary and high school teachers, industrial and government researchers and practitioners, and several counterpart organizations both within Canada and in other countries.

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[1] There is also a pending application for sponsorship by the Government of Alberta through the Alberta Science and Research Authority.

Chapter 2

PIMS Management

2.1 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 Program.

  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, 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. 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

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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 dét at 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 employs 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. Cooper Langford**, Vice-President Research at the University of Calgary, holds an AB in Chemistry from Harvard and a Ph.D. in Physical Chemistry from Northwestern. He was an NSF (US) post-doctoral fellow in inorganic chemistry at University College, London. He taught at Amherst College, Carlton University, Concordia University and as a visitor at Columbia University before coming to Calgary. He is a co-author of four books and over 200 research publications chapters and articles. He has chaired the Chemistry Department at Concordia and served there as Associate Vice-Rector for Research. He was a founding Director of the Laboratory for Inorganic Materials at Concordia. He has served on a number of NSERC committees and spent two years on secondment as Director of Physical and Mathematical Sciences at NSERC. He has chaired the Ontario Confederation of University Faculty Associations. Dr. Langford is a Fellow of the Royal Society of Canada, the American Association for the Advancement of Science, and the Chemical Institute of Canada. He has held an Alfred P. Sloan Foundation Research Fellowship.

- **Dr. Alex McAuley** was born and educated in Scotland, attended the University of Glasgow, and completed both a Ph.D and (later) a D.Sc. in Chemistry. He was awarded a Fulbright Scholarship to study in the United States and returned to university posts in Scotland prior to moving to Canada in 1975. Since his appointment as professor of chemistry at the University of Victoria, he has served successively as Department Chairman, Dean of Graduate Studies and Associate Vice-President Research.He has also served

on National Science committees and as Chair of the Chemistry competition. His research interests include the synthesis of new complex compounds, the influence of ligand structure on the reactivity and stabilisation of less common oxidation states and the kinetics of substitution and electron transfer at encapsulated metal centers. He has published more than 140 papers, lectured widely and supervised over 20 Ph.D. students.

- **Dr. Barry McBride** has been the Dean of Science at the University of British Columbia since 1990. He received his Ph.D. from the University of Illinois (Urbana) in 1970. He was 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 Poincare', 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 honors 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 comparative 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.

Advisory Council

The Board will be assisted by the following Advisory Council who will receive all the relevant documentation. These members will give their input to the Board about PIMS priorities and activities at their discretion.

- **Larson C. Brodner**, Alberta Research Council, Vice-President of marketing
- **Kung Ching Chang**, Chinese Mathematical Society, President
- **Bogwhan Dua**, University of Lethbridge, Dean of arts and science.
- **Chris Garrett**, University of Victoria, Lansdowne Professor of Ocean Physics
- **Ivan L. Head**, University of BC, Chair of South-North Studies

- **John S. MacDonald**, MacDonald Dettwiler and Associates Ltd, Chairman of the Board
- **Becky Mattews**, BC Ministry of Education, Director of Student Assessment Branch
- **Robert O'Malley**, University of Washington, Professor of Applied mathematics
- **William R. Pulleyblank**, IBM Research Center, Director of Mathematical Sciences
- **Brent Sauder**, Advanced Systems Institute, Executive Director

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

2.2   Scientific Review Panel

The Scientific Review Panel is responsible for:

- The review and selection of scientific programs 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** 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. His expertise lies in computational electromagnetics, numerical modeling 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.

- **John Kalbfleisch** received his Ph.D. from the University of Waterloo in 1969 and joined the faculty at Waterloo as Associate Prof. in the Department of Statistics in 1973. Prior to this, he held appointments as a Research Associate at University College, London and as an assistant professor at the State University of New York, Buffalo. At Waterloo he was promoted to professor in 1979, was Chair of the Department of Statistics and Actuarial Science from 1984 to 1990 and has been Dean of the Faculty of Mathematics since 1990. Dr. Kalbfleisch has also been a Visiting Scientist at the Institut Jules Bordet in Brussels, Belgium, and at the Fred Hutchinson Cancer Research Centre in Seattle, Washington. He has also held appointments as a visiting professor in the Department of Biostatistics, University of Washington; in the Department of Statistics, North Carolina State University, Raleigh; at the Centre for Statistics, University of Lancaster; in the Department of Biostatistics at the University of Michigan; and in the Department of Epidemiology at the University of California, San Francisco. He is an elected Fellow of the American Statistical Association and the Institute of Mathematical Statistics. In 1994, he was elected Fellow of the Royal Society of Canada and was awarded the Gold Medal of the Statistical Society of Canada. Dr. Kalbfleisch has authored/co-authored more than 60 publications in refereed journals, books and conference proceedings. As well, he has co-authored one book.

- **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. He is currently 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.

2.3 Executive

The executive committee consists of the Director, the five Associate Directors, and any 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, Math)
A. Gupta (SFU, Computer Sciences)
I. Putnam (UVic, Math. & Stats.)
D. Rolfsen (UBC, Maths)
C. Laflamme (UC, Math. & Stats.)
A. Rhemtullah (UA, Mathsci.)

2.4 Business, Industry and Resource Sector Panel

The Business, Industry, and Resource Sector Panel is responsible for planning and oversee-

ing PIMS activities with the private and government sector. It assists in developing new partners and receptors in the private sector and encourages the involvement of mathematical scientists in its programs. If necessary, it will help seek out funding for new initiatives between PIMS scientists and private sector partners.

Co-chair, BC: B. Alspach (SFU, Math & Stats)
Co-chair, Alberta: B. Moodie (UA, Mathsci.)
J. Borwein (SFU, Math. & Stats., ex-officio)
T. Calvert (SFU, Computer Sciences)
E. Croft (UBC, Mechanical Engineering)
B. Funt (SFU, CSS)
P. Gorton (MacDonald-Dettwiler)
G. Greer (BC Ministry of E&I)
L. Hafer (SFU, Computer Sciences)
L. Higham (UC, Computer Sciences)
J. Hoover (UA, Computing Sciences)
N. Horspool (UVic, LACIR)
R. Illner (UVic, Math. & Stats., ex-officio)
B. Joe (Private sector, Alberta)
J. Joyce (Hughes Aircraft)
D. Kirkpatrick (Computer Sciences, UBC)
M. Kropinski (SFU, Math. & Stats.)
M. Lamoureux (UC, Mathematics)
M. Lesperance (UVIC, Math. & Stats.)
A. Peirce (UBC, Mathematics)
B. Seymour (UBC, Mathematics)
S. Shen (UA, of Mathematical sciences)
R. Ward (UBC, CICSR)

2.5   Education Panel

The Education and Communication Panel is responsible for planning and overseeing PIMS activities in education at all levels and in the communication of the mathematical sciences to the public. It encourages the involvement of mathematical scientists, college teachers, and school teachers in its programs and assists in planning public awareness activities associated with all major PIMS-sponsored events. If necessary, it will seek funding sources and new partners for its initiatives.

Co-chair, BC: M. Dubiel (SFU, Math. & Stats.)
Co-chair, Alberta: C. Laflamme (UC, Math.)
M. Fellows (UVic, Computer Sciences)
G. Bluman (UBC, Mathematics.)
M. Yedlin (UBC, Elec. Eng. Geophys. & Astronomy)
D. Leeming (UVic, Math. & Stats.)
K. Heinrich (SFU, Math. & Stats.)
S. Dawson (SFU, Faculty of Education)
L. Gupta (Pivotal Software Ltd)
B. McAskill (BC Ministry. of Education)
G. Lorway (VP BCAMT, Tumbler Ridge elementary school teacher)
E. Perkins (UBC Mathematics, ex-officio)
S. Friesen (UC, Math. & Stats.)
J. Timourian (UA, Mathematical sciences)
H. Kharaghani (UL, Faculty of sciences)
M. Stone (UC, Math. & Stats.)
I. Lagu (Mount Royal College)
H. Sanders (Ministry of Education, Alberta)
R. Shillabeer (Private sector, Alberta)

2.6   Research Panel

The Research Panel is responsible for planning PIMS' research activities and soliciting research proposals from its members. It assists in the planning of regular activities such as the PIMS colloquium and summer schools and works with the Education and Business Panels, where appropriate, in planning programs for graduate students.

Chair: D. Rolfsen (UBC, Mathematics)
U. Ascher (UBC, Computer Sciences)
P. Binding (UC, Math. & Stats.)
P. Borwein (SFU, Math. & Stats.)
G. Cliff (UA, Mathematical sciences)
C. Dean (SFU, Math. & Stats.)
R. Froese (UBC, Mathematics)
A. Gupta (SFU, Computer Sciences, ex-officio)
P. Hell (SFU, Computer Sciences)

I. Putnam (UVic, Math. & Stats.)
G. Semenoff (UBC, Physics, ex-officio)
J. Sniatycki (UC, Mathematics)
L. Stewart (UA, Computer Sciences)
N. Tomczak-Jaegermann (UA, MathSci., ex-officio)

2.7 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-Ann Kropinski (Math)
Alistair Lachlan (Math)
Mehrdad Saif (Eng.)
Tiko Kameda (CS)

UA

Site Director: Akbar Rhemtullah
Admin. Assistant: Patti MacDonald
Gerald Cliff (Math)
Jim Hoover (CS)
Bryant Moodie (Math)
Sherm Riemenschneider (Math)
Mazi Shrivani (Math)
Lorna Stewart (CS)
Jim Timourian (Math)
Nicole Tomczak-Jaegermann

UBC

Site Director: Dale Rolfsen
Admin. Assistant: Emma MacEntee
Austin, David (Math)
Ascher, Uri (CS)
Bluman, George (Math)
Croft, Elizabeth (Mech. Engineering)
Haussmann, Uli (Math)

Jorgensen, Bent (Statistics)
Jull, Ed (Electrical Engineering)
Keshet, Leah (Math)
Kirkpatrick, David (CS)
Miura, Robert (Math)
Oldenburg, Doug (Earth and Ocean Sciences)
Pai, Dinesh (CS)
Peirce, Anthony (Math)
Perkins, Ed (Math)
Puterman, Martin (Commerce & Business Admin.)
Rolfsen, Dale (Math)
Seymour, Brian (Math)
Shizgal, Bernie (Chemistry)
Steyn, Douw (Geography)
Ward, Michael (Math)
Yedlin, Matthew (Geophysics and Elec. Engineering)
Gordon Semenoff (Physics)
John Weymark (Commerce)
Jim Zidek (Statistics)

UC

Site Director: Claude Laflamme (Math and Stat)
Admin. Assistant: Joanne Longworth
Rod Blais (Geomatics)
Ted Bisztriczky (Math and Stat)
Lisa Higham (Computer Science)
Mike Lamoureux (Math and Stat)
Peter Lancaster (Math and Stat)
Jon Rokne (Computer Science)
Mike Stone (Math and Stat)
Gordon Sick (Management)
Jedrzej Sniatycki (Math)
Peter Zvengrowski (Math and Stat)

UVic

Site Director: Ian Putnam (Math & Stat)
Admin. Assistant: Kelly Choo
M. Fellows(CS)
P. van den Driessche (Math & Stat)
M. Lesperance (Math & Stat)
D. Leeming (Math & Stat)
A. Sourour (Math & Stat)
G. Macgillivray (Math & Stat)
W. Reed (Math & Stat)
F. Ruskey (CS)
V. King (CS)
Reinhard Illner (Maths)

Chapter 3

PIMS Scientific Personnel

3.1 PIMS Research Fellows

The PIMS Partnership Program 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 programs, joint projects with an industrial partner or educational projects. Funding and support for this program is shared by PIMS and the participating departments.

- B. Alspach (Math, SFU), 96/97
- D. Austin (Math, UBC), 96/98
- N. Ghoussoub (Math, UBC), 96/98
- A. Gupta (CS, SFU), 96/98
- R. Illner (Math, UVic), 96/97
- C. Laflamme (Math & Stat, UC), 97/98
- E. Perkins (Math, UBC), 96/98
- I. Putnam (Math, UVic), 97/98
- D. Rolfsen (Math, UBC), 96/98
- G. Semenoff (Physics, UBC), 96/97
- J. Sniatycki (Math & Stat, UC), 96/97
- N. Tomczak-Jaegermann (Math. Sci, UA), 96/97
- A. Rhemtullah (Math. Sci, UA), 97/98
- M. Ward (Math, UBC), 96/97.

3.2 PIMS Postdoctoral Fellows

Twelve PIMS Postdoctoral Fellowships have been awarded in 97/98 and twenty-seven will be awarded in 98/99 (including renewals) 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.

1997 Competition:
The award decisions for the academic year 1997/1998 were made by: David Boyd (Chair), Gordon Slade, Nick Pippenger, Allister Lachlan and Robert Moody.

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

- **Rostyslav Hryniv**
  Department of Mathematics, U. Calgary
  Sponsor: P. Binding, P. Lancaster
  Project: Spectral Theory

- **Sadok Kallel**
  Department of Mathematics, UBC

Sponsor: D. Sjerve
Project: Algebraic Topology

- **David A. Krebes**
Department of Mathematics, UBC
Sponsor: Dale Rolfsen, K. Lam
Project: Knot theory

- **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

- **Qing Lin**
Department of Mathematics, U. Victoria
Sponsor: Ian Putnam
Project: Operator algebras

- **Kazuhisa Makino**
School of Computing Science, SFU
Sponsor: T. Kameda
Project: Studies on Positive and Horn Boolean
Functions with Applications to Data Analysis

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

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

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

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

- **Meijun Zhu**
Department of Mathematics, UBC
Sponsor: C. Gui

Project: Partial Differential Equations

1998 Competition

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).

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

- **Philippe Bolle**
Department of Mathematics, UBC
Sponsor: Nassif Ghoussoub
Project: Variational Methods in PDE

- **Krishna Busawon**
School of Engineering Science, SFU
Sponsor: Mehrdad Saif
Project: Nonlinear Systems

- **Paul Centore**
Department of Math. Sciences, U. Alberta
Sponsor: Peter Antonelli
Project: Finsler Geometry

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

- **Alon Effrat**
Department of Computer Science, UBC
Sponsor: David Kirkpatrick, Jack Snoeyink,
Project: Computational Geometry

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

- **Marina Gavrilova**, 98/99
Department of Computer Science, U. Calgary
Sponsor: J. Rokne

Project: Theoretical and Applied Computational Geometry

- **Chun-Hua Guo**
Department of Math and Stats, U. Calgary
Sponsor: Peter Lancaster
Project: Numerical Analysis and Scientific Computing

- **Eldad Hebber**, 98/99
Department of Computer Science, UBC
Sponsor: U. Ascher
Project: Geophysical & Medical imaging applications

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

- **Alexander Kurganov**
Department of Mathematics, UBC
Department of Mathematics, SFU
Sponsor: Brian Wetton, Tao Tang
Project: Computational PDE's

- **Tim Lewis**
Department of Mathematics, UBC
Sponsor: Robert M. Miura
Project: Applied Mathematics

- **Geraint Lewis**
Department of Physics & Astronomy, U. Victoria
Sponsor: A. Babul
Project: Gravitational Lensing & Galaxy Clusters

- **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

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

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

- **Monica Nevins**
Department of Math. Sciences, U. Alberta
Sponsor: Arturo Pianzola
Project: Algebra and Representation Theory

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

- **Junping Shi**
Department of Mathematics, UBC
Sponsor: Changfeng Gui
Project: Concentration phenomena

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

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

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

- **James Watmough**
Department of Math and Stats, U. Victoria
Department of Mathematics, UBC
Sponsor: Pauline van den Driessche, Leah Edelstein-Keshet
Project: Biological Modelling

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

- **Lin Yuan**
  Department of Maths & Stats, SFU
  Sponsor: R. Sitter
  Project: Bayesian Methods

- **A. Zatezalo**
  Department of Mathematics, UBC
  Sponsor: U. Haussmann
  Project: Filtering Theory

3.3   PIMS Visiting Fellows

Visiting Fellowships are awarded to senior scientists who will be spending more than three months at a PIMS university, in conjunction with the PIMS activities related to the Fellow's area of expertise. The nominations come from scientists affiliated with PIMS. Funding and support for this program is shared by PIMS and the nominating scientists.

- **Zalman I. Balanov**, 97/98
  Department of Mathematics, U. Alberta
  Sponsor: W. Krawcewitz
  Subject: Non-linear Analysis

- **Ted Cox**, 97/98
  Department of Mathematics, UBC
  Host: E. Perkins
  Subject: Probability theory.

3.4   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 company carrying 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 identified for support.

- Project: **Reality-based Modeling and Simulation of Physical Systems in Virtual Environments, UBC**
  Sponsors: U. Ascher, V. Hayward, A. Mackworth, D. Pai and R. Woodham (IRIS 3 Core Thrust Project)
  Industrial Partners: Softimage Inc. and Haptic Technologies Inc.
  Researcher: Sebastian Reich

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

- Project: **Noise Reduction of digitally compressed video signals, UBC**
  Sponsor: R. Ward (CICSR, UBC)
  Industrial Partners: Canadian Cable Labs
  Researcher: Julong Du

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

- Project: **Risk Management, Calgary**
  Sponsors: G. Sick, P. Zvengrowski (Calgary)
  Industrial Partner: R.I.T.A Labs Inc.
  Researcher: Y. Shkolnikov

- Project: **Multi-surface Geological Modelling, Calgary**

  Sponsors: R. Blais (Calgary)

  Industrial Partner: Geological survey of Canada

  Researcher: C. Jessop

- Project: **Medical Imaging, SFU**

  Sponsors: A. Celler (Vancouver General Hospital) and J. Borwein (SFU)

  Industrial Partners: Siemens

  Researcher: P. Marechal

- Project: **Algorithmic Optimization, SFU**

  Sponsor: L. Hafer (SFU)

  Industrial Partner: Amber Computer Systems

  Researcher: Y. Wang

- Project: **Multiple Target Classification and Tracking, Alberta**

  Sponsor: Robert Elliott and Mike Kouritzin (U. Alberta)

  Industrial Partner: Lockheed Martin

  Researcher: D. Li

- Project: **Vehicle Routing studies**

  Sponsor: Marty Puterman (UBC)

  Industrial Partner: BC Tel.

  Researcher: M. Oosten

3.5 PIMS Industrial Facilitators

PIMS industrial facilitators are scientists who spend time interacting with both university researchers and industrial partners. This gives industry 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 Modelling Workshops* . They have also initiated several industrial projects for PIMS members.

- **Dr. Dan Calistrate** of the University of Calgary (Part-time, 96/98).
- **Dr. Tim Myers** of Cranfield University in the U.K. (Summer 97)
- **Dr. Barbara van de Fliert** of the University of Leiden. (Summer 97)
- **Dr. Huaxiong Huang**, UBC and SFU (Full time, January 1, 98–December 31, 99).
- **Dr. Mark Solmonovich**, U. Alberta (July-December 97).

3.6 Awards, Distinctions and Prizes

In 1996/97, several mathematical scientists associated with PIMS-participating departments have been recognized by their peers for their exceptional contributions to their discipline and to Canada.

- **Jonathan and Peter Borwein** (Mathematics, SFU) were presented with the British Columbia/CUFA Academic of the Year 1996 award by the BC Confederation of University Faculty Associations.
- **Colin Clark** (Mathematics, UBC) has been elected foreign fellow of the Royal Society. Clark is an applied mathematician known for his work in the fields of resource economics and behavioral ecology. His work in resource economics treated renewable resources as forms of "natural capital," an idea that was to become a leading paradigm in the modern school of Ecological Economics. Clark used elementary technique (integration by parts) to demonstrate that private ownership of renewable resources is no guarantee of their conservation by profit-maximizing firms. He believes that this fact (which sharply contradicted received wisdom in resource economics at the time) may be implicated in the continuing saga of overexploitation of bioresources. Simple

dimensional analysis showed that slowly growing species such as whales and trees are particularly vulnerable to the risk of deliberate overexploitation. Clark's 1976 book "Mathematical Bioeconomics" (second edition 1990) is a standard reference in this field.

