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Pacific Institute for the Mathematical Sciences

Alberta Government contributes $1.147-million to PIMS for 2006-2009

The Pacific Institute for the Mathematical Sciences (PIMS) has received a renewal of support from the Alberta Innovation and Science (AIS) for PIMS mathematical activities in Alberta. PIMS will receive $1.147-million over three years from the Alberta government agency.

AIS focused on PIMS' established record in mathematical research and education in Western Canada as the reason to renew and increase funding to $1.147-million between 2006 and 2009. With the initial AIS funding in 2004, PIMS developed activities towards mathematical education and outreach in Alberta, demonstrating PIMS' dedication to developing inclusive programmes for Alberta's mathematical community. With the new funding, PIMS plans to increase its commitment to education and outreach in Alberta, and will participate in the AIS' three major research priorities: life sciences, energy research, and information and communication technologies.

Interview with Ingrid Daubechies

The Princeton professor speaks with PIMS about mathematics, research in industry, and being a woman in a male-dominated field.

Interview on Page 15

Inside this Issue

Institutional Autonomy Consecrates BIRS's Role as World Resource

The Banff International Research Station (BIRS) — which was launched in September, 2001, and inaugurated in March, 2003 — was the fulfillment of a remarkable international effort led by PIMS on the Canadian side and by MSRI (Berkeley, CA) on the American side, along with the help and participation of the MITACS network. Encouraged by BIRS' successful five-year funding renewal by the AIS (Alberta), the NSF (US), NSERC (Canada) and CONACYT (Mexico), the BIRS founding institutions announce that the research station has reached the stage where it is ready to assume full scientific and administrative autonomy.

With a 30-member Scientific Advisory Board, drawn from an international pool in all areas of the Mathematical Sciences, BIRS now solely administers its research programmes. The Program Committee stresses scientific excellence and adequate representation of all areas of math sciences, as well as an appropriate geographic balance among organizers. The Executive Committee, consisting of the directors of BIRS, PIMS, MSRI, MITACS and IM-UNAM, now forms a separate body dealing solely with issues pertaining to management. The Scientific Director of BIRS is the liaison between this committee and the SAB. The requirement to have a Canadian and American organizer for each five-day workshop has been removed, and the competition is now open to all.

The new organizational structure of BIRS ensures a transparent and uniform governance structure that will enable BIRS to attract the best proposals from all over the world. PIMS, MSRI and MITACS congratulate BIRS on its renewal and on the new era of scientific excellence upon which it is about to embark. BIRS will continue its mission to encourage the collaboration and research interaction between researchers in all areas of the mathematical, computational and statistical sciences.

For more on BIRS, please see pages 8-9.

PIMS Launches Partnerships with Latin America

The Pacific Institute for the Mathematical Sciences (PIMS) and the Centro de Modelamiento Matemático (CMM) have signed a cooperation agreement. CMM, based at the University of Chile in Santiago, is the leading centre in Latin America for applied and industrial mathematics.

PIMS has also signed an agreement with Instituto de Matemáticas (UNAM) in Mexico, for cooperation on scientific research.

For more on PIMS and CMM, please see pages 4-5. For more on PIMS and IM-UNAM, please see page 7.

Director's Notes

by PIMS Director Ivar Ekeland

I was lucky enough to benefit from an excellent education in mathematics. Very early on, it struck me that mathematics is a school for critical thinking and personal freedom. Only in mathematics can you raise your hand and challenge your teacher on equal grounds: there is a mistake there, or there is a better proof. The answer can never be: there is no mistake, because I say so, or there is no better proof, because I would have found it. In mathematics, you must convince people. When I was much younger, mathematics taught me to argue, and now it teaches me to listen. Not many children benefit from this kind of education nowadays. This is doubly unfortunate, because we are depriving ourselves of good citizens and future scientists. I also note that although mathematics are universal, and in principle should be the least sensitive to cultural, social, and gender barriers, in reality it is the privileged in society who have the best exposure to mathematics, with others being too often considered unworthy of high expectations.

Ivar Ekeland, PIMS Director

This is the reason why PIMS has gone so strongly into mathematical education. For many years, PIMS has been on the forefront of mathematical education and outreach in Alberta and B.C., with such events as Math Fairs, Math Mania and ELMACON. Since 2005, we have intensified our efforts by appointing Melania Alvarez-Adem as Education Coordinator in B.C., with the support of John Hepburn and UBC. We are increasing our education budget, and developing a working program with various First Nation communities. This program has been presented to the B.C. government, and has attracted private donors, whom I thank for their generosity. You will find a description of our Education Programmes in the enclosed insert.

Educating the young is not enough. You also have to open up opportunities for them. PIMS has been trying to do so, in three directions: developing mathematical science (creating opportunities for research), creating joint programs with industry (creating added opportunities for research, because of an influx of new mathematical problems, and also opening up employment opportunities for mathematicians), and creating international programs jointly with foreign institutions (exposing students and young researchers to international standards, and bringing to Canada top-level researchers in fields not represented domestically).

In December, 2005, PIMS signed an agreement with CMM, the Center of Mathematical Modeling at the University of Chile in Santiago. The activities of CMM are complementary to ours, with a strong emphasis on partial differential equations, dynamical systems and applied mathematics. Coming on the heels of our agreement with the Institute of Mathematics UNAM in Mexico City, this will bring to PIMS a steady flow of Latin American students and researchers. The Summer School on "Frontiers of Mathematics and Economics," held in Vancouver in July, 2006, organized jointly by PIMS and CMM, is a good example of the collaboration we envision, as was the joint PIMS-UNAM meeting in Algebra held at BIRS in the same month. We hope that these international collaborations will extend into the industrial sector. PIMS is presently developing a mining initiative with partners in B.C. and Chile, and an oil initiative with industrial partners in Alberta and Mexico. There will be more information in the next newsletter, and already in this one you will find an interview with Alejandro Jofré, deputy director of CMM, who tells us about his vision for the PIMS-CMM collaboration.

Among the major events at the PIMS sites this year, I want to single out PIMS Education Day at the University of Alberta, where the PIMS education prizes were given to Malgorzata Dubiel and Bill Sands; the Graduate Industrial Mathematics Modelling Camp (GIMMC) and Industrial Problem Solving Workshop (IPSW) at Simon Fraser University; and the meeting of the Geophysical Inversion Workshop at the University of Calgary in August, 2006. Our thanks to JF Williams, who was in charge of the IPSW this year, and our best wishes and support to Thomas Hillen, who will organize the IPSW next year.

The Institut des sciences mathématiques (ISM) and the Centre de recherches mathématiques (CRM) have initiated Acromath, a mathematics magazine for high school students, similar to PIMS's Pi in the Sky, and in August, the Fields Institute organized an IPSW with MITACS. The fact that our ideas are taken up by others is a measure of our success, and PIMS has provided Fields with all the help possible for bringing IPSW to Ontario. Our collaborations with Canada's other mathematical institutes extend beyond programme sharing of programme ideas: In May, 2006, I gave the second lecture at CRM's Grande Conference du CRM, *Le meilleur des mondes possibles,* in Montreal. Not only in industrial initiatives are we leaders: we are also opening up new areas for mathematics away from the classical applications to the natural sciences, and towards the social sciences. To explain these new directions, we have included in this newsletter an interview with Jean-Charles Rochet, an economist from the celebrated Institut d'Economie Industrielle in Toulouse, and a major contributor to contract theory.

As I write these lines, I receive the news that we have received major funding from Alberta Innovation and Science worth $1.147-million over three years. This is a testimony to the trust that Alberta and its universities put in PIMS and its abilities to enhance the Alberta scientific priorities in the life sciences, energy sector and ICT. We are excited at this prospect, and all the other ones that lie open before us.

Did you know? PIMS is at the forefront in attracting high-calibre mathematical scientists to PIMS member universities as a product of its national and international mandate. Over the next 10 years, there will be a large turnover of mathematics professors in North American universities due to retirement. The sense of community in PIMS, along with the connections to high-quality scientific activities, are already a draw to young researchers, professors and graduate students. By joining a PIMS university, these mathematical scientists become part of a larger and in-touch scientific community where links between mathematics and other scientific disciplines have already been established.

Synergy

In mathematics, progress cannot be measured by infrastructure or machinery, but by the intellectual currency and the connections between mathematicians, in the innovation and ideas that emerge as we build toward a stronger future of knowledge and research. PIMS plays a vital role in Canada and internationally, helping to create and nurture these intellectual collaborative bonds.

We strive to empower mathematicians in their research and in mathematics education in North America and in the growing international community. With six member universities in Western Canada and the Pacific Northwest, three affiliated Canadian universities, and a leadership role in the newly developed Pacific Rim Mathematical Association (PRIMA), PIMS holds a unique synergistic role among Canadian mathematical organizations. PIMS stands at the centre of mathematical research, industrial collaboration and education.

-Ivar Ekeland, PIMS Director

Canadian Partnerships

- Six member universities and three affiliate universities
- Support of AARMS and NPCDS
- Cosponsor of events and joint thematic programs with MITACS, CRM, Fields, CMS, PITP
- CRM-Fields-PIMS Prize

International

- Creator of BIRS
- Partnerships with MSRI and University of Washington
- Founding member of PRIMA, Pacific Rim mathematical initiative
- Collaborations with Latin America

Education

- Pi in the Sky magazine
- First Nations education initiative
- Post-secondary curriculum development
- K-12 math camps and contests, Math Fairs in Alberta
- Teacher training activities
- Sponsorship of Canadian IMO team

Training

- 25 postdoctoral fellows at PIMS member universities and training of highly qualified personnel
- Summer schools
- Conference and workshop travel funds for Canadian and international faculty and students
- Graduate Industrial Mathematics Modelling Camp (GIMMC)

Research

- Collaborative Research Groups (CRGs)
- Emerging interdisciplinary areas of mathematics
- International research collaborations
- PIMS Distinguished Lectures
- Thematic activities for Canadian scientists

Industrial

- Mathematics of mining initiative
- Mathematics of oil exploration, geophysics and seismic imaging initiative
- Initiator of IPSW, GIMMC in Canada
- Lunchbox seminars in Calgary

PIMS: International Initiatives

by Alejandro Adem, PIMS Deputy Director

International

Since its foundation, PIMS has been committed to developing international initiatives for the benefit of the Canadian mathematical community. Through our partnership with the Mathematical Sciences Research Institute in Berkeley (MSRI), we developed the highly successful Banff International Research Station (BIRS), which is now running as an autonomous entity in charge of its own scientific programming. The University of Washington provides important scientific leadership, which benefits the entire PIMS community.

More recently, PIMS has started developing international programs further afield. We have sought to develop close ties with mathematicians in Latin America and also to develop a collaborative network across the Pacific Rim.

In Latin America we have two strategic partners: the Centro de Modelamiento Matemático (CMM) in Chile and the Instituto de Matemáticas (UNAM) in Mexico. We have signed formal agreements of collaboration, which have already led to extensive interactions between Canadian mathematicians and colleagues in Chile and Mexico. We held a joint PIMS/UNAM Algebra Summer School at Banff in July, 2006, and with CMM we co-organized the PIMS Frontiers in Mathematics and Economics Summer School, held at UBC in July, 2006. A second joint meeting with CMM, on the mathematics of mining, is planned for next February in Santiago. An important development arising from our engagement with the Mexican mathematical community is the first joint meeting of the Canadian Mathematical Society and the Sociedad Matemática Mexicana, which will take place in Guanajuato, Mexico, in September, 2006.

As for the Pacific Rim, PIMS co-sponsored (together with MSRI) the establishment of the Pacific Rim Mathematical Association (PRIMA), which is a network of mathematical institutes, departments and societies throughout the region, seeking to promote collaboration and mobility. The first PRIMA events were held this summer and there are plans for a PRIMA Congress in 2009, to be held in Sydney, Australia. As part of this initiative the Director and Deputy Director of PIMS traveled to China last May, establishing important contacts with several universities there, as well as with the National Natural Science Foundation of China. We expect significant exchanges between PIMS and the Chinese mathematical community from this initiative. These exciting developments have made PIMS a leader in international networking among North American mathematical institutes and will surely lead to significant new developments in the near future.

PIMS and Centro de Modelamiento Matemático

On Dec. 7, 2005, Alejandro Jofré, Deputy Director of Centro de Modelamiento Matemático (CMM), and Ivar Ekeland, Director of PIMS, signed a cooperation agreement between CMM and PIMS. The PIMS Board ratified that agreement on Dec. 13. The Centre for Mathematical Modeling of the University of Chile in Santiago is the leading centre for applied and industrial mathematics in Latin America. Several areas of common interest between CMM and PIMS have been identified: partial differential equations, from the pure and applied sides, and mathematical economics, from the theoretical and numerical sides.

In 2005, two meetings were organized in Banff by the two institutions, and on Dec. 7, 2005, a meeting was organized at UBC between PIMS, a delegation of CMM, and representatives of the mining industry. In 2006, PIMS and CMM jointly held a Summer School on Frontiers of Mathematics and Economics from July 10-31 at UBC. The two institutes are also planning a workshop on the structural equations of rocks, and PDE problems connected with mining. We hope that, as our cooperation develops, PIMS will see a steady flow of researchers and graduate students from CMM and the whole of Latin America.

Did you know?

To date, PIMS has financially supported over 165 postdoctoral fellows. In addition, PIMS activities at its member universities in Alberta, British Columbia and Washington State attract many mathematics-related graduate students and postdoctoral fellows in fields ranging from pure math to computer science, finance and math-biology. In this way, PIMS contributes to developing highly qualified human capital to North America.

Rock Mechanics and Planning in Mining Workshop

Feb. 26 to March 2, 2007, in Santiago, Chile

As a result of the Natural Resources and Mathematical Economics meeting, organized by the CMM and PIMS at the Banff International Research Station from Nov. 26 to Dec. 1, 2005, both centres have decided to promote the organization of a workshop in *Rock Mechanics and Planning in Mining* in Santiago, from Feb. 26 to March 2, 2007, jointly with the centres of excellence in Australia, Canada and Germany: MASCOS, MATHEON and MITACS.

The scale of the world's largest open pit and underground mass mining operations has grown at a continuing rate over the last decades. This growth has implied increasing rates of production and deeper mines. In this process, new challenges have been posed in the area of rock mechanics and planning requiring efficient, low-cost and safe production plans. Most of these requirements demand the study of sophisticated mathematical models based on partial differential equations, optimization and stochastic models. The purpose of this workshop is to foster exchanges and discussions of researchers coming from five centres of excellence located in different countries and strongly related in some way to mathematical modelling in the mining industry, mainly in copper mines. This meeting is a starting point for a wider and more fruitful collaboration among these centres, which share common goals.

Mining and Applied Mathematics: CMM at the Forefront

Alejandro Jofré, deputy director of Chile's Centro de Modelamiento Matemático, spoke with PIMS regarding the developing synergistic relationship between mining and applied mathematics across international boundaries. He provided a look deep into CMM's activities in applied mathematics and its relationship with industry in the Western Hemisphere and beyond.

In the search for economical and feasible methods of mineral extraction and resource management, industry is increasingly turning to the academic world to seek novel solutions to their challenges.

At the Centro de Modelamiento Matemático (CMM), researchers invert the traditional relationship of mathematical and industrial collaboration. Instead of the more traditional method of attempting to apply a theoretical mathematical solution to an existing problem, CMM researchers take real problems and challenges from industry and address the issues directly. While CMM is involved in sectors of forestry, energy, telecommunications, transportation, information technology and education, its largest research area is mining: appropriate, given that CMM's home country of Chile is the world's largest producer of copper, with approximately 20 per cent of the world's annual copper production.

Alejandro Jofré, CMM Deputy Director

CMM, based in Santiago, Chile, was created in April, 2000, using a multi-million dollar grant from the Chilean government. CMM's mission is to create new mathematics to model and solve complex problems arising in industry and other scientific disciplines. CMM is now a mixed research unit of France's Centre national de la recherche scientifique (CNRS). CMM is headed by Dr. Rafael Correa, Director, and Dr. Alejandro Jofré, Deputy Director.

From the beginning, CMM has connected with industry, not only in Chile but across South America. The Centre concentrates on six main areas of applied mathematics: differential equations, discrete mathematics, mathematical mechanics, numerical analysis, optimization and equilibrium, and stochastic modelling. Over 50 CMM researchers work in areas of mathematical modelling and related fields, with half coming from academia, while the remaining half are from industry and engineering. The Centre boasts some 40 postdoctoral fellows, with 30 coming from a multitude of countries spanning the globe. Over the past four years, over 340 articles from CMM members have been published in international scientific journals.

CMM is involved in an international collaborative network with the Pacific Institute of Mathematical Sciences (PIMS), the Centre de recherche sur les transports in Montreal, Matheon in Germany, the Centre of Excellence for Mathematics and Statistics of Complex Systems (MASCOS) in Australia, and the Laboratoire Jacques Louis-Lion in France. Additionally, CMM is involved with various institutional international agreements with CNRS, PIMS, University Pierre and Marie Curie, the European Commission, and the U.S. National Science Foundation.

On Dec. 7, 2005, Dr. Jofré on behalf of CMM, and Dr. Ivar Ekeland, Director of PIMS, met to sign a cooperation agreement between the two centres, for collaboration in areas of common interest between the centres, including partial differential equations from pure and applied mathematical aspects, as well as mathematical economics. The collaboration between PIMS and CMM will span many areas. As both Chile and Canada are home to some of the largest mining companies in the world, it is imperative for the centres to work together to produce mathematical models for the production and planning issues in mining, especially copper mining. From the mathematical angle, PIMS and CMM have expertise in the types of models that have already been applied in copper mining.

The importance of CMM's global industrial collaborative connections with relation to copper and mining cannot be understated, as the three largest copper mining companies in the world, Corporación Nacional del Cobre (CODELCO), Anglo American PLC and BHP Billiton are located in Chile, Canada and Australia, respectively.

PIMS and CMM will host a Rock Mechanics and Planning in Mining Workshop in Santiago, Chile, from Feb. 26 to March 2, 2007. MASCOS, Matheon and MITACS will also help organize the event. The meeting will welcome groups from Canada, Chile and Australia, as well as Germany and South Africa. In light of the importance of the meeting, BHP Billiton and CODELCO have announced that they plan to sponsor the conference.

As the global demand for base and precious metals increases, companies around the globe are looking for a competitive mining edge. The industry-research synergy created through the work by PIMS and CMM will give its partners a definite competitive edge in the growing international market.

Dr. Jofré is a professor at the University of Chile's Department of Mathematical Engineering, and has been the Deputy Director of the Centre for Mathematical Modeling for six years. His research focuses include optimization and mathematical economics. He is also a Professor of the PhD program on Mathematical Economics at the University Paris 1- Sorbonne and an associate member of the Center for Experimental Math, Canada. Dr. Jofré holds a PhD in Applied Mathematics from the University of Pau, France.

PRIMA Launched at BIRS

Pacific Rim Mathematical Forum, Mini-Symposium and Reception, Oct. 14-15, 2005

The Pacific Institute for the Mathematical Sciences and the Mathematical Sciences Research Institute (Berkeley) jointly hosted the Pacific Rim Mathematical Forum at the Banff International Research Station. The goal of the meeting was to lay the groundwork to establish a network of mathematical centres throughout the Pacific Rim.

The first part of the meeting consisted of presentations by our foreign visitors. Each individual described their institution and their goals for this meeting. Immediately after that, sleeves were rolled up and participants went to work on formulating specific action items for international networking, as well as developing the appropriate framework. Most importantly, participants agreed on a vision statement, which formulates the guiding principles in our collaborative network.

(l to r) Chong-Kyu Han (Seoul National University), Ivar Ekeland, Dohan Kim (Seoul National University)

The policy-setting meeting was complemented by two high-level lecturers, who spoke about cutting-edge developments in pure and applied mathematics. PIMS Director Ivar Ekeland gave a thought-provoking lecture on *The Role of Mathematics in Economics and Finance*, and Gang Tian (Princeton University) gave a beautiful presentation on *Geometry and Analysis of Low-Dimensional Manifolds*, in particular providing a tantalizing update on the groundbreaking work of Perelman on the Poincaré Conjecture.

Pacific Rim Mathematical Forum participants at Banff International Research Station

After two days of hard work, everyone agreed that a well-coordinated and concerted effort among our institutions and countries will stimulate a vibrant and interconnected mathematical community, the activities of which would have an unprecedented impact on economic, social and cultural development. A resolution was made to establish an organization, to be known as the Pacific Rim Mathematical Association (PRIMA), and to develop an action plan to achieve these goals.

The mission of PRIMA will be to promote and facilitate the development of the mathematical sciences throughout the Pacific Rim region. The principal objectives of PRIMA will be:

1. To create a network for the exchange of ideas and the dissemination of scientific knowledge;
2. To coordinate and encourage wider participation in scientific activities in the region in order to maximize their effectiveness;
3. To substantially increase the region's capacity in training the next generation of mathematical scientists;
4. To identify geographical areas in need of mathematical advancement and to assist them in strengthening their expertise and infrastructure;
5. To promote breadth and diversity within the mathematical sciences community;
6. To share expertise in the promotion of the mathematical sciences, and their impact on society and the global economy; and
7. To pool resources where appropriate, and to identify potential new resources to assist the scientific development of every community in our region.

Alejandro Adem and Rustum Choksi, SFU PIMS Site Director

After the meeting at BIRS, many of our guests traveled to Vancouver, where PIMS hosted a mini-symposium on Oct. 17, highlighting activities at PIMS universities.

John Hepburn, Vice President of Research at UBC, met with the participants, and as part of a group discussion, talked about the various ways in which UBC and PIMS can establish international research connections with Pacific Rim nations.

