



# Pacific Institute *for the* Mathematical Sciences

Year in Review 2011



Simon Fraser University • University of Alberta • University of British Columbia • University of Calgary  
University of Regina • University of Saskatchewan • University of Victoria • University of Washington  
University of Lethbridge • Portland State University • University of Northern British Columbia

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## *From the Director*

**It is a pleasure for me to write these lines in our Year in Review 2011**, which is a publication containing an overview of the multiple activities held at PIMS during the year.

This has, as usual, been a year of hectic activity and remarkable accomplishments by the PIMS community. In 2011 we launched a new Collaborative Research Group on Applied and Computational Harmonic Analysis, anchored by colleagues in Edmonton, Vancouver and Calgary. Meanwhile our CRG in L-functions and Number Theory put together a wonderful focused period of thematic activity in Alberta and hired some amazing postdoctoral fellows. The CRG in Mathematics of Quantum Information has reported some significant research accomplishments that you can read about on page 5. Our pipeline for CRGs continues to grow, and in 2012 we expect to launch two new ones, connecting researchers at various PIMS sites.

In 2011 PIMS hosted the special thematic program Applied Mathematics Perspectives in collaboration with CAIMS, MITACS and BIRS. The timing was designed to take advantage of the ICIAM meeting which was held in Vancouver in July. The interwoven workshops, student presentations and glorious social events made this a truly memorable program, I would like to congratulate the organizers, in particular Ian Frigaard for their success.

This past year our educational programs were awarded an important distinction - PIMS received \$100,000 from the BC government as legacy funding from their 2010-2011 Year of Science for our outreach programs for the Aboriginal/First Nations Community. Only PIMS and Science World (a marvellous science education facility in Vancouver) received this recognition. It was immediately put to good use, with multiple teacher workshops and math camps taking place in 2011 and others in preparation for next year.

On the international front, PIMS' status as an Unite Mixte Internationale of the French CNRS was renewed in 2011 and extended to include Regina and Saskatchewan. Since 2007 PIMS has hosted 18 French scientists on year-long visits under this program. We were the first mathematical institute in North America to receive this recognition.

We are also pleased to report that the University of British Columbia became a PIMS affiliate in 2011. We are happy to welcome UNBC colleagues to the PIMS community.

I also want to share the exciting news that PIMS-UBC will be moving to a state-of-the-art building on the UBC campus in July 2012. This long-sought improvement of our facilities will provide us with excellent offices for research visitors, classrooms for lectures and a lounge for critical social interactions. Rumor has it that we will have an ocean view...

Let me conclude this introduction to the PIMS Year in Review 2011 by expressing our gratitude to all of our generous donors, with particular thanks to Darell Duffie, Haig Farris, Hugh Morris, Vaho Rebassoo, Brian Russell, Ken Spencer, Ken Terao and Andy Wright.

Alejandro Adem  
*Director*

# About PIMS

**The Pacific Institute for the Mathematical Sciences was founded in 1996, it is a consortium of universities in the Pacific Northwest and Western Canada.**

*Member universities:* University of Alberta, University of Calgary, University of British Columbia, Simon Fraser University, University of Victoria, University of Washington (USA), University of Regina and the University of Saskatchewan.

*Affiliates:* University of Lethbridge, Portland State University and University of Northern British Columbia.

The PIMS mandate is to promote research and applications of the mathematical sciences of the highest international caliber; to facilitate the training of highly-qualified personnel at the graduate and postdoctoral level; to enrich public awareness of mathematics through outreach; to enhance mathematical training for teachers and students in K-12; and to create mathematical partnerships with similar organizations in other countries, with a particular focus on Latin America and the Pacific Rim.

The central office is at the University of British Columbia, with a PIMS site office and a Site Director local to each of the eight major universities. The Site Director facilitates local opportunities and synergies, while the PIMS site offices provide administrative assistance for organizing local events. This distributed structure renders it quite unique, involving strong local site offices and activities, and allowing a broad impact across Western Canada and beyond.