In his 1988 book "Dynamic Modeling in Behavioral Ecology" (with Marc Mangel) Clark introduced dynamic state variable models to the field of evolutionary biology. This approach, which allows ecologists to analyze dynamic adaptations of all kinds, is now widely used in studying foraging, reproduction, antipredator defense, migration and other types of behavior. There are many applications to resource and conservation biology.

- **Joel Feldman** (Mathematics, UBC) won the John L. Synge award, the top research prize in the mathematical sciences in Canada awarded infrequently, and only for the third time by the Royal Society of Canada. Feldman's best known early result was the construction of an interacting relativistic quantum field theory in three space-time dimensions. Recently, he and his collaborators developed machinery capable of controlling many-fermion models at low temperature. In particular, they proved local Borel summability for a wide class of models and constructed the first interacting Fermi liquid at temperature zero. They also proved that, in three dimensions, there are no nontrivial istropic, unitary solutions of the gap equation for superconductivity with angular momentum greater than one, while in two dimensions they exist in all angular momentum sectors. In another subject, they have identified a wide class of infinite genus Riemann surfaces, characterized by geometric axioms, to which the classical theory of compact Riemann surfaces extends. One application is the almost periodicity in time of all smooth spatially periodic solutions of the Kadomcev-Petviashvili equation. In yet a third subject, they have shown that, for generic lattice or for generic boundary conditions, almost all eigenvalues of periodic Schrodinger operators remain almost stationary even under large perturbations of the potential. They have also found infinitely many eigenvalues (forming a set of density zero in the set of all eigenvalues) that move a lot.

- **Chen Greif** (IAM student, UBC) is one of the three winners of this year's SIAM Best Student Paper competition. Chen will present his winning paper in the SIAM Annual Meeting at Stanford, in July 1997.

- **Kathy Heinrich** (Mathematics, SFU) received the 1996 YWCA Women of Distinction Award for Science & Technology. This award recognizes a "contribution to practice, research and administration in education, employee training and development".

- An undergraduate **Vera Hoffman**, combined honours in mathematics and chemistry at UBC, was awarded the E. Gordon Young Scientist Prize at the Annual Western Canadian Undergraduate Chemistry Conference for her talk, "A Topological Approach to the Jahn-Teller Effect", based on her thesis.

- **Maria Klawe** (Computer Sciences, UBC) received the 1997 YWCA Women of Distinction Award for Science & Technology. This award recognizes a "contribution, through research or application, in scientific-related fields, or technological advancement and the expansion of women's participation and opportunities in these fields."

- **A. C. F. (Andy) Liu** (Mathematical Sciences, U. Alberta) won the 1996 David Hilbert International Award (World Federation of National Mathematics Competitions) This Award was established to recognise contributions of mathematicians which have played a significant role in the development of mathematical challenges at the international level and which have been a stimulus for the enrichment of mathematics learning.

- **T. B. (Bryant) Moodie** (Mathematical Sciences, U. Alberta) won the 1996 Artur Beaumont Award (Canadian applied Mathematical Society). This is an Award for outstanding contributions to CAMS. Moodie is presently a Director of the Applied Math Institute at the U of A and Co-Editor-in-Chief of the Canadian Applied Mathematics Quarterly.

- **Robert V. Moody** (Mathematical Sciences, U. Alberta) has won the 1995 Wigner Medal (The Group Theory and Fundamental Physics Foundation) (jointly with Victor Kac), The 1995 Jeffery-Williams Prize Lecture (CMS), the 1996 J. G. Kaplan Award for Excellence in Research (University of Alberta) and the 1996 Outstanding Leadership in Alberta Science (Alberta Science and Technology Leadership Awards Foundation (ASTech))

In 1967, Robert Moody started to develop the theory of a new class of infinite-dimensional Lie

algebras, simultaneously with, but independent from Victor Kac. The most important class of such algebras, since then called "Kac-Moody algebras", made an essential impact on theoretical physics. His work has concentrated on Lie groups and algebras and representation theory. More recently, his interests have been directed towards analysis of aperiodic order and structure of quasi-crystals.

- **Jim Morey and Djun Kim** (Mathematics, UBC) won Sun workstations in the JavaCup programming contest organized by Sun Microsystems. Their entries represent cutting edge innovation in presenting mathematical ideas on the web.

- **Ed Perkins** (Mathematics, UBC) and Steven N. Evans (Berkeley) were awarded the G. de B. Robinson award for an outstanding publication in 1994/1996 by the Canadian Mathematics Society for the paper entitled "Measure-Valued Branching Diffusions with Singular Interactions" published in the Canadian Journal of Mathematics, Volume 46(1) 1994.

- **Nick Pippenger** (Computer Sciences, UBC) was elected a Fellow of the Royal Society of Canada in 1996. CITATION: Nicholas Pippenger is a world leader in theoretical computer science. His dozens of papers on switching networks have earned him the reputation of being *the* world expert in the field. He has also made fundamental contributions to Boolean circuit complexity, algebraic function complexity, and theory of parallel computation. He is noted both for his technical prowess and mathematical erudition. His results use tools from analysis, algebra, combinatorics, probability theory, coding theory, and information theory. His selection as an IBM Fellow and an IEEE Fellow and his technical achievement awards demonstrate that many of his results have practical importance in addition to their mathematical depth and elegance".

- **Martin Puterman** (Commerce, UBC) received the 1996 Lanchester Prize from INFORMS for the most outstanding publication in operations research last year for his book "Markov decision Processes".

- **Steve Ruuth** (ex-IAM student, UBC) won the Canadian Applied Mathematical Society Doctoral Dissertation Award for 1996/7. He did give a plenary talk at the June 97 CAMS meeting in Toronto. Steve finished his PhD last Fall under the supervision of Brian Wetton and Uri Ascher. He is currently doing a postdoc at UCLA.

- **Michael Ward** (Mathematics, UBC) won the 1997 Coxeter-James Prize given annually by the Canadian Mathematics Society to an outstanding Canadian mathematician under 40 years of age. He was recently awarded the prestigious NSERC's 1998 Steacie fellowship.

- **Nicole Tomczak-Jaegermann** (Mathematical Sciences, U. Alberta) has been elected a Fellow of the Royal Society of Canada in 1996. CITATION: Dr. Tomczak-Jaegermann is a leading researcher in the mathematical theory of Banach spaces, has solved a number of difficult longstanding problems. She is a leading expert on the Banach–Mazur distance between convex bodies. Her work with Komorowski constituted a major component of the recent celebrated resolution of Banach's homogeneous space problem. In collaboration with Koenig, she combined techniques from several mathematical disciplines to solve the projection constants problem in a remarkable piece of original research. Her achievements and ideas had a major impact on both the infinite- and finite-dimensional theory of Banach spaces.

She has also received a Canada Council Killam Research Fellowship for1997-1999 for the project "Asymptotic Aspects of Functional Analysis" and she is one of two Canadians invited to lecture at the International Congress of Mathematicians in Berlin in 1998.

Chapter 4

PIMS Thematic Scientific Programs

PIMS is organizing thematic programs consisting of a group of scientific activities dealing with a specific theme of current importance to Canada and to the discipline in order to achieve the following objectives:

- attract sufficient mathematical expertise to Western Canada for a substantial period of time so that critical masses of specialists can develop and work together for the advancement of the concerned area

- bring together researchers working on a common theme but from complementary perspectives so as to create settings for synergetic interactions

- facilitate communication of ideas and create opportunities for collaboration between the visiting and the resident mathematical scientists

- develop new and thriving areas of mathematical research in Western Canada and

introduce Canadian mathematicians to the interesting mathematical problems arising in other disciplines; and

- expose graduate students, the scientific community at large and the math-users in the private sector to the recent advances in a specific theme of mathematical research and its applications.

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 upcoming themes will be *Mathematical Economics and Finance* in 1998, *Mathematical Biology* in 1999 and *Combinatorial Optimization* in 2000.

4.1 Probability Theory and its applications, July-August 1997

Organizers: M. Barlow, D. Dawson, E. Perkins, P. Greenwood

Probability theory plays an important role in many areas of mathematics including partial differential equations, harmonic and functional analysis, and potential theory, and has had significant connections with many other mathematical fields including number theory, combinatorics and geometry. It provides the theoretical basis for statistics. Recent new connections with mathematical biology, finance, statistical mechanics, theoretical computer science and telecommunications, to name a few key areas, have led the subject in a variety of new directions and led to new unexpected applications of established areas.

The first PIMS thematic summer consisted of two specialized workshops, a major conference and several mini-courses covering various aspects of stochastic analysis. The goal was to highlight some of the many areas of application of current research in probability with an emphasis on areas of expertise in the extensive Canadian probability community. Over 100 scientists participated in these events.

Workshop on Stochastic non-linear dynamics, August 4-9, 1997

Organizer: P. Greenwood

This workshop centered on three lectures by **Howell Tong** (Institute of Mathematics and Statistics, University of Kent at Canterbury) and three lectures by **Colleen D. Cutler** (University of Waterloo) on non-linear dynam-

ical systems in the presence of random noise. Stochastic models of this type arise in a variety of settings including population dynamics, epidemiology and financial time series. The lectures studied both probabilistic and statistical problems associated with these processes. The workshop is being jointly sponsored by the special year on "Crisis Points" at the Wall Institute, the Fields Institute and The Pacific Institute for the Mathematical Sciences.

Workshop on Stochastic Partial Differential Equations, August 11-15, 1997

Organizers: D. Dawson (FI), E. Perkins (UBC)

Stochastic partial differential equations are used to model classical systems exposed to random influences or operating in a random environment. They may also arise as scaling limits of interacting particle models in statistical physics, as limits of models for the distribution of gene types involving mutation, selection and random genetic drift in population genetics, or as hydrodynamical limits of a microscopic description of a physical system in the critical regime.

This workshop brought together some of the leading international experts and a number of outstanding young people in the field in a working environment – a total of 35-40 participants attended. The following one-hour lectures were given:

- **Leonid Mytnik**, UBC:"Weak Uniqueness for the Heat equation with noise".

- **Andreas Greven**, U. Erlangen-Nurnberg, Germany:"Renormalization analysis of spatial branching and resampling models".

- **Klaus Fleischmann**,(Weierstrass Institute for Applied Analysis ans Stochastics, Berlin, Ger-

many):"A super-Brownian motion in a super-Brownian medium"

- **Carl Mueller**, U. Rochester:"The width of the interface for random growth models".

The rest of the time was allotted to informal presentations and discussion of open or recently resolved problems. Some emphasis was given to the relationship between measure-valued diffusions and models in population genetics and statistical physics (especially branching polymers and percolation). A special session on *duality techniques* was scheduled. This powerful method for proving uniqueness in spde's also gives deep insights into the steady-state behaviour of complex interacting systems. Unfortunately it is highly non-robust. Tom Kurtz and Don Dawson are two of the leading experts in the field and Leonid Mytnik has recently developed techniques which expand the method's applicability.

First Vancouver Meeting on Probability, August 19-28, 1997

Organizers: M. Barlow (UBC), D. Dawson (FI) and E. Perkins (UBC)

Six advanced short courses of four lectures were provided by some of the leading researchers in the world. Stochastic models incorporating the spatial distribution of species have emerged in a variety of areas in mathematical biology and population genetics. Rick Durrett reported on some of the fruitful collaborations between biologists and probabilists in this field. Hans Foellmer spoke on the stochastic models used to price derivatives in financial markets. This is one of the most celebrated areas of application of mathematics. Tom Kurtz

discussed systems of equations used in population genetics and the central role of exchangeability. Jean-Francois Le Gall discussed a class of stochastic models which arose from branching paritcle systems and has proved to be a powerful technique in the study of a class of nonlinear pde's. Recently the range of applicability of this technique has been significantly extended. Percolation theory provides one of the simplest microscopic descriptions of a disordered system which leads to prohibitively difficult problems on the macroscopic scale. Newman described some recent progress on qualitative behaviour on the latter scale. Stroock discussed some of the connections between probability and analysis.

Main speakers:

- **R.T. Durrett** (Cornell) on: *Stochastic Spatial Models*.
- **H. Föllmer** (Berlin) on: *Probabilistic Problems in Finance*.
- **T. Kurtz** (Wisconsin) on: *Infinite Systems of Stochastic Differential Equations*.
- **J-F. Le Gall** (Paris VI): *Superprocesses, Markov Snakes and Partial Differential Equations*.
- **C. M. Newman** (N.Y.U.): *Random Geometry of First Passage Percolation*.
- **D. W. Stroock** (M.I.T.): *Applications of Analysis to Pathspace*.

There were also a series of special sessions including the following:

- Branching Processes and Particle Systems
- Measure-Valued Diffusions and SPDE
- Brownian Motion and Markov Processes
- Particle Systems
- Diffusions on Fractals

Speakers:

- **Simon Harris:** School of Mathematical Sciences, University of Bath
  Martingales for a typed branching diffusion

- **Anton Wakolbinger:** FB Mathematik, Frankfurt University
  Occupation time fluctuations in branching systems

- **Vladimir Vinogradov:** Department of Statistics, University of British columbia
  On asymptotic expansions of age-dependent branching processes

- **J. Alfredo Lopez-Mimbela:**
  Length of Galton-Watson Trees and blow-up of semi-linear equations

- **David Hobson:** School of Mathematical Sciences, University of Bath
  Extremal inequalities for the maxima of a martingale and an application to finance

- **Vlada Limic:** Department of Statistics, University of California
  Multiplicative coalescent

- **Chris Burdzy:** Department of Mathematics, University of Washington
  Stochastic bifurcation models

- **Leon Koralov:** SUNY at Stony Brook, Stony Brook NY
  Effective diffusivity of stationary time dependent vector fields

- **Jean-Francois Delmas:**
  Catalytic super-Brownian motion

- **Aurel Stan:** Department of Mathematics, Louisiana State University
  The Heisenberg uncertainty principle for white noise analysis

- **Carl Mueller:** Department of Mathematics, University of Rochester
  The critical exponent for an SPDE to hit zero.

- **Luis Gorostiza:** Departemento de Mathematicas, Cinvestav Mexico
  Self-intersection local time of generalized Wiener and Ornstein-Uhlenbeck processes

- **Haya Kaspi:** Faculty of Industrial Engineering and Management, Technion Haifa Isreal
  On p-variation of families of local times of 2-dimensional stable processes on lines

- **Ivor McGillivray:** Department of Mathematics, University of Bristor
  Large time volume of the pimmed Wiener sausage

- **Ana Perez-Palomares:** Departamento de Metodos Estadisticos, Edificio Matematicas, Universidad de Zaragoza Spain
  Stochastic orders and coupling techniques in preservation properties of positive linear operators.

- **Ilie Grigorescu:** NYU-Courant
  Self-diffusion for Brownian motions with local interactions.

- **Rene Dahms:** email:dahms@mathltu-berlin.de
  Large deviation principles for random interfaces.

- **Hideki Tanemura:**Department of Mathematics and Information, Chiba University
  Uniqueness of Dirichlet forms associated with infinitely many particle systems.

- **Nick Frangos:**
  The stochastic wave equation in two spatial dimensions.

- **Ben Hambly:** Department of Mathematics and Statistics, University of Edinburgh
  Transition density estimates for p.c.f. fractals

- **Takashi Kumagai:** Graduate School of Polymathematics, Nagoya University
  Heat kernel estimates for diffusion processes on homogeneous random Sierpinski carpets

- **Svein Nyberg:** Department of Mathematics and Statistics, University of Edinburgh JCMB
  Diffusions on fractals: stability under certain perturbations of the fractal.

- **Andras Telcs:** International Business School Budapest
  Random walks and the electrical network technique: how far can we go?

- **Ana M. Valle:** Departamento de Matematica Aplicada y Estadistica e Investigacion Operativa, Universidad del Pais Vasco
  Optimal centered Poisson approximation of uniform empirical processes.

This conference was sponsored jointly by the CRM, the Fields Institute and PIMS.

Participants in the thematic summer: Adell Jose, Adler Robert (University of North Carolina at

Chapel Hill), Altschuler Steve (Microsoft Corporation), Athreya Siva (U. Washington), Bakal Jeffrey (U. Calgary), Belili Nacereddine, Bonnet Guillaume (UNC-CH Chapel Hill), Burdzy Krzysztof (University of Washington), Caputo Pietro, Carmona Phillippe (Universite Paul Sabatier, Toulouse), Chou Chung-Sung (National Central University Chung-Li, Taiwan, ROC), Cox Ted (Syracuse University), Crisan Dan (Imperial College, London), Dahms Rene (Berlin, Germany), de la Cal Jesus (Universidad del Pais Vasco, Bilbao, Spain), Dalang Robert (Tufts University), Dawson Don (Fields Institute), Jean Francois (U. Marne La Vallee, France), Derbez Eric (UBC), Durrett Rick (Cornell University), Evans Steve (Berkeley), Feng Shui (Mcmaster University), Fleischmann Klaus (Weierstrass Institute for Applied Analysis ans Stochastics, Berlin, Germany), Foellmer Hans (Berlin), Frangos Nicholas, Git Yoav, Gorostiza G. Luis (Mexico), Griogorescu Ilie (Courant Institute), Greven Andreas, Hambly Ben (University of Edinburgh), Harris Simon (University of Bath, UK), Hernandez-Lerma, O., Hobson David (University of Bath, UK), Hochberg Kenneth (Bar-ILan University, Israel), Jankowiak-Roslanowska Malgorzata (Bar-ILan University, Ramat Gan, Israel), Kaspi Haya (Technion Haifa, Israel), Klenke Achim (Germany), Konno Norio (Yokohama National University, Yokohama, Japan), Koralov Leonid (SUNY at Stony Brook), Kouritzin Michael(IMA, Univ. of Minnesota & University of Alberta), Kumagai Takashi (Nagoya University, Japan), Kurtz Thomas G. (University of Wisconsin, Madison), Kwon Youngmee (Hansung University, Seoul, Korea), Lawnicz Anna (Guelph University), Le Gall Jean-Francois (Universite Paris 6, France), Limic Vlada (University of Cal. Berkeley, Lopez Miguel (Fields Institute), Lopez-Mimbela J.A. (Guanajuato, Mexico), Lyons Terry, March Peter (Ohio State University), McGillivray Ivor (University of Bristol), Morales Carlos (Brookline MA), Mueller Carl (University of Rochester), Newman Charles (Courant Institute, NY), Nyberg Sven (University of Edinburgh, UK), Peterson Dave, Pinelis, Iosif (MTU Houghton, MI),

Puterman Martin (UBC), Matthew (Prince George, BC), Rosen Jay, Salopek Donna (Fields Institute), Serlet Laurent (Paris, France), Shah Nikhil (Cornell, Ithaca, NY), Shiga Tokuzo (Tokyo Inst. of Technology), Shius Elias, Skoulakis Georgios, Stan Aurel Iulian (Louisiana State University), Stroock Dan (MIT), Takaoka Koichiro (Oh-okayama,Tokyo, Japan), Tanemura Hideki (Chiba University, Chiba, Japan), Telcs Andras (Int'l Business School Budapest, Hungary), Tribe Roger (University of Warwick,UK), Vinogradov Vladimir (UNBC), Wakolbinger Anton (Frankfurt University), Warren Jonathan (University of Bath, UK), Wehr Jan, Williams Ruth, Winter Anita (Erlangen, Germany), Mario Wu, Lani (Microsoft Corporation), Yuan George Xian-Zhi (Dalhousie University, Halifax).

4.2 Math. Economics and Finance, July-August, 1998

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

A group of activities dealing with mathematical problems arising in economics and finance are planned. The goals are to:

- expose graduate students, the scientific community at large and the banking sector to the modern aspects of mathematical economics and finance;

- introduce Canadian mathematicians to the interesting mathematical problems arising in these fields;

- develop this new and thriving area of mathematical research in Western Canada and to connect the mathematicians with the business and management schools; and

- prepare interested maths graduates for work in the banking sector.