In the afternoon, visitors were able to attend lectures by distinguished scholars, including the IAM-MITACS-PIMS Distinguished Lecture by Eitan Tadmor (University of Maryland), and the Department of Mathematics Colloquium Lecture by Michael Cowling (University of New South Wales, Australia). In order to celebrate these important achievements and to recognize the wonderful community of mathematical scientists in Vancouver, PIMS hosted an evening reception at the world-famous Museum of Anthropology, where our extended family was warmly welcomed by Dr. Hepburn and Dr. Ekeland, as well as PIMS Deputy Director Alejandro Adem. Visitors had a chance to mingle with colleagues from UBC, SFU and UVic, and to visit the stunning First Nations exhibits in the Great Hall.

PIMS Directors Visit China for PRIMA Collaboration

PIMS Director Ivar Ekeland and Deputy Director Alejandro Adem visited China, in order to discuss international mathematical collaborations as part of the PRIMA network, between May 20 and June 3, 2006. This trip marks the first time Dr. Ekeland and Dr. Adem have visited China on behalf of PIMS.

Ivar Ekeland presenting a public lecture at the Chern Institute

The trip included visits to Peking University, Beijing Normal University, Tsinghua University, the Chern Institute at Nankai University, Fudan University and Nanjing University. Dr. Ekeland was invited to present lectures at the Chern Institute and at Nanjing University. The public lectures, on *Frontiers in Mathematics and Economics,* were aimed at an undergraduate audience, and were very well received by all. Also during the trip, Dr. Adem delivered invited research seminars to mathematical colleagues.

Chern Institute in Nankai

A meeting was also held with the head of the mathematics section of the National Natural Science Foundation of China (NSFC), to establish and promote links within the PRIMA network.

National University of Mexico (UNAM) Signs Collaboration Agreement with PIMS

On March 9, 2006, PIMS Director Ivar Ekeland and Deputy Director Alejandro Adem signed a collaborative agreement between PIMS and the Instituto de Matemáticas at the Universidad Nacional Autónoma de México. The signing ceremony was held in Mexico City.

On the Mexican side, the agreement was signed by Dr. René Drucker, Coordinator of Scientific Research at UNAM, as well as Dr. José Antonio de la Peña, Director of IM-UNAM.

Under the agreement, PIMS and IM-UNAM will collaborate on research projects for the mathematical sciences. Additionally, the institutes plan to hold bilateral symposia and conferences, in order to facilitate the exchange of knowledge and personnel between Canada and Mexico. One such event has already been held: the PIMS/UNAM Algebra Summer School at BIRS in July, 2006.

The agreement is part of PIMS's commitment to international activities and the exchange of ideas across borders. IM-UNAM has an established track record of developing and promoting mathematical research in Mexico and internationally.

CMS-SMM Meeting

The Mexican Mathematical Society (Sociedad Matemática Mexicana, SMM) hosted the first joint CMS-SMM special session at its annual meeting in Mexico City on Oct. 25, 2005. The scheduled events included a plenary lecture by Gordon Slade (UBC) on Critical Oriented Percolation, as well as invited lectures by Thomas Salisbury (York/Fields, CMS President-Elect) and Alejandro Adem (PIMS Deputy Director). At this meeting, CMS representatives discussed further interactions with the SMM, including plans for a joint meeting of the two societies. The Canadian Mathematical Society (CMS) and PIMS supported the event.

The CMS and the SMM will hold their first joint meeting at the Centro de Investigación en Matemáticas in Guanajuato, Mexico, from Sept. 21-23, 2006.

PIMS Supports PASI in Mexico

Morelia, Jan. 9-20, 2006

The *Stringy Topology* conference was held in Morelia, Mexico, on Jan. 9-20, 2006. This conference featured new ideas in string theory, in particular D-branes and their relevance to open strings, which have in many ways revolutionized modern quantum field theory. The subject is currently highly heuristic: its formalization and mathematical development has barely begun. The geometric naturality and flexibility of these concepts has fostered rapid development, but their codification is completely open. Orbifolds, gerbes, and stacks are all topics with well-established classical literature, but the idea that they should be grouped together, and that the various kinds of twistings they manifest are relevant to physics, is a new idea in mathematics.

The workshop was a Pan-American Advanced Studies Institutes Program. It was part of the one-semester programme, "New Topological Structures in Physics," which was organized by MSRI. Funding was provided by the Office of International Science and Engineering of the National Science Foundation and the Office of Basic Science of the Department of Energy. PIMS funded the Canadian participants for the conference.

Did you know?

PIMS has international collaborations with many countries around the world. In addition to supporting conferences attended by international students and researchers, PIMS works jointly with mathematical institutes in Chile, Mexico, the United States, and nations around the Pacific Rim.

PIMS also supports Canadian mathematical scientists in developing international ties, supporting their travel to national and international conferences.

Banff International Research Station
for Mathematical Innovation and Discovery

Banff International Research Station

The Banff International Research Station (BIRS) is a joint Canada-U.S.-Mexico initiative that provides an environment for creative interaction and the exchange of ideas, knowledge and methods within the mathematical sciences, related sciences and industry.

BIRS' principal activity is the 48 five-day workshops that it hosts every year. The station also holds two-day events, suitable for promoting industry-academic collaborations, as well as summer schools and graduate training camps.

BIRS' mandate is to embrace all aspects of the mathematical, computational and statistical sciences, from the most fundamental challenges of pure and applied mathematics, theoretical and applied computer science, statistics, and mathematical physics, to financial and industrial mathematics, as well as the mathematics of information technology and the life sciences.

The key to BIRS' success is its ability to attract top scientific proposals, thanks to its unique research-conducive environment. The Scientific Advisory Board consists of 30 internationally recognized experts representing a broad spectrum of the mathematical sciences community.

The BIRS executive committee is composed of the Director of PIMS, the Director of MSRI, the Director of Instituto de Matemáticas - Universidad Nacional Autonoma de México (IM-UNAM), the Director of MITACS and the BIRS Scientific Director.

BIRS 2008 Call for Proposals

The **Banff International Research Station for Mathematical Innovation and Discovery** (BIRS) is accepting proposals for its 2008 programme. Full information and forms are available on the BIRS website at http://www.pims.math.ca/birs/.

BIRS is aiming for a 48-week scientific programme in 2008. Each week, the station will run either a full workshop (40 people for five days) or two half-workshops (20 people for five days). BIRS provides meals, accommodation and research facilities at no cost to organizers or participants, in a setting conducive to research and collaboration. The deadline for Five-Day Workshop proposals is Oct. 2, 2006.

In addition, BIRS will operate its Research in Teams and Focused Research Groups programmes, to allow several weeks of uninterrupted work to smaller groups of researchers at the station. BIRS supports summer schools for graduate students and postdoctoral fellows, with an emphasis on the emerging areas of the mathematical sciences and their applications. Oct. 2, 2006 is the preferred deadline to apply for these programmes. Proposals for projects involving Research in Teams or Focused Research Groups can be submitted at any time, subject to availability, and must be received at least four months before the requested start date.

Proposals should be submitted through the BIRS website, at https://www.pims.math.ca/birs/proposals_menu/propform.php.

Nassif Ghoussoub reappointed for second term as BIRS Scientific Director

The Executive Committee of BIRS is pleased to announce that it has recommended the appointment of Dr. Nassif Ghoussoub for a second term as Scientific Director of the Banff International Research Station (BIRS), and that the PIMS Board of Directors has accepted its recommendation. Dr. Ghoussoub's second term will run from Jan. 1, 2007, to Dec. 31, 2009. Dr. Ghoussoub succeeded Dr. Bob Moody as Scientific Director of BIRS on Jan. 1, 2004. During his first term, Dr. Ghoussoub masterminded the renewal of BIRS, which resulted in five-year funding for the station from NSERC, Alberta Innovation and Science (AIS), the U.S. National Science Foundation (NSF) and the Mexican CONACYT, marking the first time that a project will be funded jointly by the national scientific agencies from the three North American countries.

Dr. Ghoussoub's new term will see the implementation of the new statutes of BIRS. The governance of the station is now firmly in the hands of the BIRS Executive Committee, composed of the Directors of PIMS, MSRI (Berkeley), Instituto de Matematicas-UNAM, MITACS, and the BIRS Scientific Director. On all scientific matters, decisions are made by an international Scientific Advisory Board, which allocates workshops purely on a basis of merit. This will have consequences for the PIMS community, since the 12 weeks that were reserved for PIMS activities have disappeared, as have the six weeks that were reserved for MSRI activities. We are happy that BIRS has attained such a stature in so short a time. We feel that the benefit of having such an outstanding research station in Canada, with its constant stream of major mathematicians from around the world, the access of which is based on scientific merit alone, far outweighs the loss to PIMS and MSRI of their guaranteed weeks at BIRS.

We believe that BIRS is now recognized as one of the best research stations of its kind in the world. This unmitigated success is largely due to the uncompromising search for scientific excellence that Dr. Ghoussoub has come to embody. We congratulate him on his first term, and wish him as successful a second term.

Ivar Ekeland, Chair, on behalf of the BIRS Executive Committee: David Eisenbud, Jose Antonio de la Peña and Arvind Gupta.

New BIRS Website Launched

The Banff International Research Station has launched a new website: **http://www.pims.math.ca/birs**

We hope you find the website useful and informative. If you have any suggestions or comments, please contact the BIRS Prgramme Assistant at birs-secretary@pims.math.ca.

Banff International Research Station: 5-Day Workshops in 2007

Jan. 1-19 **Mathematical Programming in Data Mining and Machine Learning:** K. Scheinberg (IBM TJ Watson Research Centre), M. Jordan (Berkely), J. Peng (McMaster), T. Poggio (MIT), D. Schuurmans (Alberta), T. Terlaky (McMaster).

Jan. 21-26 **Innovations in Mathematics Education via the Arts:** G. Hart (Stony Brook), G. de Vries (Alberta), R. Sarhangi (Towson).

Jan. 28-Feb 2 **Nonholonomic Dynamics and Intergrability:** B. Khesin (Toronto), S. Tabachnikov (Penn State).

Jan. 29-Feb 2 **Numerical Analysis of Multiscale Computations:** R. Tsai (Texas at Austin), B. Engquist (Texas at Austin), O. Runborg (Royal Institute of Technology, Sweden), S. Ruuth (SFU).

Feb. 4-9 **Explicit Methods for Rational Points on Curves:** N. Bruin (SFU), B. Poonen (Berkeley)

Feb. 11-16 **Operator Structures in Quantum Information Theory:** D. Kribs (Guelph), M.B. Ruskai (Tufts).

Feb. 18-23 **Mathematical Methods in Philosophy:** R. Zach (Calgary), A. Antonelli (UC Irvine), A. Urquhart (Toronto).

Feb. 25-March 2 **Topology:** I Hambleton (McMaster), M. Kreck (Heidelberg), R. Stern (UC Irvine).

March 4-9 **North American Workshop on Tropical Geometry:** G. Mikhalkin (Toronto), I. Itenberg (Strasbourg), Y. Soibelman (Institute des Hautes Etudes Scientifiques).

March 11-16 **Mathematical Developments Around Hilbert's 16th Problem:** C. Rousseau (Montreal).

March 18-23 **Contemporary Schubert Calculus and Schubert Geometry:** F. Scottie (Texas A&M), J. Carrell (UBC).

March 25-30 **Interactions of Geometry and Topology in Low Dimensions:** H. Boden (McMaster), D. Auroux (MIT), O. Colin (UQAM), J. Etnyre (Georgia Tech).

April 1-6 **Discrete Geometry and Topology in Low Dimension:** K. Bezdek (Calgary), R. Connelly (Cornell), H. Edelsbrunner (Duke).

April 8-13 **Complex Data Structures in the Health, Social and Environmental Sciences:** J. Stafford (Toronto), J. Berger (Statistical and Appiled Mathematics Institute), D. Brillinger (Berkeley), C. Leger (Montreal), J. Ramsay (McGill), H. Wynn (LSE).

April 15-20 **Stochastic Dynamical Systems and Climate Modelling:** B. Khouider (Victoria), R. Kleeman (Courant), A. Monahan (Victoria).

April 22-27 **The Many Strands of the Braid Gorups:** D. Rolfsen (UBC), J. Birman (Barnard College, Columbia University), P. Dehornoy (Caen), R. Fenn (Sussex), V. Jones (Berkeley).

April 29-May 11 **Summer School: The Mathematical Modelling of Climate and Energy Risk:** U. Horst (UBC), P. Imkeller (Institut fur Mathematik Humboldt Universitat zu Berlin), C. van Kooten (Victoria).

May 13-18 **New Applications and Generalizations of Floer Theory:** V. Ginzburg (UC Santa Cruz), O. Cornea (Montreal), E. Kerman (Illinois UC), F. Lalonde (Montreal).

May 20-25 **The Mathematics of Knotting and Linking in Polymer Physics and Molecular Biology:** K. Millett (UC Santa Barbara), E. Rawdon (Dusquesne), C. Soteros (Saskatchewan), A. Stasiak (Lausanne), S. Whittington (Toronto).

May 27-Jun 1 **Algebraic Lie Theory:** G. Roehrle (Southampton), G. Lehrer (Sydney), A. Pianzola (Alberta), A. Premet (Manchester), A. Ram (Wisconsin-Madison).

June 3-8 **Modular Forms: Arithmetic and Computation:** R. Sharifi (McMaster), J. Cremona (Nottingham), H. Darmon (McGill), K. Ribet (Berkeley), W. Stein (Washington).

June 24-29: **Statistical Methods for High-Throughput Genetic Data:** J. Chen (Waterloo), C. Fu (York), M. Lesperance (Victoria), D. Siegmund (Stanford), H. Zhang (Yale), H. Zhao (Yale).

June 25-July 9 **Summer School: 2007 Summer IMO Training Camp:** W. Sands (Calgary).

July 1-6 **Bioinformatics, Genetics and Stochastic Computation: Bridging the Gap:** A. Doucet (UBC), R. Gottardo (UBC), C. Robert (Ceremade, University Paris Dauphine).

July 8-13 **L-Functions, Ranks of Elliptic Curves, and Random Matrix Theory:** B. Conrey (AIM), M. Rubinstein (Waterloo), N. Snaith (Bristol).

July 15-20 **Quadrature Domains and Laplacian Growth in Modern Physics:** M. Putinar (UC Santa Barbara), D. Crowdy (Imperial College), B. Gustafsson (Royal Institute of Technology, Stockholm), M. Mineev (Los Alamos National Laboratory).

July 22-27 **Mentoring for Engineering Academia II**: R. Gray (Stanford), S. Hemami (Cornell), E. Riskin (Washington), R. Ward (ICICS).

July 29-Aug. 3 **Topological and Geometric Rigidity:** J. Davis (Indiana), S. Weinberger (Chicago).

Aug. 5-10 **Canada-China Workshop on Industrial Mathematics:** Arvind Gupta (SFU), Huaxiong Huang (York University), Gong Qing Zhang (Peking University).

Aug. 12-17 **Geometric Mechanics: Continuous and Discrete, Finite and Infinite Dimensional:** J. Marsden (California Institute of Technology), J. Ortega (CNRS, Universite de Franche-Comte), G. Patrick (Saskatchewan), M. Roberts (Surrey), J. Sniatycki (Calgary), C. Stoica (Laurier).

Aug. 19-24: **Operator Spaces and Group Algebras: E.** Kaniuth (Paderborn), A. Lau (Alberta), Z. Ruan

Aug. 26-31 **Loss of Compactness in Nonlinear PDE: Recent Trends:** P. Esposito (UBC), F. Pacard (Universite Paris XII), G. Tarantello (Universita' di Roma).

Sept. 2-7 **Hochschild Cohomology of Algebras: Structure and Applications:** R.O. Buchweitz (Toronto), L. Avramov (Nebraska), K. Erdmann (Oxford), J.L Loday (Institut de Recherche Mathematique Avancees), S. Witherspoon (Texas A&M).

Sept. 9-14 **Applications of Macdonald Polynomials:** J. Haglund (Ohio State), F. Bergeron (Universite du Quebec a Montreal), J. Remmel (UC San Diego).

Sept. 16-21 **Group Embeddings: Geometry and Representations:** D. Doty (Loyola), M. Brion (Grenoble), L. Renner (Western Ontario), E. Vinberg (Moscow State).

Sept. 23-28 **Trends in Applied Harmonic Analysis:** R.Q. Jia (Alberta), T. Chan (UCLA), C. Chui (Stanford).

Sept. 30-Oct. 5 **Entropy of Hidden Markov Processes and Connections to Dynamical Systems:** B. Marcus (UBC), K. Petersen (North Carolina), T. Weissman (Stanford)

Oct. 7-12 **Recent Progress on Nonlinear Elliptic and Parabolic Problems and Related Abstract Methods:** Y. Du (New England), E. Dancer (Sydney), K. Mischaikow (Georgia Tech), P. Polacik (Minnesota), X.Q. Zhao (Memorial).

Oct. 14-19 **Infinite Graphs:** G. Hahn (Montreal), R. Diestel (Hamburg), B. Mohar (SFU), P. Seymour (Princeton), R. Thomas (Georgia Tech).

Oct. 21-26 **Low-Dimensional Topology and Number Theory:** P. Gunnells (Massachusetts), D. Boyd (UBC), W. Neumann (Columbia), A. Sikora (New Mexico State).

Oct. 28-Nov. 2 **International Workshop on Robust Statistics and T:** M. Salibian-Barrera (UBC), C. Agostinelli (Universita Ca Foscari), P. Filzmoser (Vienna University of Technology), A. Stromberg (Kentucky).

Nov. 4-9 **Mathematical Methods for Medical Image Analysis:** G. Hamarneh (SFU), R. Abugharbieh (UBC).

Nov. 11-16 **Modern Approaches in Asymptotics of Polynomials:** D. Lubinsky (Georgia Tech), P. Borwein (SFU), E. Saff (Vanderbilt).

Nov. 18-23 **Physics-Based Mathematical Models of Low-Dimensional Semiconductor Nanostructures: Analysis and Computation:** R. Melnik (Laurier), L. Lew Yan Voon (Wright State), M. Willatzen (Syddansk).

Dec. 9-14 **Minimal Submanifolds and Related Problems:** J. Chen (UBC), A. Fraser (UBC), R. Schoen (Stanford), Y. Yuan (Washington).

PIMS: Industrial Initiatives

by Ivar Ekeland, PIMS Director

PIMS has been a leader in industrial mathematics over the past decade. Our Graduate Industrial Mathematics Modelling Camp and Industrial Problem Solving Workshop are major international events. As you will read on the following pages, this year both events were hugely successful, due in large part to the remarkable talents of our colleague JF Williams and the rest of the organizing team at Simon Fraser University. Our Collaborative Research Groups also have important industrial components. For example, the CRG on Inverse Problems, led by Gunther Uhlmann (U. Washington) and Gary Margrave (U. Calgary) organized a major international summer school on Seismic Imaging and a workshop on Geophysical Inversion this summer. As you might guess, such conferences are fundamentally connected to problems in oil exploration.

Recently PIMS has also expanded its scientific activities to include focused research projects in industrial mathematics which combine cutting-edge mathematics with strategic industrial problems. In particular, we are developing an exciting project on the Mathematics of Mining in collaboration with our partners at the Centro de Modelamiento Matemático in Chile. We will be co-organizing an important international meeting on this topic in Santiago next February. An international project on the mathematics of oil exploration is currently being developed, connecting scientists in Alberta with our partners in Mexico.

Industrial & Applied

PIMS Frontiers in Mathematics and Economics Summer School

University of British Columbia, July 10-28, 2006

The PIMS Summer School Frontiers in Mathematics and Economics, held at the University of British Columbia from July 10-28, 2006, brought together graduate students, postdoctoral fellows and young faculty members from business schools, economics, mathematics and operations research with leading economists and mathematicians. Students from business administration and economics were exposed to mathematical models and methods that are useful in their research, while graduate students and young researchers in mathematics and operations research examined new mathematical problems arising from economic theory.

The focuses of the summer school were a set of four courses on *Dynamic Contract Theory and Corporate Finance* by **Jean-Charles Rochet** (University of Toulouse); *Equilibrium: Theory and Computation* by **Kenneth L. Judd** (Hoover Institution on War, Revolution and Peace), **R. Tyrrell Rockafellar** (University of Washington) and **Alejandro Jofré** (University of Chile, CMM Deputy Director); *Information and Markets* by **William R. Zame** (University of California, Los Angeles) and *The Mathematical Structure of Quality Pricing* by **Ivar Ekeland** (University of British Columbia, PIMS Director). Mathematically, the lectures involved methods and techniques from deterministic and stochastic optimization, numerical dynamic programming, stochastic and convex analysis, and efficient numerical methods for analyzing general equilibrium models. All courses were accompanied by introductory tutorials that helped the students to familiarize themselves with the underlying economic and mathematical problems.

The program had 78 participants from more than 12 different countries, including 45 from Canada. The event was co-organized by PIMS and CMM, and co-sponsored by MITACS, UBC's Math and Economics departments, and NSERC (through individual grants).

PIMS Frontiers in Mathematics and Economics Summer School participants at the welcoming barbecue.

Mathematics in Economics: Fundamental Tool or Red Herring?

Jean-Charles Rochet is a Professor of Mathematics and Economics at the University of Toulouse I in France. His interests lie in the areas of applied mathematics and economics.

Q. How useful is mathematics in economics? How has the increased use of mathematics in economics over the years changed both math and economics?