The Board of Directors oversees the administration of PIMS, with membership consisting of the V. P. of Research from each of the member universities, as well as distinguished scientists and representatives from industry. An independent Scientific Review Panel composed of internationally renowned mathematical scientists assesses proposals for scientific events and programs.

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# 2011 Activity Overview

**PIMS is a leading mathematical institute in North America**, with worldwide impact on the mathematical sciences and their applications. PIMS has established innovative programs which have had a transformative effect on mathematical research and training of students and postdoctoral fellows.

**During 2011 PIMS helped to support over 70 scientific activities.** These involved a total of over 4,100 attendees who spent nearly 15,000 attendee days at PIMS activities.

**Conferences and Workshops:** In 2011 there were over 3,300 participants at PIMS supported conferences and workshops, including WAVES 2011 at Simon Fraser University, the 35th Conference on Stochastic Processes and their Applications (SPA 2011) in Oaxaca, Mexico and the International Conference on Applied Harmonic Analysis and Multiscale Computing at the University of Alberta.

**Summer Schools:** The largest summer school in 2011 was the CRG hosted Computational Harmonic Analysis Summer School at the University of Alberta, Edmonton.

**Lecture and Seminar Series:** PIMS supported ongoing seminar series at member universities in 2011 including the PIMS/UBC Distinguished Colloquium which featured speakers such as Dusa McDuff and Jean Michel-Bismut, as well as the Hugh C. Morris Lecture Series and seminar series on topics such as number theory, math biology, applied mathematics and mathematical physics.

**Industrial and Applied Activities:** PIMS is pleased to continue the popular PIMS/Shell Lunchbox lecture series in Calgary which attracted over 300 participants in 2011 and the IMA/PIMS Mathematical Modeling in Industry workshop held in Minnesota in 2011. This workshop is designed to provide graduate students and qualified advanced undergraduates with first hand experience in industrial research.

**Special Thematic Programs:** These intensive activities cover a specific area of research of current importance, with participants ranging from students to world experts in the mathematical sciences. The Applied Mathematics Perspectives thematic program took place in July 2011, see page 12.



Gene Golub Summer School, University of British Columbia.



Dusa McDuff, PIMS/UBC Distinguished Colloquium



Applied Mathematics Perspectives participants

# Collaborative Research Groups

**PIMS Collaborative Research Groups (CRGs)** develop research and training networks, establishing lasting interdisciplinary links between geographically separate groups of researchers at member universities. Groups organize thematic activities, such as workshops, summer schools and seminars, make joint postdoctoral fellowship (PDF) appointments, and/or develop joint graduate training programs. PIMS has developed 23 CRGs since its inception in areas ranging across all the mathematical sciences. These have served as catalysts for producing mathematical research of the highest quality in Western Canada and attracting outstanding faculty to PIMS universities.

**The Operator Algebras and Non-commutative Geometry CRG** concluded in 2011. This group was led by Douglas Farenick (U Regina), Marcelo Laca (UVic), Anthony Lau (U Alberta) and Ian Putnam (UVic). They engaged 3 postdocs, 17 graduate students and welcomed many world leaders in non-commutative geometry including Joachim Cuntz. Amongst other accomplishments, their work has stimulated a wider interest in research on the interface between  $C^*$ -algebras and number theory.

## Applied and Computational Harmonic Analysis (2011-2014)

Applied and Computational Harmonic Analysis is an interdisciplinary branch of modern mathematics and is concerned with the applied and computational aspects of harmonic analysis and approximation theory, with special emphasis on wavelet analysis, time-frequency analysis, redundant representations, and their applications in many areas such as signal/image processing, computer graphics, and numerical algorithms in scientific computing. Many problems in sciences and applications are multiscale in nature. One of the core goals of applied and computational harmonic analysis is to develop and study various mathematical multiscale based methods that can represent and approximate a given set of functions/signals/data efficiently and sparsely with fast algorithms. This CRG held two flagship events in 2011, The International Conference on Applied Harmonic Analysis and Multiscale Computing (July 25-28, 2011) at the University of Alberta, Edmonton and a summer school which followed.