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

Organizers: 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). The aim of this workshop is to provide a mini-course in social choice theory and related issues of distributive justice, with special emphasis on topics that illustrate the diverse branches of mathematics that the subject draws upon (such as algebra, analysis, topology, functional equations, game theory, graph theory, measurement theory, and majorization theory). Each lecture is self-contained and is designed to provide an introduction to the topic for nonspecialists and a fresh perspective on the subject for the specialist. Each of the lectures is two hours long. The three lectures on July 2nd will provide enough of an introduction to social choice theory for interested parties to benefit from the papers presented to the Society for Social Choice and Welfare conference, July 3-6. The primary audiences for this workshop are economists, mathematicians, philosophers, and political scientists, but the lectures will be of interest more generally.

- **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

Programme Committee: David Austen-Smith (Northwestern University), Walter Bossert (University of Nottingham), John Conley (University of Illinois at Urbana-Champaign), Rajat Deb (Southern Methodist University), John Duggan (University of Rochester),

James Foster (Vanderbilt University), Carmen Herrero (Universidad de Alicante), Hideo Konishi (Southern Methodist University), Michel Le Breton (GRE-QAM and Université de la Mediterranée), Jordi Masso (Universitat Autónoma de Barcelona), Philippe Mongin (CNRS, THEMA, and Université de Cergy-Pontoise), Efe Ok (New York University), Hans Peters (Universiteit Maastricht), Tatsuyoshi Saijo (Osaka University), Arunava Sen (Indian Statistical Institute, Delhi Centre), Yves Sprumont (Université de Montréal), John Weymark (Chair, University of British Columbia), Elena Yanovskaya (St. Petersburg Institute for Economics and Mathematics).

Local Organizing Committee: Charles Blackorby, David Donaldson, Hugh Neary, and John Weymark (Chair).

Approximately two hundred contributed papers will be presented in parallel sessions. The featured speakers have all made fundamental contributions to the study of social institutions when individuals use private information strategically. The conference will be used to help celebrate Professor Mirrlees' recent Nobel Prize and the twenty-fifth anniversary of the Gibbard-Satterthwaite Theorem.

Keynote Speakers:

- **Allan Gibbard**, Richard B. Brandt Distinguished University Professor of Philosophy at the University of Michigan
- **James Mirrlees**, Nobel Laureate and Professor of Economics at Cambridge University
- **Mark Satterthwaite**, Earl Dean Howard Professor of Managerial Economics at Northwestern University
- **Herve Moulin**, James B. Duke Professor of Economics at Duke University (Presidential Address)

Summer Conference on Industrial Organization, July 10-11

Organizer: Thomas Ross, UBC

Main speakers:
- **Jean-Jacques Laffont** (Toulouse)
- **Matthew Turner** (Toronto)
- **Joseph Harrington** (Johns Hopkins)
- **Shane Greenstein** (Northwestern)
- **Randall Kroszner**, U. of Chicago
- **Tom Hubbard** (UCLA)

Workshop on Design of markets and organizations under incomplete information, July 13-17

Organiser: J. C. Rochet.

Mechanism design theory is concerned with the design of social decision procedures when economic agents have private information and use it strategically. It is now possible to apply this theory to solve concrete problems, e.g., how to construct a revenue-maximizing auction, how to construct efficient trading mechanisms, how to design optimal tariff schedules for telephone or electricity, or how to design complex organizations in a way that prevents corruption. The practical implementation of the theory poses statistical and numerical problems that are just beginning to be solved by the use of powerful tools from functional analysis. These methods are likely to be of independent interest to applied mathematicians. The main objectives of this workshop

are (1) to survey mechanism design theory in a way that is accessible to non-economists, (2) to illustrate the power of the theory by studying four kinds of applications: auctions, trading mechanisms, nonlinear pricing, and the design of organizations, and (3) to consider the mathematical difficulties introduced by the practical implementation of mechanism design theory. The primary audiences for this workshop are applied mathematicians (particularly specialists in statistics, numerical analysis, and functional analysis) and economists. July 15th is devoted to the study of auctions in theory and practice. These lectures will include analyses of the recent spectrum auctions for telecommunications in the US and the electric power auction that is currently being implemented in California. Each of the other five topics will be covered in two lectures spread over two days. The special session on auctions can be followed independently of the rest of the workshop.

Main Speakers:

- **Bruno Biais** (Université des Sciences Sociales, Toulouse) Trading Mechanisms

- **Philippe Choné** (ENSAE) and **Jean-Charles Rochet** (Université des Sciences Sociales, Toulouse): " Computation and Estimation of Optimal Nonlinear Prices"

- **Ken Hendricks** (University of British Columbia) and Robert Porter (Northwestern University): " Empirical Methods in Auctions".

- **Jacques Laffont** (Université des Sciences Sociales, Toulouse): " Modelling Corruption in Organizations".

- **David Martimort** (Université des Sciences Sociales, Toulouse): "Theory of Bureaucracy".

- **Lars Stole** (University of Chicago): "Competition in Nonlinear Prices".

- **Robert Wilson** (Stanford University): " Design of Auction Markets".

Workshop on Recent Developments in Mathematical Economics, July 20-23

Organizers: I. Ekeland (Paris), J. Weymark (UBC)

Recent developments in economic theory have required the use of advanced mathematical techniques and have raised many interesting mathematical problems. The aim of this workshop is 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 from areas such as game theory, optimization theory, calculus of variations, differential geometry, numerical analysis, and logic. Each lecture is three hours long and does not presuppose that members of the audience have heard previous talks in the series. The primary audience for this workshop are scholars working in economics, mathematics, and operations research, but specific lectures will be of interest to others (such as mathematical biologists and logicians).

Main speakers:

- **Susan Athey** (MIT), "Recent Advances in Comparative Statics: Theory and Applications to Games of Incomplete Information".

- **Robert McCann** (Brown), "Optimal Transportation, Hierarchical Structures, and Incentive Compatibility".

- **Richard McKelvey** (CalTech) and Andrew McLennan (Minnesota), "Computation of Equilibria in Finite Games".

- **Ken Judd** (Stanford), "Numerical Methods in Economics".

- **Philippe Mongin** (Universite de Cergy-Pontoise and CNRS), "Logic and the Foundations of the Theory of Games and Decisions".

- **Jeroen Swinkels** (Washington University), 'Evolutionary Game Theory".

- **Ivar Ekeland** (Universite de Paris-Dauphine) "Disaggregation Problems in Consumer Theory: A Partial Differential Equations Approach".

Conference on Stochastic Programming, August 10-14

Organizing 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, Andrew Turner.

Speakers:

- Zvi Artstein, Weitzmann Institute–Gains of information in stochastic programming
- Ron Dembo and Dan Rosen, Algorithmics–Experiences at Algorithmics using stochastic programming for risk management
- Michael Dempster, Cambridge University– Dymanic sampling algorithms
- Chanaka Edirisinghe, University of Tennessee– Bounds and approximations for multiperiod stochastic programming
- Wim Klein Haneveld and Maarten van der Vlerk, University of Groningen– Stochastic integer programming
- John Mulvey, Princeton University–Solving many similar large scale stochastic programs in asset/liability management
- Georg Pflub, University of Vienna–Error estimates of sampling
- Andras Prekopa, Rutgers University– Probabilistic programming
- Andrzej Ruszcynski, Rutgers University–Large scale stochastic programming algorithms and computational experiences
- Andy Turner, Frank Russell Company– Development and use of stochastic programming at the Frank Russell Company

- Roger Wets, UC, Davis and William Ziemba, UBC–Scenario choice, aggregation and deletions for multiperiod stochastic programming problems
- Stavros Zenios, University of Cyprus–Solving large scale stochastic programs in mortgage backed security analysis
- Julie Higle, University of Arizona– Statistical approximation in stochastic linear programming
- R. Tyrell Rockafellar, University of Washington– Duality in stochastic programming
- Gabriella Salinetti, University of Rome– Stochastic programming in statistics.

Stochastic Programming: Tutorial Program Aug. 8-9

This program is organized by Julia Higle. Partial support for carefully selected graduate students will be available. The lecturers are:

- Stein W. Wallace– Introduction and overview of stochastic programming
- Janos Mayer– Chance constrained programming
- Maarten van derVlerk– Stochastic integer programs
- Julie Higle and Suvrajeet Sen– Modeling in stochastic programming using a case study approach
- Rudiger Schultz– Stability in stochastic programming
- Chanaka Edirishinghe– Bounding techniques in stochastic programming

Asset and Liability Management Seminar for Institutional Investors, Aug. 15-16

This is organized by John Mulvey and William Ziemba. The main speakers are:

- Adam Berger, Princeton Portfolios and John Mulvey, Princeton University– Asset-liability management for individuals

- Sanjiv Das, Harvard Business School– International portfolio choice with stochastic correlations

- Ron Dembo and Dan Rosen, Algorithmics Inc., Toronto–Algorithmics' value at risk models

- Michael Dempster, Cambridge University–Risk management of option adjusted portfolios

- Karl Frauendorfer–Software

- Wayne Ferson, University of Washington–Factors in international portfolio management

- Robert Haugen, University of California, Irvine–Development and use of a monthly factor model for determining super stock and long short portfolios

- David Heath, Cornell University–What makes a good risk measure?

- Robert Heinkel, University of British Columbia, will serve as a session chair

- Chris Hensel, Frank Russell Company–Use of mean-variance analysis at the Frank Russell Company

- Gerd Infanger, Stanford University–A new approach using the Neyman-Pearson Lemma for finding superior performing stocks

- Robert Jarrow, Cornell University–Valuation of non-maturity demand deposits and credit card loan portfolios

- John Mulvey, Princeton University and Eric Thoralias–Falcon Asset Management, experiences with the Towers Perrin Model

- Steve Murray, Frank Russell Company–A model for individual asset liability management in the Italian context

- Soren Nielson, University of Texas and University of Copenhagen–Binomial lattice sampling distributions in bond portfolio management

- Eric Reiner, Union Bank of Switzerland–Pricing exotic options for alternative stochastic processes

- Markus Rudolf, Swiss Institute of Banking–Intertemporal surplus management

- John C. Sweeney, Falcon Asset Management–Multi-currency asset-liability analysis in the insurance industry

- Glen Swindle, Cornell University–Robust hedgings methods for multiperiod asset Pricing models

- Andrew Turner, Frank Russell Company–The Mitsubishi Trust Model

- Stavros Zenios, University of Cyprus–Asset and liability management for fixed income securities

- William Ziemba, University of British Columbia–Strategies for scenario selection

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.

4.3 Mathematical Biology, June-August 1999

Organizing Committee: Leah Keshet, Department of Mathematics, University of British Columbia, Yue-Xian Li, Departments of Mathematics and Zoology, University of British Columbia, Robert M. Miura, Department of Mathematics, University of British Columbia, Pauline van den Driessche, Department of Mathematics, University of Victoria, Marc Mangel, Department of Environmental Studies, University of California, Santa Cruz, Michael Waterman, Department of Mathematics, University of Southern California.

Overview:

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 the biological and medical sciences. These areas encompass all aspects of life including populations at all levels from animal to micro-

bial, epidemics, ecology, physiology including neurobiology, cardiology, endocrinology, renal physiology, muscle physiology, and biofluid-dynamics 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. Many of these areas break down further into more specialized topics. Consequently, 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.

Given the number of researchers with expertise in mathematical biology at the PIMS' institutions, it is natural for PIMS to sponsor this Special Summer on Mathematical Biology. There are educational and research objectives of this program. The educational component is to introduce participants to the background, problems, modelling, analysis of the models, results, and interpretation of the results for the various topics. The research component is to encourage researchers (especially students and postdocs) to consider new problems, to get feedback on ongoing research, to form new collaborations, and generally to increase the level of research activity in western Canada in mathematical biology.

Program Summary and Schedule

The Summer program will consist of five sessions on the following topics: Cell Biology Ecology Epidemiology Genomics Physiology.

Each of the five sessions in this Special Summer program will run for 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. These topics are described below. Formal talks by invited speakers will be interspersed with informal seminars and discussions among the participants. Spreading the formal talks over a two week period will permit participants to more fully absorb the material being presented and to have ample time to clarify this information. Scheduling of the sessions will be as follows:

- Epidemiology - May 31-June 11, 1999

- Ecology - June 14-25, 1999

- Genomics - July 19-30, 1999

- Cell Biology - August 2-13, 1999

- Physiology - August 16-27, 1999

The break of three weeks in the latter part of June and during July is to allow participants and speakers to attend the International Conference on Theory and Mathematics in Biology and Medicine in Amsterdam (June 29-July 3, 1999; the Annual Meeting of the Society for Mathematical Biology is being held in conjunction with this conference) and the following International Conference on Industrial and Applied Mathematics in Edinburgh (July 5-9, 1999).

Program Description:

Below we describe each of the five sessions in more detail and give a list of proposed speakers and participants.

Session on Mathematical Epidemiology, May 31-June 11, 1999

Mathematical epidemiology is concerned with modeling 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. Classical epidemic models assumed that the total population is constant and were formulated as a system of ordinary differential equations. When the disease causes death (e.g., HIV/AIDS), the assumption of a constant population may not be valid. 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. It is important to have an interdisciplinary group of speakers and participants. The focus will be on the presentation and discussion of models relevant for rapidly increasing diseases (e.g., HIV/AIDS, Lyme disease), diseases that are re-emerging (e.g., tuberculosis, dengue fever), and vector diseases (e.g., Chagas' disease, malaria). The mathematical analysis involved includes identification of important thresholds that determine whether the disease dies out or becomes endemic. Some models can exhibit bifurcation to periodic solutions or more complicated behavior. Data analysis and numerical simulation play an important role. It is intended that this workshop will continue the evolution of modern applied mathematics motivated by epidemic models.

Invited Speakers: Linda Allen, Texas Tech. Lubbock **Roy Anderson** (alt. M Nowak), Oxford **Viggo Andreasen**, Roskilde Denmark **Sally Blower**, University of California, San Francisco **Carlos Castillo-Chavez**, Cornell University **Andy Dobson**, Princeton University **Karl Hadeler**, Tuebingen Germany **Herbert Hethcote**, University of Iowa **Angela McLean**, Pasteur Institute Paris **Carl Simon**, University of Michigan **Glenn Webb**, Vanderbilt University

Other Potential Participants: Fred Brauer, University of British Columbia/University of Wisconsin **Vincenzo Capasso**, Milan Italy **Ken Cooke** Pomona College **Klaus Dietz**, Tuebingen Germany **Richard Durrett**, Cornell University **Lourdes Esteva**, UNAM Mexico **Zhilan Feng**, Purdue University **Elizabeth Halloran**, Emory University **Hans Hesterbeek**, Wageningen Netherlands **Mirjam Kretzschmar**, RIVM Bilthoven Netherlands **Chris Kribs**, University of Texas, Arlington **Jia Li**, University of Alabama, Huntsville **Claude Lefevre**, University of Bruxelles **Michael Li**, Mississippi State University **Denis Mollison**, Heriot Watt Scotland **Jim Muldowney**, University of Alberta **Johannes Mueller**, Utrecht Netherlands **Andreas Pugliese**, Trento Italy **Shigui Ruan**, Dalhousie University **Matt Schuette**, University of Iowa **Horst Thieme**, Arizona State University **Jorge Velasco-Hernandez**, UAM Mexico **Mary Lou Zeeman**, University of Texas, San Antonio **Xingfu Zou**, University of Victoria

Session on Mathematical Ecology, June 14-25, 1999

Ecology is the study of the distribution and abundance of organisms. Mathematical analysis and methods contribute to this study 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 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 turbluence 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.

Potential Participants:
Theory builders: Fred Adler, Danny Grumbaum, Marc Mangel, Steve Pacala, George Sugihara, Steve Elner.
Theory users: Greg Dwyer, Bill Morris, Shea Gardner, Jonathan Newman, Daniel Doak.

Session on Genomics, July 19-30, 1999

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. It is an exciting time for genomics with the current success at generating huge amounts of basic data. There is a continuing concern with generating this data in ever more efficient and inex-

pensive ways. In addition the big new challenge must be met: to decode the information in the genome. For example, just to find all the genes is a much harder problem than it was imagined in the early days of molecular biology. After the genes are identified, it is necessary to determine how the gene products function and interact. In addition, our ideas of evolution will be developed by the data coming from genomics. This session will bring together people from a variety of disciplines including molecular biology, evolutionary biology, discrete mathematics, and statistics. New technologies will be developed and applied to obtain new genetic data which in turn must be interpreted and analyzed by new techniques from the mathematical sciences.

One of the most interesting areas in mathematical biology is modeling evolutionary processes. Bringing theory into the mass of sequence data is one of the most challenging problems we have. The details of modeling 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.

Finding patterns in sequences is a major activity. The database search methods in BLAST and its variants use sophisticated computer science and statistics. Estimating the statistical significance of matches between words (molecular sequences) requires some sophisticated tools. Hidden Markov Models (HMMs) are used to estimate more sophisticated statistical patterns. The area of determining DNA coding for proteins is called

"gene finding" and has become very active. The importance in the era of genome sequencing cannot be overestimated.

Finally we mention the area of DNA structure. (Protein structure is another major area of activity, but we have not made that part of this proposal as it seems to enlarge the scope too much.) DNA structure, particularly that of closed circular duplex DNA, is central to understanding the general chemistry and biology of DNA. Of relevance are topological, geometric and elastic properties. Twist, writhe, and linking numbers have been studied. X-ray crystallography and NMR are powerful methods that have given important information about protein structure, but are not well suited to studying the dynamic processes of the cell. Applications of non-obvious topological and geometrical methods have already yielded some valuable insights.

Invited Speakers: David Sankoff, Andreas Dress, Pavel Pevzner, Gary Stormo, Samuel Karlin, David Haussler, Jim White, DeWitt Sumners, Tao Jiang.
Other Potential Participants: Ming Li, Val. King, Mike Fellows, Tod Wareham, Bill Day, Gene Myers, Mike Waterman, Gary Benson, S. Hannenhalli, Sampath Kannan, Webb Miller, Ron Shamir.

Session on Mathematical Cellular Biology, August 2-13, 1999

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 en-

vironment, 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 articificial 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. Mod-

els 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.

Invited Speakers: Yue Xian Li, University of British Columbia **Alex Mogilner**, University of California, Davis **George Oster**, University of California, Berkeley **Garry Odell**, University of Washington **Victoria Foe**, University of Washington **Tom Daniel**, University of Washington **Lee Segel**, Weizmann Institute **Carla Wofsy**, University of New Mexico **Byron Goldstein**, Los Alamos National Laboratory **Robert Tranquillo, Jennifer Linderman, Micah Dembo**, Boston University, **Albert Goldbeter**, U. Bruxelles **Doug Lauffenburger**, Massachusetts Institute of Technology **Robert Dillon**, Washington State University **Ed Pate**, Washington State University **Lisa Fauci**, Tulane University **Dean Bottino**, University of Utah

Session on Mathematical Physiology, August 16-27, 1999

This session is 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 colloborative 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. Mathematical and computational approaches have become two of the favorite methods of analysis in most research areas of neuroscience which range from the study of $Ca2+$ buffers and channel gating dynamics at the molecular level to the study of the properties of large scale neural networks and artificial intelligence. 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.

  Invited Speakers: Larry Abbott - Brandeis University **Andrew Charles** - University of California, Los Angeles **Bard Ermentrout** - University of Pittsburgh **Nancy Kopell** - Boston University **Yue-Xian Li** - University of British Columbia **Eve Marder** - Brandeis University **John Milton** - University of Chicago **Robert Miura** - University of British Columbia **Ernest Puil** - University of British Columbia **John Rinzel** - New York University **Murray Sherman** - State University of New York, Stonybrook **Greg Smith** - National Institutes of Health **Mircea Steriade** - Laval University

- *Cardiology* is the study of the heart and its functions and has become a very active area of research in the medical sci-

ences. 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. Periodic rhythms characterize the normal heart, whereas aperiodic and complex oscillations (arrhythmias) characterize the diseased heart. In this session, we bring together some of the leaders in modelling these phenomena from different points of view. Some of the specific issues deal with complex electrical activity in cardiac cells, effects of electrical coupling of cells by gap junctions on entrainment and synchronicity, development of complicated wave fronts, dynamics of myocardial tissue, correlating electrocardiograms with electrical activity, and drug effects.