I am reminded of the statement by Paul Samuelson, the first prestigious economist to systematically use mathematics in his work. He said, "I think literary economics, when you do not use any equations, may be superior, but it is too difficult for me." The interactions between people are far more complex than interactions between particles in physics, for example. This is why mathematics are needed in economics, even more than in physics. If you do not simplify things by using mathematical modelling, you cannot know what is happening. There is no filter, no control of the reasoning. Having said that, I feel that the use of math in economics may be dangerous sometimes, because you can lose the focus on the bigger picture. You can develop a taste for the mathematical tool and lose sight of the goal. You need math to understand the very complicated patterns, these interactions between people, but focusing too much on the tool can distract from the motives.

Criticism exists, to a larger extent in Europe than in North America, that mathematics in economics can be used as an ideological tool.

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Jean-Charles Rochet interview

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One example of this viewpoint are the critics who challenge that mathematical proofs are used as an ideologically tool in order to prove the superiority of the capitalist system. When Gerard Debreu, a brilliant mathematical economist, received his Nobel Prize in economics in 1983, he was interviewed by a very famous French newspaper, which later titled the interview: "Gerard Debreu: I Proved Mathematically the Superiority of the Capitalist System." Such a representation of his work is nonsense, but indicates the ideas held by some on mathematics in economics.

I believe it is important to develop alternative models, because I think that mainstream economics are currently too influential, in particular in finance. As it stands, there are many problems related to the functioning of societies that are not sufficiently taken into account in current economic research. In many cases, the public does not care for economics because they believe that economists do not have any consideration for ethical problems. If that is the case, it is not because the economists use mathematics, it is because the mainstream ideas are too powerful. In an ideal world, I would like to have several economic schools of thought that compete with each other, all using mathematics, instead of the current system of one dominant school of thought that has eliminated all competitors.

Q. As an economist, do you think that mathematics is helping the direction of economics, or is too much attention being paid to mathematics?

I think we have to be careful that mathematics, while needed, are not the final objective. The final objective always depends on the initial economic question. Mathematics is only a tool, and should not be the final objective. There are examples, but relatively few, where problems arising in economics have allowed the development of new mathematical techniques. General equilibrium is one such example. The fixed-point theorem that was needed to solve general equilibrium problems was not available when the study began, and was developed by mathematical economists in response to the issue.

I was very keen to find such a problem when I developed a model of adverse selection, which was presented by Dr. Ekeland at the PIMS 2006 Summer School Frontiers in Mathematics and Economics. It is a problem that has important mathematical consequences. I was very glad to have found a problem that had an interest from the mathematical point of view, but such a case is very infrequent. In my career, it will happen perhaps two or three times. Sometimes, the problems that arise are very interesting from an economic point of view, but elementary from a mathematical point of view. You cannot tell when initially examining the problem.

Q. Tell our readers about "asymmetry of information."

Asymmetric information models are obscure, very difficult to explain, because people do not see immediately the implication of the subject. To step back, the development of mathematical economics can be seen as different waves. There was an important wave, in the 1950s and 1960s, on general equilibrium, where economists realized that they could model the behaviour of markets in a very elegant way, establishing that competition was a powerful force to achieve economic efficiency.

That was not the end of the story, because there are many circumstances where the general equilibrium theory does not explain market function. This happens, for instance, when the quality or the characteristics of the goods are not observed by the buyer. Akerlof, in the 1970s, developed this idea in a famous paper, "A Market for 'Lemons'," where he studied second-hand trade in cars. What develops are circumstances with asymmetric information: the seller has more information than the buyer. In such cases, the markets typically do not function properly.

We must find ways to improve the functioning of markets. The mathematical tools needed to understand these problems are very complex and are related to partial differential equations and numerical analysis. I see asymmetric information as a second wave of economic development, after the wave of general equilibrium. General equilibrium was the first example in economics where mathematics were important. The first ideas behind general equilibrium were elaborated by Adam Smith in the 18th century. It took more than 200 years to solve the problem from a correct mathematical point of view.

We are in the middle of the second wave, the wave of asymmetric information models. This field of study is still very active, but now we are moving toward a third wave of study. Of course, we do not throw out the baby with the bathwater: we are building on the knowledge we have of general equilibrium and asymmetric information, and are going further, with are problems that use different mathematical techniques. In particular, stochastic control is very important. We do not know yet where this will lead us in mathematical economics.

Essentially, in applied mathematics we turn the technique backwards. The old method was to seek out real challenges on which to use mathematical techniques. Now, if we are interested in a field, we look at real and existing problems and then search for techniques that are appropriate to solve the problem. We cannot know in advance which techniques we will need, and I enjoy the mathematical challenge.

Q. Can you give us some examples of asymmetry of information as it applies to real life situations, such as insider trading in the stock markets?

Insider trading is a very good example of asymmetric information. There is a question in economics of whether we should allow people to trade public stocks on their private information. On the one hand, you say it is unfair, because those people are going to make money at the expense of others who do not have this information. On the other hand, if you prohibit insider trading altogether, then nobody will bother collecting information on the stocks, and therefore the prices will not play the role of signals for investors, because the prices will not contain any important information.

The difficulty facing regulators and economists is to find the limit on the information that can be used for trade, and determine what is a reasonable profit for the effort one makes for collecting the information. There are also situations where the insider trading is purely exploiting people who do not have access to the information, so the limits on the activity are a tricky question. Mathematical models can be very helpful in this case. Insider trading and other asymmetrical information questions are the kind of questions that cannot be solved without mathematical models.

(l to r) Ali Lazrak (UBC Commerce); Jean-Charles Rochet (University of Toulouse I); Ivar Ekeland (PIMS Director)

9th PIMS Graduate Industrial Mathematics Modelling Camp
Simon Fraser University, June 21-25, 2006

Contributed by JF Williams

The 9th PIMS Graduate Industrial Mathematics Modelling Camp (GIMMC) was held at Simon Fraser University from June 21-24, 2006. A record 147 people from six countries applied for the camp, resulting in 42 participants. GIMMC prepares students for the Industrial Problem Solving Workshop (IPSW) by giving them an opportunity to meet the other participants, work in a group setting and learn new modelling techniques from established experts. To do this, students worked mostly independently on the problems that were presented by mentors, who had previously worked on the problems. The mentors took an arm's-length approach, allowing the students to develop their own ideas and directions. At this year's event, three of the six GIMMC problems were directly geared towards IPSW problems.

The assembled students divided into groups and worked on six different problems with a diverse set of mentors:

Jose Adachi (Schlumberger Oilfield Services, Sugarland, Texas)

Mr. Adachi presented a real problem related to a recent accident on an offshore oil rig operated by one of Schlumberger's partners. When drilling, the company needs to pump mud for many kilometres underground through the wellbore to cool the drilling and data collection tools located at the end of the shaft. The GIMMC team developed a model to understand how high the temperature would rise if the flow of mud stopped during the drilling process, and how the temperature at the tool site depends on the flow rate of mud coolant. Mr. Adachi was very impressed by the group's work and is keen to return next year with fresh challenges.

Derek Bingham (Simon Fraser University)

Dr. Bingham, a member of the Statistic department at SFU, brought a problem on experiment design to the GIMMC. The basic question was simple: How can we best explore a parameter space when data collection is very expensive? The team worked on a model problem from queuing theory related to wait times for a web server. In this scenario, the business is interested how long customers need to wait under different demand conditions. Knowing that customers will leave after waiting a given length of time, the business would like to understand how the tuning of their servers could impact availability. Detailed simulations are very expensive and the object of primary interest is the boundary between customers leaving and staying. The students developed an algorithm to adaptively seek out this boundary, rather than exploring the entire parameter space.

Poul Hjorth (Technical University of Denmark)

Dr. Hjorth brought a classical problem on bell ringing: If we have *n* bells in a tower and we would like a bell at a fixed interval, how can we pull on the bells to change the order in which they ring? The group modelled this situation and developed both analytical and numerical solutions as to when, and how hard, each ringer should ring each bell in order to perform a given sequence. Being true mathematics students, this group even took the time to prove a related theorem. This problem has appeared at a previous student meeting but their mentor was convinced that this year's solution was superior.

Keith Promislow (Michigan State University)

Dr. Promislow is an industrial mathematician who has worked for many years with Ballard Power in Vancouver. He brought a difficult problem on modelling the build-up of carbon dioxide in running fuel cells. Fuel cells are a clean-burning energy source, which harness the released electrical energy when hydrogen and oxygen are combined to form water. In most practical units air is recirculated to provide the oxygen source but this can lead to a build-up of carbon dioxide. The group built a simple model of the dynamics within a fuel cell and explored simple ways to alleviate the build-up of carbon dioxide.

Randall Pyke (SFU)

One of this year's IPSW problems involved the numerical simulation of forest fires, so Dr. Pyke presented a problem using an alternate approach for modelling such phenomena. The students worked to develop a discrete cellular automaton model of the spread of forest fires so they would understand the strengths and weaknesses of such an approach. Several of the students applied what they learned on this problem to the forest fire problem presented at the IPSW.

Juan Restrepo (University of Arizona)

Many physical models have undetermined coefficients and need to be compared to noisy physical data. Dr. Restreppo presented his group with several different approaches to overcoming these problems and had them work through one in detail. This fundamental background was very helpful to the many students who chose to work on the IPSW problem presented by the B.C. Ministry for Finance.

At the end of the meeting, each group made a presentation of their findings. The results will be available on the PIMS website.

In general, both students and mentors found this to be a valuable experience that they would attend again and recommend to their colleagues. Conference organizer JF Williams (SFU), a former student participant, believed this year's conference was the strongest group of students that PIMS has ever attracted to GIMMC. Next year's GIMMC will be held in Edmonton on June 5-9, 2007.

IPSW

Connecting Industry to Solutions

10th PIMS Industrial Problem Solving Workshop
Simon Fraser University, June 26-30, 2006

Contributed by JF Williams

The 10th PIMS Industrial Problem Solving Workshop assembled a group of 65 academics from across Canada, the United States, the United Kingdom, Denmark, Mexico, Singapore, Austria and Australia to work on seven problems submitted by both public and private industry. The workshop was held at Simon Fraser University from June 26-30, 2006, and organized by JF Williams (SFU).

The problems were presented on the morning of June 26. The students who attended GIMMC worked with 20 additional academic participants for the week. Unusually for the conference, seven non-academic participants, representing five of the seven submitted problems, remained onsite at the workshop. Findings were presented June 30.

Applied Innovations: *Scheduling road maintenance procedures.*

Applied Innovations consults with the Government of Saskatchewan on various maintenance issues. They were interested in the best schedule for different road treatment procedures over the lifetime of a road, given that different problems occur at different times and at different rates. The problem was made difficult by noise in both the data on road conditions and the models of wear over time. While working on this problem, the IPSW group managed to prove the theorem "A stitch in time saves nine"! Two employees from Applied Innovations remained at IPSW, and afterwards said they will take back many new ideas.

Aurel Systems: *Numerical solution of multicomponent vapour-liquid calculations.*

Aurel is a small company near SFU that develops simulation and optimization software for manufacturing plants operating in many industries. They brought a seemingly simple problem involving the numerical solution of a small set of nonlinear algebraic equations. However, with discontinuities and non-physical bifurcations, this problem turned out to be surprisingly subtle. The work started at this workshop was sufficiently important to Aurel that the company plans to engage in further collaboration with PIMS scientists.

B.C. Centre for Disease Control: *Determining the impact of a new testing procedure on the spread of HIV.*

A new test for HIV has recently entered the market, one that can determine infection earlier but is more expensive than the test currently in use. The BC CDC wanted a model that would help determine the impact of catching infection in the earliest possible stage (when the carrier is most infectious) in order to evaluate the new test. The problem presenter remained at IPSW for the whole week and had two other colleagues join her on different days. It is expected that this problem will lead the BC CDC to further collaboration with PIMS scientists and possibly to new public policy in B.C.

B.C. Ministry for Advanced Education: *How can we predict future student demand at post-secondary institutions?*

The B.C. Ministry for Advanced Education is responsible for developing and implementing the government's policies for post-secondary education in the province. The ministry came to IPSW with a problem about how to best predict future student demand for university seats, given trends on high school graduation rates and grades. After the presentation, the ministry representative said the work done at the workshop will have an immediate impact in the ministry.

B.C. Ministry of Finance: *Modelling future electricity prices.*

Corporate Finance and Planning is a group within the B.C. Ministry of Finance that determines the financial viability and funding arrangements of future publicly funded projects in B.C. At the moment, the ministry is evaluating a proposal for a new hydro generating station and wanted a new model for electricity pricing in B.C. Most electricity is sold at fixed prices, but the surplus is sold on the open market in Alberta and the Pacific Northwest. Due to data availability, the IPSW group focused on the Alberta market and developed a model that took into account demand not only of electricity but of other resources as well. Most of the work on this problem was done by students who had attended the GIMMC, who had excellent preparation for the challenge.

Prometheus (the Canadian Forest Fire Model): *Improving the numerical simulation of forest fires.*

Prometheus is a group within Alberta Sustainable Resource Development and Natural Resources Canada that provides governmental agencies in Canada with forest fire simulation software. Their code uses local information about topography, fuel type and current conditions to advance a burning front. Their approach has many advantages but also disadvantages related to the topology of the fire's front. The group working on this problem attempted to address both Prometheus' current difficulties as well as proposing a new level set implementation of their model for future work. Two employees from Prometheus joined us for the entire week. The presentation included a working example of the new level set formulation on a model problem, which was very encouraging.

Schlumberger Oilfield Services: *Modelling the release of an encapsulated breaker.*

Encapsulated breakers are used as a cleaning agent in the hydraulic fracture stage of drilling oil wells. The formulation of this product as used by Schlumberger does not behave precisely as the company or the manufacturer expected. In 2002, Sclumberger performed an inconclusive experiment and tasked the workshop with developing a model to explain their observations. A series of potential models were presented and the main result of this investigation was a suggestion for detailed experiments that Schlumberger could perform in order to seek answers.

Detailed problem descriptions are available at http://www.pims.math.ca/industrial/2006/06ipsw/problems.html. Final reports will be available on the PIMS website when they are completed.

All presenters indicated they were very excited about the work done at IPSW. In particular, both Lisa Ransom (Min. Adv. Ed.) and Clare Kirkland (Applied Innovations) said the results were what they had hoped for and would have an immediate impact. Because of the strong involvement by problem presenters throughout the week, the meeting was able to generate considerable knowledge transfer from academia to industry, as well as initiate new collaborations and opportunities for both students and faculty alike.

This year's IPSW has roundly been described as the largest and most successful study group that PIMS has organized. All participants are hoping that next year's event in Edmonton, on June 11-15, 2007, will be even better!

Fields-MITACS-PIMS Summer School on Mathematical Modelling of Infectious Diseases York University, June 10-20, 2006

Contributed by Jianhong Wu

The Summer School on Mathematical Modelling of Infectious Diseases, held at York University in Toronto from June, 10-20, 2006, highlighted the mathematical modelling process and the interaction between epidemiology and mathematics, to provide language and framework for the students to think and formulate infectious diseases problems mathematically. This process demonstrated modelling approaches for public health issues.

The school focused on deterministic models, but there were substantial lectures on stochastic and network models, how parameters in deterministic models are identified and estimated using statistical methods, and how simple deterministic models can be fine-tuned to deal with disease transmission heterogeneity and spatio-temporal spread patterns.

The series of public lectures covered a wide range of issues and diseases relating to public health, illustrating the general framework and abstract mathematical theory in an applied setting. Pauline van den Driessche (University of Victoria) opened the conference by discussing how mathematical modelling contributes to infectious diseases control. Fred Brauer (UBC) closed the lecture series by discussing the MITACS group's work on modelling pandemic influenza. There were lectures about the capacity of major cities to resist emerging infectious diseases (D. Earn); the challenge and opportunities in modelling wildlife diseases (L. Allen); the mathematical epidemiological approaches towards public security (C. Castillo Chavez); and the integration of epidemic models into cost-effectiveness analysis of a universal Hepatitis A vaccination in Canada (C. Bauch). The MITACS group and collaborators also presented their recent work on modelling HIV in India (P. Jha); how commercial air traffic is a global conduit for emerging infectious diseases (K. Khan); and how mathematical modeling contributed to the study of West Nile Virus (P. van den Driessche and H. Zhu).

The Summer School, which developed from a successful BIRS summer program in 2004, was funded by PIMS, MITACS and Fields.

Sequences and Codes Simon Fraser University, July 17-21, 2006

The Sequences and Codes conference, held at Simon Fraser University on July 17-21, 2006, was an interdisciplinary meeting that brought together mathematicians, electrical and computer engineers, and informatics and computer scientists. The conference's 70 participants, split almost evenly between attendees from Canada, the United States and overseas universities, represented the wide and varied coverage of the relatively new research area of sequences and codes. The interaction between the fields of sequences and codes is relatively new, and is sparking new cross-disciplinary collaborations. Participants examined new research directions within the fields of sequence design and algebraic error-correcting codes, including radar applications of sequence design, algebraic constructions of space-time codes, and pseudocodewords.

The lectures and discussions were well received by all participants. The plenary lectures by Jean-Claude Belfiore (ENST, France), Stephen Howard (DSTO, Australia), Ralf Koetter (University of Illinois), Bernhard Schmidt (NTU, Singapore) and Judy Walker (University of Nebraska) were a complete success. The two PIMS Distinguished Lectures, given in parallel with the conference, were quite a coup. Princeton University mathematical scientists Robert Calderbank and Ingrid Daubechies each gave an hour-long lecture on July 18, followed by a question and answer session exclusively for graduate and undergraduate students to address practical topics in working in the field of the mathematical sciences.

Robert Calderbank (background) and Ingrid Daubechies (foreground) answer questions from undergraduate and graduate students at a special session.

On the fourth day of the conference, an unusual panel discussion was held, entitled *Future Directions in Sequences and Codes*. The panel discussed the direction the subject may take over the next several years, at the technical, organizational and mathematical levels, and how such growth will be achieved. Arvind Gupta (MITACS), James Davis (University of Richmond) and Ralf Koetter (University of Illinois) led the panel.

Richard Turyn, one of the founders of sequences and codes subject area, attended the conference, and was the recipient of a certificate of recognition for his lifetime of achievement. He received the certificate at the conference banquet on Thursday night.

Several innovative decisions by the organizers allowed the conference to reach out to students and early career participants. Generous funding allowed early career participants attend from as far away as Australia, Israel, Norway, Germany and France. The conference was selective in the number of participants and the talks accepted, in order to represent the breadth of the subject matter. Conference participants were very impressed with the interdisciplinary nature of the research and the comprehensive nature of the talks.

Jonathan Jedwab (left) presents Richard Turyn with a certificate of recognition.

The conference was an initiative of PIMS and was co-sponsored by MITACS, the NSF and PRIMA. The week-long event was held at SFU's IRMACS Centre. The conference was organized by Nigel Boston (University of Wisconsin, Madison), Robert Calderbank (Princeton University) and Jonathan Jedwab (Simon Fraser University).

Ingrid Daubechies, Wavelets and Beyond

Ingrid Daubechies received her PhD in 1980 from the Free University in Belgium.She is now the William R. Keenan Jr. Professor with the Mathematics Department and the Program in Applied and Computational Mathematics at Princeton University. Her research interests focus on the mathematical aspects of time-frequency analysis, in particular wavelets, as well as applications. She visited SFU in July, 2006, for the Sequences and Codes conference.

Q. You started your academic career in physics, and subsequently moved to the field of applied mathematics. What prompted this change in your subject area?

The shift happened gradually, I did not make a conscious decision to change fields. I originally worked in the area of mathematical physics, which is already close to applied mathematics, where mathematical tools are used to understand and to prove things rigorously for physics problems. From there, it was a short step to use those mathematical tools, but other application of mathematics. It was my experience with the tools that guided me to other applications and fields.

Q. The majority of your research is on wavelets — how did you come to focus on this area? Has your focus changed over time?

There was an interesting development in wavelets in the early 1980s, using dilations and translations with wavelet building blocks to understand signals, short-lived transients and images. I became very interested in that area, because the tools were close to those used in quantum mechanics, an area of study I was familiar with. With wavelets, new mathematical questions continuously arose. The discoveries drove the research, and it was an extremely exciting period, because it turned out that many researchers in different fields were working on the same problem from different angles. When the researchers came together, their synthesis was suddenly more powerful than what each of the fields could have done alone.

Mathematician Ingrid Daubechies

Now, the time to build and refine the mathematical tools for wavelets is largely over, except for various generalizations that are being developed, an area that I am still working on. During the Sequences and Codes conference at SFU, I visited UBC to collaborate with Dr. Matt Yedlin on the mathematical investigation and study of problems in electrical engineering. We are working on analog-to-digital conversion, which ties in directly with my connection to the conference.

With analog-to-digital conversion, we want to work with sequences of 1 and -1, in order to represent signals. Digital signal processing has made such a difference, but the signals we are interested in are not digital. The reason the digital world is so much better than analog is that our recording components are imperfect. Once you know that the only levels you have are really 0 and 1, then if you register 0.89, you know it should have been a 1 and you can correct for it. In analog, before you get to the stage where everything is measured as 0 and 1, a reading of 0.89 does mean 0.89, not 1. We must first move from analog to digital, and that move has to address the imperfect performance as well. It is a very different type of mathematical thinking, where we have to find the appropriate algorithms and prove things rigorously, even though the components themselves are rather flaky.

Q. You spent several years working at the AT&T Bell Laboratories before returning to the university setting. What insights has your time in both industry and academia given you, in terms of both research and mathematics?

It has been my impression that time in industry development laboratory can be more directed and narrow, and less oriented on the research. However, if you go into a research laboratory in an industry or company with available money, then you can really get into the research that is of interest to you, and it becomes such a fascinating world. You spend so much more time on your research than you do in academia. On the other hand, I enjoy teaching and being in the university environment. That is one of the main reasons I ended up back in academia.