This CRG is led by Bin Han (U Alberta), Rong-Qing Jia (U Alberta), Elena Braverman (U Calgary) and Ozgur Yilmaz (UBC).

## CRG Leaders



Bin Han  
(U Alberta)



Rong-Qing Jia  
(U Alberta)



Elena Braverman  
(U Calgary)



Ozgur Yilmaz  
(UBC)

# Collaborative Research Groups

## Mathematics of Quantum Information (2010–2013)



CRG visitor, David Kribs  
(U Guelph).

The PIMS CRG for the Mathematics of Quantum Information, established in 2010, comprises quantum information groups at the Universities of British Columbia, Calgary, Washington and Simon Fraser University.

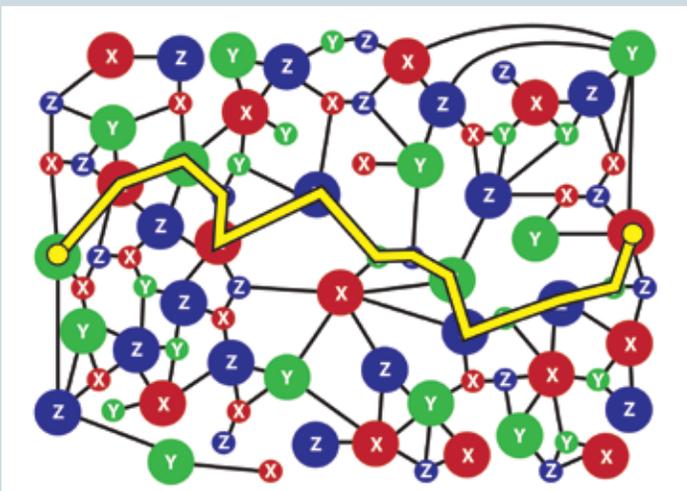
The group is quite active with team members visiting each other, plus attracting top visitors including Fernando Brandão from Brazil's Universidade Federal de Minas Gerais, David Kribs from Guelph, Patrick Hayden from McGill and Netanel Lindner from Caltech.

The CRG works at the forefront of mathematical quantum information with several significant results. These advances include non-randomized construction of highly entangled subspaces, a proof that the Affleck-Kennedy-Lieb-Tanaka states in condensed matter physics are a universal resource for quantum computation by local measurement, a closed formula for relative entropy of entanglement in all dimensions, and an efficient algorithm for optimizing adaptive quantum metrology processes. Major efforts are underway on quantum error control codes especially concerning the LU-LC conjecture.

### Research Impacts:

#### Affleck-Kennedy-Lieb-Tasaki State on a Honeycomb Lattice is a Universal Quantum Computational Resource

*Robert Raussendorf and his colleagues Tzu-Chieh Wei and Ian Affleck at the University of British Columbia showed that Affleck-Kennedy-Lieb-Tasaki states, which are ground states of a simple, highly symmetric Hamiltonian, can serve as a universal resource for quantum computation by local measurement. Their result, which makes use of percolation theory, opens the possibility that universal computational resources could be obtained simply by cooling.*



#### References:

R. Raussendorf, T.C. Wei, I. Affleck  
Affleck-Kennedy-Lieb-Tasaki State on a Honeycomb Lattice is a Universal Quantum Computational Resource.

#### See:

<http://prl.aps.org/abstract/PRL/v106/i7/e070501>

For more research impacts please visit [www.pims.math.ca](http://www.pims.math.ca).

# Collaborative Research Groups

## L-functions and Number Theory (2010–2013)

Number theory is a subject as diverse as it is ancient, and this diversity is well represented in the mathematics departments of PIMS universities. These universities are home to academics with expertise in algebraic and analytic number theory, arithmetic algebraic geometry, computational number theory, number theoretic cryptography and information security, and representation theory, and have long-held reputations for producing cutting-edge research in these fields.