Invited Speakers: **Leon Glass** - McGill University **Michael Guevara** - McGill University **James Keener** - University of Utah **Tim Lewis** - University of Utah **Michael Mackey** - McGill University **Andrew McCullough** - University of California, San Diego **Charles Peskin** - New York University **Arthur Winfree** - University of Arizona.

- *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. It now is known that all hormones are secreted in a pulsatile manner with multiple periodicities ranging from minutes to a month or longer. Of great importance is the ever increasing evidence that these rhythmic patterns are indispensable in the physiological function of these hormonal signals. The understanding of the origin, dynamics, and mechanisms of these hormonal rhythms is important for clinical treatment of various endocrine diseases and in designing novel drug delivery regimes to achieve maximum pharmacological effects. The rhythmogenesis of these hormonal signals also poses challenging mathematical problems of synchrony in coupled oscillators and the emergence of rhythms in a network of coupled cells. This session will bring some of the leading researchers in this area together to give an overview of some of their recent research activities.

Invited Speakers: **Illani Atwater** - National Institutes of Health **Richard Brown** - Dalhousie University **Gerda de Vries** - National Institutes of Health and University of Alberta **Albert Goldbeter** - University of Brussels **Joel Keizer** - University of California, Davis **Garrett Leng** - University of Edinburgh **Yue-Xian Li** - University of British Columbia **Patrice Mollard** - France **Mark Pernarowski** - Montana State University **Arthur Sherman** - National Institutes of Health **Ei Terasawa** - University of Wisconsin .

4.4 Graph Theory & Combinatorial Optimization, June-Aug. 2000

This is a joint proposal to 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.

Program 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 focussing 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 twelve workshops: three at the Fields Institute during Fall '99, four at the Fields Institute during January–May '00, and five 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.

Proposed 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.

We intend to hold workshops 10 through 14 at PIMS.

Graduate Courses

A main goal is to involve graduate students in the activities of the program. 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 the 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; definitions 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 modeling 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 independent 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 converted 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 (Carleton), 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 consideable 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).

Chapter 5

PIMS Ongoing Programs

5.1 PIMS Lecture Series

PIMS Colloquium Series

Organizer: D. Rolfsen (UBC)

PIMS is currently running a colloquium series 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.

19 Sept. 96: **William R. Pulleyblank**, Director, Mathematical Sciences IBM T.J. Watson Research Center, Yorktown Heights, N.Y.
Title: "Mathematics, Computing and Industry"

26 Sept. 96: **Donald Ludwig**, Dept. of Mathematics and Zoology, UBC.
Title: "Statistics and Public Policy".

4 Oct. 96: **Richard Karp**, U. of Washington.
Title: "Combinatorial Optimization as a Tool for Molecular Biology".

4 Oct. 96: **Donald Saari**, Northwestern University.
Title: "The Chaotic Complexity of Economics and the Social Sciences".

4 Oct. 96: **David Brillinger**, UC, Berkeley.
Title: "Studying the Tracks of Elephant Seals".

6 Feb. 97: **V. Kumar Murty**, Dept. of Mathematics, U. Toronto.
Title: "Frobenius distributions and Galois representations".

1 May 97: **Jerry Bona**, Dept. of Mathematics, U. Texas at Austin.
Title: " Solitons, singularities, and the formation of sand bars".

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".

Distinguished Lecturer Series on the Frontiers of High-Performance Computing

Organizer: P. Lancaster (UC)

In its first full year of operation, PIMS presented five lectures by distinguished scientists. The topic of each lecture were consistent with the general title of "The Frontiers of High-Performance Computing". Each lecture highlighted recent advances in, and the limits imposed by theory, machine architectures and software development (for example, the frontiers in error control, complexity, distributed and parallel programming, symbolic computing). The lectures were accessible to a wide audience of mathematical scientists and were jointly sponsored by WurcNet.

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One lecture was delivered on each campus with video links to the other four. The lecturers were resident at the lecture site for at least two days and, in addition, were invited to stay for an informal seminar or discussions with a more specialist audience.

23 Jan. 97: **Jack Dongarra**, Dept. of Computer Science, U. Tennessee and Oak Ridge National Lab.
Title: "Recent Work in Parallel Algorithms for Linear Algebra".

6 March 97: **Erich Kaltofen**, Dept. of Mathematics, North Carolina State University.
Title: "The Black Box Representation of Symbolic Mathematical Objects: New Algorithms, Record Breaking Simulations".

3 April 97: **David Jefferson**, Digitial Equipment Corporation".
Title: "Information Immortality and its Consequences".

17 April 97: **Steve McCormick**, Dept. of Applied Mathematics, U. of Colorado at Boulder.
Title: "First-Order System Least Squares (FOSLS) of Partial Differential Equations".

5.2   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. Most notable among these are the following regional activities:

- Pacific Northwest Geometry Seminar
- Pacific Northwest Probability Seminar
- Pacific Northwest Mathematical Biology Seminar
- Pacific Northwest Number Theory Seminar
- West Coast Optimization Seminar
- Cascade Topology Seminar
- POTLATCH (Combinatorics and graph theory)
- Western Canada Linear Algebra Meeting (W-CLAM)

Rather than replacing these grass roots initiatives, PIMS is supporting them while promoting the formation of similar organizations in other fields by providing assistance in several ways. Some of these organizations already have some support from the US NSF or other granting agencies (in some cases that support only applies to meetings held in the US). Where such support is absent or insufficient, PIMS is –or will be– providing support in the following way:

- **Infrastructure support:** Through its established offices, PIMS provides advertising, room bookings, housing arrangements, etc. This will free the organizers to concentrate on the scientific goals of the meetings.

- **Encouragement of young scientists:** PIMS provides housing expenses incurred by Canadian students and postdoctoral fellows who attend these regional meetings. This provides incentive for young people to become part of the larger scientific community.

- **Expenses for speakers:** PIMS provides additional funding of the travel costs of lecturers, when needed. These funding decisions are made by the scientific review panel, on the same basis as other conferences and workshops.

PNW Geometry Seminar

The Pacific Northwest Geometry Seminar was started in 1973 by Jim Carrell, Arnold Kas and Jim Morrow as a way of bringing together the people in algebraic and differential geometry at UBC, Oregon State and the University of Washington. The seminar quickly grew to include the University of Oregon, Berkeley and Utah. The last one was held on February 7, 1998 at the Mathematical Sciences Research Institute, Berkeley, CA. The speakers were Xiu-Xiong Chen (Stanford), Ana Cannas da Silva (UC Berkeley), Kefeng Liu (Stanford) and Jun Li (Stanford)

The seminar has been supported by the NSF for many years. In addition, one meeting per year is funded by MSRI. Meetings are held three times a year on a rotating basis among the participating schools with the exception that the February meeting is always held at MSRI. The number of participants varies with the location, but there are frequently 75-100 people attending.

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. Washington although in the last few years it has been hosted by U. 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).

The previous PNW Probability Seminar was held at U. of Washington on March 1 1997. The speakers were: E. Housworth, Oregon State U., G. Slade, McMaster U. and W. Woycinski, Case Western U.

The next meeting will be sponsored by PIMS and will be held on Saturday, March 7, 1998 at the University of Washington and will feature two talks:

- **Leonid Mytnik**, UBC: "A duality approach to uniqueness"

- **Achim Klenke**, Berlin: "Branching random walks in a random environment"

PNW Workshop on Math Biology

This spring the University of Washington will host the nth annual Pacific Northwest Workshop on Mathematical Biology (PNWWMB – fondly the punawumba). The meeting, organised by Tom Daniel will be held on Saturday, March 26-28, 1998 at the University of Washington. It will be supported by the University of washington and the NSF. PIMS will provide funding to cover the expenses of Canadian particpants.

PNW Number Theory Seminar

The first meeting was held at Reed College, Portland, on April 5th, 1997. The organizers were Joe Buhler, Reed, and Tom Schmidt, Oregon State. Approximately 60 attended including participants from British Columbia, Washington, Oregon, California, Massachussetts and the Netherlands. It featured four one hour talks by **David Boyd** (UBC), **Ralph Greenberg** (University of Washington), **Hendrik Lenstra, Jr.** (University of California, Berkeley) and **Peter Stevenhagen** (University of Amsterdam).

The next meeting will be sponsored by PIMS and will be held on May 2nd, 1998 at the Harbour Centre campus of Simon Fraser University. The organizers are Peter Borwein, Simon Fraser U., David Boyd, U. British Columbia and Joe Buhler, Reed College. There will be two one hour talks by: **Joe Buhler**, Reed College and **Fernando Rodriguez Villegas**, U. Texas, Austin, and four half hour talks by **Michael Bennett**, U. Illinois, Urbana-Champaign and Institute for Advanced Study, **Rajiv Gupta**, University of British Columbia, **Chris Skinner**, Institute for Advanced Study, and one further speaker still to be confirmed.

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 program. In spring 1997 the featured guest was Boris Mordukhovich of Wayne State University; in autumn it was Olvi Mangasarian of the University of Wisconsin at Madison; in spring 1998 it will be **Kenneth Kortanek** from the University of Iowa. The technical sessions are always well attended (30-40 people usually come), often drawing audiences from the business schools affiliated with universities in the host city. People with industrial connections sometimes come along to the talks when the meeting occurs in Seattle. A distinctive feature initiated in Seattle about five years ago and now a firm tradition is to include in the program some 10-minute "mini-talks" by Ph.D. students nearing the end of their research work. This keeps everyone in this area aware of who's doing what, and provides valuable experience for students about to graduate.

The last meeting was held in Seattle, 15 November, 1997. It featured **Rafal Goebel**, PhD student in Mathematics, Univ. of Washington, **Yves Lucet**, a PIMS postdoc. at SFU/CECM, **Russell Luke**, PhD student in Applied Mathematics, Univ. of Washington, **René Poliquin**, Univ. of Alberta/Mathematics, **Olvi Mangasarian**, Univ. of Wisconsin, Madison/Computer Science, **Pierre Marechal**, PIMS Industrial postdoc. at SFU/CECM and Vancouver Hospital Imaging Group, **Terry Rockafellar**, Univ. of Washington/Math and Applied Math.

The Spring 1998 session of the West Coast Optimization Meeting will take place on 24-25 April at the SFU Harbour Centre Campus in downtown Vancouver and will be sponsored by PIMS.

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 most recent meeting was sponsored by PIMS and was held at UBC on November 15-16, 1997. It

was organized by David Austin, Dale Rolfsen, Denis Sjerve.

Speakers:

- **Steve Humphries**, Brigham Young University: "Braid groups, transvections and representations"
- **Nick Pippenger**, University of British Columbia: "Complexity of problems in knotting and linking"
- **Jack Morava**, Johns Hopkins University: "Spaces of points on real curves of genus zero, and a conjecture of Januszkiewicz"
- **Brian Steer**, Oxford University: "Approximating non-compact spaces by orbifolds"
- **Nancy Waller**, Portland State University: "Constructing spines of 3-manifolds with finite fundamental group"

Approximately 35 persons attended, including 10 graduate students and 5 postdoctoral fellows. Participants included mathematicians from Oregon, Utah, Alberta and B. C., as well as England and Maryland.

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 upcoming meeting is planned just prior to the Workshop on Hadamard Matrices, Coding Theory, Cryptography and Computer Security at the University of Lethbridge, August 3-7, 1998 and will be sponsored by PIMS. It is anticipated that some participants will attend both events. It will be held at the University of Victoria, July 30-31, 1998.

The Organizers are 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 are **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. who uses linear algebra in electrical engineering problems (e.g., control, signal processing, circuit design). Approximately 20-25 presentations and 25-30 participants are expected.

POTLATCH

This is an annual informal gathering of mathematical experts in Combinatorics and graph theory. The last one was sponsored by PIMS and was held at Simon Fraser University, Harbour Centre, Vancouver, BC, May 24th, 1997. The organizers were **Brian Alspach** and **Kathryn Heinrich**, SFU. The speakers were:

- **Gary MacGillivray**, University of Victoria on: *The Achromatic Number of Graphs.*

- **Kathie Cameron**, Wilfrid Laurier University on: *Disjoint Monotone Paths in Simple Regions*

- **Peter Hamburger**, Indiana-Purdue at Fort Wayne on:*A graph-theoretic approach to problems in elementary and combinatorial geometry.*

5.3 PIMS Industrial Problem Solving Program

This program consists of a series of initiatives designed to bring together academic scientists, graduate students, and industrial researchers in the mathematical sciences to investigate mathematical problems arising in the industrial sector. Here are the ongoing initiatives developed by PIMS for that program.

Industrial Working Seminar Series

The Industrial Working Seminar Series is designed to establish links with the local industry on a continuous basis. Once a month, an industry representative is 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, **Huaxiong Huang** identifies suitable problems, contacts the appropriate research groups associated to PIMS and CICSR and keeps both industrialists and academics in constant contact.

- The first seminar was given on February 12 by **Murray Margolis**, Manager of **Powerex** and 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?

- The second seminar will be given on March 19 by **Marcel Lefrancois**, Research scientist at **Vortek Industries Ltd.** and will deal with "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° C per second to

temperatures around $1100°$ 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 $1050°$ C. Dr. Lefrancois will present a simple RTP tool configuration and discuss the technical problems in meeting the processing requirements.

A similar event will be initiated soon in Alberta.

The Industrial Problem Solving Workshop

The format of this 5 days workshop follows the formula developed by the Oxford Study Group. The participants are introduced on the first day to a number of mathematical problems presented by the industry scientists. Thereafter, the participants split up into several groups to ask more detailed questions of the industrial researchers and to initiate the work on the posed problems. On the final day of the worskhop, team leaders present their results to a gathering of all participants. This is followed by questions and comments by the industrial participants. Each group then writes a progress report for the proceedings of the workshop which is then printed and widely distributed by PIMS.

- The first Industrial Problem Solving Workshop (**PIMSIPS 1**) was held on August, 1997 at UBC with contributions from Powertech. Inc., Petro-Canada Corp., MacMillan Bloedel Inc, Kinetic Sciences Ltd. and the BC Cancer Agency.

- The second Industrial Problem Solving Workshop (**PIMSIPS 2**) will beld in June 1-5, 1998 at the University of Calgary.

For more details, see Chapter 7.

5.4   PIMS   Ongoing Projects with elementary schools

Alternative Mathematics Education Events

This program 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 first Alternative Math. Education event was held at **McKenzie Elementary School** in Victoria on Jan. 23, 1997

- A second one was presented at **Hillcrest Elementary School** in Gordon Head, on Oct. 2, 1997

- A third one is planned for **Cloverdale Elementary School**, on March 3, 1998.

Amongst regular people participating 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).

Math Evenings in Alberta

These evenings are similar in nature to the Victoria program. We plan mathematics activities with elementary school kids and their parents to explore mathematics, to go beyond

the accepted impression that mathematics is a boring and dry subject, and other evenings are completely dedicated to teachers themselves, helping them with new developments in the curriculum. This series was created to celebrate math awareness week, and we are planning annual events surrounding this event.

During the two evenings held in April and May 1997, we had a wide variety of math exploration activities including number bracelets, zeros and ones, and an elementary version of markov chains acted by the participants. Parents were directly involved in these activities with their children. Later in the evening, kids were gathered to watch *The Lion King* on video while the over 100 parents were assembled in the gym to discuss the new curriculum, a session chaired by Sharon. We heard some straight questions and Sharon gave some straight answers. Parents were also concerned about the communication between them and teachers, where relevant material could be found, and what problem solving is good for compared to the "good old" mad minute. Usually, the evening ends with pizzas for everyone and a chance to discuss the evening with the parents and teachers.

Another evening was a session prepared by Sharon Friesen directly for elementary teachers that focused first on the new curriculum and the second part focused on problem solving. Participants commented that they particularly enjoyed and benefited from working with a teacher and a mathematician and they asked for more sessions like this one. A listserv has been set up to support teachers and keep them in contact with each other and with the presenters as they start to work with a more problem solving approach in their classrooms.

As a direct result of these evenings sessions, several other groups have approached PIMS for inservice sessions on problem solving and the new curriculum. These include two high schools, 3 middle schools, and 34 teachers from elementary schools. Sessions are being planned to take place on a regular basis at Banded Peak School. The organizers of these events are **S. Friesen** (Banded Peak School), **C. Laflamme** and **M. Stone** (U. C).

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 being presented by all levels of instructors, including university professors, school district personnel, 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 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 is planned for April 23, 1998 again in Westwood Elementary in Coquitlam with a keynote address given by **Dr. Maria Klawe** (UBC).

Both events were organized by **Pamela Hagen** (Westwood Elementary). We expect to continue this program an 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 Novem-

ber, 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.

Chapter 6

Extra-Thematic Scientific Workshops

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 programs 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.

This chapter 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. Those that are held abroad –mostly in Pacific Rim countries– usually have PIMS scientists closely involved in the planning and organization. PIMS support is limited to the participating Canadian scientists. The selection and funding decisions are made by the Scientific Review Panel.

6.1 PIMS Sponsored Workshops in 1997

Conference on Group Rings and Representations, Kananaskis, Alberta, February 18-21, 1997

Organizing Committee: S. Sehgal (UA), M. Shirvani (UA)

This meeting, the sixth in an annual series with the aim of bringing together national and international experts in algebra, is the first one on group rings for a number of years.

Invited Speakers:

- **Yuly Billig** (U. New Brunswick) :"Principal vertex operator representations for the toroidal Lie algebras".

- **Antonio Giambruno** (U. Palermo): "G-identities in rings".

- **Robert Guralnick** (USC):"Finite orbit modules for algebraic groups".

- **Alexander Lichtman** (U. Wisconsin, Parkside):"Valuation methods in group rings an division rings".

- **Robert Moody** (U. Alberta):"Self-similarity and diffraction in quasicrystals".

- **Mike Parmenter** (Memorial U Newfoundland):"Hypercentral and n-central units in integral group rings".
- **Cesar Polcino** (U. Sao Paulo):"Some remarks on central idempotents in group rings".
- **Don Passman** (. Wisconsin, Madison):"Group rings and polynomical identities".
- **David Riley** (U. Alabama):"Algebras with semigroup identities".

Additional Participants: M. M. Parmenter (Memorial U), E. Jespers (Memorial U), A. W. Weiss (UA), G. Cliff (UA), G. Peschke (UA), A. Pianzola (UA), S. K. Sehgal (UA), H. Brungs (UA), M. Shirvani (UA), K. Hoechsmann (UBC), S. Sidki (Brasilia), C. Polcino (Sao Paulo), J. Z. Gonçalves (Sao Paulo), Z. Marciniak (Warsaw), C. K. Gupta (U Manitoba), N. D. Gupta (U Manitoba), K. Varadarajan (UC), K. W. Nicholson (UC), and S. Berman (U Saskatchewan).

Workshop on Smoothing Methods for Mapping Incidence Rates, Vancouver, May 17-19, 1997

Organizing Committee: C. Dean (SFU, Chair), P. Gustafson (UBC), M. Hayes (B.C. Ministry of Health), N. Le (B.C. Cancer Control Agency), Y. MacNab (B.C. Ministry of Health)

Development of methods for the analysis of cancer or other mortality rates for local health regions is an important area of research. Public health professionals and policy makers use these regional rates, usually presented in the form of maps, to determine chronic disease 'hotspots' requiring medical follow up, or to identify specific areas whose populations are at elevated risk for certain diseases. Since several causes of death are area-specific, an analysis of the regional differences in mortality rates can help to identify factors which may be linked to different causes of mortality and, hence, generate hypotheses for epidemiological study.

The usual method of analysis yields regional mortality rates which lack precision, mainly for those regions where the population sizes are not large; there are several of these in British Columbia. The problem has acute ramifications at the policy-making level where a small-population region may be identified as a 'hotspot' in one year, and not in the next, simply because of the large variability in the rate estimate. There is an important requirement of reliability in the estimates for the policy makers who direct programs at the level of the local health areas which must be addressed.

Several new methods have been proposed recently to improve the rate estimates. Most of these involve some type of 'spatial smoothing'. The development of 'smoothed' maps of rates is one which has generated a lot of interest lately. This is especially true because of some recent advances in Bayesian Statistics which have generated some new tools applicable to this problem.