Q. What other fields are you working in right now besides wavelets? What are you experimenting with, what are you looking towards, what has caught your interest recently?

I am currently working in neuroscience, mainly on signal analysis for neuroscience, but I am also developing an interest in the problems involved in neuroscience itself. Additionally, I am working with geophysicists, who are using data from earthquakes to understand the deep structure of the Earth's mantle. As I previously mentioned, I am working on analog-to-digital conversion. It is a field with no existing satisfactory mathematical models. The imprecision and the imperfection of the components plays a role in the process, and we are working on figuring out the complications. For the moment, we do not know what we will learn, but we are trying.

Q. As one of the premier women in mathematics, you have achieved several "firsts" — first woman full professor of mathematics at Princeton, first woman to receive the National Academy of Sciences (NAS) award in mathematics. What challenges have you faced as a woman in the field of mathematics, and do you have any advice for women in mathematics?

I have not consciously felt any setbacks. Part of the reason was that my parents were extremely encouraging, and that I attended an all-girls' public high school in Belgium. It was only once I entered college that I encountered the attitudes that if you were a woman, you could not be good in math. By then, I could shrug it off. It never really had an impact on me.

There have been occasions, as every woman has probably experienced, where I was in a meeting and put forward an idea that was not recognized, and then five minutes later a more visible man proposed the same idea and everybody hailed it as wonderful. Those incidents are annoying, but not of serious importance.

When I was younger, I wondered if it was possible to have a family

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and to do well in research. After meeting a prominent woman mathematician, Cathleen Morawetz, who has four children, the worry fell away. Dr. Morawetz gave me some good advice that I continue to pass on: if you want to maintain the family/career balance, it is worth investing in good child care. There are very few women who can do research well and also take care of children. You cannot concentrate whole-heartedly on your research if you are not totally confident that the children are in excellent hands. When the children are little, it is worth paying for the child care.

My husband and I met when I was 30, so we were both mature. It was important to us to have a working relationship, to discuss our priorities. I tell young women that it is important early in a relationship to talk about roles in the partnership. In books I have written, I have thanked my husband, because juggling our careers and our family meant that both of us proved fewer theorems.

Q. Do you have any comments on the Sequences and Codes conference?

The conference is a mix of many things, and it is particularly interesting to have an event such as this where people from different backgrounds, from mathematicians to engineers, come together and discuss research, and how their work relates to other fields. I have heard talks that spark my interest, in seeing where the results will lead. It is important to have people from different communities talk to each other. Whenever there is the opportunity to bring such groups of people together, you want to listen. When the time is right for researchers in different fields to listen to each other and interact, when there are people from different communities looking at similar problems but from different angles, it can be extraordinarily fruitful.

International Conference on Stochastic Analysis and Its Applications

University of Washington, Aug. 7-11, 2006

The International Conference on Stochastic Analysis and Its Applications was held at the University of Washington on Aug. 7-11, 2006. The conference was devoted to several areas of stochastic analysis, including Markov processes, jump type processes, measure-valued processes, Dirichlet forms and multiparameter processes such as Brownian sheets. These related directions of research are central to modern probability theory. About 60 participants attended.

(l to r) Masatoshi Fukushima, Ed Perkins, Rene Schilling

(l to r) Michael Roeckner, Michael Cranston, Byron Schmuland, Masatoshi Fukushima,

The main goal of the conference was to bring together researchers from all over the world to survey the changes in the rapidly growing field, to exchange ideas and to foster future collaborations. Conference organizers wanted young researchers and PhD students to have access to the most recent developments in active areas of probability theory.

The conference invited prominent mathematicians and junior researchers to present talks on developments in the field of stochastic analysis. There were 28 invited research lectures given over the five-day conference. To read about the lectures, including abstracts, please visit http://www.math.washington.edu/~zchen/Conference/.

The conference devoted Thursday's program to celebrate Professor Masatoshi Fukushima's 70th birthday. Dr. Fukushima is a renowned mathematician who has made many fundamental contributions to probability theory. He and Martin Silverstein are the two pioneers in the theory of symmetric Dirichlet forms. Dr. Fukushima visited University of Washington as the PIMS Distinguished Professor from July 17 to Aug. 27, 2006.

To expose young researchers and PhD students to the most recent developments in active areas of probability theory, the conference had three tutorial series by Dr. Fukushima, Davar Khoshenevisan and Michael Roeckner, on topics of 1-dimensional diffusion and Dirichlet forms, additive Levy processes, and stochastic partial differential equations and their invariant measures.

In addition to the invited lectures and tutorial lectures, there were five contributed talks by advanced PhD students and recent PhDs. A session was held for participants who were encouraged to give short informal presentations of their work and discuss problems in an informal atmosphere.

The conference, organized by Krzysztof Burdzy and Zhen-Qing Chen, was financed from several sources, including NSA and University of Washington, and was co-sponsored by PIMS.

PIMS Travel Grants

The Pacific Institute for the Mathematical Sciences provides travel grants to defray some of the travel expenses to PIMS-sponsored conferences, workshops and summer schools for selected Canadian participants. Priority will be given to graduate students and post-doctoral fellows, as well as faculty members from Canadian institutions provided they are not NSERC grantholders. (Holders of NSERC graduate and post-graduate fellowships are eligible.) PIMS is committed to increasing the participation of women and other underrepresented groups in all aspects of Canadian mathematical activities.

Applications for support are to be sent by the workshop organizers to reception@pims.math.ca.

Please see the PIMS website for more information.

PIMS Travel Grants to BIRS

The Pacific Institute for the Mathematical Sciences provides travel grants to defray some travel expenses to BIRS for selected Canadian participants. Priority will be given to graduate students and post-doctoral fellows, as well as faculty members from Canadian institutions as long as they are not NSERC grantholders. (Holders of NSERC graduate and post-graduate fellowships are eligible.) PIMS is committed to increasing participation of women and other underrepresented groups in all aspects of BIRS activities.

Workshop organizers should send applications for support to the BIRS Programme Coordinator at birs@pims.math.ca

Other travel support to BIRS may also be available from MITACS, MSRI and UNAM. For more information, please contact these organizations directly.

The University of Calgary hosted the Seismic Imaging Summer School and Geophysical Inversion Workshop on Aug. 7-18, 2006. The conferences brought together mathematicians and geophysicists to discuss developments in the field of seismic imaging and wave propagation.

The two conferences were co-sponsored by PIMS, the Canadian Society of Exploration Geophysicists (CSEG), the Consortium for Research in Elastic Wave Exploration Seismology (CREWES) and MITACS, and organized by Gary Margrave (University of Calgary), Gunther Uhlmann (University of Washington), Mauricio Sacchi (University of Calgary), Peter Cary (CSEG) and Robert Stewart (CREWES).

Seismic Imaging Summer School

University of Calgary, Aug. 7-11, 2006

The Seismic Imaging Summer School focused on seismic imaging and related inverse scattering theory. Over 50 students attended the course, including graduate students in mathematics, geophysicists, practicing scientists and mathematicians in the oil industry, and academic scientists.

The purpose of the school was to present foundational material relevant to seismic imaging and wave propagation, to help prepare students for the advanced research to be presented in the Geophysical Inversion Workshop (GIW) in the subsequent week. Gary Margrave (University of Calgary) presented an overview lecture at the beginning of the conference, emphasizing a common inverse scattering perspective, and then at the end of the week presented two lectures on the utility of pseudodifferential operators and Gabor methods in imaging.

Michael Lamoureux (University of Calgary) gave three lectures on the fundamental mathematics of the wave equation including boundary and initial conditions, well posedness, fundamental solutions, and Huygen's principle.

Charles Ursenbach (CREWES) had three lectures that covered mathematics and physics of the Kirchhoff seismic imaging algorithm, which is the most widely used seismic imaging technique, and also emphasized the basis of the method in inverse scattering.

David Colton (University of Delaware), the only lecturer from outside the seismic community, presented the mathematical basis for the linear sampling method, an inverse scattering technique widely used in electromagnetics, and provided a valuable ongoing commentary from the perspective of an unbiased applied mathematician.

Robert Ferguson (University of Texas, Austin) presented three lectures on the nature on the so-called wave-equation migration methods, in which he emphasized the need for better imaging conditions.

Finally, Mauricio Sacchi (University of Calgary) gave a lucid set of lectures on the imaging problem from the perspective of mathematical inverse theory, emphasizing the utility of adjoint methods over full inversion and showing how regularization methods can be used to control the trade-off between resolution and uniqueness.

Participants hard at work at the SISS

The tone of the workshop proved to be informal and interactive. There were often excellent questions and comments from the students, which added considerably to the learning process. Since many of the "students" were actually senior scientists in industry, this interaction provided a much-needed practical perspective.

Geophysical Inversion Workshop

University of Calgary, Aug. 14-18, 2006

The Second Geophysical Inversion Workshop opened on Aug. 14 at the University of Calgary, delving into the dual themes of seismic imaging and wave propagation. The list of participants included a number of students who participated in the Seismic Imaging Summer School the previous week.

The conference centred on lectures from invited speakers:

Norm Bleistein (Colorado School of Mines) *Kirchhoff inversion for incident waves synthesized from common-shot data gathers.*

Workshop participants listening to a lecture by Norm Bleistein

Chris Chapman (Schlumberger Cambridge Research) *Some comments on the Born approximation.*

David Colton (University of Delaware) *Electromagnetic imaging of buried objects.*

Maarten de Hoop (Purdue University) *Advances in wave equation tomography.*

John T. Etgen (BP) *Imaging below salt: where are we and how did we get there, an "industrial" perspective.*

Lou Fishman (Slidell/MDF International) *A Hitchhiker's Guide to the seismic phase space and path integral universe*

Samuel H. Gray, James Sun and Yu Zhang (Veritas DGC) *Industrial-strength depth imaging methods: One-way, two-way, or two-pass one-way?*

Dmitri Lokshtanov (Norsk Hydro Research Centre, Norway) *3D wave-equation prediction of multiples.*

Wim A. Mulder (Shell International Exploration and Production, the Netherlands) *Nonlinear migration and full waveform tomography.*

Frank Natterer (Muenster) *Least Squares Inversion Revisited.*

Victor Palamodov (Tel Aviv) *Reconstruction of medium from boundary measurements. New prospections.*

George Papanicolaou (Stanford University) *Interferometric array imaging in clutter and optimal illumination.*

Gerhard Pratt (Queens University) *Velocity models from seismic waveform tomography: Making the theory work with data, and making the data work with the theory.*

Robert Stolt (ConocoPhilips) *Some observations on multipath asymptotic imaging.*

William Symes (Rice University) *A software framework for inversion.*

Arthur B. Weglein (University of Houston) *Responding to pressing seismic challenged: Removing multiples and depth imaging and inverting primaries without knowing or determining the velocity model.*

Ru-shan Wu (University of California, Santa Cruz) *True-amplitude, true-reflection imaging and scattering tomography.*

PIMS Board of Directors: New Members

John Hepburn, Dean of Science at the University of British Columbia from 2003-2005, received his PhD in Chemistry in 1980 from the University of Toronto, where his supervisor was Nobel prize winner Dr. John Polanyi. Following a period as a NATO Fellow at the Lawrence Berkeley Laboratory at the University of California, Berkeley, Dr. Hepburn taught Chemistry and Physics at the University of Waterloo from 1982-2001, chairing the Chemistry Department for two years. In 2001, he became Head of Chemistry at UBC before being appointed Dean of Science.

John Hepburn

He has been a member of the PIMS Board of Directors since October, 2005.

Ron Irving is the Interim Dean of the College of Arts and Sciences and a professor in the Department of Mathematics at the University of Washington. Professor Irving received his PhD in Mathematics from MIT in 1977. He is co-founder and executive director of the Summer Institute for Mathematics at U. Washington, a program that introduces 24 high school students from the Pacific Northwest to advanced mathematics. Dr. Irving served as chair of Mathematics at U. Washington from July, 2001, to June, 2002. In July, 2002, Dr. Irving became Divisional Dean of Natural Sciences at U. Washington.

Ron Irving

He has been a member of the PIMS Board of Directors since December, 2005.

Vaho Rebassoo is Chief Technology Officer, IT Services, of the Boeing Company. He has over 25 years of experience in systems engineering and technical management in network and computing. This includes key roles with the Pentagon Telecommunications Center, Bell Laboratories in development of the 5ESS switch and the System 85 PBX, while at Boeing, designing, implementing and operating large complex networks and computing infrastructures. Dr. Rebassoo received his Masters and PhD degrees from the University of Washington.

Vaho Rebasso

He has been a member of the PIMS Board of Directors since June, 2006.

Zelda B. Zabinsky is a Professor in Industrial Engineering at the University of Washington. She started at U. Washington in 1985, after completing her PhD in Industrial and Operations Engineering from the University of Michigan. Dr. Zabinsky was awarded a Benton Fellowship for her graduate studies in Operations Research at the University of Michigan. In 1992, at U. Washington, she received a Research Initiation Award from the National Science Foundation (NSF) to develop global optimization algorithms for engineering design. She currently has a second NSF grant to continue developing optimization in engineering design. This software is in use at the Boeing Company, to design fuselage panels with advanced composite materials.

Zelda Zabinsky

She has been a member of the PIMS Board of Directors since April, 2006.

Spotlight on University of Washington

by Gunther Uhlmann, Site Director

After several years of working towards the cross-border promotion of the mathematical sciences, the University of Washington has officially become a full PIMS member. Since 1999, U. Washington has participated as a PIMS member in many activities, including Pacific Northwest Seminars, Thematic Years, BIRS, and Collaborative Research Groups. U. Washington faculty have active roles in the current PIMS CRGs in algebraic geometry, cohomology and representation theory, inverse problems, mathematical modelling, and probability and statistics.

In 2004, the National Science Foundation (NSF) awarded the university a VIGRE grant that has allowed joint funding of PIMS activities at U. Washington, including the Summer Graduate School on Algebraic Geometry and the Summer Graduate School on Inverse Problems, both held in 2005. During 2006, PIMS and VIGRE co-sponsored the International Conference on Stochastic Analysis and Its Applications, and the Stability and Instability of Non-Linear Waves Workshop.

William Symes (Rice University) gave the PIMS 2005 Distinguished Lecture on Seismic Imaging, while Ding Weiyue (Peking University) gave the 2006 Distinguished Lecture on Geometric Analysis and Partial Differential Equations. Masatoshi Fukushima (Osaka University) presented the PIMS Distinguished Lecture on Stochastic Analysis in August, 2006. U. Washington is planning summer schools in Electrical Impedance Tomography and Optical Tomography and in Envirometrics in 2007. As part of the PIMS 10th Anniversary, we will host a series of speakers, with confirmed lectures from Peter Lax (Courant Institute), Kari Astala (University of Helsinki), and Carlos Kenig (University of Chicago).

U. Washington looks forward to an increased involvement in the continuing development of PIMS as an international centre of mathematics research and outreach.

Scientific Review Panel

PIMS welcomes the two new members of the PIMS Scientific Review Panel.

Barry Sanders is the iCORE Professor of Quantum Information Science and Director of the Institute for Quantum Information Science at the University of Calgary. He is known for contributions to theories of quantum-limited measurement, highly non-classical light, practical quantum cryptography, and optical implementation of quantum information tasks. His research interests include quantum resources and optical and atomic implementations of quantum information tasks and protocols.

Richard Kenyon, Professor of Mathematics at UBC, received his PhD in 1990 at Princeton University under the direction of William Thurston. Dr. Kenyon held a postdoctoral position at the Institut des Hautes Etudes Scientifiques and then a position at CNRS (Centre national de la recherche scientifique) in France. He was appointed as a Canada Research Chair at UBC in 2004. His research interests are in statistical mechanics, combinatorics and discrete geometry.

PIMS thanks outgoing SRP members **Hugh Williams** (U. Calgary) and **David Brydges** (UBC) for their contributions to the Scientific Review Panel.

PIMS Scientists Receive Honours

Pauline van den Driessche Receives the 2007 Krieger-Nelson Prize

The Canadian Mathematical Society (CMS) has awarded Pauline van den Driessche with the 2007 Krieger-Nelson Prize, which recognizes outstanding research by a female mathematician.

Dr. Pauline van den Driessche is one of Canada's leading applied mathematicians, known for her work in mathematical biology and linear algebra. Her major impact in mathematical biology has been the application of new mathematical methods to the study of dynamics of epidemics. The referees cite her work on epidemic models with variable population size, the role of immigration on disease dynamics, the possibility of multiple steady states, and reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission. The mathematical tools she has developed have been applied to multicity disease dynamics, HIV-AIDS control and, more recently, West Nile virus outbreak predictions.

Her work in linear algebra includes a famous paper with Jeffries and Klee in the Canadian Journal of Mathematics, in which they characterize sign-stable matrices, as well as a series of papers in factorization theory. Many of the deep questions in matrix theory she has worked on have arisen from problems in biological modelling.

Dr. van den Driessche has played a major leadership role in the Canadian applied mathematics community. She has served as a mentor to a growing number of young mathematicians. A look at her impressive list of about 150 publications reveals an unusually large number of collaborators, many of them students and junior colleagues. The referees for the 2007 Krieger-Nelson Prize commented on her "tremendous productivity and vision," and described her as an example and inspiration for new generations of mathematical researchers.

Dr. van den Driessche is a Professor in the University of Victoria's Department of Mathematics and Statistics, cross-appointed in the Department of Computer Science**.** She will present the 2007 Krieger-Nelson Prize Lecture at the CMS meeting at the University of Manitoba in June, 2007.

Nassif Ghoussoub Awarded 2007 Jeffery-Williams Prize

PIMS mathematician Nassif Ghoussoub is the recipient of the Canadian Mathematical Society's Jeffery-Williams Prize, which recognizes mathematicians who make outstanding contributions to mathematical research.

Dr. Ghoussoub is a leading expert in partial differential equations, variational problems, and geometric and nonlinear functional analysis. His service to the Canadian mathematical community is nothing short of extraordinary.

Among the highlights of his 100 papers is his resolution with Gui of De Giorgi's Conjecture, a long-standing open problem. This work is described as a "magnificent breakthrough," involving original ideas with other applications to the study of elliptic partial differential equations.

He was the founding director of the Pacific Institute for the Mathematical Sciences, co-founder of the MITACS network, and a founder and the current Scientific Director of the Banff International Research Station. He is a Professor and a Distinguished University Scholar at UBC, as well as an Adjunct Professor at the University of Alberta.

Dr. Ghoussoub will present the 2007 Jeffery-Williams Prize Lecture at the CMS summer meeting hosted at the University of Manitoba in June, 2007.

PIMS Notes

Simon Fraser University

Malgorzata Dubiel is the co-recipient of the PIMS Education Prize 2006, awarded in June at the PIMS Education Day.

University of Alberta

Nicole Tomczak-Jaegermann won the 2006 CRM-Fields-PIMS Prize.

University of British Columbia

Nassif Ghoussoub won the 2007 Jeffery-Williams Prize, given by the CMS.

Robert Miura is the co-recipient of the 2006 Leroy P. Steele Prize with C.S. Gardner, J.M. Greene, and M.D. Kruskal for the seminal paper Korteweg-de Vries equation and generalization. The Steele Prize is awarded by the American Mathematical Society.

Jozsef Solymosi has been awarded a 2006 Sloan Research Fellowship.

Vinayak Vatsal has won the 2006 Ribenhoim Prize, awarded by the Canadian Number Theory Association. Dr. Vatsal has also been invited as a speaker to the 2006 International Congress of Mathematicians (ICM) in Madrid.

Tai-Peng Tsai is the co-recipient of the 2005-2006 André-Aisenstadt Prize, along with Iosif Polterovich (University of Montreal).

Miguel Angel Moyers Gonzalez has been awarded the Canadian Applied and Industrial Mathematics Society (CAIMS) Cecil Graham Doctoral Dissertation Award for 2006 for his doctoral thesis, Transient Effects in Oilfield Cementing Flows.

University of Calgary

Bill Sands is the co-recipient of the PIMS Education Prize 2006, awarded in June at the PIMS Education Day.

University of Regina

Katherine Heinrich is the recipient of the 2005 Adrien Pouliot Award, awarded by the CMS. The award is given to those who have made significant and sustained contributions to mathematics education in Canada.

University of Victoria

Pauline van den Driessche has won the CMS 2007 Krieger-Nelson Prize. The Krieger-Nelson Prize recognizes outstanding research by a female mathematician.

David Leeming, Managing Editor of Pi in the Sky and recently retired Professor of Mathematics, received a University of Victoria Community Leadership Award in January, 2006. The award acknowledges exemplary leadership in linking UVic and the community for greater public benefit.

In a Special Convocation held in Taiwan on June 3, 2006, **Hari M. Srivastava** received an Honorary Doctor of Science degree by Chung Yuan Christian University. Chung Yuan Christian University has so far awarded only 15 honorary doctorate degrees.

CRM–Fields–PIMS Prize: Nicole Tomczak-Jaegermann

By Nassif Ghoussoub, Scientific Director of the Banff International Research Station, and Professor of Mathematics at the University of British Columbia

Nicole Tomczak-Jaegermann, of the University of Alberta, has been awarded the 2006 CRM–Fields–PIMS prize. According to the citation, *"She has made outstanding contributions to infinite dimensional Banach space theory, asymptotic geometric analysis, and the interaction between these two streams of modern functional analysis. She is one of the few mathematicians who have contributed important results to both areas. In particular, her work constitutes an essential ingredient in a solution by the 1998 Fields Medallist W. T. Gowers of the homogeneous space problem raised by Banach in 1932."*

Tomczak-Jaegermann received her Master's (1968) and Ph.D. (1974) degrees from Warsaw University, where she held a position until moving to the University of Alberta in 1983. There she holds a Canada Research Chair in Geometric Analysis. She is a Fellow of the Royal Society of Canada, lectured at the 1998 ICM, and has won the CMS's Krieger-Nelson Prize Lectureship. She has served the Canadian and international research community in many ways, including her current position on the BIRS Scientific Advisory Board and previously as a Site Director of PIMS in Alberta.