2011 event highlights included Analytic Aspects of  $L$ -functions (May 29 - June 3, 2011), one of the CRG's flagship events. This event featured Number Theory celebrities Brian Conrey (AIM), Ram Murty (Queen's University) and Kanaan Soundararajan (Stanford University) and a special session at the CMS (Canadian Mathematical Society) Summer Meeting titled Number Theory and  $L$ -functions. These sessions brought together gifted postdocs and talented young faculty in order to make professional connections, foster future collaboration, and – of course – share their latest research.

CRG activities were also coordinated with the Banff International Research Station (BIRS) with the fourth installment of Alberta Number Theory Days, the BIRS workshop on  $L$ -packets, Women in Numbers and a workshop entitled, Cycles on Modular Varieties.

## CRG Visitors



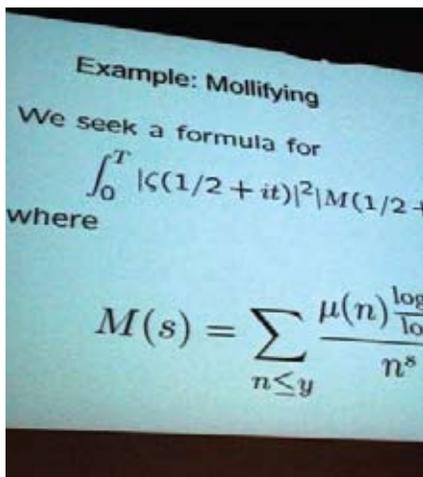
Brian Conrey  
(AIM)



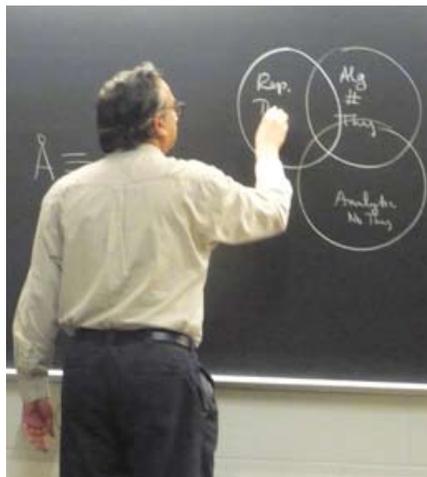
Ram Murty  
(Queen's University)



Kanaan Soundararajan  
(Stanford University)



Analytic Aspects of L-functions



# *International Graduate Training Centre in Mathematical Biology*



IGTC Director, Dan Coombs

**The PIMS vision for creating the International Graduate Training Centres (IGTC) is to “Seize scientific leadership on the world stage and to launch a strategic training program in emerging areas in mathematics.”** This is to be achieved through training a generation of researchers in the application of new mathematics to present-day global problems. The PIMS IGTC in Mathematical Biology was created in 2007. This year, founding director Mark Lewis handed over his position to Dan Coombs at the University of British Columbia.

The 2011 IGTC Research summit was held in conjunction with the large Applied Mathematics Perspectives thematic program at the University of Victoria in July 2011. During the summit IGTC graduate students discussed and presented their posters and research and had the opportunity to interact with some of the leading researchers in mathematical biology. Seven students, including those pictured graduated from the IGTC program.



Betsy Varughese, IGTC Graduate



Ulrike Schlagel,  
IGTC Graduate



Ben (John) Wilson,  
IGTC Graduate



Cory Simon,  
Poster Contest Winner



Bernhard Konrad, IGTC Graduate

## PIMS is proud to support IGTC student Anastasia Lukyanova

“My research is focused on mathematical modeling of the composting process. I work in collaboration with the Edmonton Waste Management Center of Excellence, a non-profit organization that connects researchers and industry to meet waste management challenges. I have developed a spatial PDE model that predicts temperature, oxygen concentration, and air flow in a compost pile to allow for better process control and optimization.

The PIMS IGTC in Math Biology has been an integral part of my graduate experience. Through my participation in IGTC summits, I had an opportunity to learn about current mathematical biology research. It has been invaluable for me to connect with other students participating in the program, discover their work, and share our experiences. The financial support of PIMS has allowed me to devote more time and energy to my research.”