This workshop brought together researchers from government agencies in BC (Vital Statistics in the Ministry of Health and the B.C. Cancer Control Agency), in the U.S. (the Center for Disease Control), and in France (International Agency for Research on Cancer). An important function of these agencies is the production of maps displaying geographic variation in incidence rates of various diseases. A primary aim of the workshop is to act as a stimulus to facilitate ongoing future research links between Vital Statistics, the B.C. Cancer Control Agency, UBC and SFU. Representatives from Statistics Canada were also invited to participate in the workshop as well as statisticians who work in isolation in B.C. on this topic, for example, those from Vancouver Hospital and the Canadian HIV Network.

- **Owen Devine**, CDC, "Introductory Comments on Spatial Epidemiology"

- Session 1: Discussion Chair: **Brian Leroux**, University of Washington

  Speakers: **Noel Cressie and Hal Stern**, Iowa State University, on "Bayesian Inference for Extremes in Disease Incidence Rates at Aggregated and Point Levels"

- Session 2: Discussion Chair: **Penny Brasher**, University of Calgary

  Speaker:**Karen Kafadar**, University of Colorado-Denver, "Smoothing and Simultaneous Adjustment of Cancer Rates: Melanoma Rates among Whites in U.S. Counties".

- Session 3: Discussion Chair: **Ian MacNeill**, University of Western Ontario

  Speaker: **Jim Zidek**, University of British Columbia, "Imputing Unmeasured Explanatory Variables in Environmental Epidemiology With Application To Health Impact Analysis of Air Pollution".

- General Discussion Chair: **Andrew Lawson**, University of Abertay Dundee

- Session 4: Discussion Chair: **Marc Moore**, Ècole Polytechnique

  Speaker: **Julian Besag**, University of Washington, "On the Detection of Clusters and the Assessment of Risk ".

- Session 5: Discussion Chair: **Tony O'Hagan**, University of Nottingham

  Speaker: **Brad Carlin**, University of Minnesota, "Bayesian Methods in Geographic Information Systems: Population Interpolation over Incompatible Zones"

  Discussants: **Tony O'Hagan** and **Tim Swartz**, Simon Fraser University

Joint PIMS-CMS Workshop in Group Theory and Topology, Winnipeg, June 10-11, 1997

Organizers: S. Boyer (UQAM), D. Rolfsen (UBC)

This was a two-day workshop following the CMS annual summer meeting in Winnipeg which extended the special session on the same theme.

- **Steve Boyer**, UQAM, on " Characteristic submanifold theory and Dehn surgery".

- **Gerald Cliff**, University of Alberta, on " Finite groups of matrices over group rings".

- **Mike Davis**, Ohio State University, on " Isomorphisms between Coxeter groups".

- **Martin Dunwoody**, University of Southampton, " Algebraic annulus and torus theorems".

- **Roger Fenn**, University of Sussex, (plenary lecture) on " The Kervaire conjecture: at the crossroads of topology and algebra".

- **Steve Gersten**, University of Utah, on " A cohomological characterization of hyperbolic groups".

- **Rita Gitik**, California Institute of Technology, on "A construction of hyperbolic 3-manifolds with LERF fundamental group".

- **Peter Hill**, University of Toronto, on " Alexander polynomials of torus-bridge-one knots".

- **Jim Howie**, Heriot Watt University, on " Free subgroups in groups of small deficiency".

- **Sergei Matveev**, University of Chelyabinsk, on " On computer recognition of 3-manifolds".

- **Andrew Nicas**, McMaster University, on " Universal formulas for higher Casson invariants of knots".

- **Luis Paris**, Univ. de Bourgogne, on "Geometric subgroups of surface braid groups".

- **I. B. S. Passi**, Panjab University, on " Bass conjecture and the group trace property".

- **Dale Rolfsen**, University of British Columbia, on " Ordered groups, zero divisors and braids".

- **Denis Sjerve**, University of British Columbia, on " Cyclic group actions on Riemann surfaces".

- **Peter Zvengrowski**, University of Calgary, on " The cohomology ring of Seifert manifolds and applications".

Conference on experimental and constructive mathematics, SFU, June 23-24, 1997

Organizer: J. Borwein (SFU)

This is a collection of (informal) talks in and around the general areas of interest to CECM (analysis, computational mathematics, experimental mathematics, number theory, symbolic algebra, and more). It was sponsored by the Pacific Institute for the Mathematical Sciences (PIMS) and the Centre for Experimental and Constructive Mathematics (CECM). It consists of 4 sessions:

1. NONLINEAR ANALYSIS

   - **Jim Zhu**, Western Michigan University, on "Sensitivity analysis for optimization problems in reflexive Banach spaces"
   - **Zili Wu**, University of Victoria, on "Proximal subgradients and integration"
   - **Rene Poliquin**, University of Alberta, on "Recent developments in the study of prox-regularity"
   - **Mihaela Radelescu**, University of British Columbia, on "The convex function associated with a monotone operator".

2. OPTIMIZATION

   - **John Dennis**, Rice University, "Trust-Region Methods for Optimization with Some Applications"
   - **Pierre Marechal**, Simon Fraser University, "On the regularization of the Fourier Synthesis inverse problem and related topics"
   - **Stephen Braham**, Simon Fraser University, "Demonstration of Polynet Technology"

3. COMPUTATION and COMBINATORICS

   - **Pal Fischer**, University of Guelph, on "Some new logarithmic inequalities and Maple"
   - **Dominique Villard**, Simon Fraser University, on "The use of Automatic Differentiation for computing efficient dynamic models of multibody systems"
   - **Ian Affleck**, Simon Fraser University, "Minimizing Expected Broadcast Time in Arc-unreliable Networks"

   - **Scott Allen**, Toronto, "A Procedure for Generating Alternate Representations of Zeta Functions"

4. NUMBER THEORY

   - **David Boyd**, University of British Columbia, on "The order of vanishing at $x = 1$ of polynomials with coefficients in $\{-1, 1\}$"
   - **Doug Bowman**, University of Illinois (Urbana), To be announced
   - **Mike Mossinghoff**, Appalachian State University, on "Perturbed products of cyclotomic polynomials"
   - **Luis Goddyn**, Simon Fraser University, on "A Cute Little Problem Regarding the Distribution of Primes and arizing from J. Will's "Lonely Runner Problem".

International Conference on Nonlinear Phenomena in Dynamical Systems and Variational Problems, Methods and Applications, Whitehorse, Yukon, July 2-6, 1997

Organizing Committee: J. Macki (UA), W. Krawcewicz (UA), J. Mawhin (Louvain), H. Smith (Arizona State U), P. Zecca (U Firenze).

This conference was devoted to various aspects of dynamical systems and variational problems involving nonlinear phenomena, connections to bifurcation theory, functional/ ordinary/partial differential equations, with particular focus on topological and geometrical methods, applications to mathematical biology, optimization and mathematical physics.

The great interest in dynamical systems and its multiple applications to areas such as biology, economics, hydrodynamics, engineering and medicine, has contributed significantly to the rapid development of this field in recent years. It is not surprising that a great deal of

research is motivated and influenced by various applied problems involving nonlinearities. There is an unquestionable need for scientific exchanges related to the recent developments, trends, new methods and open problems in diverse aspects of dynamical systems and variational problems involving nonlinear phenomena. The objective of this conference was to provide researchers with such an opportunity.

Main Speakers:

- **Paul H. Rabinowitz, U. of Wisconsin:** *Multibump Methods in Differential Equations*

- **John Mallet-Paret, Brown U. :** *Dynamics of Spatially Discrete Systems*

- **Alessandro Fonda, U. of Trieste, Italy:** *Periodic Solutions of Scalar Second Order ODE's*

- **Anna Capietto, U. of Torino, Italy:** *On the Existence of Two Sequences of Solutions for a Superlinear Sturm-Liouville Boundary Value Problem*

- **Herbert Freedman, U. of Alberta:** *A Model of Chemotherapy Strategies in Cancer Treatment*

- **Zeev Ditzian, U. of Alberta:** *Best Approximation of K-functionals*

- **Velmar Headley, Brock U., TBA**

- **Heinrich Steinlein, U. of Munich, Germany:**
  Talk 1:*On the Commutativity and the (mod p)-property of the Equivariant Degree*
  Talk 2:*On the Topological Structure of Discrete Dynamical Systems*

- **Brian Hunt, U. of Maryland:** *Optimal Periodic Orbits of Chaotic Systems*

- **Shui-Nee Chow, Georgia Institute of Technology:** *Travelling Waves in Lattice Dynamical Systems*

- **Michel Delfour, U. de Montreal:** *Optimization Problems with Respect to Shapes and Geometries*

- **Keith Promislow, Simon Fraser U.:** *Stability of Travelling Waves for a Coupled Nonlinear Schrodinger Equation*

- **Jedrzej Sniatycki, U. of Calgary:** *Structure of the Solution Space of Yang-Mills Equations*

- **Valeri V. Obukhovskii, Voronezh State Pedagogical U.:** *Survey of Some Properties of Nonlinear Differential Inclusions in Banach Spaces*

- **Michael Renardy, Virginia Tech. U.:** *Takens-Bogdanov Bifurcation on the Hexagonal Lattice*

- **Brian Hassad, U. of Buffalo:** *On the Commutativity and the (mod p)-property of the Equivariant Degree*

- **George Sell, U. of Minnesota:** *A Paradigm for the Dynamics of the Navier-Stokes Equations on Thin 3D Domains*

- **Veri Benci, U. of Pisa, Italy:** *On the Existence of Lorenz Invariant Solutions in Dimension 3*

- **Edward N. Dancer, U. of Sydney, Australia:** *Degree Theory and Populaton Models*

- **William Langford, The Fields Institute:** *Mayer Waves: A Dynamical System Analysis*

- **Pauline Van Den Driessche, U. of Victoria:** *A Model for HIV/AIDS with Infections*

- **Yihong Du, U. of New England, Australia:** *A Non-Standard Singular Perturbaton Approach to a Predator-Prey System with Neumann Boundary Conditions*

- **Andre Vandrbauwhede, U. of Gent, Belgium:** *Normal Forms and Periodic Solutions in Reversible Systems*

- **Jorge Ize, U. N. A. M., Mexico:** TBA

- **Zalman Balanov, Bar Ilan U., Israel:** *Morse Complex and Asymptotically Linear Elliptic Equations with Resonance at Infinity*

- **Waclaw Marzantowicz, Gdansk U., Poland:** *Periodic Points and Braids which Imply Chaos for a Surface Homomorphism*

- **Tomasz Kaczynski, U. de Sherbrooke:** *Finitely Representable Set-Valued Maps and Computation of Topological Invariants*

- **Moxun Tang, U. of Alberta:** *Nonlinear Phenomena: Existence and Uniqueness of Semilinear Elliptic Equations*

- **Madjid Allili, U. de Sherbrooke:** *An Algorithmic Approach to the Construction of Homomorphisms Induced by Maps in Homology*

- **James Yorke, U. of Maryland:** *Bifurcations that Occur in Piecewise Smooth Systems, as in Electrical Circuits*
- **Judy Kennedy, U. of Delaware:** TBA
- **Harold Hastings, Hofstra U. :** *Time Scales in Nile River Dynamics and Other Large, Non-linear Systems*

International Category Theory Meeting (CT97), UBC, Vancouver, July 13-19, 1997

Organizer: John MacDonald

One of the founders of the subject, **Saunders MacLane** gave the keynote address. These meetings took place in the Pacific Northwest for the first time. They have not been held in the Pacific region since the MSRI meetings in 1993.

Scientific program: There were 45 talks from all areas of the subject, including applications to computer science, algebra and foundations. The participants are nearly all mathematicians or computer scientists and come from 22 countries.

Speakers:

- **Saunders Mac Lane:** The Scope of Category Theory
- **Michael Barr:** Some questions–and some answers–on *-autonomous categories
- **Heinrich Kleisli:** The chu *-algebra of a group
- **Susan Niefield:** A Skeletal Topos of Finite Sets: Implementing Finite Structures in Mathematica
- **Robert Dawson:** When can a double diagram be composed?
- **John MacDonald:** Distributivities and Liftings
- **Art Stone:** Soft adjunctions: stacking cubes, co-existence
- **Michel Hebert:** Syntactic characterization of locally finitely generated categories
- **Ron Ferguson:** Pullbacks and the unit group of ZC^n

- **Fred Linton:** Cones, convexity, star-shapedness, contractibility and Cone-algebras
- **Ross Street:** Developments in Higher Category Theory
- **Jiri Velebil:** Categories as domains
- **Marco Grandis:** Weak subobjects and weak limits in categories and homotopy categories
- **Peter Johnstone:** Which first-order theories have classifying toposes?
- **Claudio Hermida:** Spans, multicategories and operads
- **Renato Betti:** Cauchy generators of functor categories
- **Michael Johnson:** Higher homotopies and higher category theory
- **Anneliese Schauerte:** Separation properties in the category of biframes
- **David Benson:** Martin L"of Type Theories with Family Structure have Diers categories as Duals
- **Steve Lack:** On the monadicity of finite monads
- **F.W. Lawvere:** "Geneology and Kinship" an application of topos theory
- **G. Rosolini:** Some general constructions of models of the lambda-calculus
- **R.A.G. Seely:** Linearly distributive functors and nuclearity for linearly distributive categories
- **Vaughan Pratt:** Is linear logic complete for di-naturality in Chu?
- **Peter Freyd:** Paracategories
- **Dominique Bourn:** n-groupoids from n-truncated simplicial objects
- **Jim Otto:** Unifying lambda-terms using bicategories of resolutions
- **Max Kelly:** On Property-like Structures
- **Jürgen Koslowski:** Beyond the Chu-Construction
- **Paul Taylor:** An Abstract Stone Duality
- **Jiri Rosicky:** Enriched accessible categories
- **Phil Mulry:** A Lifting Result for Algebras
- **Hiroyuki Miyoshi:** Combinatorial structure and weak omega categories
- **Till Plewe:** Weakly connected maps of locales

- **Sandro Fusco:** Stable Functors and the Grothendieck Construction
- **Jorge Picado:** A theorem of Eframovic in pointfree context
- **Jonathon Funk:** Bifibrations and KZ-doctrines
- **Joanne Walters-Wayland:** Regular Lindelof frames-Rings of continuous functions
- **Cristina Pedicchio:** Exactness and regularity for locally presentable categories
- **Walter Tholen:** Separated and dissonant morphisms
- **Anders Kock:** A deRham chain complex in Synthetic Differential Geometry
- **Hongde Hu:** Coherence completions and free bicompletions of categories
- **Lourdes Sousa:** On the existence and construction of solid hulls
- **Dorette Pronk:** The fundamental group of a triangulated orbifold
- **Francisco Marmolejo:** Pseudomonads and KZ-doctrines
- **Bob Pare':** Further developments on double limits
- **Bob Rosebrugh:** Entity-relationship models and sketches
- **Robin Cockett:** Feedback in (=traced) linearly distributive categories
- **R. J. Wood:** Groupoidal completely distributive lattices

PIMS-APCTP Summer Workshop on Physics Particles, Fields and Strings, Vancouver, July 7-25, 1997

Organizers: Taejin Lee (Asia Pacific Center), Gordon Semenoff and Ariel Zhitnitsky (UBC), Yuri Makeenko (Institute for Theoretical and Experimental Physics, Moscow.

The Workshop took place at the University of British Columbia during the three week period of July 7-25, 1997. It was jointly sponsored by the Asia Pacific Center for Theoretical Physics and the Pacific Institute for Mathematical Sciences.

The Workshop consisted of 32 lectures about current research topics in mathematical physics, 4 discussion sessions and four lectures by graduate students on the subjects of their research. It also provided the participants with facilities for carrying on their scientific work. There were 53 participants from 11 different countries. Of them, 30 were university faculty, 13 were Postdoctoral Fellows, 9 were graduate students and 1 was an undergraduate student. The scedule of lectures covered three weeks and was kept purposely light in order to allow participants time for scientific work. The style was informal and the format was intended to inspire discussion.

Program:

- Opening Remarks by **G. Semenoff** and **Yongmin Cho**
- **A.M. Polyakov**, 'String theory and quark confinement'
- **D. Austin**, 'Seiberg-Witten theory from a mathematical perspecive'
- **Yongmin Cho**, 'Electroweak Monopole'
- **P. Cotta-**, "Connections on path and loop spaces and four dimensional BF theories'
- **P. Orland**, 'Potential topography and dynamical mass generation'
- **A. Zhitnitsky**, 'Two dimensional QCD: what can we learn from that'
- **P.Pouliot**, 'Pedagogical lectures on M(atrix) theory'
- **L.C.R.Wijewardhana**, 'Zero temperature chiral transition in gauge theories'
- **P. Pouliot**, 'Pedagogical lectures on M(atrix) theory continued'
- **V. Kazakov** "Turbulence"
- **A. Dubin**, "Constructive renormalization of confining Yang-Mills theories"
- Fireside chat at Green College led by **V. Kazakov**.

- **M. Martellini** "Non-Perturbative QCD in the BF Approach: Towards Confinement"
- **S.-J. Sin**, "Seiberg-Witten curves and superpotentials for N=1 super YM from M-theory: Multiple branes and matter"
- Discussion session on string theory led by **A.M. Polyakov**
- **H. Verlinde** "Matrix string theory"
- **T.-J. Lee**, "2+1 Dimensional Black Hole and 1+1 Dimensional Quantum Gravity"
- **R. Brandenberger** "Aspects of Backreaction in Cosmology"
- **Ch. Gattringer** "On the role of topology in lattice gauge theory"
- Discussion session on string theory led by **A.M. Polyakov**
- **K.M. Lee** 'Monopoles, Instantons and D-Branes'
- **C.-Y. Lee** "Back reaction in 2-D charged dilaton and gravity; towards comparison with the D-brane approach"
- Discussion session on the matrix approach to superstring theory led by **H. Verlinde**
- **J. Ambjorn**, "What has happened after matrix models in 2d gravity?"
- **Y. Kitazawa**, "Matrix model for IIB superstring"
- Discussion session on superstrings led by **Y. Kitazawa**
- Student lecture, **P. Paul**, "Mirror Symmetry and T duality"
- **P. Wiegmann**, "Discrete integrable equations"
- **W.-T. Kim**, "Quantum back reaction in two-dimensional gravities" ,
- **Q.-H Park**, "Non-Abelian sine-Gordon theory and application to optics"
- Student lecture, **S. Jaimungal**, 'Effective String Theory'
- **I. Kostov**, "Chiral Weingarten model and non-folding strings in 2 dimensions"
- **I. Halperin**, "Exact results in gluodynamics": topological susceptibility, condensates and θ-dependence"
- **S. Rutherford**, "Algebraic topology and the Jahn–Teller effect in molecules",

- Student lecture, **T. Fugleberg**, 'Condensates and vacuum structure of adjoint two dimensional qcd'
- **A. D'Adda**, "A gauge approach to discrete gravity"
- **Ch. Kristjansen**, "A distance in 2d quantum gravity with matter"
- **R. Szabo**, "Quantum spacetimes in noncommutative geometry"
- Student lecture, **L.Paniak**, "Order parameter for confinement with fundamental matter at large N"
- **Y. Makeenko**, "A pedagogical overview of Matrix Theory"
- **B. Unruh**, "Dumb holes, black hole thermodynamics and entropy
- **G. Semenoff**, "Closing remarks".