What is this area of mathematics which has produced two recent Fields medallists (J. Bourgain and T. Gowers) among many other modern prominent mathematical figures, and yet is still so misunderstood by even the most seasoned of mathematicians? The story starts with the 1932 book of Stefan Banach where he laid the foundation of—infinite dimensional—Banach space theory. It was to be a unifying framework for many problems arising in differential equations and applied fields, but the intellectual curiosity of the customers of the "Scottish cafe" in L'vov took over, and the quest for a "classification theory" for infinite dimensional Banach spaces started soon after. Most problems turned out to be deep and hard and way beyond the reach of the mathematicians of the 30s and 40s. All these questions have now been answered and many solutions had to wait till the end of the century. But while the questions look like mere mathematical curiosities, the techniques developed to answer them turned out to be rich and far reaching: from convex analysis to combinatorics, and from infinite dimensional Ramsey theory, to the refined asymptotics of finite dimensional convex bodies, via the theories of random matrices and of Gaussian processes.

Undoubtedly motivated by the structural rigidity of the classical Banach spaces (Hilbert space, L^p-spaces and spaces of continuous functions), S. Banach posed in his book, several intriguing problems about the structure of general infinite dimensional spaces. Are they isomorphic to their own hyperplanes? to their squares or to their cubes? But the most well-known of the lot were undoubtedly *the Schauder basis problem* and *the homogeneous space problem*. Among Nicole Tomczak-Jaegermann's numerous defining contributions to this field, I shall only describe her contributions to these two problems. I will also discuss briefly her more recent work on the *metric entropy*. I will unfortunately not be able to describe her other equally important contributions to *Banach-Mazur distances* between Banach spaces—in particular between the Schatten classes of operators, to her multiple results with H. Koenig [5] of the *best projection constants problem*, her introduction of the seminal concept of *complex convexity* in infinite dimensional complex spaces, her influential paper with A. Pajor [9] on an important strengthening of the so-called *Sudakov's minoration theorem* in the theory of Gaussian processes, as well as her most recent results with S. Szarek discovering the phenomenon of *finite-dimensional saturation* and solving a number of open problems from the early 1980s. For all that, I refer the interested reader to her encyclopedic 1989 monograph [10] and of course to her published work.

Before going into more specifics, it is worth emphasizing that the quest to solve these classical problems has led to a whole new field of study now known as *Asymptotic Geometric Analysis*. Initiated and developed by V. Milman and eventually by many others, this new area of research calls for a deeper understanding of infinite dimensional phenomena via the analysis of various functions of an arbitrarily large number of free variables, as well as certain geometric objects that are determined by an infinitely growing number of parameters. This in turn led to spectacular developments in the so-called *asymptotic theory of convex bodies*, which is roughly concerned with geometric and linear properties of finite-dimensional objects, and the asymptotics of their various quantitative parameters as the dimension tends to infinity.

Results developed in two opposite—yet equally striking—directions. The "optimistic" side was triggered by an early spectacular result of A. Dvoretsky: *every Banach space of sufficiently large dimension contains a subspace that is almost isometric to Hilbert space* (ℓ_2^k) of a given dimension k. In other words, one can find in any n-dimensional convex body a central section of dimension $\log(n)$ which is arbitrarily close to a Euclidean ball. This eventually led to a large number of surprising results, the spirit of which being that certain structures get better and better as the dimension grows to infinity. The fact that most of these results can be explained by the *concentration of measure phenomenon* started with the exceptional insight of V. Milman, who subsequently developed the concept further in collaboration with M. Gromov and others (e.g., see [7]) leading to equally remarkable results in geometry and combinatorics. This effort was taken up by M. Talagrand and others in the 90s with great results and striking applications to probability and information theory.

The *pessimistic side* was mostly triggered by Gluskin's result who used probabilistic methods to randomly select certain "pathological" projections of the n-dimensional octahedron (the unit ball in ℓ_1^n). These new objects were then superposed by extremely clever techniques for gluing finite dimensional spaces—initiated by J. Bourgain, S. Szarek, N. Tomczak-Jaegermann and many others—to construct exotic infinite dimensional counterexamples to several long standing problems, some of which are described below.

I. The Schauder basis problem: *Does every Banach space have a basis?*

This problem was of course solved negatively by P. Enflo in the 1970s when he constructed a Banach space without the *approximation property*, and therefore computations in such a space cannot be summarily reduced to manipulating finite dimensional objects, or finite rank operators. In the

1990s, Nicole Tomczak-Jaegermann and her collaborator P. Mankiewicz went way beyond that particular construction, as they developed an ingenuous method to build such counterexamples in a generic way starting from any non-Hilbertian space. They proved the following

Theorem 1 *(N. Tomczak-Jaegermann, P. Mankiewicz [6]) If X is a Banach space not isomorphic to Hilbert space, then $\ell_2(X)$ has necessarily a quotient space which itself contains a subspace with no Schauder basis.*

Recall that if $(X_n)_n$ is a sequence of Banach spaces, their ℓ_2-sum, $(\bigoplus X_n)_{\ell_2}$, is then the Banach space of all sequences of vectors $z = (z_n)$, with $z_n \in X_n$ for all n, such that $\|z\|_{\oplus X_n} = (\sum_n \|z_n\|^2_{X_n})^{1/2} < \infty$. If $X_n = X$ for all n, we then write $\ell_2(X)$ instead of $(\bigoplus X)_{\ell_2}$.

In other words, spaces without a Schauder basis can now be constructed in just three canonical operations starting from an *arbitrary* Banach space X not isomorphic to Hilbert space. Such spaces are of the form $Z = (\bigoplus Z_n)_{\ell_2}$, where Z_n are *finite-dimensional* quotients of subspaces of $\ell_2(X)$. It should be noted that this theorem is amazingly sharp, in the sense that starting with $\ell_2(X)$—as opposed to X itself— is necessary, since W. J. Johnson had constructed earlier a Banach space X not isomorphic to Hilbert space, all of whose quotients of subspaces do have a basis.

More remarkable are the techniques used for such a construction. They consist of building infinite-dimensional spaces by properly gluing finite-dimensional ones which are themselves obtained by probabilistic methods for selecting appropriate "random quotients". This line of study was initiated by Gluskin who considered random projections of the n-dimensional octahedron (the unit ball in ℓ_1^n) and proved that the diameter of the Banach-Mazur compactum of n-dimensional normed spaces is of order n. The first one to use finite-dimensional random quotients of ℓ_1^n in an infinite-dimensional construction is J. Bourgain who used it to construct a real Banach space that admits two non-isomorphic complex structures.

II. Banach's homogeneous space problem: *Is Hilbert space the only homogeneous Banach space? i.e., is it the only one that can be isomorphic to all of its infinite dimensional subspaces*[1] *?*

Now we know that the answer to this question of Banach is affirmative, thanks to independent and remarkably complementary contributions by T. Gowers on one hand, and by N. Tomczak-Jaegerman and her student R. Komorowski on the other. The first obvious difficulty in attacking the homogeneous space problem is the lack of information on the uniform boundedness of norms of the isomorphisms. Even up to this day no direct proof is known of the fact that X being homogeneous, must imply that X is *uniformly* isomorphic to all of its infinite-dimensional subspaces, as is the case for Hilbert space which X is supposed to be after all. However, the breakthrough came when N. Tomczak-Jaegerman and R. Komorowski proved that much can be said if the space has an *unconditional basis*: that is a basis $\{z_i\}$ such that for some $C > 0$ we have for any scalars $\{a_i\}$, and any choice of signs, $\{\varepsilon_i\}$, that $\|\sum_i \varepsilon_i a_i z_i\| \le C\|\sum_i a_i z_i\|$.

Theorem 2 *(N. Tomczak-Jaegermann & R. Komorowski [4]) Let X be a Banach space with an unconditional basis, then either X contains a Hilbertian subspace or otherwise it must contain a subspace without an unconditional basis.*

An immediate corollary is the following curious conditional result: If X is a homogeneous Banach space not isomorphic to a Hilbert space, then X cannot have an infinite-dimensional subspace with an unconditional basis. This curiously made a connection with another famous question coming from the 1950s:

Does every infinite-dimensional Banach space has an infinite-dimensional subspace with an unconditional basis?

This question had however received—around the same time—a negative answer by T. Gowers and B. Maurey, via a breakthrough construction that opened a whole new understanding of infinite-dimensional phenomena. This new understanding very fast led to negative solutions for several other problems open for decades, such as *the hyperplane problem* of Banach mentioned above, *the distortion problem* solved by E. Odell and Th. Schlumprecht in [8], as well as many other longstanding open problems. Actually, the Gowers-Maurey space X_0 has a stronger property: no subspace of X_0 is a topological direct sum of two infinite-dimensional Banach spaces. Equivalently, given any two infinite-dimensional subspaces Z and W of X_0, we necessarily have

$$\inf\{\|z - w\|; z \in Z, w \in W, \|z\| = \|w\| = 1\} = 0.$$

That is, the unit spheres of any two infinite dimensional subspaces almost intersect. Such a space X_0 is called *hereditarily indecomposable* (an H.I. space). Moreover, they proved the following.

Theorem 3 *(Gowers-Maurey [3]) A hereditarily indecomposable Banach space is not isomorphic to any proper subspace of itself.*

In other words, these spaces are essentially the counterpart of homogeneous spaces. Note also that an H.I. space cannot have an infinite-dimensional subspace with an unconditional basis, since otherwise, such a subspace would be a direct sum of the span of the even elements of the basis and the span of the odd elements. However, the opposite implication is clearly false since there exist spaces which can be decomposed but still have no subspace with an unconditional basis. Many interesting examples of spaces having these and related properties were eventually constructed by Gowers-Maurey, Odell-Schlumprecht, and Argyros and his co-authors, but the precise connection between subspaces with unconditional basis and H.I. subspaces was finally clarified by the spectacular structural dichotomy proved by Gowers in 1993. In particular, it provided the last missing piece in the solution of the homogeneous space problem.

Theorem 4 *(T. Gowers [2]) Every infinite-dimensional Banach space either has an infinite dimensional subspace with an unconditional basis or has a hereditarily indecomposable subspace.*

The theorem is actually a consequence of a general combinatorial result, which is, in a sense, a vector space analogue of infinite versions of Ramsey theorem.

Once all these results were proved, the solution to the homogeneous space problem is now simple. By the theorem of Tomczak-Jaegermann

[1] Here and throughout, all subspaces are assumed to be closed

and R. Komorowsky (Theorem 2), a homogeneous space X not isomorphic to Hilbert space cannot have an infinite-dimensional subspace with an unconditional basis. By Gowers dichotomy theorem, it must contain an H.I. subspace, and hence X itself must be H.I. since it is homogeneous. But then, Theorem 3 of Gowers-Maurey says that it cannot then be isomorphic to any proper subspace of itself, which means that X is not homogeneous after all.

III. The finite-dimensional isomorphic version of the homogeneous space problem

It is well known that all finite dimensional Banach spaces of the same dimension (say n) are isomorphic to Euclidean space ℓ_2^n. However, the isomorphism constants can vary wildly, and so one can ask the following finite-dimensional version of the homogeneous space problem:

For $0 < \alpha < 1$ and $K \geq 1$ does there exist $f(\alpha, K) > 0$ such that an n-dimensional space X is necessarily $f(\alpha, K)$-isomorphic to Euclidean space ℓ_2^n, whenever all of its $[\alpha n]$-dimensional subspaces are K-isomorphic?

This question is an isomorphic finite-dimensional version of two questions from Banach's book. The first one regards an n-dimensional symmetric convex body all of whose k-dimensional sections are affinely equivalent which was almost completely solved by Gromov in his doctoral thesis ($K = 1$ in the above question). The second one was the homogeneous space problem discussed above.

A positive answer to the above question was proved for sufficiently small α in 1987 by J. Bourgain. In 1989, N. Tomczak-Jaegermann and P. Mankiewicz managed to prove the result for all α, with a "reasonable" function $f(\alpha, K)$. Actually, $f(\alpha, K) \leq cK^{3/2}$ for $0 < \alpha < 2/3$, and cK^2, for $2/3 \leq \alpha < 1$, where c is a constant only depending on α. Both solutions rely again on the study of random quotients of normed spaces already mentioned above. We note that even though the method for constructing specific convex bodies from random projections of polytops, were initiated by Gluskin in 1981, the consideration of random quotients in a general form started with the above results of J. Bourgain and P. Mankiewicz-N. Tomczak-Jaegermann, and its study was eventually developed jointly by the last two authors in a series of papers over the years.

IV. The metric entropy problem

If K and B are two subsets of a vector space (or just a group, or even a homogeneous space), the *covering number* of K by B, denoted $N(K, B)$, is the minimal number of translates of B needed to cover K. Similarly, the *packing* number $M(K, B)$ is the maximal number of disjoint translates of B by elements of K. The two concepts are closely related and we have

$$N(K, B - B) \leq M(K, B) \leq N(K, (B - B)/2).$$

If now B is the unit ball of a normed space and K a subset of that space (the setting and the point of view functional analysts usually employ), these notions reduce to considerations involving the smallest ϵ-nets or the largest ϵ-separated subsets of K.

Besides the obvious geometric framework, packing and covering numbers appear naturally in several fields of mathematics, ranging from classical and functional analysis, through probability theory and operator theory to computer science and information theory (where a code is typically a packing, while covering numbers quantify the complexity of a set). As with other notions related to convexity, an important role is often played by considerations involving duality.

In an operator-theoretic context, one considers the so-called *entropy numbers of an operator* $u : X \to Y$ where X and Y are Banach spaces. They are defined as

$$e_n(u) = \inf\{\varepsilon; \text{ such that } N(uB_X, \varepsilon B_Y) \leq 2^{n-1}\}.$$

These numbers are used to quantify compactness properties of the operator and one can easily see that u is a compact operator if and only if $\lim_n e_n(u) = 0$. Now a classical theorem of Schauder states that u is a *compact operator* if and only if its adjoint u^* is compact, which readily means that the limiting behaviours of the sequences $e_n(u)$ and $e_n(u^*)$ are similar. In 1972, Pietsch asked several specific questions regarding *entropy numbers* and *duality*. Roughly speaking, do these dual entropy numbers always obey similar asymptotic behaviours? For example, is it true that $\{e_n(u)\}$ belongs to the space ℓ_p (for some $1 \leq p < \infty$) if and only if $\{e_n(u^*)\}$ does? The strongest version of Pietsch's conjectures can also be formulated in the language of covering numbers in the following way:

There exist numerical constants $a, b \geq 1$ such that for any dimension n and for any two centrally symmetric convex bodies K, B in $\mathbb{R}^n$ one has

$$b^{-1} \log_2 N(B^\circ, aK^\circ) \leq \log_2 N(K, B) \leq b \log_2 N(B^\circ, a^{-1}K^\circ)?$$

Here $A^\circ := \{u \in \mathbb{R}^n : \sup_{x \in A} \langle x, u \rangle \leq 1\}$ denotes the polar body of A.

This conjecture is still open in its full generality. However, the question about the "global" behaviour of entropy numbers was settled positively in 1987 by N. Tomczak-Jaegermann in the special but central case, when either the domain or target space is a Hilbert space, and more generally by J. Bourgain, A. Pajor, S. Szarek and N. Tomczak-Jaegermann in 1989, in the much more general situation where one of the spaces is of type p, for some $p > 1$. Such spaces also comprise all ℓ_p and L_p-spaces (whether classical or non-commutative) for $1 < p < \infty$, as well as all uniformly convex and all uniformly smooth spaces. In this case, the constants a, b depend only on p and they are uniformly bounded if p stays away from 1 and ∞. More recently, the strongest version of Pietsch's conjecture stated above, was established by Artstein, Milman and Szarek in 2003, again in the case when one of the spaces is a Hilbert space (equivalently, when the convex body is an ellipsoid). N. Tomczak-Jaegermann joined effort with them in 2004 (see [1]) to establish the conjecture when one of the spaces is of type $p > 1$, and to develop the theory still further.

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Call for Nominations: 2007 CRM–Fields–PIMS Prize

The Centre de recherches mathématiques (CRM), the Fields Institute for Research in Mathematical Sciences, and the Pacific Institute for the Mathematical Sciences (PIMS) invite nominations for the joint CRM-Fields-PIMS Prize, in recognition of exceptional research achievement in the mathematical sciences. The candidate's research should have been conducted primarily in Canada or in affiliation with a Canadian university. The prize was established as the CRM-Fields prize in 1994. Renamed in 2005, the 2006 and later prizes will be awarded jointly by all three institutes. Previous recipients are H.S.M. Coxeter, George A. Elliott, James Arthur, Robert Moody, Stephen A. Cook, Israel Michael Sigal, William T. Tutte, John Friedlander, John McKay, Edwin Perkins, Donald Dawson, David Boyd and Nicole Tomczak-Jaegermann. The selection committee struck by the three institutes will select a recipient for the 2007 prize on the basis of outstanding contributions to the advancement of the mathematical sciences, with excellence in research as the main selection criterion. A monetary prize will be awarded and the recipient will be asked to present a lecture at each of CRM, the Fields Institute, and PIMS. Nominations should be submitted by Nov. 1, 2006, by at least three sponsors of recognized stature, and should include the following elements: three supporting letters, curriculum vitae, list of publications, and up to four preprints.

Submit nominations to:
Alejandro Adem
adem@pims.math.ca
Deputy Director, PIMS Central Office
Room 200, 1933 West Mall
University of British Columbia
Vancouver, BC V6T 1Z2
Canada

CENTRE DE RECHERCHES MATHÉMATIQUES

FIELDS

PIMS

Motives and Periods University of British Columbia, June 5-12, 2006

by Jim Carrell

The Motives and Periods conference at UBC on June 5-12, 2006, covered recent developments in the study of motives and periods, with an emphasis on this area of study's connections to physics, arithmetic and algebraic cycles. The conference had an instructional component, which consisted of a series of survey talks by Henri Gillet (University of Illinois, Chicago) on *Arithmetical Weight Complexes*, Madhav Nori (University of Chicago) on *Hyperplane Arrangements and Mixed Tate Motives*, Marc Levine (Northeastern University) on *An Introduction to Algebraic Cobordism*, and Dirk Kreimer (IHES, Paris) on *What a Physicist should tell a Mathematician about Quantum Field Theory*. Each speaker gave three talks.

One of the goals of this conference was to provide an opportunity for young speakers to present their results. Another goal was to bring together leading mathematicians who approach the subject of motives and periods from different angles, with the intent of stimulating future collaborations. It is fair to say that the objectives of this conference were met, and it proved to be an enormous success. Indeed, there was a great deal of "electric" interaction between lecturers and the audience. Subsequently, collaborations among researchers went on throughout the evenings.

A series of one-hour talks on the latest developments of the subject were delivered by: Salman Abdulali (East Carolina University), Matt Kerr (University of Chicago), Gregory Pearlstein (Duke University), Zhaohu Nie (Texas A & M), Mona Mocanasu (Northwestern), Amir Jafari (Duke University), Hidekazu Furusho (Nagoya University), Claudio Pedrini (University of Genoa), Jacob Murre (Leiden University), Donu Arapura (Purdue University), Herbert Gangl (University of Durham), Mark Walker (University of Nebraska, Lincoln), Ramesh Sreekantan (Tata Institute of Fundamental Research), Tomohide Terasoma (University of Tokyo), Francis Brown (Bordeaux University), Nero Budur (Johns Hopkins University), Mikhail Kalmykov (Baylor University), Li Guo (Rutgers University) and Morihiko Saito (Kyoto).

Roughly 70 participants attended the conference. The beautiful backdrop of Vancouver and the unexpectedly pleasant weather added to the upbeat mood of this conference. A Sunday afternoon was set aside for participants to explore Vancouver.

The conference was organized by James D. Lewis (U. Alberta), Stefan Müller-Stach (Universität Mainz), Andreas Rosenschon (University at Buffalo), Pramath Sastry (University of Toronto) and Jim Carrell (UBC).

Canadian Number Theory Association IX Meeting

University of British Columbia, July 9-14, 2006

The **Canadian Number Theory Association** (CNTA) held its ninth meeting on July 9-14, 2006, at the University of British Columbia. Speakers spanned the spectrum of number theory research, with over 200 people registered for the conference. Of the participants, 156 came to the conference from outside of Canada.

Number theory is a rapidly developing area of mathematics in Canada, with a large and active research community. The CNTA holds one of the two large number theory conferences in the world, with the other, Journées Arithmetique, held in Europe. The CNTA meetings and Journées Arithmetique meetings are held on alternating years.

The six-day conference featured 12 plenary speakers, with lectures covering the breadth of number theory research: Frits Beukers (Utrecht), Henri Cohen (Bordeaux), Brian Conrad (Michigan), John Friedlander (Toronto), Jeffrey Lagarias (Michigan), Carl Pomerance (Dartmouth), Bjorn Poonen (Berkeley), Karl Rubin (UC, Irvine), Chris Skinner (Michigan), K. Soundararajan (Michigan), William Stein (UCSD), and Michel Waldschmidt (Jussieu).

The conference featured a number of sessions on number theory: *Algebraic Number Theory*, organized by Vinayak Vatsal (UBC); *Analytic Number Theory*, organized by Greg Martin (UBC); *Arithmetic Algebraic Geometry*, organized by Imin Chen (SFU); *Computational Number Theory*, organized by Nils Bruin (SFU); and *Diophantine Analysis and Approximation*, organized by Michael Bennett (UBC).