# Education

**An integral part of the PIMS mandate is to enrich public awareness of mathematics through outreach and to enhance mathematical training for teachers and students in K-12.** PIMS is nurturing the pipeline of younger generations in Western Canada, including those with First Nations backgrounds. PIMS promotes numeracy as an integral part of development and learning.

- PIMS supported Math Manias continue to be a popular event at elementary schools. The largest Math Mania was held in February 2011 at École Glen in Coquitlam, BC.



- PIMS supports several math and science competitions as well as summer camps throughout Western Canada.



- PIMS also runs teacher workshops and conferences. Many teacher workshops take place in rural areas such as Lytton and Moricetown, BC. The annual *Changing the Culture* conference continues to bring math educators together for a day of learning and discussion.



- PIMS has developed a partnership with First Nations schools in Alberta, Saskatchewan and British Columbia, with the aim of providing aboriginal students with the tools they need to make their own career choices.



# Postdoctoral Fellows

**Every year PIMS sponsors numerous postdoctoral fellows (PDFs), attracting outstanding young scientists who contribute to PIMS research programs, many of whom later become faculty members at Canadian universities.** PDFs are distributed throughout PIMS sites on a competitive basis. In addition, each CRG is allocated several PDFs, the selection of which is determined by an assessment panel. In 2011 PIMS supported a total of 39 PDFs at 7 PIMS sites.

**2011 incoming postdocs:** Christiane Lammersen (SFU), Ori Gurel-Gurevich (UBC), Claude Warnick (U Alberta), George Giakkoupis, (U Calgary), Shahla Nasserar (U Regina), Oluwaseun Sharomi, (U Saskatchewan), Hung Minh Phan (UBCO/UVic).

**CRG postdocs:** Jun Kitigawa (UBC), Ce Bian (U Calgary), David Roe (U Calgary), Christopher Marks (U Alberta), Collin Trail (U Calgary), Vlad Gheorghiu (U Calgary), Vijaykumar Singh (SFU), Maritza Hernandez (UBC), Kun Wang (U Alberta), Enrico Au-Yeung (UBC).

## Featured Postdoctoral Fellow: Ori Gurel-Gurevich

“I’ve completed my Ph.D. at Weizmann Institute of Science in Israel, under the supervision of Prof. Itai Benjamini. I’ve been interested in many aspects of Probability theory and related fields, such as randomized algorithms and game theory, but I find that the subfields I like most are those which are most general and simple. In the case of probability, this means the theory of simple random walks on general graphs.

Before coming to UBC, I spent 2 years as a postdoc at the theory group at Microsoft Research in Seattle. Although most of the work there was theoretical, like at any university, I enjoyed some of the questions we got from the more applied departments, which turned into interesting mathematical problems.

Currently, I am most interested in harmonic functions on general Markov chains’ state space. It seems that not much is known about that, and I hope to gain some understanding of the topic. In my spare time, I play classical guitar and am trying to raise two future mathematicians.”



# 2011 Prizes & Awards

## CRM - Fields - PIMS Prize

### Mark Lewis (University of Alberta)

The CRM-Fields-PIMS Prize is the premier Canadian award for research achievements in the mathematical sciences. Professor Mark Lewis is a faculty member at the University of Alberta, where he holds the Canada Research Chair in Mathematical Biology. Professor Lewis' research is in mathematical biology and ecology, including modelling and analysis of nonlinear PDE and integral models in population dynamics and ecology. Applications made to case studies with detailed data and biology, include wolf territories, elk migration in Yellowstone Park, spatial spread and impact of introduced pest species, vegetation shift in response to climate change and recolonization of Mount St. Helens.



## CAIMS/PIMS Early Career Award in Applied Mathematics

### Adam Oberman (Simon Fraser University)

This award recognizes outstanding research in any branch of applied mathematics. Professor Adam Oberman is an exceptional researcher who ranks among the top young applied mathematicians in the world today. Professor Oberman brings his abilities as a mathematical analyst and computational scientist to bear on some of the most difficult and timely problems in nonlinear partial differential equations (PDEs). He has made fundamental contributions to a diverse set of problems in this field, including numerical methods for nonlinear PDEs, numerical solvers for the Monge-Ampere equation, and numerical homogenization. His work is having a profound influence on a number of problems in mathematical analysis and numerical computing.