LIST OF PARTICIPANTS:

I. Affleck (UBC), J. Ambjorn (Niels Bohr Inst), D. Austin (UBC), R. Brandenberger (Brown), W.-F. Chen (Helsinki), Y.-M. Cho (APCTP), G. Cicuta (Parma), M. Clark (UBC), O. Conradt (Basel), P. Cotta-Ramusino (Milan), A. D'Adda (Torino), A. DeBenedictis (SFU), J. Douglas (UBC), A. Dubin (UBC), T. Fugleberg (UBC), C. Gattringer (UBC), G. Grignani (Perugia), J. Hallin (UBC), I. Halperin (UBC), S. Jaimumgal (UBC), V. Kazakov (ENS Paris), W.-T. Kim (Sogang), Y. Kitazawa (Tokyo), I. Kostov (Saclay), C. Kristjansen (Niels Bohr Inst), B.-H. Lee (Sogang), H.-C. Lee (APCTP), C.-Y. Lee (Sejong), K.-Y. Lee (Columbia), T.-J. Lee (APCTP), Y. Makeenko (ITEP), M. Martellini (Milan), D. Martinez (UBC), W. Mueck (SFU), P. Orland (Baruch NYU), Q.-H. Park (Kyunghee), L. Paniak (UBC), P. Paul (Saskatchewan), D. Persson (UBC), A. Polyakov (Princeton), P. Pouliot (Santa Barbara), A. Rutherford (UBC), S. Sakhi (UBC), S.-J. Sin (Hanyang), P. Sodano (Perugia), R. Szabo (Oxford), W. Unruh (UBC), H. Verlinde (Amsterdam), D. Vollick, K. Viswanathan (SFU), P. Wiegmann (Chicago), L.C.R. Wijewardhana (Cincinnati), A. Zhitnitsky (UBC).

Actuarial Research Conference, Calgary, August 6-8, 1997

Organizer: Professor David P.M. Scollnik (Calgary).

The annual Actuarial Research Conference provides an opportunity for academics and practitioners interested in actuarial science to meet and discuss actuarial problems and their solutions. The 32nd Actuarial Research Conference was held at the University of Calgary in Calgary, Alberta, Canada. The conference was co-sponsored by PIMS, the Actuarial Education and Research Fund, American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society, Conference of Consulting Actuaries, Society of Actuaries, The University of Calgary (Faculty of Science and the Department of Mathematics and Statistics) and The University of Alberta (The Department of Mathematical Sciences). Traditionally a mix of academic actuaries and actuarial practitioners operating in government and industry participate.

Speakers:

- **Robert W. Batcher**, posthumously **Cecil Nesbitt**, University of Michigan, and **Marjorie Van Eenam Batcher**:"An Unfinished Thesis from the 1950's".

- **Nancy Behrens**, Chairperson, Continuing Education Coordinating Committee of the Society of Actuaries, "Continuing Education and the Academic Community".

- **Claire Bilodeau**, University of Waterloo, "The Ownership of the Pension Plan Surplus Using Co-operative Game Theory".

- **Philip Booth**, City University, "Regulation and Professional Development in a Liberal Market".

- **Robert L. Brown**, University of Waterloo, "Is Social Security Regressive ?".

- **Jacques F. Carriere**, University of Alberta, "New Salary Functions for Pension Valuations".

- **Steve Craighead** , Nationwide Life Ins. Co. Mark Tenney, "Economic Scenario Generation".

- **Geoffrey Crofts**, "Karup-King Formula with Unequal Differences".

- **Edward W. (Jed) Frees**, and **Robert B. Miller**, University of Wisconsin - Madison, "Designing Effective Graphs".

- **Richard W. Gorvett**, University of Illinois at Urbana-Champaign, "The Dynamic Financial Analysis of Property-Liability Insurance Companies".

- **Lijia Guo**, Ball State University, "The Sequential Analysis of a Stochastic Volatility Model".

- **Matt Hassett**, Arizona State University, "Data Analysis for the Society of Actuaries' "Safest Annuity Rule" Research Project :Implications for the Education of Actuarial Students".

- **Bruce Jones** , University of Western Ontario, "A Model for Analyzing the Impact of Selective Lapsation on Mortality".

- **Zaki Khorasanee**, City University, Ho Kuen Ng , San Jose State University, "ARetirement Plan Based on Fixed Accumulation and Variable Accrual".

- **Warren R. Luckner**, Director of Research, Society of Actuaries, "The Work of the SoA Research Effectiveness Task Force and Your Input".

- **R.A. Majorov, O.V. Gusev, N.I. Krainyukov** , Non-State Pension Fund of Avto-Vaz, Togliatti, Samarskoi obl., Russia, "Pension Fund Modelling".

- **B. John Manistre**, Crown Life, "A Geometric Approach to Exact Solutions in Finance and Actuarial Science".

- **Esther Portnoy**, University of Illinois at Urbana-Champaign, "Recent Trends in Race-Specific Mortality Rates".

- **Anna Rappaport**, President-Elect, Society of Actuaries, "Challenges of an Aging Society".

- **Margie Rosenberg**, University of Wisconsin - Madison, "AFlexible Model for Time-Dependent Data".

- **Arnold F. Shapiro, Thomas A. Defilppo, Katharine J. Phinney**, and **Jing Zhang** , Penn State University, "Technologies Used in Modeling".

- **Hoque Sharif**, Drake University, "Stepwise Recursion for Compound Lagrange Distributions".
- **Elias Shiu** , University of Iowa, "Annuity Coefficients".
- **Elias Shiu** , University of Iowa **Hans Gerber**, Universite de Lausanne, "Option Pricing Theory".
- **Vladimir Kalashnikov** , Institute of Systems Analysis , Russian Academy of Science, "Bounding and Asymptotic Behaviour of Ruin Probabilities".
- **Emiliano A. Valdez**, and Edward W. (Jed) Frees , University of Wisonsin - Madison, "Understanding Relationships Using Copulas".
- **Julia Lynn Wirch**, University of Waterloo, "Value-at-Risk for Risk Portfolios".
- **Jenny Young**, University of Wisconsin - Madison, "Equilibrium in Competitive Insurance Markets Under Adverse Selection and Yaari's Dual Theory of Risk".

Non-holonomic Constraints in Dynamics, Calgary, August 16-29, 1997

Organizing Committee: L. Bates (UC), R. Cushman (Utrecht), J. Sniatycki (UC)

In recent years there has been a revival of interest in the west in the study of mechanical systems with non-holonomic constraints. This can be attributed partly to the importance of the problem of non-holonomic constraints in control theory, the availability of new geometric techniques, and the difference of conclusions of the Vakonomic and the Newtonian approaches to the problem. Moreover, there is a connection between the non-holonomic constraints in mechanical systems and the dynamical constraints in relativistic field theories (general relativity and Yang-Mills theory) which are of importance in physics.

Conference Participants

- **Bates, L., Calgary**: Gauge conservation laws and singular reduction.
- **Cuell Charles, University of Calgary**: TBA
- **Cushman, Richard, University of Calgary**: Monodromy in Routh's Top
- **Foote, Robert L., Wabash College Crawfordsville, Indiana**: Geometry of the Prytz planimeter
- **Galperin, E.A., Université du Québec à Montréal**: Dynamical equations with accelerations and higher order derivatives of motion in the right hand sides are in agreement with Newton's laws.
- **Graham, Robin, University of Washington**: TBA
- **Kemppainnen, D. University of Calgary**: Nonlinear nonholonomic constraints and particles with spin
- **Koiller, Jair, Laboratoria Nacional de Computaciao Cientifica Rio de Janerio, Brazil**: On efficiency concepts for nonholonomic locomotion problems
- **Koon, Wang S. University of California at Berkeley**: Poisson reduction of nonholonomic mechanical systems with symmetry
- **de Leon, Manuel, Instituto de Matematicas y Fisca Fundamental**: Implulsive constraints and Reduction of non-holonomic mechanical systems with symmetry
- **Lewis, Andrew D., University of Warwick**: Derivation of the equations of motion
- **Marle, Charles, Université Pierre et Marie Curie, Paris**: Various approaches to conservative and nonconservative nonholonomic mechanical systems
- **Marsden, Jerrold E., Caltech**: Selected topics in nonholonomic mechanics The geometry of nonholonomic systems
- **Ostrowski, Jim O., University of Pennsylvania**: Optimal controls for nonholonomic locomotion systems
- **Ruina, Andy, Cornell University**: Walking models
- **Schneider, David, Univeristy of Washington**: TBA
- **Sniatycki, Jedrzej, University of Calgary**: The nonholonomic Noether theorem and reduction.

Joint CMS- PIMS session on Partial Differential equations, Victoria, December 14-17, 1997

Organizers: N. Ghoussoub, C. Gui

This was a three-day workshop following the CMS annual Winter meeting in Victoria which extends the special session on the same theme. The CMS plenary lecturer was **Alice Chang** (UCLA) while the Coxeter-James lecture was given by **Michael Ward** (UBC).

Speakers:

- **Sun-Yung Alice Chang** Department of Mathematics, University of California: *Higher order elliptic equations and applications in conformal geometry*

- **Stanley Alama,** Department of Mathematics and Statistics, McMaster University: *Elliptic equations with indefinite sublinear nonlinearities*

- **Nick Alikakos,** Department of Mathematics, University of Tennessee: *sphericity in multiparticle diffusion*

- **Walter Allegretto,** Department of Mathematics, University of Alberta: *Solutions for the Amorphous Silicon system and related problems*

- **Peter W. Bates,** Department of Mathematics, Brigham Young University: *Multi-peaked solutions to the Cahn-Hilliard equation*

- **Jingyi Chen,** Department of Mathematics, UBC: *Energy minimizing maps from Riemann surfaces*

- **David G. Costa,** Department of Mathematical Sciences, University of Nevada: *Existence and Multiplicity Results for Strongly Indefinite Functionals*

- **Lawrence C Evans,** Department of Mathematics, UC Berkeley: *Uniqueness and the partial regularity of energy-minimizing maps with a Jacobian constraint*

- **Joel Feldman,** Department of Mathematics, UBC: *Asymmetric Fermi Surfaces for Magnetic Schroedinger Operators*

- **Richard Froese,** Department of Mathematics, UBC: *The curvature equation on the plane with infinitely many punctures*

- **Nassif Ghoussoub,** Department of Mathematics, University of British Columbia: *On a conjecture of De Giorgi and related problems*

- **Changfeng Gui,** Department of Mathematics, UBC: *Multiple-Peak Solutions for Singularly Perturbed Neumann Problems*

- **Reinhard Illner,** Department of Mathematics and Statistics, University of Victoria: *On Vlasov-Poisson and related equations*

- **Fanghua Lin,** Courant Institute and University of Chicago: *Vortex dynamics for the nonlinear wave equations*

- **Keith Promislow,** Department of Mathematics, SFU: *Birefringence and Bistability in Nonlinear Fiber Optics*

- **Michael Sigal,** Department of Mathematics, University of Toronto: *The Ginzburg-Landau Equation*

- **J. Sniatycki,** Department of Mathematics, University of Calgary: *Regularity of constraints and reduction in the Minkowski space Yang-Mills theory*

- **Catherine Sulem,** Department of Mathematics, University of Toronto: *Schroedinger equations and related systems*

- **Hussein Tehrani,** University of Nevada, Las Vegas: *Elliptic equations with nonlinearities that are sum of a sublinear and a superlinear term*

- **Jack Xin,** Department of Mathematics, University of Arizona: *On the Dynamical Law of the Ginzburg-Landau Vortices on the Plane*

- **Paul Yang,** Department of Mathematics, University of Southern California: *Regularity of harmonic and biharmonic maps*

- **Meijun Zhu,** Department of Mathematics, UBC: *Uniqueness Results Through A Priori Estimates*

6.2 PIMS Sponsored Workshops in 1998

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.

Program:

- 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, McMaster U.

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.

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 Canadian Applied Mathematics Society (CAMS/SCMA) will be holding its 19th. Annual meeting at Simon Fraser University (SFU) in 1998. This international research meeting will be held simultaneously with the 13th. Canadian Symposium on Fluid Dynamics (CSFD),following a practice that began at Winnipeg in 1996. The Applied and Computational Mathematics Program at SFU and the Faculty of Engineering & the Institute of Industrial Mathematical Sciences at the University of Manitoba will co-sponsor both meetings.

In addition collegial arrangements have been entered into with Societa Italiana di Matematica Aplicata e Industriale (SIMAI) and the Society for Industrial and Applied Mathematics (SIAM).

These involve a joint Canadian/Italian minisymposium (8 talks) at CAMS/SCMA; CSFD-98 on Mathematics and Biomedicine, which will be co-ordinated by Dr. Vinicio Boffi of the Italian Society and Dr. Anna T. Lawniczak, President of CAMS/SCMA. It is expected that SIAM will contribute 5 minisymposia to CAMS/SCMA-98, possibly involving bio-mathematics and bio-informatics. (In turn CAMS/SCMA is invited to contribute minisymposia to SIAM's summer meeting in Toronto at the end of July'98)

Also, collaborative arrangements are being made, through the help of Mr.Bruno Di Stefano of Nuptek Systems Limited, with the Institute of Electrical and Electronics Engineers Incorporated (IEEE Canada; Toronto and Vancouver Sections) which will result in minisymposia at CAMS/SCMA;CSFD-98 on fibre optics and telecommunications networks. Furthermore, Dr. Shiyi Chen (deputy director of the Center for Nonlinear Studies at Los Alamos) has agreed to organize 3 minisymposia with 4 speakers each on turbulence and fluid dynamics on Saturday May 30, 1998; following two meetings on the same topic at Los Alamos.

P.N. Shivakumar, Director of the Institute of Industrial Mathematical Sciences at the University of Manitoba and Mary Williams of Memorial University of Newfoundland and Institute for Marine Dynamics of the National Research Council at St. John's will be asked to organize a workshop on Industrial Mathematics.

The overall theme of the conferences will be applications of mechanics and electromagnetics. But, contributed talks will be solicited and accepted on all aspects of applied and industrial mathematics and mechanics.

Invited speakers

- Canadian Applied Mathematics Society (CAMS/SCMA-98)

  M.M.Carrol, Rice University, Houston, Texas, **Susan N. Brown**, University College London, England, **Bengi Guo**, University of Manitoba, **Chris Jones**, Brown University, Providence, R.I., **Xanthippi Markenscoff**, University of

California, San Diego,**A.J.M. Spencer**, FRS, University of Nottingham, England.

- Canadian Symposium on Fluid Dynamics (CSFD-98)

  Madeleine Coutanceau, Université de Poitiers, France, **W.O. Criminale**, University of Washington, **Stan Dennis**, University of Western Ontario, **J.J. Gottlieb**, University of Toronto,**W.G. Habashi**, Concordia University, Montreal, **Grafton Hui**, Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong, **D.Ingham**, University of Leeds, England, **T.B. Moodie**, University of Alberta, **L. Quartapelle**, Instituto di Fisica del politecnico di Milano, Milan, Italy, **Norman Riley**, University of East Anglia, England, **P.D. Wiedman**, University of Colorado, Boulder.

The 1998 Canadian Operator Theory and Operator Algebras Symposium, U. Alberta, Edmonton, May 21-May 25, 1998

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

The annual Canadian Operator Theory and Operator Algebras Symposium attracts between 70 and 100 mathematicians from Canada, the United States, and overseas. Canada's strength in these areas has enabled us to host one of the two most important conferences in this area in North America (the other being the American counterpart - the Great Plains Operator Theory Symposium), and arguably one of the top three annual conferences in Operator Theory/Algebras in the world.

It is one of the aims of the Canadian Operator Theory and Operator Algebras Symposium to introduce graduate students and recent graduates in Operator Theory into this active mathematical community, helping to maintain Canada's position as one of the leaders in this field.

For 1998, **G.K. Pedersen** of the University of Copenhagen (Kobenhavns Universitet) in Denmark will be the principal speaker. Pedersen is a leading authority in the theory of C*-algebras and group actions. Pedersen will deliver a series of lectures on "Pullback and pushout constructions in C*-algebra theory".

Invited speakers:
Curto, R., University of Iowa, **Davidson, K.R.**, University of Waterloo, **Elliott, G.**, University of Toronto, **Hadwin, D.**, University of New Hampshire, **Handelman, D.**, University of Ottawa, **Kaniuth, E.**, Universitaet Paderborn, **Larson, D.**, Texas A&M University, **Paulsen, V.**, University of Houston, **Ruan, Z.-J.**, University of Illinois at Urbana-Champagne, **Smith, R.R.**, Texas A&M University

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), **S. Donaldson** (Stanford, Oxford), **K. Fukaya** (Kyoto), **W. Fulton** (Chicago), **A. Givental** (Berkeley), **M. Hwang** (Seoul), **J. Li**

(Stanford), **P. Li** (Irvine), **N. Mok** (Hong Kong), **Y. Ruan** (Wisconsin), **C. Taubes** (Harvard), **G. Tian** (MIT), **R. Schoen** (Stanford), **L. Simon** (Stanford), **K. Uhlenbeck** (Texas), **S.-T. Yau** (Harvard).

There will be three types of talks. The first consists of two series of short expository courses, one on quantum cohomology and another on mirror symmetry, to be held in the mornings. Secondly, there will be two one hour talks each morning given by principal lecturers. After the lunch break, there will be sessions for short contributed talks followed by another principal speaker later in the afternoon. The organizers hope to avoid having too many talks so that there is plenty of time for participants to interact mathematically with one another.

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 is 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 will be representatives of new directions like the kinetic theory of semiconductors, kinetic models in granular flow, and others.

The scope of the meeting will include 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.

The format will include 10 to 12 main lectures, approximately 20-30 minute invited lectures, and one or two poster sessions. Refereed papers based on presentations at the conference will be published in a special issue of Transport Theory and Statistical Physics.

List of participants

Chris Bose, University of Victoria **Nassif Ghoussoub**, UBC Vancouver **John Heywood**, UBC Vancouver **Reinhard Illner**, University of Victoria **A. Lawniczak**, University of Toronto, **Fausto Milinazzo**, Victoria **Brian Wetton**, UBC Vancouver **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**, Universite 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**, Universite de Orleans **Robert De-**

war, Canberra **Jack Dorning**, University of Virginia, Charl. **Raffaele Esposito**, University of Rome **Yasuhide Fukumoto**, Fukuoka **Irene Gamba**, University of Austin **Carl Gardner**, University of Ariz., **Ingo Gasser**, TU Berlin **Renee Gatignol**, Universite Paris VI **Bob Glassey**, University of Indiana **Isaac Goldhirsch**, Tel Aviv **Francois Golse**, Universite Paris VII **Jim Greenberg**, University of Pittsburgh **Yan Guo**, Courant Institute, New York **Roger Hosking**, University of Queensland **J.W. Jerome**, Northwestern University **Shi Jin**, Georgia Insitute of Technology, At. **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**, Universite de Nice **Mario Pulvirenti**, Universita di Roma **Rolf Rannacher** Universitaet Heidelberg **Michel Rascle**, Universite di Nice **S. Rjasanow**, Universitaet Saarbruecken **Michael Ruzicka, Christian Schmeiser**, University of Vienna **Maria E. Schonbek**, University of California **Yoshihiro Shibata, 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, NY **H. Dean Victory**, Texas Tech University, **M. Cedric Villani**, Universite Paris VI **Wolfgang Wagner**, Inst.fuer Angewandte Math.und St. **Bernt Wennberg**, University of Goeteborg **Kun Xu**, Hong Kong **Paul Zweifel**, Virginia Polytechnic Inst.

Workshop on Micromechanical Models of Fracture Processes, UBC, July 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.

Invited speakers:

L. **An** (IBM), **P. Cundall** (University of Minnesota), **N. Cook** (UC Berkeley), **E. Detournay** (University of Minnesota), **J. Jenkins** (Cornell University), **D. Martin** (Lakehead University), **J. Napier** (CSIR, South Africa), **A. Peirce** (UBC), **D. Potyondy** (Itasca), **J. Rice** (Harvard), **P. Yip**

(MIT).

The number of participants is limited to keep the workshop small enough that it is possible for each person to contibute to the discussion and developments. There will be 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 will be followed by discussion groups in which participants will work on the problems that have been posed. The planned duration of the workshop is three days.

Chapter 7

PIMS Industrial Program

The PIMS industrial strategy is to establish on-going contacts and collaborations between PIMS academic and industrial members. Presently, too few mathematicians in the university sector have a working relationship with industry. Partially this stems from a lack of understanding by industry as to the research performed at the universities and partially because academics have not felt the need to communicate their work outside their peer group.

It has been a priority for PIMS to identify research opportunities with the industrial sector. Towards this, PIMS has followed the following strategy.