The CNTA was founded in 1987 at the International Number Theory Conference at Laval University. The purpose of the CNTA is to enhance and promote learning and research in number theory, particularly in Canada. To advance these goals, the CNTA organizes major international conferences with the aim of exposing Canadian students and researchers to the latest developments in number theory.

Previous meetings have been held in Banff (1988), Vancouver (1989), Kingston (1991), Halifax (1994), Ottawa (1996), Winnipeg (1999), Montreal (2002) and Toronto (2004). These conferences have wide participation from the international number theory community.

The conference was sponsored by PIMS, UBC and SFU, as well as the Number Theory Foundation. For more information on the conference, please see h**ttp://www.pims.math.ca/science/2006/06cnta/**.

Public Lecture: Some Arithmetic Problems Raised By Rabbits, Cows and the Da Vinci Code, by Michel Waldschmidt

On July 12, 2006, in association with the CNTA IX meeting, Professor Michel Waldschmidt of the Institut de Mathématiques de Jussieu at Chevaleret gave a public lecture at SFU's Harbour Centre, on number sequences developed by Italian mathematician Fibonacci and Indian mathematician Narayana, before delving into mathematical sequences that have appeared recently in popular culture offerings such as the Da Vinci Code and musical arrangements. According to Dr. Waldschmidt, sequences of integers, related to Fibonacci's rabbits and Narayana's cows, as well as other similar sequences, raise a number of interesting arithmetic problems, some of which have been solved recently, while others are still open.

Michel Waldschmidt

The lecture was attended by many participants of the CNTA conference, as well as numerous math enthusiasts.

Ribenboim Prize 2006 Awarded to Vinayak Vatsal

UBC's **Vinayak Vatsal** is the 2006 recipient of the Ribenboim Prize. Dr. Vatsal delivered a plenary lecture on Friday, July 11, 2006, the final day of the Canadian Number Theory Association IX meeting at UBC. Dr. Vatsal's talk, on *Special Values of L-Functions Modulo P*, was a survey on results on non-vanishing of p-adic families of twists of L-functions modulo a prime. The goal of the talk was to emphasize that all the known results in this area seem to rely on rather surprising rigidity results for one kind or another. All of these results are analogous to an old and elementary theorem of Kronecker, on the closure of a 1 parameter group orbit in a torus. Basically, the key principle states that the closure of certain group orbits is again the orbit of a group.

Dr. Vatsal was presented with the 2006 Ribenboim Prize by 1999 winner Andrew Granville (University of Montreal) and 2004 winner Michael Bennett (UBC).

*About the **Ribenboim Prize***

The Canadian Number Theory Association (CNTA) established a prize for distinguished research in number theory to be awarded to a mathematician who is Canadian or has connections to Canadian mathematics. The prize, named for mathematician Paulo Ribenboim, is normally awarded every four years in conjunction with a CNTA meeting, and is the only award for Number Theory in Canada.

(l to r) Michael Bennett, Vinayak Vatsal, Andrew Granville

PIMS Notes

Frank den Hollander: PIMS Distinguished Chair

Frank den Hollander visited PIMS from January through August, 2006, as the PIMS Distinguished Chair with the PIMS Collaborative Research Group on Probability and Statistical Mechanics (2004-2006). Below is a personal account of his visit.

It is wonderful to come to PIMS for an extended sabbatical. After having been the scientific director of EURANDOM for five years (until Oct. 1, 2005), I needed a break. PIMS is the perfect place to be: an intensive mathematical programme in an otherwise quiet environment, with a support staff going out of their way to make life comfortable, a top mathematics department around the corner with colleagues to talk to and to work with, excellent students and a beautiful campus in a great city. What more do you need?

Let me first tell you about EURANDOM, which has much in common with PIMS. EURANDOM is a European research institute for the stochastic sciences, located in Eindhoven in the Netherlands. It opened its doors in September, 1998, and currently hosts 25 postdocs and graduate students working in probability theory, statistics and stochastic operations research. EURANDOM has two main financiers: the Netherlands Organization for Scientific Research (NWO) and Eindhoven University of Technology (TU/e). Together they provide approximately 60 per cent of the budget. Other funding sources are various European science foundations (through bilateral agreements), European Union funds, European Science Foundation networks and industrial contracts.

Research at EURANDOM is currently organized into three parallel programmes:

Random Spatial Structures:
- Critical Phenomena
- Disordered Systems
- Combinatorial Probability

Queuing and Performance Analysis:
- Performance Analysis of Production Systems
- Performance Analysis of Communication Systems
- Queuing Theory
- Multivariate Risk Modelling

Statistical Information and Modelling:
- Statistical Signal and Image Analysis
- Statistics in Biology
- Statistics in Industry

Frank den Hollander, PIMS Distinguished Chair

Through these themes, special attention is given to the interfaces with physics, biology, telecommunication and industry. Each programme hosts six to eight postdocs and graduate students, and is supervised by two to four senior scientific advisers (coming to EURANDOM one day a week), organizes two to three workshops a year, and runs a visitor programme. Strategic decisions about the scientific course of EURANDOM are taken by the scientific council, which is currently chaired by Don Dawson (Ottawa).

Since the start, some 80 postdocs and graduate students have been working at EURANDOM. About 80 per cent of them leave EURANDOM for tenured positions in academia or industry, which is testimony to the healthy state of stochastics and the facilitating role EURANDOM has to offer.

Last year, an important event at EURANDOM was the evaluation of the institute by an international review panel, requested and organized by NWO. EURANDOM came out of this evaluation with excellent scores. In its report, the panel stated, "In the seven years of its existence, EURANDOM has become a pre-eminent centre for the study of stochastics, playing a key role in the development of the discipline both locally within the Netherlands and globally within Europe and beyond."

Most of the above observations apply equally well to PIMS. As institutes, we have much in common, our main goals being to facilitate national and international collaboration, to help talented young researchers find their way to academia and industry, and to stimulate cross-border scientific exchange. These are important challenges, requiring constant care. But the rewards are high.

During my stay at PIMS, four postdocs from EURANDOM came over to work with me, each for one month: Gregory Maillard, Reda Messikh, Nicolas Petrelis and Rongfeng Sun. PIMS generously offered them hospitality and support. They had a very fruitful time, taking part in the various activities at PIMS and at the UBC Mathematics Department, presenting talks about their work, and interacting with the staff and the visitors. They take home a unique experience and a key message: international research has open boundaries and is fun.

In the past there have been intensive exchanges between Canada and the Netherlands. Gordon Slade has been a regular visitor for 10 years, working closely with Remco van der Hofstad (Eindhoven) and myself on the lace expansion approach to critical phenomena. Many return visits were paid to UBC. Gordon came to EURANDOM in the fall of 2003 as Thomas Stieltjes Institute Chair. Akira Sakai, who was a postdoc with Gordon, spent three years at EURANDOM. He recently moved to Bath in the United Kingdom. This month he is back at UBC, giving a mini-course on the lace expansion for the Ising model. Mark Holmes, who was a graduate student with Gordon, is currently at EURANDOM. David Brydges has accepted the invitation to be the 2008 EURANDOM chair, to which we are looking forward in anticipation.

My further activities at PIMS include teaching a graduate course on "Large Deviations"; working with Omer Angel, Jesse Goodman and Gordon Slade on invasion percolation; and working with Ed Perkins on interacting diffusions. The latter project involves Richard Bass (Connecticut), who was the PIMS Distinguished Chair 2004/2005, as well as Don Dawson, Andreas Greven (Erlangen, Germany), Jan Swart (Prague, Czech Republic) and Rongfeng Sun.

Apart from two short visits to Princeton and Microsoft, I decided not to travel this year. Hey, I don't need to!

PIMS Collaborative Research Groups

The Economics and Finance of Climate Risk and Natural Resources

Overview

There is significant research activity in mathematical economics in Western Canada; however, this research has no supporting network. The goal of the Economics and Finance of Climate Risk and Natural Resources CRG is to promote interdisciplinary co-operations among Canadian experts in mathematics, finance, economics and econometrics, and to establish an internationally visible network of academic excellence in mathematical economics. To this end, the aim of this CRG is to organize a two-year concentration period on the Economics and Finance of Climate Risk and Natural Resources starting September, 2006.

This includes a variety of training and research opportunitues:

· Hedging and Insurance of Climate and Energy Risk.
· Mathematics of Economic Geography and Resource Management.
· Contract Theory.
· Numerical Methods for Partial Differential Equations.

Scientific Activities:

· Summer School on Frontiers in Mathematics and Economics, July 10-28, 2006, at the University of British Columbia
· Summer School on Mathematical Modelling of Climate and Energy Risk, April 29 to May 13, 2007, at BIRS
· Rock Mechanics and Planning in Mining Workshop, Feb. 26 to March 2, 2007, Chile

CRG Leaders: Arthur Robson (SFU), Abel Cadenillas (U. Alberta), Ulrich Horst (UBC), Tony Ware (U. Calgary), Cornelius van Kooten (UVica), Alejandro Jofré (Universidad de Chile).

Mathematical Modelling and Computation in Biology

Overview

The primary focus of the Mathematical Modelling and Computation in Biology CRG is mathematical modelling driven by biological applications. The goal is to promote research and cooperation both within specific research areas and across different areas of application. This CRG proposes three themes, focuses on the interests of team members as well as emerging opportunities for research at the mathematics-biology interface:

· Infectious Diseases.
· Cellular Mechanics and Dynamics.
· Fundamental Applied Mathematics in Biology.

In keeping with the interdisciplinary nature of the rapidly developing field of Mathematical Biology and the specific areas listed above, this CRG provides avenues for interaction between theoretical, clinical and experimental researchers, something not always feasible in the context of large discipline-focused national and international society meetings. In addition, and arguably fundamentally important to the continuation of this valuable trend of cross-fertilization, it will give young mathematicians (undergraduate and graduate students, postdoctoral fellows) an opportunity to interact with theoreticians involved in experimental collaborations as well as with experimentalists themselves. This kind of interaction is a crucial step in interdisciplinary career development, one that is rarely available to students due to the departmentally focused nature of most educational and training programs.

Scientific Activities:

· Bridging the Scales of Disease Dynamics Workshop on Infectious Disease: Sept. 28-29, 2006
· Frontiers in Biophysics: Modelling and Experiment: Oct. 13-15, 2006: A cross-institute retreat including members of the UBC Math Biology group, the UBC Biophysics group and the SFU Biophysics group among others at PIMS institutes.

CRG Leaders: Eric Cytrynbaum (UBC), Daniel Coombs (UBC), Rachel Kuske (UBC), Pauline van den Driessche (UVic), Eirikur Palsson (SFU), Ed Munro (UW).

Postdoctoral Fellow: Peter Borowski

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Geometric and Harmonic Analysis

Overview

Geometric functional analysis is concerned with geometric and linear properties and structure of finite- and infinite-dimensional Banach spaces and their unit balls. Abstract harmonic analysis relates to the studies of Banach algebras of spaces of measures or functions associated to (unitary representations of) a locally compact group involving powerful tools from group representations, geometry of Banach space, operator algebras and operator space theory. Modern abstract harmonic analysis has broad impact to related fields such as operator space theory, Banach space theory, operator algebras, Banach algebras, geometric group theory, non-commutative geometry and locally compact quantum groups.

Commercial applications include the development of cell phone technology, and seismic processing tools used in oil and gas exploration. Ongoing research includes developing links between geometric ray theory in wave propagation and the more recent wave field and path integral methods of time-frequency analysis. Discrete geometry investigates combinatorial and analytic properties of configurations of geometric objects. It offers sophisticated results and techniques of great diversity, and it is a foundation for fields such as computational geometry or combinatorial optimization and also it includes some classical areas such as (analytic) convexity and geometry of numbers.

Scientific Activities:

- Distinguished Chair Lecture: Thomas Hales (University of Pittsburgh), fall 2006 at the University of Calgary.
- Distinguished Chair: Apostolos Giannopoulos (University of Athens), Nov. 12-19, 2006, lectures on *Isotropic Convex Bodies and the Slicing Problem* and *Asymmetrical Geometry of Random 0-1 Polytopes* at the University of Calgary.
- Distinguished Chair: Henry Cohn (Microsoft Research), fall 2006 at the University of Calgary.
- Lectures: Hermann Koenig (Kiel University), Sept. 4-29, 2006, at the University of Alberta.
- Lectures: Eberhard Kaniuth (Institut für Mathematik der Universität Paderborn), March, 2007, at the University of Alberta.
- Operator Spaces and Groups Algebras Workshop, Aug. 19-24, 2007, BIRS.

CRG Leaders: Karoly Bezdek (U. Calgary), Michael Lamouroux (U. Calgary), Anthony To-Ming Lau (U. Alberta), Nicole Tomczak-Jaegermann (U. Alberta)

Postdoctoral Fellow: Hung Le Pham

CRG Call for Proposals

PIMS invites interested researchers to submit letters of intent for periods of concentration of a collaborative research group to start in or after **April 1, 2007**. Letters of intent should be between two and four pages. On advice of the PIMS Scientific Review Panel, the PIMS Director will invite successful groups to submit a full proposal for a period of concentration. Full proposals are usually developed in consultation with the PIMS Deputy Director and PIMS Site Directors.

All letters of intent and proposals should contain each of the four sections in the outline below. Give affiliations of all persons cited. Item 4 should be at most 100 words and may appear in public announcements.

1. Name of Collaborative Research Group.
2. Names, affiliations and CV/biosketch of CRG Leaders (at least two different PIMS sites should be represented).
3. List of proposed events/modules.
4. Summary of scientific and other objectives.

For more details, see: http://www.pims.math.ca/Scientific_Programme/Call_for_Proposals/

PIMS Notes

Upcoming PIMS Activities

Bridging the Scales of Disease Dynamics

University of British Columbia, Sept. 27-29, 2006

The ongoing HIV pandemic, the brief SARS epidemic of 2003 and recurrent fears of a serious influenza outbreak have raised public consciousness of issues surrounding the behaviour and evolution of infectious diseases as they spread through a population. Theoretical/mathematical analysis of infectious disease has become organized around two key scales: First, understanding epidemics across populations of individual hosts, and second, understanding the disease progression within one such host. At the larger scale, models are informed by epidemiological data and sociological notions of host population structure and the frequency of infectious contacts between such hosts. At the scale of a single host, models often rely on experimental data obtained from patients, and from in vitro and in vivo laboratory experiments.

This workshop will provide a forum for presentation of leading-edge research focused on disease dynamics at both population and host scales as well as from scientists working to understand the interaction of the scales on the behaviour and evolution of infectious disease. Applications to clinically important diseases will be stressed. The overall goal of the workshop is to bring a broader perspective to understanding the behaviour and evolution of infectious diseases by facilitating interactions between scientists working at these multiple scales of inquiry.

This event is sponsored by PIMS and is part of the activities of the PIMS CRG on Mathematical Modelling and Computation in Biology.

Details are available at **http://www.pims.math.ca/science/2006/06disdyn/**

Analysis of Ecological Systems Under Uncertainty, Change And Adaptation: Confronting Models With Data

University of Calgary, Kananaskis Field Stations, Oct. 1-7, 2006

The Graduate Short Course on the analysis of ecological systems under uncertainty, change and adaptation is designed for students who are involved in this research area. The students will be introduced to theories and techniques for modelling and analyzing ecological systems as well as statistical methods for testing models and hypotheses against data.

The instructors are experts who will introduce students to the most recent developments in the field.

Details are available at **http://www.ucalgary.ca/~mccauley/course/**

Frontiers in Biophysics: Modelling and Experiment

Loon Lake, B.C., Oct. 13-15, 2006

Frontiers in Biophysics: Modelling and Experiment is a weekend retreat that is being organized by graduate students and faculty in biophysics and mathematical biology at Simon Fraser University and the University of British Columbia.This event is meant to unite biophysics and modelling in molecular and cell biology research communities in the Vancouver area. Connections between researchers at our respective institutions will be created or strengthened, especially for those who are interested in modelling problems in cellular and molecular biology, single molecule studies, networks of interacting biomolecules, and whole cell approaches to biophysics. The retreat will also broaden horizons and inspire new graduate students by immersing them in a dynamic and active research environment, and exposing them to research avenues of which they may not have been aware. The retreat will offer students (graduate and undergraduate) an opportunity to present their research in a relaxed but focused environment, meet and converse with keynote speakers of international renown, and the chance to strengthen research ties within the local biophysics community.

Frontiers in Biophysics: Modelling and Experiment is sponsored by PIMS, the SFU Department of Physics, and the Pacific Institute of Theoretical Physics (PITP). It is part of the activities of the PIMS CRG on Mathematical Modelling and Computation in Biology.

Details are available at **http://www.sfu.ca/biophysics/frontiers/**

Saskatchewan Mathematics Challenge

University of Regina, March, 2007

The Saskatchewan Mathematics Challenge is an annual one-day mathematics competition open to all students in grades 8-10 within Saskatchewan. The competition consists of one individual round and two team rounds.

The challenge is a provincially developed mathematics competition that draws high school students from across Saskatchewan. The challenge aims to reinforce the students' appetite for mathematics, and the nurturing and encouragement of the mathematical talents of all students. PIMS is co-sponsoring this event.

Did you know?

PIMS supports a broad range of graduate summer schools and workshops, designed to demonstrate mathematics in applied and industrial problems, and to develop graduate students' skills in specific areas of research. These summer schools and workshops provide opportunities for students to connect with their contemporaries, opening the door for future collaborations, as well as giving them the chance to meet and work with top researchers.

Upcoming PIMS Activities

Applied Inverse Problems 2007

UBC, June 25-29, 2007

The enormous increase in computing power and the development of powerful algorithms has made it possible to apply the iechniqpues of inverse problems to real-world problems of growing complexity. Applications include a number of medical as well as other imaging techniques, location of oil and mineral deposits in the Earth's substructure, creation of astrophysical images from telescope data, finding cracks and interfaces within materials, shape optimization, model identification in growth processes and, more recently, modelling in the life sciences.

The series of AIP Conferences aim to provide a primary international forum for academic and industrial researchers working on all aspects of inverse problems, such as mathematical modelling, functional analytic methods, computational approaches and numerical algorithms.

The success of the first conference in Montecatini in 2001 with more than 150 participants and several parallel sessions led to the proposal to have this conference every two years, alternating between North or South America and Europe or a site outside the Western hemisphere. A second equally successful conference was held in Lake Arrowhead, Calif., in 2003, and a third was held in Cirencester in the U.K. Cotswold region from June 26-30, 2005.

Each AIP conference will follow the pattern of a number of invited talks from international experts and a set of minisymposia on topical themes. The venues have been chosen to encourage the maximum interaction between all participants. The Vancouver conference will have in excess of 150 participants.

The main organizers are **Gary Margrave** (U. Calgary), **Richard Froese** (UBC) and **Gunther Uhlmann** (U. Washington).

The local organizing committee is **Uri Ascher**, **Michael Bostock**, **Anna Celler**, **Joel Feldman** and **Felix Herrmann**.

The steering committee consists of **Mario Bertero** (U. Genova, Italy), **Michael Lamoureux** (U. Calgary), **Joyce McLaughlin** (RPI), **Adrian Nachman** (U. Toronto), **William Rundell** (NSF and Texas A&M), **Erkki Somersalo** (Helsinki Institute of Technology) and **Michael Vogelius** (Rutgers).

This conference is an activity of the PIMS CRG on Inverse Problems.

For details on previous workshops and more information, see the webpage: **http://aip.disi.unige.it**.

AMS Western Section Meeting

UBC, Oct. 4-5, 2008

PIMS and the Mathematics Department at UBC will be co-hosting the American Mathematical Society (AMS) Western Section Meeting in 2008.

It will be the first meeting of the Western Section ever held in Canada (at least over the last 30 years, which is as far as the AMS staff could verify).

This event will include a highly prestigious Einstein Lecture, a mathematical talk for the general public.

Michel Lapidus is the Western Section Secretary for the AMS.

For more information see **http://www.ams.org/amsmtgs/sectional.html**.

International Congress on Industrial and Applied Mathematics

Vancouver, July 18-21, 2011

The **International Congress on Industrial and Applied Mathematics (ICIAM)** will be held in Vancouver in 2011. This is a major event, attracting over 3,000 researchers from all over the world. The bid was presented by MITACS and CAIMS with strong support from the local PIMS community.

PIMS/Shell Lunchbox Lectures, Calgary

Sept. 21, 2006

Stuart Kauffman (Santa Fe Institute): *Title to be announced*

Oct. 19, 2006

Shawn Marshall (University of Calgary): *Title to be announced*

Nov. 16, 2006

Geoffrey Hay (University of Calgary): *Title to be announced*

Dec. 5, 2006

Len Bruton (University of Calgary): *Some Applications of Mathematics in Multidimensional Signal Processing.*

IAM-PIMS-MITACS Distinguished Colloquium Series, UBC

Sept. 6, 2006

Alexander Mogilner (University of California, Davis): *System Level Mathematical Analysis of Mitosis.*

Sept. 13, 2006

William Kath (Northwestern University): *Models of Initiation and Propagation of Dendritic Spikes in Hippocampal CA1 Pyramidal Neurons.*

Nov. 6, 2006

Peter A. Forsyth (University of Waterloo): *Hedging Under Jump Diffusion with Transaction Costs.*

Feb. 12, 2007

James Rice (Harvard University): *Episodic Slow Slipping of Seafloor Under Cascadia: What Physical Processes Cause Aseismic Deformation Transients?*

March 19, 2007

Paul Bressloff (University of Utah): *Mathematical Models of Protein Receptor Trafficking and Its Role in Synaptic Plasticity.*

PIMS Notes

PIMS Postdoc 2005 Day

On Oct. 29, 2005, PIMS-UBC hosted the annual PIMS Postdoc Day, which was jointly organized with the University of Washington VIGRE Program. The event provided much needed information for the professional development of postdocs; topics which were discussed at length included:

· teaching and mentoring
· research connections
· industrial connections
· job applications
· interview skills

Nigel Boston

Over 30 postdocs from UBC, U. Washington, UVic and SFU attended this event, which included presentations as well as question-and-answer sessions. There was also a featured speaker during lunch, Nigel Boston (University of Wisconsin), who gave advice to students based on his ample experiences in academia and industry.