## PIMS Education Prize

### Veselin Jungic (Simon Fraser University)

This prize recognizes individuals who have played a major role in activities which have enhanced public awareness and appreciation of mathematics. Dr. Veselin Jungic's contributions to outreach include his prominent role in "Taste of Pi", a PIMS/SFU enrichment program for high school students and the co-development of a distance-education version of introductory calculus in which lectures are available as video streams. He has played a leading role in SFU Aboriginal university preparation programs and setting up mentorship programs for Aboriginal students at the Vancouver Friendship Center and at the Native Education College. Recently he has co-authored and produced a series of stories based on mathematical adventures of a young First Nations boy named 'Small Number'. These are available in Blackfoot, Cree, Squamish and are available on [www.mathtube.org](http://www.mathtube.org).



*PIMS is grateful to CGG Veritas & Hampson-Russell for sponsoring this award.*

# Hugh C. Morris Lecture Series



L-R: Hugh Morris, George Papanicolaou, Brian Russell (PIMS Board President), Alejandro Adem (PIMS Director)

**PIMS was proud to present the inaugural lecture in the new Hugh C. Morris Lecture series on November 7, 2011.** In a hall packed with students and faculty from many different disciplines this lecture was given by Stanford University's George Papanicolaou.

His talk, which was brilliantly conceived and masterfully delivered, dealt with two mathematical problems of increasing importance: Uncertainty Quantification and Systemic Risk. The lecture was built on an elegantly simple three-parameter system of stochastic differential equations that contained three essential components: stochastic forcing, a term that drove each member of the population toward the mean, and a term that characterized the potential of interaction between two stable states, one desirable and the other not so.

The objective is to understand complex systems that operate in regimes where small changes in parameters can lead to very different solutions, which in turn leads to systemic risk analysis, i.e. the calculation of probabilities that a large number of components in a complex, interconnected system will fail simultaneously. While the model is very general, Professor Papanicolaou couched the discussion in terms of financial systems in which the components are banks that assume a certain risk and are subject to nonlinear couplings between them, thus connecting the mathematics with a concrete and timely example to which everyone could relate.

*This lecture series was made possible by an endowment from Dr. Hugh Morris, former Board Chair and longtime friend of the mathematical sciences.*



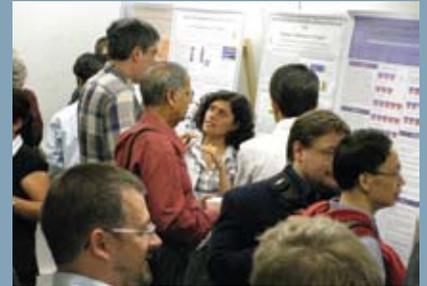
Lecture attendees: Dr. Gregory Miermont (CNRS visitor), Roland Bauerschmidt (graduate student) and Dr. Gordon Slade (UBC Mathematics Professor and Associate Head for Research).

# Applied Mathematics Perspectives

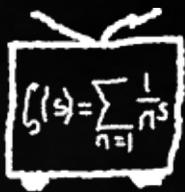
**Approximately 250 people from around the world attended Applied Mathematics Perspectives on the UBC campus, July 13-17, 2011.** Seven workshops targeted diverse areas of applied mathematics including imaging, fluid mechanics, delay differential equations, numerical solutions of differential equations, Ricci flows and reproducible research.



Two further workshops were held at University of Victoria and an additional two at BIRS. This sequence was a satellite event to the large ICIAM meeting and allowed a greater focus in concentrated areas. PIMS, MITACS, BIRS and CAIMS/SCMAI were coorganisers of the events, with additional travel support from NSF.



As well as diversity in subject and application, coordination of the workshops to run simultaneously allowed cross-pollination of ideas over communal lunches, coffee breaks and social events. A number of participants presented their work in more than one workshop and junior participants presented their work in a joint poster session.