7.1 The First Industrial Problem Solving Workshop, UBC, 1997

Organizing committee: Gordon Semenoff (Physics, UBC), Douglas Beder (Physics, UBC), Arvind Gupta (CS, SFU), Uri Ascher (CS, UBC), Michael Ward (Math, UBC), Dan Calistrate (Math, Calgary), Anthony Peirce (UBC).

In the initial phase, Oxford scientists were recruited as consultants towards developing the Oxford study group model in Canada. The purpose was to identify the best possible strategy for establishing PIMS industrial outreach infrastructure. This allowed PIMS to build on the expertise of a group who have helped set up similar infrastructure in over 30 jurisdictions.

Dr. Tim Myers of Cranfield University in the U.K. and Dr. Barbara van de Fliert of the University of Leiden are members of the Oxford Study Group who came to BC and Alberta in the summer of 1997 to act as consultants towards developing the PIMS industrial strategy. Their experience in soliciting, selecting and developing industrial problems and organizing the workshop itself was extremely useful for our local scientists to learn whatever they could teach us about these activities. The result was a successful workshop - the first of its kind in Canada.

Eighty mathematical scientists (including over 20 graduate students) answered PIMS' invitation to attend the first PIMS industrial problem solving workshop at UBC on August 20, 1997. The following problems were presented by six industrial scientists:

1. **Powertech Inc.** Estimate the stress intensity of composite storage vessels. Such vessels are used,

for example, for compressed gaseous fuels in natural gas or hydrogen vehicles.

2. **Petro-Canada Corp.** Devise a minimally sensitive method for vertical seismic profiling. The current methods are too sensitive to small errors.

3. **MacMillan Bloedel Inc.** Find the optimal placement of cuts in a log to optimize the total value of the resulting lumber.

4. **Kinetic Sciences Ltd.** Develop an efficient algorithm for fingerprint identification that uses a new low cost light scanner. This would allow extremely small fingerprint security systems.

5. **BC Cancer Agency.** Identify pre-invasive bronchial epithelial lesions from a single 2-dimensional section. This could result in much earlier and accurate predication of lung cancer.

6. **MacMillan Bloedel Inc.** Estimate the stress involved in thermorolls in order to determine the extent to which cracking is caused by normal maintenance.

The mathematical scientists split into six teams and worked on the problems for the next five days (and many nights!). Major progress was made in Problems 1, 2 and 6 with the industry scientists expressing their satisfaction with the proposed solutions. Several conceptual suggestions made on problem 4 were positively received by Kinetic Sciences Ltd. and follow ups will be done by the company's researchers. A most interesting experience was that of the team investigating Problem 5. Simultaneous to this workshop was a completely independent PIMS event at UBC: The thematic summer in probability and its applications which was attended by over 100 world experts, At an overlapping coffee break, the Cancer Agency problem was leaked to the probabilists and R. Durett, a world leading mathematician from Cornell University went to work with the team which consisted mostly of graduate students. They devised a new stochastic model for the development of this type of malignant cells that will hopefully be pursued and eventually prove useful. The analysis of problem 3 was deemed unsatisfactory by the MacMillan Bloedel representative but then, not all the constraints of the problem had been available to the scientists from the start. However, the analysis

by the scientists determined that the problem is also intrinsically hard and that it would be difficult to devise an optimal strategy for all cases. A core group of scientists from this team will continue their investigation of the problem. Overall the scientists found the workshop intellectually challenging and fun. Each team eventually wrote a detailed report on their work for the "proceedings of the workshop" which was then published and widely distributed by PIMS.

7.2   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. This year, the basic format consists of:

- A PIMS organized *Graduate Industrial Modeling Workshop* where graduate students from Canadian universities come 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 modeling techniques from experts in the field. The students should come 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 6),

- The *Second PIMS Industrial Problem Solving Workshop* described below.

Graduate Industrial Mathematical Modeling Workshop, SFU, May 25-29 1998

Organisers: Keith Promislow (Chair), SFU, Arvin Gupta, SFU, Mary Catherine Kropinski, SFU, Huaxiong Huang, PIMS

The main objective of this workshop is to provide experience in the use of mathematical modeling as a problem solving tool for graduate students in mathematics and computer science and employees of local industrial companies. The problems will come from industial and engineering applications, and be provided by a mentor who will guide a team through its resolution.

List of potential mentors:
Donal Drew, Rensselaer Polytechnic Institute, **Luis Goddyn**, Simon Fraser University, **Ron Graham**, Lucent Technologies, **Colin Please**, Southampton University, England, **David Ross**, Eastman Kodak, USA, **H. Huang**, PIMS.
Between 25 and 30 graduate students will come together to learn techniques for solving industrial mathematics problems. The participants will work in small groups learning the most recent modeling 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.

There will be an application process for participants, with a limited amount of travel and room expenses for up to 15 out-of-town graduate students. Priority is given to students who will also participate in the upcoming PIMS Industrial Problem Solving Workshop. We envision that this program will be valuable as a recruitment tool for attracting top undergraduates and graduate students to PIMS programs.

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

Organizers: R. Wesbrook (Calgary), D. Calistrate (Calgary), H. Huang (PIMS).

The format of the workshop will essentially be the same as the first workshop in Vancouver. It is anticipated that many of the participants at the CAMS meeting will take the unique opportunity of attending the workshop in Calgary. PIMS will cover the travel expenses of the graduate students attending the three events. The students will now have a chance to try out their newly acquired skills (in the Industrial Modeling Workshop) and make a significant contribution to the solutions of these new problems.

7.3 Industrial Working Seminar Series

(See chapter 5: PIMS Ongoing Programs)

7.4 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 re-

search 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. Dan Calistrate**, University of Calgary and University of Alberta.

- **Dr. Huaxiong Huang**, UBC and SFU.

Dr. Calistrate has been in action in the Calgary area since October 96. The Industrial Facilitator in Edmonton worked until December 1997 and PIMS has committed funds to appoint a part-time industrial facilitator at the University of Alberta beginning April 1998. At present Dan Calistrate is also covering the Edmonton region. Finally, PIMS and CICSR have appointed Dr. Huang to act as a long-term BC Industry-University coordinator beginning January 1998.

7.5 PIMS-initiated projects with the private sector

The list of industrial projects initiated and co-sponsored by PIMS is long and still growing. Here is a list of some of these projects.

- PIMS members have been approached by *Hughes Aircraft of Canada* to solve a statistical problem arising in one of their packages. A solution devised by Bill Hammack (a visiting probabilist at UBC) has been communicated to Hughes.

- A consulting contract between *Pan Canadian Corp.* and Dr. C. Laflamme & D. Calistrate has been initiated by the PIMS facilitator in Calgary. The objective is to develop the mathematical foundation for a new business knowledge-representation model that Pan Canadian is designing. Relevant area(s) of mathematics: Combinatorics, logic.

- A consulting contract between *Diagnostic Engineering Inc.* and Dr. M. Lamoureux has been initiated by the PIMS facilitator in Calgary. The objective is to research, design and implement a software solution for well depth measuring using acoustic waves. Relevant area(s) of mathematics: Numerical Analysis, Computer Mathematics.

- A project to develop Interactive Linear Algebra on the Web is co-sponsored by PIMS and the *LEE envelope* (Government of Alberta). It is being developed by Drs. Claude Laflamme and W. Keith Nicholson from the University of Calgary. Relevant area of mathematics: Linear algebra.

- A potential research partnership between *Veritas Seismic* and Dr. K.Salkauskas is being pursued. The objective is to investigate and, possibly, implement new wavelet transform techniques for 2D and 3D seismic data analysis. Relevant area(s) of mathematics: Approximation Theory, numerical Analysis.

- PIMS has co-organized the Seminar on Mathematics in Industry in Calgary. The

invited lecturer was Dr. Kamal Botros from *NOVA Corporation*. Numerous sources for potential mathematical applications in the gas-transmission industry were identified. A couple of subsequent meetings with Dr. Botros led to the conclusion that a partnership (in the form of consulting relating to a specific problem) with Prof. R. Westbrook is desirable. Relevant area(s) of mathematics: Non-linear differential equations, numerical analysis.

- PIMS-Calgary organized an Industry-University Workshop on Wavelet Transforms in Signal Processing (date April 30, 1997). It included a morning mini-course on wavelets and an afternoon session on industry applications. It is expected that this event will be the base for collaboration on a regular basis between industry scientists from the well-represented seismic-acquisition industry in Calgary and the faculty in the Applied Mathematics division of our department (at U of C). Partial funding was provided to the workshop by *Husky Oil*.

- PIMS organized a workshop on Mathematics in the Telecommunications Industry (jointly with the Alberta Research Council) during the summer of 1997. The focus was on wireless communications and the relevant areas of mathematics were: Geometry, combinatorial optimization, compression and coding theory.

7.6 Industrial contacts and partners

Here is an abbreviated list of companies and corresponding contacted persons that showed interest in collaborating with PIMS.

- Novacor - Kamal Botros, P.Eng. Research fellow
- Veritas Seismic - Scott Cheadle, Ph.D. Director, Research and Development
- Husky Oil - Michael Enachescu, Ph.D., D.Ing., P.Geoph. Exploration Specialist
- PanCanadian - Roger Coates, Ph.D. Coordinator Technology Group
- Alberta Research Council - Larson Brodner, VP marketing
- Diagnostic Engineering Inc. - Thomas Vyskocil, M.Sc., P.Eng. General Manager
- Canadian Energy Research Institute - Anthony Reinsch, VP
- Imperial Oil (research center) - Rick Kry - Ph.D. Senior Physicist
- Computer Modeling Group - F. Meyer, President
- Petro Canada - Michael Slawinski, Ph.D. Geophysicist
- Shell - David Hanley, Ph.D. Geophysicist
- Integrated Flight Systems, L. Hawn, Director
- Canadian Cable Labs, John Madden,
- Powertech Lab Incorporated, Prabha Kundur, President
- MacDonald-Dettwiler Associates, Paul Gorton, Director of Engineering
- Sun Canada, Bob McCartney, Senior account representative
- Hughes Aircraft, J. Joyce
- VGH/Siemens, Anna Celler
- Shaw Cable, Alex Park
- Harley Street Software, Stephan Bulakowski
- Ballard Technologies, John Kenna
- Hongkong Bank of Canada
- IBM Canada
- Dynapro
- Stentor
- Corel Corporation
- MacMillan Bloedel Ltd.
- CRA-RTZ
- Creo Corporation

- CREWES
- Amber Computer Systems.
- BIOTOOLS, Dr. Wishart, Director
- Powertech, Murray Margolis, Manager
- FinancialCad, Owen Walsh, Director
- Vortek, Marcel LeFrancois
- Crystar Research Inc., David Reid
- Raytheon, Jerry Grammer
- Environment Canada, Rob McCandless
- BC Cancer Research Center, Victor Ling

7.7   Industrial postdoctoral fellowship program

Central to the PIMS strategy is the identification of industrial projects that can be tackled by young mathematical scientists. We have already found industry to be enthusiastic and have thus identified a number of opportunities for PDF candidates to initiate and develop specific projects. We expect that as we develop further contacts with industry (through the facilitators) the numbers of mathematical problems identified and formulated will quickly multiply.

We are of the opinion that the Industrial PDF program provides an opportunity for PIMS to establish long-term ties with industry researchers. Many of the fellows will find work within the companies they meet through their PDF. Others who take up industrial or academic appointments elsewhere will have established strong ties to both PIMS and their industrial counterparts. PIMS is committed to keeping these PDF's as part of the PIMS family by inviting past PDFs to workshops and other activities.

Six Industrial PDFs were awarded in 1997 in the following fields, and upto seven will be awarded in the coming year.

- **PDF with IRIS 3 Core Thrust Project, UBC**

  PIMS splits the cost of the followship with the proposed IRIS 3 Core Thrust Project "Reality-based Modeling and Simulation of Physical Systems in Virtual Environments" (D. Pai, Project Leader; U. Ascher, V. Hayward, A. Mackworth and R. Woodham, Principal Investigators). The industrial collaboration involved includes support from *Softimage Inc.*, MPB Technologies, Hymarc Ltd, Point Grey Research, International Submarine Engineering and *Haptic Technologies Inc.* The first and last of these are particularly relevant for the proposed PDF research. The PDF works on developing simulation software for deformable models and constrained differential equations with parameter uncertainty. The supervisors are U. Ascher and D. Pai.

- **Simplification in Computer Algebra Systems, SFU**

  The goal of this project is to develop new algorithms for simplifying formulae involving elementary and special functions in a computer algebra system and implement the design in Maple. The postdoctoral fellow Petr Lisonek will be working under the supervision of Dr. Michael Monagan (CECM, SFU). *Maple Waterloo* is providing the matching funds.

- **PDF on Noise Reduction of digitally compressed video signals, UBC**

  PIMS partially funds D. Li whose research is part of a larger research effort in collaboration with the *Canadian Cable Labs* (Shaw Cable and Rogers Cable TV) and under the supervision of Dr. Rabab Ward (UBC). The PDF is working on noise reduction prior to compressing the video signal as well as after decompressing it. This should lead to better compression performance and higher channel bandwidth capacity. General Instruments Inc. and TCI have shown much enthusiasm for this project. The various industrial partners and the PDF supervisors are committed to providing the remaining funds.

- **PDF on Acoustic Oil-well Soundings, U. Calgary**

  A PDF at the University of Calgary works on ongoing and developing industrial projects jointly with PIMS scientists. These includes current projects on data models of business knowledge representation with *Pan Canadian Petroleum*

Ltd. under the direction of C. Laflamme, on analysis of acoustic oil-well soundings with Diagnostic Engineering Inc. under the direction of M. Lamoureux, and on modeling of the coking process in the oil industry under the direction of R. Aggarwala and M. Lamoureux. The industrial partners and supervisors are committed to providing the remaining funds.

- **PDF in Medical Imaging, SFU**

  For three years, researchers under the direction of J. Borwein (SFU) have been collaborating with the Medical Imaging Group at Vancouver Hospital and Health Science Center (VHHSC) (under the direction of A. Celler). Siemens Canada has committed for the study of methods to correct for attenuation. The specific study involves determination of heart metabolism by measuring uptake of a radioactive fatty acid substitute. The PDF is working on the mathematics, physics and computation relating to Dynamic SPECT (photon emission tomography) with specific attention to attenuation correction, correction for Compton scattering, maximum likelihood methods for reconstruction , maximum entropy and other iterative methods for rapid large scale functional reconstruction from SPECT data. The remaining is provided by *Siemens* through the Vancouver General Hospital.

- **PDF in Algorithmic Optimization, SFU**

  The optimization group at Simon Fraser University is currently working with Amber Computer Systems to develop new algorithms for machine shop scheduling for a number of local industry. These problems occur in industry where many different jobs are ongoing, require near real-time performance and allow preemption (but at high cost). Work started in the summer of 1997 to model the problems. PIMS, Amber and the participating scientists each pays half the cost of the PDF who works with the group to implement various scheduling strategies.

- **PDF in Multiple Target Classification and Tracking, U. Alberta**

  A PDF was created at the University of Alberta to work on the exciting, new area of multiple non-cooperative target classification and tracking. The needed techniques are from Stochastic processes, analysis, and computational mathematics. The project is co-sponsored by *Lockheed Martin Canada* (Winnipeg, Montreal) and *Lockheed Martin Tactical Defense* (Minnesota). The PDF is supervised by Michael Kouritzin.

- **PDF in Vehicle Routing studies, UBC**

  Under the supervision of Marty Puterman (Commerce, UBC), Dr. M. Oosten will be working on two industrial projects. He will develop solution methods for the challenging problem of vehicle routing for the Court Escort Services. He will also be involved in the development of large scale integer programming models to optimally select and schedule projects subject to manpower, equipment and capital constraints. The industrial Partner on this project are BC TEL and the "BC Attorney General's office court escort services".

- **PDF in the Mathematics of Risk Management Systems, U. Calgary**

  Under the supervision of G. Sick and P. Zvengrowski (Calgary), Y. Shkolnikov will use modern topological methods to deal with the area of energy derivatives and other Risk Management Systems under study by R.I.T.A Labs Inc. which is co-sponsoring the project.

- **PDF in Multi-surface Geological Modelling, U.Calgary**

  Under the supervision of R. Blais (Calgary), Dr. C. Jessop will be developing a consistent multi-surface geological 3D modelling program. The software would include the ability to derive and analyse economic, geological and other spatial information. The fellowship will be co-sponsored by the "Geological survey of Canada".

7.8 Industrial workshops and mini-courses

We have found considerable enthusiasm from industry for workshops and mini-courses where state-of-the-art research material can be presented and debated. Industry scientists have a great desire to stay in contact with current research being carried out at the universities. At the same time academics are constantly looking for relevant problems.

Mini-courses with topics of interest to both industry and academia will be 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 will be more interactive than the mini-courses. The academics and industrial users will discuss ideas and problems that arise.

Workshop on Wavelet Transforms in Signal Processing, Calgary, April 30th, 1997

Organizer: Dan Calistrate PIMS Industry-University facilitator.

The modern mathematical theory of wavelets was introduced by experts in the field. Differences and similarities with established signal processing methods were emphasized. The level of general mathematical knowledge assumed for the audience was limited to first and second year courses in Engineering and Science programs; no background on wavelets was necessary. The target Audience was Industry Scientists, Faculty and Students.

Mini-Courses on Wavelets were given by **Dr. L. Bos, Dr. K. Salkauskas** and **Dr. M. Lamoureux** from the Department of Mathematics and Statistics at the University of Calgary.

Three short presentations focused on concrete aspects of applying new mathematical methods to Geophysical Data Processing and Signal Processing in general. They were given by **Dr. R. Stewart**, Department of Geology & Geophysics, **Dr. Xiao-Gui Miao**, Veritas Seismic and **Dr. M. Slawinski**, Petro-Canada.

There were also a question period followed by informal discussions. Partial support was provided by Husky Oil and the Crewes Project.

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

Organizer: Richard Cleve

The invention of public-key cryptography 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 provably 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 proposed workshop would include discussion of both theoretical and practical issues, with a view towards bridging them. Participants would include academic researchers and well as people in industries that produce cryptographic products.

Invited speakers:
Shawn Abbott (Rainbow Technologies, Calgary), **Josh Benaloh** (Microsoft, Seattle), **Peter Borwein** (SFU, Burnaby), **Dan Freedman** (FSA Corp, Calgary), **Daniel Simon** (Microsoft, Seattle), Representatives of (Net:X Corp, Calgary).

Computation, Statistics and Visualization in Petroleum Industry, Calgary, June 8-10, 1998

Organizers: S. Shen and S.D. Riemenschneider, University of Alberta, and Y. Wang, Computer Modelling Group, Calgary.

This symposium is a special session (to be confirmed) in the Annual Meeting of the Petroleum Society at Calgary, June 8-10, 1998. The session includes invited and contributed lectures on the recent advances in the following areas of computations and statistics applied to petroleum industry: computational efficiency, visualization software, grid design, geostatistics, optimal sampling, and stochastic process.

Invited participants:

Richard Ewing, Texas A&M University, **Robert Sharpley**, University of South Carolina, **Mike Celia**, Princeton University, **James Glimm**, SUNY Stonybrook, **Gary Pope**, University of Texas, **Tom Russell**, University of Colorado, **Mary Wheeler**, University of Texas, **Ron Sawatsky**, Alberta Research Council, **John Zhou**, Alberta Research Council, **Sherm Riemenschneider**, University of Alberta, **Yarlong Wang**, Computational Modelling Group, Calgary, **Sam Shen**, University of Alberta, **Michael Kouritzin**, University of Alberta, **Yanping Lin**, University of Alberta, **John Bowman**, University of Alberta, **Bryant Moodie**, University of Alberta, **Bruce Sutherland**, University of Alberta.

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

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

Combinatorial Matrix Theory is an emerging branch of combinatorics. Applications include Coding Theory, Cryptography, and recently Computer Security. There has been little conference activity in western Canada on any of these topics. 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 is to bring together a leading group of researchers to promote the research in western Canada in the area.

Invited speakers : **Jennifer Seberry**, University of Wollongong, Australia **Charlie Colbourn**, University of Vermont **Vladimir Tonchev**, Michigan Technical University **Mieko Yamada**, Kyushu University, Japan **Christos Koukouvinos**, University of Athens **Robert Craigen**, Fresno Pacific University **K. T. Arasu**, Wright State University **Noboru Ito**, Meijo University, Japan.

This is primarily an instructional workshop designed for graduate students and all those concerned with computer security. There will be five main lectures for each of Coding Theory, Cryptography and Computer Security, delivered by experts in the fields. In addition around 13 lectures on Hadamard matrices and applications to Coding Theory, Cryptography and Computer Security will be offered. There will be one lecture per day in each of Coding Theory, Cryptography and Computer Security and at least two lectures every day on Hadamard matrices. There will be contributed sessions in each topic for each day of the conference.

Chapter 8

PIMS Math. Educational Activities

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.

8.1 Math. Education Initiatives for elementary school students

(See Chapter 5: PIMS Ongoing Programs)

Alternative Mathematics Education Events, Victoria, BC

Organizers: R. Illner and D. Leeming (U.Vic)

Mathematics Unplugged, Westwood Elementary School, Port Coquitlam, BC

Organizer: P. Hagen (Westwood Elementary)

Math Fairs and SMART Club

Organizers: A. Liu (U. Alberta), T. Kemp (U. Calgary)

Math Evenings in Alberta, Bragg Creek, Alberta

Organizers: S. Friesen, C. Laflamme & M. Stone

8.2 Mathematics Education Initiatives with High School Students

Dynamics for High School Students, Summer 1998

Organizer: I. Putnam (UVic)

This event will be based on similar ideas that have been implemented at Boston University by Robert Devaney and his group. Basically, the idea is that a lot of beautiful and deep concepts in the study of dynamical systems are really available to someone with a reasonable amount of ability and a very elementary background in mathematics. The study of rather intricate systems on the real line and the complex plane just needs some calculus and elementary facts about complex numbers. This means that these subjects can be presented to very bright high school students with a reasonable background.

The event consists of bringing a group of twenty or so of the best high school math students from the Victoria area to the University for perhaps ten one and a half hour lectures over a period of a few weeks in late May or early June. The students would be given lectures on the subject of dynamics on the real line and complex plane. The students would also be given time in a computer lab for experimentation and some "hands-on" learning. The lectures and projects for the students would involve a fair amount of work on the computer.

8.3 Mathematics Education Initiatives with undergraduates

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

Organizers: L. Keshet, A. Gupta, K. Promislow, G. Swaters, R. Wesbrook.

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.

The emphasis on the weekend was to let the students know about many of the very exciting research projects and initiatives taking place in the Mathematical Sciences departments. 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 grad 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 programs 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.

International Mathematics Olympiad Training Camp, UofC, 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 will be in Taiwan, and the Mathematics Department of the University of Calgary in collabioration with PIMS will host the national summer training camp, scheduled for June 30 – July 13, 1998. This will be the first time in quite a few years that a training camp will be held in Alberta (it was in B. C. in 1990 and 1994).

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 will be 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. There are about 110 students expected to participate in the conference and of these about 30 will give presentations. In addition, five guest speakers, including three from local universities and two keynote speakers from out-of-town, will be invited to address the conference. The guest speakers shall be selected so as to represent as widely as possible the mathematical community. This is why we intend to have guests from Applied Mathematics, Pure Mathematics and Statistics.

The Canadian Undergraduate Mathematics Conference is especially beneficial for undergraduates because it allows them to meet other students interested in mathematics. The con-

ference 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. For the host university it is an opportunity to meet over 100 talented young mathematicians and promote the merits of graduate studies there.

Invited Speakers: **Jacques Laskar**, Bureau des Longitudes, Paris, celestial mechanics and celestial motion, **Vaughan Jones**, University of California, Berkeley, algebra, **Jean Meloche**, UBC Statistics, image processing, **David Austin**, UBC Mathematics, knot theory, **Peter Borwein**, SFU Mathematics, pi.

8.4 PIMS Programs for Graduate Students

Graduate Industrial Modeling Workshop, SFU, May 25-29, 1998

Organisers: K. Promislow, A. Gupta & M. Kropinski (SFU), H. Huang (PIMS).
(See Chapter 7: PIMS Industrial Initiatives).

8.5 Educational Initiatives with Math Teachers and Educators

Math Leaders Symposium, University of Calgary, Calgary, Alberta, May 9th, 1997

Organizer: Cynthia Ballheim and Mike Stone

The 8th semi-annual math leaders symposium was a joint effort of PIMS, the Alberta Teachers Association and the Alberta Ministry of Education. Over 75 teachers, administrators and government officials gathered for a full day of events related to mathematics education. The program consisted of 2 presentations, one by high school teacher Phil Radomsky on "Using magic to motivate students", and a second by Prof Michael Williams on "Mathematical Instruments through the ages". Also part of the day was a 2 hour Math Exploration Workshop, given by Sharon Friesen, Claude Laflamme, Indy Lagu, Mike Stone and Robert Woodrow. Finally Hugh Sanders of Alberta Education discussed new K-9 resources, curriculum, and various updates on the ministry's activities. This was a much more diversified format for the symposium, and we received good feedback from an evaluation form distributed at the end of the day.

Math PD Evening at Banded Peak School, Bragg Creek, Alberta, May 28, 1997

Organizers: Sharon Friesen and Mike Stone

Sharon prepared a presentation for elementary school teachers that focused first on the new curriculum and the second part focused on problem solving. This evening was a direct result of the Math Symposium as the teachers asked Sharon for this professional activity day. Evaluation from the teachers was extremely favorable. Participants commented that they particularly enjoyed and benefited from working with a teacher and a mathematician. They wanted to have more sessions like this one. A listserv has been set up to support teachers and keep them in contact with each other and with the presenters as they start to work

with a more problem solving approach in their classrooms. As a direct result of the evening's session, several other groups have approached PIMS for inservice sessions on problem solving and the new curriculum. These include two high schools, 3 middle schools, and 34 teachers from elementary schools. Sessions are being planned to take place early in the fall at Banded Peak School. We also plan to make the listserv available to these teachers as well.

PIMS-CMS Education Session, Victoria, Dec 14-17, 1997

Organisers: Malgorzata Dubiel (SFU) and Mike Fellows (UVic)

Public talks were given at the semi-annual meeting of the Canadian Mathematical Society (CMS). PIMS will work with the other Institutes toward establishing such a session as regular feature of the CMS meetings.

Speakers:

- Public Talk by **Maria Klawe**, VP Student and Academic Services, Computer Science, UBC: "Mathematics, Computers and Your Daughter's Future"

- Plenary talk by **Neal Koblitz**, Mathematics, Washington University, Seattle: "The role of University mathematicians in K-12 math education"

- **George Bluman**, Department of Mathematics, UBC "A new course at UBC: Mathematics Demonstrations"

- **Reinhard Illner**, Department of Mathematics and statistics, University of Victoria: "Teaching Math without Pain"

- **Pamela Hagen**, Westwood Elementary School, Pt. coquitlam, BC: "Broadening the Perception and Enjoyment of Mathematics in Elementary Schools"

- **Michael R. Fellows**, Computer Science, University of Victoria: "Formulating reasonable goals and projects concerning the popular appreciation of mathematics."

- **Geri Lorway**, Iron River School, Alberta: "Ya Gotta Give Em a Reason to Reason: Reflections from the Mathematics Classroom and Beyond."

- **Peter Taylor**, Mathematics, Queens University: "Doing Mathematics with High School Students."

Conference on Changing the Culture, SFU at Harbour center, Feb. 20-21, 1998

Organisers: Malgorzata Dubiel (SFU), Lorene Gupta (Pivotal Software), Pamela Hagen (Westwood Elementary), Kathy Heinrich (SFU), Bruce McAskill (BC Ministry of Education), Ed Perkins (UBC),

The conference is 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. There were approximately 80 participants, drawn from all 3 groups. The conference was advertised throughout the BC High school system.

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 studennts Pamela Hagen (Westwood Elementary School) Nathalie Sinclair (Simon Fraser, Island Pacific School) George Bluman (University of British Columbia)

Additional support for the conference was provided by SFU, the Canadian Mathematical Society, The BC ministry of Education, Skills and training.

Chapter 9

Technology-based Mathematical Sciences

New advances in technology are creating opportunities for mathematicians to communicate their work more effectively at all levels. The Pacific Institute is using this technology to develop new communication tools more fully as well as providing guidance for the evolution of these developments.

Historically, the communication of mathematics has been hampered by the traditional media used to convey it; paper journals and texts do not accurately reflect the way in which mathematicians think about their own work. Consequently, it is often necessary for a mathematician to translate an idea into a form appropriate for publication and trust that the audience can translate back to the original idea. This is a problem in communicating mathematics at the highest levels and an often impenetrable barrier for students attempting to learn mathematics.

Professional mathematicians have already reaped benefits from the coupling of mathematics and computation—tools such as symbolic algebra systems, efficient and easily accessible numerical computation and visualization software have increased our understanding of mathematics and of the world. With the advent of the world-wide web, and especially with the introduction of interactive web-objects such as Java applets, it is now possible to represent many mathematical objects dynamically and interactively. This brings the realm of mathematical expression closer to the world of mathematical thought. The challenge is now to harness this technology to lower the barriers to "thinking mathematically" at every level.

We anticipate that such developments will make learning mathematics easier and less frustrating, and hence more enjoyable. The greatest benefit from these advances would be a more mathematically sophisticated, competent, and confident society. For professional mathematicians, we expect more efficient and satisfying communications.

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.

We now include a few of the projects which illustrate our committment to these goals.

9.1 The UBC Sun SITE Project

Coordinator: Bill Casselman (UBC)

This year 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 al-most 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.

We list a few projects currently available on the UBC site, which illustrate its purpose.

9.2 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.

9.3 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.

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 undergrdaute 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 handwritten letter to Andre Weil, written while Langlands was at Princeton University, outlining what quickly became known as 'the Langlands conjectures'. The SITE presents largeformat 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.

A second example is a digital version of Oliver Byrne's 1847 graphcal 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.

9.4 Exploration Modules in Mathematics, U. Calgary

Coordinators: B. Bauslaugh, C. Laflamme, M. Lamoureux (Calgary)

This proposal aims at developing several interactive and exploratory modules in Java to be delivered over the Web. These modules will allow the students and researchers to explore various mathematical concepts, arising from elementary linear algebra as above to more advanced research oriented material.

These modules are to be developed in conjunction with the project "Interactive Linear Algebra on the Web" that the Department of Mathematics & Statistics at the University of Calgary is currently developing under the direction of Claude Laflamme and Keith Nicholson. The purpose of the latter project, funded by the Government of Alberta through the *Learning Enhancement Envelope* ($200K for 1997-99), is to convey the basic ideas of Linear Algebra to beginning students using the computer as much as possible. The aim is to give them a working knowledge of the routine and manipulative techniques of the subject, thus allowing the instructor to spend more class time on more subtle aspects such as motivation, discussion of applications, and exploration of the mathematical underpinnings.

There are several such modules already under way. One is a 3D graphing calculator which draws an arbitrary equation in $z = f(x, y)$ as a rotating 3D graph of the function. We would like to also have it plot curves, parameterized surfaces, tangent and normal vectors, maybe even intersections of two surfaces. A parser for the grapher has been written, which we intend to use for a complex number calculator in Java (Lamoureux already has a working version in C++).

We also propose some work in "computing with real numbers" (as opposed to floating point approximations). Some C++ code has already been written, and we are interested in building something more generally useful and to test a prototype in Java where concerns have been expressed about speed and numerical accuracy. Another project is to compute spectral data for infinite dimensional linear operators. Some results are useful to plot, and again, we would like to test whether Java may be useful here. Finally, we propose developing a new front end to Maple that has

a more friendly user interface. We anticipate that Java may be one way to design such a user interface, with a Maple kernel running in the background on a fast server to do the actual computations.

These exploration components will help motivate the students by allowing them to "play" and visualize the concepts of the course via hands-on manipulation of mathematical objects in electronic form. In addition to improving understanding, this will stimulate the student's imagination and promote a deeper and more creative dialogue with the instructor.

For the mathematician, these modules will serve as research tools to propose and test conjectures, or simply to get familiarized with a particular problem via various amalgamated media such as symbolic capabilities, high end graphics and high performance computing.

9.5 Generation of highly interactive software modules, U. Alberta

Coordinators: G. Peschke, J. Timourian (Calgary)

The objective is to generate highly interactive software modules, whose purpose is

- to provide a hands on, context sensitive learning environment for certain mathematical concepts, processes and skills. The level of sophistication of these modules corresponds to the 1st and 2nd year of university mathematics. They will address topics from linear algebra, differential and integral calculus, aspects of finite mathematics/combinatorics and statistics.

- to lead to a level of insight and skill such that commercially available software packages like Maple, Matlab and others can be used effectively. Here we refer specifically to the following to aspects of using such software: Firstly, the user must be able to formalize a given problem. This is an essential prerequisite for using a computer as a tool in real world applications. Secondly, the user needs enough conceptual insight into the underlying mathematical theory to be able to interpret correctly an answer given by a computer.

- to be usable on any moderately equipped computer, locally or remotely across the Internet.

- to be available at any time of the user's choosing.

The methodology is, to some extent, dictated by the objectives outlined above. It will use

- the Internet as a main distribution channel, because it is accessible at a time of the user's choosing and from many homes and other sites within Canada.

- WWW-related software technology for compatibility reasons and to achieve platform independence. Thus we use the following tools in an orchestrated form: HTML, java, javascript, Adobe Acrobat, Macromedia Authorware and Director. We are prepared to incorporate others if it turns out to be advantageous to do so.

- A highly interactive software design because actively involving the user appears most effective. In particular, this includes programmed context sensitive feedback

on user action, as far as it is reasonably predictable. We have generated one modest prototype, an electronic tutor which helps students with the mechanics of matrix multiplication.

This project will be coordinated with similar efforts proposed by others in Western Canada. Part of this project is being funded by the government of Alberta under the Learning Enhancement Envelope (LEE).

9.6 Distributed Access Resource Infrastructure (DARI), SFU

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

This is a joint proposal 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 will be created in the Polymath Development Group (PDG) at the CECM. The programmer filling this position will support 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 will provide an interactive tool which can appear on a Web page. It will allow a user immediate access to the algorithm, database, resource or information that otherwise would not be available.

Technology Transfer: The programmer will 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. While the user GUI will be delivered as an applet, the real functionality will be derived from a client-server system within the prototype network.

NumberView: A tool for visually investigating patterns in the decimal expansions of numbers - This tool allows the research both to investigate and to illustrate the behaviours found within number theory. Using powerful hardware to perform the expansions, it then allows the user to graphically represent the distribution of numbers arbitrarily with the goal of identifying any hidden patterns.

EZ-face Calculator: An interface for evaluation of Euler sums - This tool implements sophisticated algorithms for performing Euler sums and supports the users calculations remotely. The results can either be accessed directly through the interface or incorporated into an applet or interface which utilizes the service indirectly.

Code Converter: A service for converting Maple code to Fortran and C - Developed in support of the large Maple users' audience, making this service available online will allow it to be more widely used and applied. Similar to the other tools, users will either be able to directly query an interface or, as a developer, build the capability for translation into their own interfaces.

Network Monitor: A tool for representing a widely distributed network of hosts and querying their status - This interface will offer to the user collected and cached information and statistics on the status of specified hosts in a network. This will make it possible for at-a-glance assessment and support quick decision-making for the selection of resources and hardware.

Chapter 10

MITACS: A Network of Centers of Excellence in the Math. Sciences

In November 1997, the Fields Institute for the mathematical sciences, the Centre de Recherches Mathematiques and the Pacific Institute for the mathematical sciences submitted a Letter of Intent for a Network of Centres of Excellence: *Mathematics of Information Technology and Complex Systems* (MITACS). This LOI was one of the 11 successful letters out of 72 submitted to the Network of Centres of Excellence program and the three Institutes have been invited to submit a full proposal by May 1, 1998.

The invitation to present a full proposal creates an exceptional opportunity for the mathematical sciences community to develop a large scale systematic program 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 proposed network which is structured around the three mathematical sciences research institutes and the networks of universities affiliated with them.

10.1 Introduction to MITACS

MITACS was created to bring together leading 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. 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 themes are:

- **The Mathematics of Biomedical Modeling**: Examples of possible projects areas include DNA sequencing, the modeling of diseases, dynamical systems, biomedical statistics, and medical imaging.

- **The Mathematics of Information Technology**: Examples of possible project areas include computer and communication networks, the mathematics of software and software tools, secure communication and cryptography, geographic information systems and the management of high dimensional data.

- **The Mathematics of Risk Modelling and Resource Management**: Examples of possible project areas include resource optimization, risk management and the pricing of financial derivatives.

10.2 The Socio-Economic Context

The information revolution is transforming all aspects of society including communications, commerce, industry, health care and social services. These changes are based on the unprecedented quantity of available information and the speed with which it can be communicated globally via large scale networks. At the same time, developments in molecular biology and genetics are revolutionizing the medical and biological sciences, and world-wide derivatives trading is dramatically altering the financial services sector. As a result of this unprecedented increase in available scientific data, speed of communications and interconnectivity, entirely new challenges in the science and engineering of large-scale systems are emerging which need new mathematical tools. The resulting interdisciplinary mathematical science of information technology and complex systems has grown out of mathematics, computer science, systems engineering and statistics, but transcends the boundaries of each of them.

National competitiveness in the global economy is crucially dependent on innovative R&D in the exploitation of the new technologies. In Canada, telecommunications is currently the most R&D intensive industry, with financial services a close second. The pharmaceutical and computer software/hardware industries have been the fastest growing in both the long and short term. Together, these industries account for 34% of all Canadian R&D expenditures in 1995. The growth resulting from this R&D is the key to economic prosperity - 2 out of every 3 new jobs in the past 10 years were created in the technology and knowledge-based sectors. Together with the

health care system, the knowledge-based industrial sectors are key to Canadian competitiveness and quality of life and, at the same time, are those most affected by the fundamental technological challenges described above.

The ultimate goal of the Network is to provide tools to enhance Canadian competitiveness in the global economy and to improve quality of life in Canada by strengthening industry and health-care resources. National competitiveness in the global marketplace is crucially dependent on innovative R&D in the exploitation of the new technologies - and much of this research is based in mathematics. Breakthroughs in mathematics ripple throughout the scientific disciplines, which use mathematics as a fundamental tool in their own research programs, and enhance technology in the knowledge-based industries.

As these trends intensify, innovations based on state-of-the-art advances in the mathematics of information technology and complex systems will be at the very centre of these developments and will make an important difference to Canadian performance in these sectors. The major limiting factor in this performance will be the availability of highly trained personnel with the unique set of skills necessary to succeed in this rapidly changing interdisciplinary field. This Network will create a unique environment for this training which cannot be achieved in any single department or university.

The core business of MITACS is to provide the new mathematical tools to solve the emerging problems from the different user sectors. However, this focussed research program arising at the nexus of the mathematical sciences with multisector users can only be achieved by bringing together a national network of the leading mathematical scientists from both universities and industry. The

Network structure and strategy is designed to focus the research efforts on emerging problems of greatest importance to the different users sectors in order to optimize the knowledge transfer and provide the greatest opportunities for economic impact.

10.3 Proposed Research Program

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 massive 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, semianalytical 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 involved 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 criti-

cal 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.

10.4 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 program, to be developed in cooperation with existing graduate programs, 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 program 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 program with the Network?s industrial partners;

- and joint post-doctoral appointments with the research teams and industrial partners.

The student training programs 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 programs.

10.5 Networking and Partnerships

MITACS will be built upon the three existing Canadian institutes for research in mathematical sciences, Centre de recherches mathmatiques 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 program, 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.

An important advantage of the 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 programs, 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 program of joint annual meetings, and exchanges of members of the research groups will be initiated. The research teams will be mainly drawn from within Canada but a few outstanding Canadian mathematical scientists (e.g. W. Pulleyblank, P. Glynn) currently in the U.S. but with close ties to Canadian research groups will also be included.