This event was organized by Alejandro Adem (PIMS Deputy Director), in collaboration with Loyce Adams (U. Washington VIGRE Director), Tom Archibald (Chair of the Mathematics Department, SFU), Brian Marcus (Head of the Mathematics Department, UBC) and Brian Wetton (Math, UBC). A webpage with resources for postdocs was established, which includes the presentations at this meeting, as well as useful links for job applicants.

Pims postdocs listen to the speakers at the 2005 Postdoc Day

For more information about the event and copies of the slides from the presentations, see http://www.pims.math.ca/science/2005/05postdoc/

Call for 2007 Scientific Proposals in the Mathematical Sciences

The Pacific Institute for the Mathematical Sciences welcomes applications for support for conferences, workshops, seminars and related activities in the Mathematical Sciences, to occur after **April 1, 2007**.

PIMS also invites scientists at PIMS universities to submit letters of intent for a Period of Concentration of a PIMS Collaborative Research Group (see page 26).

Deadline

To ensure full consideration, proposals must be received by the **Oct. 1, 2006**, deadline. Earlier submissions are strongly recommended so that scientific input can be obtained in a timely manner. The Scientific Review Panel will meet to review proposals in November, 2006. The results will be announced by Jan. 31, 2007.

Submission

Proposals may be submitted in one of three ways:

1. Via the online application (encouraged)
2. In hard copy to the PIMS site office at your university.
3. By e-mail to proposal@pims.math.ca, cc: **PIMS site director** at your university.

Proposals submitted by e-mail should be in **text, MS Word, PDF** or **TeX format**.

For online applications, you should receive an automatically generated e-mail message confirming receipt of your application immediately. All applications will receive a response within one week to confirm that the application has been received and is complete.

Enquiries regarding the status of proposals should be directed to proposal@pims.math.ca.

Please ensure that proposals are complete and have been submitted using one of the three ways above before the deadline. Incomplete proposals, late submissions and proposals submitted by other means than those listed above may not be included in the scientific review process.

Content of Proposals - General Activities

All proposals should contain each of the nine sections in the outline below, and give affiliations of all persons cited. Item 5, the summary of scientific and other objectives, should be at most 100 words and may appear in public announcements. Further details may be discussed in section 8, as well as any unusual features of the proposal, history and possible future aspects, educational benefits, etc. The budget should be itemized and detailed to the level of, for example, a cost estimate of travel and accommodation for each invited speaker.

1. Title of proposal.
2. Name, affiliation and CV/biosketch of main organizer(s).
3. Place and dates.
4. Amount of funding requested from PIMS.
5. Summary of scientific and other objectives.
6. List of participants (invited, confirmed, etc.).
7. Intended audience, provision for students.
8. General comments.
9. List of other funding and support sources.

All proposals for general scientific activities and major education and industrial outreach events should follow the above format.

Pacific Northwest Seminars are scientific meetings of one to two days in length. Funding of up to $1,000 and administrative support may be available from PIMS. Proposals for Pacific Northwest Seminars need not be adjudicated by the Scientific Review Panel.

Please see **http://www.pims.math.ca/Scientific_Programme/Call_for_Proposals/**

Did you know? PIMS runs an internationally recognized postdoctoral program. Each year, around 12 postdoctoral fellowships are awarded to highly promising young researchers from around the world. They are sponsored by faculty at PIMS universities, and often work within the framework of a CRG. These young people bring a real sense of excitement to PIMS. Although they are primarily mentored by their faculty sponsors at our member universities and affiliates, PIMS also provides these PDFs with opportunities for professional development through postdoctoral meetings on research, the job application process and other topics of interest to prospective academics.

PIMS PDFs for 2006

PIMS is pleased to announce the PIMS Postdoctoral Fellows (PDFs) for 2006. The members of the review panel were Alejandro Adem (UBC), Ailana Fraser (UBC), Michael P. Lamoureux (U. Calgary), Arturo Pianzola (U. Alberta), Gabor Tardos (SFU), Paul Tseng (U. Washington), Pauline van den Driessche (UVic), and Ralf Wittenberg (SFU).

New 2006 PIMS PDFs:

Aravind Asok: *Algebraic Geometry:* Charles Doran (U. Washington).

Nathanael Berestycki: *Probability:* Alexander Holroyd (UBC).

Shuang Cai: *Algebraic Geometry:* Vladimir Chernousov (U. Alberta).

Alexei Cheviakov: *Partial Differential Equations:* George Bluman (UBC).

Dana Cobzas: *Algebraic Geometry:* Martin Jagersand (U. Alberta), John Bowman (U. Alberta).

Holly Freedman: *Biophysics:* Jack Tuszynski (U. Alberta).

Hung Le Pham: *Harmonic and Geometric Analysis:* Tony Lau (U. Alberta).

Xiaosheng Li: *Inverse Problems:* Gunther Uhlmann (U. Washington).

Pedro Massey: *Operator Algebras and Operator Theory*: Martin Argerami (U. Regina).

Andriy Prymak: *Approximation Theory:* Zeev Ditzian (U. Alberta).

Ali Rezakhani: *Quantum Information Science:* Barry Sanders (U. Calgary).

Robert Samal: *Graph Theory:* Bojan Mohar (SFU), Pavol Hell (SFU).

Rahul Santhanam: *Computational Complexity:* Valentine Kabanets (SFU).

Ronald van Luijk: *Number Theory:* Nils Bruin (SFU).

Xiaoming Yuan: *Statistics:* Jane Ye (UVic).

Niu Zhuang: *Algebra:* Berndt Brenken (U. Calgary).

Call for Nominations

PIMS PDFs for 2007

The Pacific Institute for the Mathematical Sciences (PIMS) invites nominations of outstanding young researchers in the mathematical sciences for Postdoctoral Fellowships for the year 2007-2008. Candidates must be nominated by one or more scientists affiliated with PIMS or by a Department (or Departments) affiliated with PIMS. The fellowships are intended to supplement support made available through such a sponsor. The Institute expects to support up to 20 fellowships tenable at any of its Canadian member universities: Simon Fraser University, the University of Alberta, the University of British Columbia, the University of Calgary, and the University of Victoria, as well as the affiliated universities: the University of Lethbridge and the University of Regina.

For the 2007-2008 competition, the amount of the award is $20,000 and the sponsor(s) is (are) required to provide additional funds to finance a minimum stipend of $40,000 (including benefits).

Award decisions are made by the PIMS PDF Review Panel based on excellence of the candidate, potential for participation in PIMS programs and potential for involvement with PIMS partners. PIMS Postdoctoral Fellows will be expected to participate in all PIMS activities related to the Fellow's area of expertise and will be encouraged to spend time at other sites. To ensure PIMS Postdoctoral Fellows are able to participate fully in Institute activities, they may not teach more than two single-term courses per year.

Nominees must have a Ph.D. or equivalent (or expect to receive a PhD by **Dec. 31, 2007**) and be within three years of their PhD at the time of the nomination (i.e., the candidate must have received her or his PhD on or after Jan. 1, 2004). The fellowship may be taken up at any time between April 1, 2007, and Jan 1, 2008. The fellowship is for one year and is renewable for at most one additional year.

Nominations must include: 1) **curriculum vitae**, 2) **statement of research interests**, 3) **three letters of reference** (including one from a sponsoring professor), 4) **statement of anticipated support from the sponsor.**

Deadline for Nominations

The sponsors should send the complete nomination package to:

Attn: **PIMS PDF Competition**
Pacific Institute for the Mathematical Sciences
1933 West Mall, University of British Columbia
Vancouver, BC V6T 1Z2, Canada

or hand-deliver the package to any one of the Canadian PIMS Site Offices.

PIMS accepts no responsibility for incomplete packages, or for individual components of a nomination package being sent to any of our offices.

Nominations must be received by **Dec. 15, 2006**.

Renewals of PIMS Postdoctoral Fellowships

Sponsors of PIMS Postdoctoral Fellowships may request a renewal of the Fellowship for a maximum of one additional year. The maximum length of a PIMS Postdoctoral Fellowship is two years. Requests for renewal must be signed by the sponsor(s) and received by **Jan. 21, 2007**. The letter must include a description of the funding commitment for the second year of the fellowship.

Inquiries concerning this competition should be directed to:
Alejandro Adem, PIMS Deputy Director
adem@pims.math.ca

PIMS 10th Anniversary Activities

To celebrate its 10th Anniversary, PIMS will host a number of Distinguished Lecturers at all of its sites. Confirmed speakers include James Arthur (University of Toronto), Darrell Duffie (Stanford University), Helmut Hofer (Courant Institute, NYU), Andrei Okounkov (Princeton University) and Raman Parimala (Emory University).

More information at: http://www.pims.math.ca/PIMS_10th_Anniversary_Activities/

James Arthur (University of Toronto) is one of the most influential mathematician in Canada, and is regarded as one of the leading mathematicians in the world in the central fields of representation theory and automorphic forms. In 1999 he received the Gerhard Herzberg Canada Gold Medal for Science and Engineering from NSERC, making him the only mathematician to have won Canada's top award in science. *Biography from the University of Toronto.*

Darrell Duffie (Stanford University) is the James I. Miller Professor of Finance at Stanford Graduate School of Business. His research interests include over-the-counter market financial modelling, financial risk management, credit risk and valuation of defaultable securities, valuation and hedging of derivative securities, term structure of interest rate modelling, financial innovation, and security design. *Biography from Stanford University.*

Helmut Hofer (Courant Institute, NYU) works in the fields of symplectic geometry, dynamical systems and partial differential equations. He is best known for the discovery of a remarkable geometry of symplectic diffeomorphism groups, now called Hofer's Geometry. Dr. Hofer also serves as the chairman of the scientific advisory board of the Max Planck Institute for Mathematics in the Sciences. He sits on the BIRS Scientific Programme Committee.

Andrei Okounkov

Andrei Okounkov (Princeton University) is one of the winner of the 2006 Fields Medal, for his contributions bridging probability, representation theory and algebraic geometry. Dr. Okounkov received his doctorate in mathematics from Moscow State University, and was awarded a Sloan Research Fellowship in 2000. *Biography from Princeton University.*

Raman Parimala (Emory University) works in the field of algebra, focusing mainly on tools from number theory, algebraic geometry and topology. She is a fellow of all three Indian academies of science. Her research was recognized with the Bhatnagar Prize in 1987, an honorary doctorate from the University of Lausanne in 1999, and the Srinivasa Ramanujan Birth Centenary Award in 2003. Dr. Parimala received the 2005 prize in mathematics from the Academy of Sciences for the Developing World for "her work on the quadratic analogue of Serre's conjecture, the triviality of principal homogeneous spaces of classical groups over fields of cohomological dimentions 2 and the μ-invariant of *p*-adic function fields."

PIMS is supported by:

- The Natural Sciences and Engineering Research Council of Canada
- The Government of the Province of Alberta
- The Government of the Province of British Columbia
- Simon Fraser University
- University of Alberta
- University of British Columbia
- University of Calgary
- University of Victoria
- University of Washington
- University of Lethbridge
- University of Regina
- University of Northern British Columbia
- **Private Donors**

Editors: **Breeonne Baxter** and **Kathleen Gamble**.
Magazine available at **www.pims.math.ca/Publications_and_Videos/PIMS_Magazines/**

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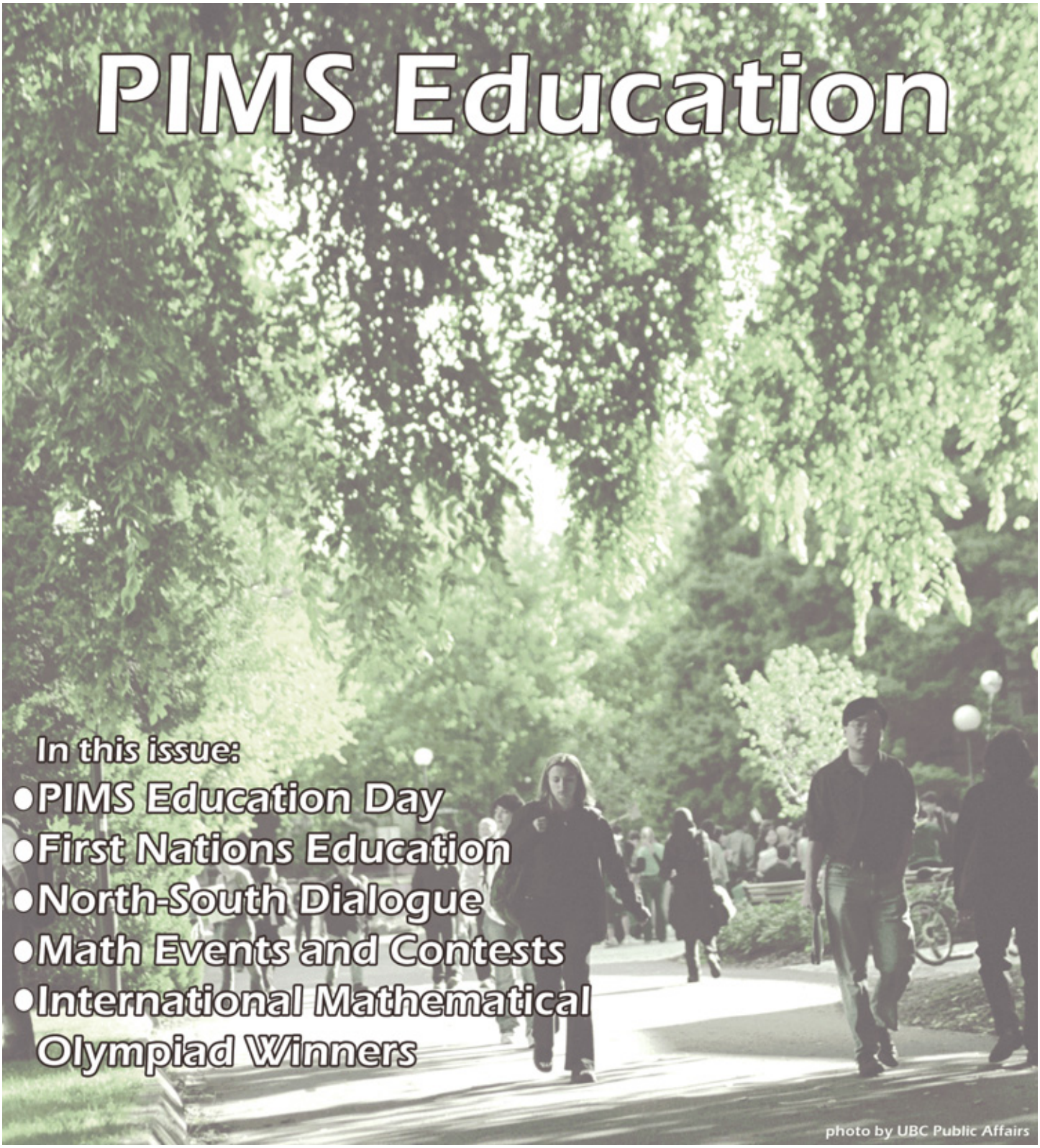
PIMS Education



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- North-South Dialogue
- Math Events and Contests
- International Mathematical Olympiad Winners

photo by UBC Public Affairs

PIMS Education Awards Day

University of Alberta, June 8, 2006

by Jack Macki

On June 8, 2006, 55 people gathered at the University of Alberta to honour the recipients of the 2006 PIMS Education/Outreach Awards. Recipients Malgorzata Dubiel (Simon Fraser University) and Bill Sands (University of Calgary) received plaques and a $1,000 award, generously funded by Veritas DGC and Hampton Russell. Fernando Aguilar and Brian Russell presented the awards. There were several distinguished guests, including special guest Margaret Armour, one of the founders of the WISEST program for the encouragement of women in science and engineering.

(l to r) Alejandro Adem, Gerald Cliff (U. Alberta Site Director), Andy Greenshaw (U. Alberta Associate VP Research, representing President Samarasekera), Ivar Ekeland, Jim Timourian, Fernando Aguilar, Brian Russell

Attendees came from colleges throughout the Edmonton area, as well as from the University of Calgary, Mount Royal College and from Red Deer College. Ivar Ekeland, PIMS Director, and Alejandro Adem, PIMS Deputy Director, attended the ceremony. Dr. Ekeland gave a short yet inspiring address, as did Dr. Russell on behalf of the PIMS Board of Directors. Andy Greenshaw and Dr. Adem also addressed the meeting. The main speaker was Jim Timourian, Professor Emeritus at the University of Alberta, who spoke on the highly successful **SNAP** program of **S**tudent-centred **N**on-competitive **A**ctive **P**articipation program, directed at students in grades 4-12.

Bill Sands examines his PIMS Education Award plaque

Annual Changing the Culture Conference at PIMS-SFU

The **Changing the Culture** conference, held on April 21, 2006, at SFU Harbour Centre, brought together 96 school teachers, college and university faculty, and graduate students to discuss issues related to teaching mathematics at all levels. This conference, as in past years, involved a mixture of talks, workshops and panel discussions.

The theme for the 2006 conference was *Teaching Mathematics for Understanding*. Past themes include:

- *Do We Need To Teach Algebra?*
- *Mathematics Curriculum: Could Less Be More?*
- *Rigour and Intuition in Mathematics.*
- *Writing, Speaking and Thinking Mathematics.*
- *Visualizing Mathematics.*
- *Narrowing the Gap.*

Malgorzata Dubiel (Simon Fraser University) is the organizer of the Changing the Culture conferences.

Winners of the PIMS Education Prizes 2006

The Pacific Institute for the Mathematical Sciences congratulates Malgorzata Dubiel (Simon Fraser University) and Bill Sands (University of Calgary), the two winners of the PIMS 2006 Education Prizes. The awards were presented at a special PIMS Education Day held at the University of Alberta on June 8, 2006. The winners were selected by the PIMS Executive Committee.

Malgorzata Dubiel

Malgorzata Dubiel is a Senior Lecturer in the Department of Mathematics at Simon Fraser University. She has tirelessly worked to promote and organize mathematical education outreach events. Her involvement with education activities includes:

- Organizer of the SFU Esso-CMS-PIMS Math Camp for high school students;
- Co-developer of the "Math in the Mall" programme that inspired Math Mania;
- School visits through the B.C. Science World Scientists in Schools programme;
- Organizer of the Changing the Culture conferences;
- Main organizer of the Connecting Women in Mathematics Across Canada Conferences; and
- Organizer of a number of Education Sessions at CMS meetings.

Bill Sands

Bill Sands is a Professor in the Department of Mathematics and Statistics at the University of Calgary. He has worked tirelessly for over 20 years to broaden the exposure of mathematics, not only to students at the university level but also to students in junior and senior high schools, as well as the public at large. His recent involvement with education activities includes:

- Weekly Math Discovery Nights at the University of Calgary;
- Organizer of the Calgary Junior Math Contest;
- Organizer of the Alberta High School Math Contest;
- Tournament of the Towns Math Contest Committee Member;
- Chairman of the International Math Olympiad (IMO) Committee of the CMS;
- Organizer of the Summer IMO Training Camp at UQAM;
- Selection Committee Member of the Canadian IMO team; and
- Chairman of the Asia Pacific Math Olympiad Committee.

Canada Places 15th in 2006 International Mathematical Olympiad

Canadian high school students won five silver medals and one bronze medal from the 47th International Mathematical Olympiad, held from July 6-18, 2006, in Ljubljana, Slovenia. The team placed 15th out of 190 countries, bettering its 2005 19th place standing.

The Canadian team consisted of Farzin Barekat, North Vancouver, Viktoriya Krakovna, Toronto, Yang (Richard) Peng, Toronto, Dong Uk (David) Rhee, Edmonton, Peng Shi, Toronto, and Yufei Zhao, Toronto.

Since 1981, Canadian students have received a total of 16 gold, 34 silver, and 58 bronze medals. The six members of the Canadian IMO team were selected from among more than 200,000 students who participated in local, provincial and national mathematics contests. The team was co-sponsored by PIMS, as well as many other Canadian institutes.

New Calgary Education Coordinator

Eva Nosal received her Masters of Education in the Czech Republic in 1960. She taught Mathematics and Descriptive Geometry as an assistant professor at the Czech Technical University in Prague from 1962 to 1968, when she immigrated to Canada.

In Calgary, Dr. Nosal worked towards her MSc in Mathematics and her PhD in Combinatorics. After completing requirements for her teaching certificate, she worked as a math teacher at Strathcona Tweedsmuir High School. When her daughter was born in 1977, Dr. Nosal worked as a sessional instructor at the University of Calgary and at Mount Royal College. In 1982, she resumed full-time teaching at Calgary Christian High School where she remained until her retirement in 2005.

Throughout her career, Dr. Nosal enjoyed preparing her students for math and physics competitions. She was awarded an Excellence in Teaching award in 1990. Dr. Nosal looks forward to putting her 40 years of mathematical teaching experience to use at PIMS.

The Alberta College Mathematics Conference: North-South Dialogue

by Jack Macki

The Alberta College Mathematics Conference met on May 4, 2006, at the Lincoln Park Campus of Mount Royal College in Calgary. The conference traditionally focuses on teaching issues specific to the colleges and their mathematics courses. The annual Alberta North-South Dialogue followed the ACMC on May 5. On May 6, a meeting was held to discuss curriculum reform and teaching issues in the colleges and universities.

The ACM program consisted of the following presentations:

· **General Education: Numeracy -- Gimmick or Long Overdue Idea** by Roberta LaHaye (Mount Royal College)

· **Wiley Plus: A New System of Online Support** by Wiley Publishers

· **Motion Through the Air: It's a Drag** by Bill Hackborn (University of Alberta)

· **Mathematics, Science and Spirituality** by Ved Madan (St. Mary's University College)

· **Math Achievement Through Math Fairs and Lesson Study** by Sharon Friesen (University of Calgary)

· **How to Engage Student in Doing Real Mathematics** by Nancy Chibry (University of Calgary)

· **Setting a Good Foundation for Mathematics Learning in the Early Years** by Janis Kristjansson (President, Math Council of the Alberta Teachers' Association)

North-South Dialogue

Teaching Math-Phobic Students, Ted Lewis (University of Alberta)

Dr. Lewis outlined the successful problem/puzzle/trick approach to involving math-phobic students, and developing ideas to keep them on track.

Pedagogy for Statistics Courses, Jim Stallard (University of Calgary)

Dr. Stallard outlined his approach to teaching statistics courses, which emphasizes Authentic Evaluation, related to what statisticians use in the real world, and Cooperative Learning, students work in teams on group projects, which develops several intangible skills. His assessment of the outcomes: an increase in inquiry and attitude improvement, scaffolding (knowledgeable students help those who are weaker), and some increase in measured achievement.

Restructuring Continuous Tutorials (CT), Bouchra Sabbagh, graduate student (University of Calgary)

Ms. Sabbagh is a graduate student who looked at the problems involved in running her labs and continuous tutorials, experimenting with various approaches as she went along. She found herself dealing with the problem of immature, uncommitted students, lacking an understanding of their responsibilities. The CT is a room with several instructors available to offer assistance with any math course to any student who walks in the door. The result was long lines of students waiting for help, many of them wanting someone to finish their homework for them or to provide a quick review for an exam.

After considerable experimentation, Ms. Sabbagh developed a firm set of "tough love" rules, which meant that students had to be ready to show what they had done before coming to the CT, and to work in groups. For example, she would not allow a student to come in near the end of term with a set of questions on the early part of the course. The response was very positive, and student attitudes and performance improved substantially.

An Introduction to WebWork, Len Bos (University of Calgary)

Dr. Bos outlined the successful computer-based system WebWork. WebWork is an Internet-based method for delivering homework problems to students over the Internet. It gives students instant feedback as to the correctness of their answers.

WebWork builds on the experiences of an earlier program, CAPA, developed at Michigan State University, differing mainly in its use of a new generation of electronic technology.

Each WebWork problem set is individualized. The students complete the assignment, log onto the Internet and enter their answers into a web browser. The WebWork system tells the students if their answers are correct, and also records the results. The student is free to try a problem as many times as the instructor has allowed until the due date.

A key educational benefit of this system is

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First Nations Education Programs and Outreach

Partnership Between PIMS and First Nations Schools in B.C.

by Melania Alvarez-Adem

One of the priorities of the Pacific Institute for the Mathematical Sciences is to participate in the mathematical enrichment of students and teachers in grades K-12. In 2005, after consultation with the First Nations Education Steering Committee (FNESC), PIMS decided to reach out to First Nations schools in British Columbia. Standardized provincial tests showed that First Nations students were not performing at a desirable level in mathematics, and PIMS felt that its mathematical scientists could offer their expertise.

Teachers at the Sk'elep School of Excellence training in 2005

Under the auspices of the FNESC, PIMS has developed a partnership with First Nations schools in British Columbia. We organized a one-week teacher training session at the end of August, 2005, to assist in the implementation of a math program at the Sk'elep School of Excellence in Kamloops and the Lelawagila Primary School in Kingcome Inlet. The schools chose a program that emphasizes the mastery of basic mathematical skills, as well as problem solving. In addition, we coordinated a mentorship program where undergraduate students in mathematics from Thompson Rivers University in Kamloops worked with teachers and students at the Sk'elep School of Excellence. PIMS B.C. Education Coordinator Melania Alvarez-Adem was in constant contact with the schools throughout the year, helping them with assessment, the implementation of the math programme and other issues related to math education at the schools.

In 2006, PIMS received several inquiries of support from First Nations schools. In particular, the Stein Valley Nlakapamux School at Lytton, Neqweyqwelsten School at Barriere, Bonaparte School north of Lytton, and the First Nations elementary and secondary schools in Bella Bella have asked for our assistance. The Stein Valley Nlakapamux School has children attending from more than six First Nations communities (Kanaka Bar, Siska, Lytton, Skuppah, Nicomen and Mount Currie).

Many enquiries came from educators who talked to the teachers at Sk'elep; they seemed pleased with our efforts. As a result, in June, 2005, PIMS organized a four-day teacher training-math development session at Lytton, attended by 19 teachers from several schools around the Fraser Valley area and Kamloops. We also held an additional two-day training and math development session at Neqweyqwelsten School in Barriere in August, where teachers from Sk'elep at Kamloops and other schools in the surrounding areas will attend. Teachers who came to our session in Lytton found it enriching as well as a challenging experience. As a direct benefit, they were able to further their knowledge in math as well as learn about the use of various strategies to improve the teaching of math at their schools. Additionally, PIMS organized a four-week math summer camp at Kamloops where 40 children received 75 minutes of daily math instruction (four groups with 10 children each).

Students tackle math problems at Math Mania events in Lytton and Sk'elep

When we began our activities with the S'kelep School in Kamloops, we conducted a diagnosis of the mathematical knowledge of the students. After a year of implementation, preliminary assessment results indicate that there has been a noticeable improvement in skills and understanding, as well as a new enthusiasm for mathematics. In addition, the teachers' mathematical confidence is enhanced, and they are engaged in this project with a uniformly positive attitude.

Teacher training is the key to education. PIMS is commited to further developing the teacher training and mentorship program for First Nations schools. The training should focus on the following:

· how to go from the concrete to pictorial to abstract concepts;
· how to explain mathematics in the simplest and clearest way; and
· how to choose and build word problems to teach ideas such as division by a fraction.

Sponsors: Funding for this project has been generously provided by Haig Farris, Ken Spencer and Andrew Wright, as well as by the Gabriella Rosenbaum Foundation.

Bella Bella Math Outreach

PIMS is working in partnership with the Bella Bella Community School, on a series of initiatives to further develop mathematical excellence among the school's First Nations students.

In May, 2006, school principal Brenda Humchitt invited PIMS B.C. Education Coordinator Melania Alvarez-Adem and UVic Education Coordinator David Leeming to visit the school and see the developments being made in mathematical programmes. During the two-day visit, Ms. Alvarez-Adem presented a talk to the school's elementary and secondary teachers on delivering math education to children. The visit ended with the school's Math Evening, where students and their families tackled round-robin math activities in a fun and exciting way.

First Nations Outreach

by Melania Alvarez-Adem

In 2006, PIMS developed a partnership program with First Nations schools, seeking to serve as a resource for enhancing the teaching of mathematics.

Teacher-training sessions

PIMS organized teacher-training sessions for teachers at First Nations schools, with the participation of mathematicians and other highly qualified lecturers with an interest in both math content and pedagogy. PIMS would like to open these sessions to teachers from several elementary schools. As a pilot program, PIMS organized a one-week teacher-training session in Kamloops at the end of August, 2005, to assist in the implementation of the math curriculum at the Sk'elep School of Excellence. Qualified personnel at PIMS have provided support throughout the school year in all matters related to mathematics.

Mentorship programs

PIMS is developing mentorship programs, where faculty and students from local universities can be paired with school teachers to assist in the teachers' mathematical training and to provide a support network. Richard Brewster at the Thompson Rivers University Department of Mathematics and Statistics has developed the initiative in Kamloops with PIMS' support. PIMS feels that these mentorship programs are an excellent idea, and have great potential to be expanded to other regions.

Mathematical Outreach

PIMS has organized mathematical outreach events at First Nations schools. We have run successful Math Mania events at several schools, and plan to expand and develop these outreach activities, which have the benefit of bringing together students, teachers and parents with mathematical scientists.

PIMS has organized meetings of mathematicians and educators from Western Canada with First Nations representatives. The first meeting was held at BIRS in June, 2006.

Grouping Resources

PIMS is pooling its resources with other academic institutions to introduce First Nations children to math and its application in society.

Future PIMS Education Plans

PIMS is currently developing a partnership with the Vancouver School Board. First Nations children in the Vancouver area sometimes experience greater academic challenges than those in the rest of the province. We are also working with the First Nations Coordinator at UBC, Tim Michel, in creating programs to improve mathematics education for First Nations children in B.C. PIMS is also developing a new partnership with First Nations schools in Bella Bella and Lytton.

First Nations: Mathematics and Science Education

Banff International Research Station, June 17-22, 2006

by Melania Alvarez-Adem

The purpose of the meeting, held on July 17-22, 2006, was to bring together mathematicians and educators interested in working with First Nations communities to investigate the promotion of mathematical opportunities. The main goal was to discuss First Nations students' access to math and science education. We looked at the challenges faced by First Nations children in the educational system, and discussed possible ways of addressing key issues of concern, especially in mathematics education.

Participants were invited to share their experiences on particular case studies or to describe ongoing research on these issues. We were also interested in learning about any significant studies and data on these topics.

Our final objective was to produce a document that encompasses all these issues, to use as a focus for addressing the major challenges in these aspects in the education of First Nations students.

FAME 2006

by David Leeming, PIMS UVic Education Coordinator

FAME is the Forever Annual Mathematics Exhibition held annually in Victoria. This year, the ninth annual FAME event was held on May 9, 2006. FAME attracts over 100 student exhibitors from kindergarten to grade 12.

There are three levels: elementary (grades K to 5), middle (grades 6 to 8) and senior (grades 9 to 12). The winning elementary school had students from grades 2 and 3. Entries are judged and prizes are awarded for the best exhibits.

Two participants at FAME 2006

Contest for Epsilons

by David Leeming

The fourth annual **Contest for Epsilons** was held on May 1, 2006. This half-day competition was held at the University of Victoria campus for students in grades 6 to 8. It is limited to 200 students from the local schools and is organized by the UVic Math and Stats Course Union (MASCU).

The event consists of written tests and also several mini-lectures given by MASCU students and departmental members. PIMS helped coordinate the event by giving logistical support. PIMS also assisted by running a Math Mania event before the content began.

Prizes were awarded to the top three competitors in each grade.

General education outreach

PIMS organizes events involving children and teachers in British Columbia to help develop interest and awareness of mathematics (with the participation of mathematical scientists), in order to help create an integrated community of teachers and learners. Specific events and activities include:

•ELMACON (Elementary Mathematics Contest) a yearly math competition for elementary school students in Vancouver (around 350 participants) in grades 5-7.

•Math Mania (approximately 10 per year), intensive outreach sessions held at schools throughout B.C.

•Teacher training sessions, to help teachers organize preparatory sessions for different math programs such as JUMP (Junior Undiscovered Math Prodigies), Singapore Math, or other programs for which teachers would like PIMS support.

•Math Workshops, to assist the UBC Mathematics department with their Math Workshops Course (Math 414); volunteers must be recruited and workshops organized at local schools. About 70 workshops are held each year.

•Science Fairs, including organizing math activities for participants of the regional as well as the Canada-wide science fairs.

•Working with school boards to assess mathematics programs.

•Coordinating with mathematical scientists and educators to help facilitate promotion of mathematics throughout B.C.

•Developing uses of mass media for mathematics outreach by PIMS. We are planning a series of short online videos that can be accessed high school students. This is a collaboration with MITACS, Fields and CRM.

•Developing international collaborations in educational matters, for example with our colleagues in Chile.

PIMS-BC Education Advisory Committee

The PIMS-BC Education Advisory Committee (EAC) held its first meeting on May 1, 2006. The members of this committee are:

· Andy Wright (Director of Product Research, PMC-Sierra)
· Haig Farris (Fractal Capital Corp.)
· David Leeming (Math Dept., University of Victoria)
· George Bluman (Math Dept., University of British Columbia)
· Malgorzata Dubiel (Math Dept., Simon Fraser University)
· Robert E. Megginson (Math Dept., University of Michigan)
· Melania Alvarez (PIMS, *ex-officio*)

After discussing plans for broadening the scope and impact of PIMS' education activities in B.C., Professor Megginson (Associate Dean for Undergraduate and Graduate Education in the College of Literature, Science, and the Arts at the University of Michigan) delivered an inspiring lecture entitled *Barriers to Native American Participation in Mathematics*.

ELMACON 2006

ELMACON, organized by PIMS under the guidance of Cary Chien, formerly of David Thompson Secondary School, in collaboration with the BCAMT and volunteers from Lower Mainland schools of all levels, is open to students in grades 5 to 7. This event gives students a chance to experience mathematics as an exciting sport. The contest is modelled after the successful **MathCounts** competitions (which are also supported by PIMS), although aimed at younger students.

On April 29, 2006, PIMS-UBC hosted the 8th Annual Elementary Grades Math Contest (ELMACON 2006). The event was a great success! A total of 288 students competed: 96 in grade 5, 95 in grade 6, and 97 in grade 7.

(top to bottom): Winners for ELMACON 2006 for Grades 5-7

BC Colleges High School Math Contest

by Melania Alvarez-Adem

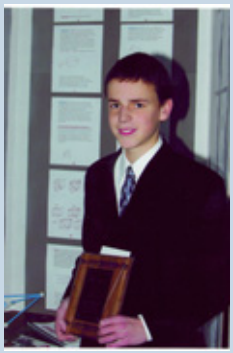
The BC Colleges High School Math Contest is a consolidation and extension of three former regional high school mathematics contests centred in British Columbia, at the University College of the Cariboo in Kamloops, the former Okanagan University College in Kelowna (now UBC Okanagan), and the College of New Caledonia in Prince George. The contest has grown to include nine colleges and universities in the province:

· Camosun College (Victoria)
· Capilano College (North Vancouver)
· College of the Rockies (Cranbrook)
· Langara College (Vancouver)
· Malaspina University College (Nanaimo)
· UBC Okanagan (Kelowna)
· College of New Caledonia (Prince George)
· University College of the Cariboo (Kamloops)
· University College of the Fraser Valley (Abbotsford)

PIMS has been one of the sponsors of this contest for the last two years and we hope to increase our commitment in the future. This competition is important for students in remote areas of our province who have limited access to these types of math competitions.

PIMS Prize at the Calgary Youth Science Fair 2006

PIMS is pleased to congratulate Mate Bezdek as the winner of the 2006 PIMS Math Prize at the **Calgary Youth Science Fair 2006**. Mate, a grade 8 student, did a project entitled X-raying and Geometry which won him the Devon Canada Top Junior Award and Pfizer Canada Travel Award, along with the PIMS Award. Congratulations to Mate who has been invited to go to the **2006 Canada Wide Science Fair.**



International Collaboration

Melania Alvarez, PIMS B.C. Education Coordinator, travelled to Chile in March, 2006. She was invited by the Centro de Modelamiento Matemático to discuss math curriculums, various math programs in an ongoing international collaboration for the creation of a Math Education Institute in Santiago.

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that the students receive immediate feedback while the problem is still fresh in their minds. They can then correct mistakes, review the relevant material before trying the problem again or seek help (frequently via e-mail) from friends, the teaching assistant or the instructor.

WebWork was developed at the University of Rochester, and is currently used at more than 100 institutions, primarily for calculus (all semesters) and linear algebra (elementary and advanced). More information is available on the program's website, at http://math.webwork.rochester.edu/docs/.

Research Presentations

Groebner Bases and Applications, Eva Krause (University of Alberta)

In 1965, Bruno Buchberger developed a method to find solutions of polynomial systems of equations, called Groebner bases. This method generalizes Gauss-Jordan elimination, and has many applications outside Algebraic Geometry and Commutative Algebra, for example to Coding Theory. It is now implemented in most Computer Algebra systems.

The Voronoi Conjectures, Wes Maciejewski (University of Calgary)

Voronoi diagrams and parallelotopes have proved to be fundamental in modern discrete geometry. In 1908, G. Voronoi conjectured that these diagrams for certain lattices and parallelotopes are actually one and the same. To this day, the conjecture remains open, except for a few specific cases.

A Classification of Spikes and Plateaus, Thomas Hillen (University of Alberta)

In the analysis of pattern formation in physical or biological systems, patterns often arise as spikes or plateaus. It has been shown that their stability properties are quite different, but so far no classification scheme had been presented. Dr. Hillen presented a scheme for classifying spikes and plateaus.

Random Dynamical Systems, Shafiqul Islam (University of Lethbridge)

A random map is a discrete-time dynamical system where one of a number of transformations is selected randomly and applied in each iteration of the process. This talk reviewed results and open problems on the existence and approximation of absolutely continuous invariant measures (acim) for random maps.

Measuring Symmetries in Dynamical Systems, Wieslaw Krawcewicz (University of Alberta)

Almost every design in architecture, engineering, electronics or networking incorporates certain symmetries, which are expressions of our tendencies to pursue elegance and balance. However, symmetries in dynamical systems cause a multitude of unexpected types of solutions exhibiting complicated symmetric or asymmetric properties. The problem of measuring such an impact of symmetries on the complexity of the dynamics constitutes a difficult task. Dr. Krawcewicz proposed the equivariant degree method as a tool for providing a full topological picture for local symmetric bifurcation phenomena.

The Spectrum of a Fourier Migration Matrix Pencil, Petr Zizler (Mount Royal College)

Dr. Zizler provided spectral asymptotic results for the matrix pencil A and showed that the migration techniques are significantly more accurate if the terminal velocities coincide. Symmetry properties of eigenvectors of the pencil A were also presented.

Key Agreement, the Algebraic Eraser, and Lightweight Cryptography, Stephane Lemieux (University of Calgary)

In order to establish algebraic cryptography both as an academic field of research and as an industrial application, many algebraic cryptographers seek to build cryptosystems, which work on constrained platforms, avoiding the need to compete with well-established "large" cryptosystems such as RSA and ECC.

Dr. Lemieux presented a new key agreement protocol for public-key cryptography suitable for implementation on low-cost platforms, which constrain the use of computational resources. Radio Frequency Identification Tags and Readers, the trademark Algebraic Eraser protocol, were also discussed.

Curriculum reform

On May 6, participants who wished to focus on curriculum and teaching issues in the colleges and universities held an update meeting. The discussion centred on two presentations: a report on Blended Learning by Manny Estabrooks (Red Deer College), and a report on the proposed new curriculum for first-year calculus by Bill Hackborn (Augustana College, University of Alberta).

Visit the PIMS website to read more about PIMS' education activities, at www.pims.math.ca/Education_Programme/

Pi in the Sky

The mathematical puzzles and game issue of *Pi in the Sky* is coming this fall! Read the magazine and all of our past issues online: http://www.pims.math.ca/pi/

Math educators: e-mail us to get your copies of *Pi in the Sky* at pi@pims.math.ca.

PIMS Mathematical Summer Camps

PIMS sponsored two UBC math camps in August, 2006.

Math and Art, held from Aug. 21-25, 2006, focused on the beauty of mathematics. Students created artwork using mathematical techniques such as perspective drawings, proportion and tessellations. They investigated why some shapes tile a plane (angle properties), and created a scale drawing of objects in order to reinforce their understanding of proportion. Through games, they investigated the "Four Colour Theorem," which states that any map can have only four colours, and no two countries sharing a borderline will share colours.

The **Math and Nature** workshop, held from Aug. 28 to Sept. 1, 2006, focused on the utility and beauty of mathematics. Activities involved computing the height of trees and other tall objects, the widths of fields, rivers or lakes, as well as the circumference of the Earth (preliminaries of trigonometry, using scale drawings and graph paper). Students also investigated Fibonacci numbers and other mathematical growth patterns that appear in nature. The workshop exposed students experimentally to the ideas of trigonometry.

PIMS would like to thank all of the teachers and volunteers who make our mathematical education programs and outreach events possible.

PIMS Fundraising Drive 2006

PIMS is involved in promoting education in the mathematical sciences through a wide range of activities. However, we have a limited budget for carrying out projects connected to important areas such as mathematics education. Private donations can make a huge amount of difference to our outreach programme. In 2005-2006, generous gifts by **Haig Farris, Ken Spencer, Andrew Wright** and **Gabriella Rosenbaum Foundation** made it possible for us to initiate a partnership with a First Nations school in B.C. (see articles on pages 4-5). **Brian Russell** and **Fernando Aguliar**, through Hampton Russell and Veritas DGC, donated prizes for the PIMS 2006 Education Awards (see article on page 2).

Please contact me at director@pims.math.ca for more information on donating to our worthy causes. Thank you in advance for your support.

Ivar Ekeland, PIMS Director

MathCircles Coaching Program "Math Academy for the Young"

There are two elements to developing mathematical competence: Learning new math, and practicing the aquired mathe skills. The MathCircles Coaching Program will teach your child to do both. Math Circles is an ongoing learning and coaching process that will gently push your child to succeed. We use thematic seminal and structured problem solving to illuminate various topics of mathematics. There are 17 classes, held on Saturdays from October, 2006, to June, 2007, meeting approximately twice a month.

The objective of the program is for your child to dramatically improve his or her math mark, cut the study time in half, eliminate the need for a math tutor in the years to come, keep expanding the math knowledge, and to share the joy of doing math with like-minded people.

If your child's results are not matching your child's potential, sign up for the MathCircles today by contacting info@mathpotentials.com, or calling 604-376-2706

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