[www.mathtube.org](http://www.mathtube.org)

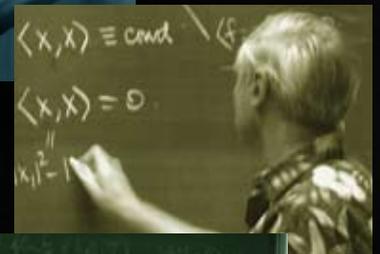
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Featuring world-class speakers from all areas of the mathematical sciences.

Check it out today!

[www.mathtube.org](http://www.mathtube.org)



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# 2012 Event Highlights

## EVENTS, CONFERENCES AND WORKSHOPS

3 - 4 February	<b>Colloquiumfest</b> University of Saskatchewan	11 - 12 June	<b>The Stability of Coherent Structures and Patterns</b> University of Washington
22 - 24 February	<b>Monte Carlo Methods in Mathematical Finance</b> , Vancouver	17 - 22 June	<b>Canadian Number Theory Association Conference</b> University of Lethbridge
25 February	<b>Dispersive PDE</b> University of Victoria	18 - 27 June	<b>Math Modelling in Industry Workshop</b> University of Calgary
26 - 29 April	<b>26th Automorphic Forms Workshop</b> University of British Columbia	11 - 15 July	<b>Canadian Undergraduate Mathematics Conference</b> University of British Columbia, Okanagan
28 - 29 April	<b>Cascade Topology Seminar</b> University of British Columbia	27 July - 5 August	<b>Cohomology and support in representation theory and related topics</b> University of Washington
2 - 5 May	<b>PIMS Young Researchers Conference</b> University of Calgary	26 - 28 September	<b>Disease Dynamics 2012: Immunization, a true Multiscale Problem</b> University of British Columbia
3 - 4 May	<b>Alberta Colleges Mathematics Conference &amp; North South Dialogue in Mathematics</b> University of Alberta	12 - 14 October	<b>PIMS International Graduate Training Centre (IGTC) Summit</b> Naramata, BC
4 - 5 May	<b>2012 Prairie Discrete Math Workshop (PDMW)</b> University of Calgary	17 November	<b>Combinatorial Potlatch 2012</b> Simon Fraser University
12 - 13 May	<b>Western Canada Linear Algebra Meeting 2012</b> University of Lethbridge		
29 May - 1 June	<b>Connections Between Algebra and Geometry</b> University of Regina		

## SUMMER SCHOOLS

3 - 13 May	<b>The Second PIMS-Mprime-CDM Summer School on Mathematical Modelling of Infectious Diseases</b> University of Alberta	2-13 July	<b>2012 AMSI/ANU/UQ Winter School on Geometric Partial Differential Equations</b> University of Queensland, Australia
4 - 29 June	<b>PIMS-Mprime Summer School on Probability</b> University of British Columbia	16 - 21 July	<b>West Coast Algebraic Topology Summer School</b> Stanford University
25 June - 6 July	<b>Probabilistic Combinatorics Summer School</b> SMS/Université de Montréal	23 - 27 July	<b>Fluid Dynamics Summer School</b> University of Alberta
1 - 28 July	<b>PIMS-SFU Undergraduate Summer School in Algebraic Graph Theory</b> Simon Fraser University	29 July - 10 August	<b>Gene Golub Summer School</b> Monterey, California
		12 - 25 August	<b>Two Weeks at Waterloo</b> A Summer School for Women in Math University of Waterloo

## PUBLIC LECTURES

30 March	<b>Kenneth Golden</b> University of British Columbia
4 April	<b>Stevo Todorovic</b> (CRM-Fields-PIMS Prize Lecture) University of British Columbia
19 April	<b>Robert Lang</b> University of British Columbia

## COLLABORATIVE RESEARCH GROUPS

2012 - 2015	<b>Optimization: Theory, Algorithms and Applications</b>
2011 - 2014	<b>Applied and Computational Harmonic Analysis</b>
2010 - 2013	<b>L-functions and Number Theory</b>
2010 - 2013	<b>Mathematics of Quantum Information</b>

# Pacific Institute *for the* Mathematical Sciences



Thank you to:

