



PIMS

CRGs 2008 — 2014 Executive Summaries

## CRG 14: Differential Geometry and Analysis 2007-2010

### CRG Leaders:

Jingyi Chen (UBC)  
Ailana Fraser (UBC)

### Abstract:

Geometric analysis is a broad field that basically involves using analytic methods to solve geometric problems. An astonishing recent achievement is the resolution of the Poincaré conjecture via the Ricci flow. Many results and techniques in geometric analysis which were developed in the past four decades or so played important roles in the proof.

Constructing special submanifolds such as minimal surfaces and constant mean curvature surfaces is an important and classical topic in differential geometry with applications in topology and physics (e.g. the theory of general relativity). These surfaces are characterized by nonlinear partial differential equations that are difficult to solve in general. Douglas-Morrey's solution to the Plateau problem is perhaps the first major advance. One may use the gluing method (a delicate application of the implicit function theorem), variational methods (such as the min-max principle or minimizing certain functionals, e.g. Sacks-Uhlenbeck's perturbed energy functional) and the heat flow method (e.g. the mean curvature flow). Usually, singularities are developed in these constructions and geometric measure theory then plays a key role in analyzing them, such as discerning the size and structure of the singular set.

This CRG focused on using geometric analysis to develop further insight into geometric flows and applications to minimal, calibrated, and special Lagrangian submanifolds.

### Events:

1. [\*Pacific Northwest Geometry Seminar\*](#), UBC, May 2-3, 2009
2. *PIMS Distinguished Chair: Richard Schoen*, UBC, July 14-30, 2010
3. [\*PRIMA Conference on Geometric Analysis\*](#), UBC, July 20-30, 2010

### Postdoctoral Fellows:

Weiyong He (UBC)  
Leobardno Rosales (UBC)  
Tobias Lamm (UBC)

This CRG ended in 2010.

## CRG 15: Environmetrics – Georisk and Climate Change 2007-2010

### CRG Leaders:

Jim Zidek (UBC)  
Charmaine Dean (SFU)  
Sylvia Esterby (UBC-O)  
Peter Guttorp (UW)

### Abstract:

The eventual goal of this project was to develop a multi-site, distributed environmetrics research centre. The main research themes were: statistical and deterministic models in georisk analysis; modeling space-time fields; agroclimate risk analysis; environmental quality assessment, with emphasis on water and linkages to agriculture and species at risk; and modeling changes in the diversity and structure of forests as a consequence of climate change. This CRG has enabled the statistics community in the Pacific Northwest to address important environmental questions where deterministic and statistical models are critically important. It was based at UW, UBC and SFU.

### Events:

1. [\*Climate Change Impacts on Ecology and the Environment\*](#), UA, May 4-10, 2008
2. [\*19th Annual Conference of the International Environmetrics Society\*](#), UBC-O, June 8-13, 2008
3. [\*The International Graduate Summer School on Statistics and Climate Modeling\*](#), National Center for Atmospheric Research August 9 - 13, 2008
4. [\*Intensive Course For Young Researchers on Statistical Software For Climate Research\*](#), Sliema, Malta, March 16-17, 2009
5. [\*Interdisciplinary Workshop on the Effects of Climate Change: Coastal Systems, Policy Implications, and the Role of Statistics\*](#), Sliema, Malta, March 18-20, 2009.
6. [\*Workshop on the Creation of a PIMS Environmetrics Research & Training Centre\*](#), SFU, April 10, 2010

### Postdoctoral Fellows:

Yiping Dou (UBC)  
Zuzana Hrdlickova (UBC)

**Status:** This CRG ended in 2010.

## CRG 16: Mathematical Problems in Climate Modeling – Multiscale Processes in the Tropics 2007-2010

### CRG Leaders:

Boualem Khouider (UVic)  
Adam Monahan (UVic)

### Abstract:

This CRG was a multidisciplinary effort bringing together mathematicians and earth/ocean scientists to understand some of the many outstanding problems in climate modeling and numerical weather prediction. Particular emphasis was placed on multiscale processes in the tropics, to bridge the gap between idealized models and the general circulation models used by government forecasters. Main objective were to provide a venue for mathematicians and atmospheric scientists to interact, as well as to train young researchers in a fully interdisciplinary setting. It was based at UV, the Canadian Centre for Climate Modeling and Analysis (CCCMA), SFU, UA and UBC.

### Events:

1. [\*Summer School on Stochastic and Probabilistic Methods for Atmosphere, Ocean, and Climate Dynamics\*](#), UVic, July 14-18, 2008
2. [\*Workshop on Stochastic and Probabilistic Methods for Atmosphere, Ocean, and Climate Dynamics\*](#), UVic, July 21-23, 2008
3. [\*Workshop on Multiscale Processes in the Tropics\*](#), BIRS, April 27–May 1, 2009
4. [\*Distinguished Visitor: George Kiladis\*](#) (NOAA), July, 2010

### Postdoctoral Fellows:

Michael Waite (UV)  
Ian Ross (UV)

**Status:** This CRG ended in 2010.

## **CRG 17: Interdisciplinary Research in Geophysical and Complex Fluid Dynamics 2007 - 2010**

**CRG Leaders:** Neil Balmforth (UBC)

Mark Jellinek (UBC)

**Abstract:**

The primary focus of this CRG was the mathematical modeling of complex and classical geophysical fluid dynamics, which are key elements in many geophysical phenomena such as volcanic eruptions, mud slides and avalanches. Bringing sophisticated mathematical and computational elements to bear on these problems was the main motivation for this project, which involved geophysicists as well as applied mathematicians. Particular emphasis was on complex geophysical fluids, multiphase flow in volcanic systems, waves in geophysical fluids, and particle-driven phenomena. It was based at UA, UBC and SFU.

**Postdoctoral Fellows:** Guillaume Carrazo (UBC)

**Status:** This CRG ended in 2008.

# CRG 18: Bayesian Modelling and Computation for Networks 2007 - 2010

**CRG Leaders:** Raphael Gottardo (UBC)

Kevin Murphy (UBC)

## **Abstract:**

This PIMS-funded collaborative research group focused on Bayesian methods for network analysis, paying special attention to model design and computational issues of learning and inference. Bayesian inference is an approach to statistics in which all forms of uncertainty are expressed in terms of probability. Non-Bayesian approaches to inference have dominated statistical theory and practice for most of the past century, but the last two decades have seen a reemergence of Bayesian statistical inference. This is mainly due to the dramatic increase in computer power and the availability of new computational tools, including variational techniques, Markov chain Monte Carlo (MCMC) and sequential Monte Carlo (SMC). Bayesian modeling has become common practice as it provides a powerful method for coping with very complex stochastic domains, including networks. Networks are widely used to represent data on relations between interacting actors or nodes. Among many things, they can be used to describe social networks, genetic regulatory networks, computer networks, and sensor networks. In these settings, traditional independence assumptions are blatantly inappropriate; the structure of relationships between the data must be taken into account. As a result, there has been increasing research developing techniques for incorporating network structures into machine learning and statistics. This collaborative research group brought together researchers resulting in novel modeling approaches, diverse applications, and new research directions. In particular we will focus on three main problems: social networks, regulatory networks and sensor networks. Even though the three problems share many similar features, both in terms of modeling and computation, they are usually treated separately.

## **Events:**

1. [\*Summer School on Bayesian Modelling and Computation\*](#), UBC, July 14 - 18, 2008
2. [\*NIPS Workshop on "Adaptive Sensing, Active Learning and Experimental Design: Theory, Methods and Applications."\*](#) Whistler, BC, December 11, 2009
3. *Distinguished Visitor*: Prof. Sylvia Richardson (Imperial College, London), UW, October, 2010
4. [\*Modelling and Computation for Social Networks\*](#), Whistler, BC, June 21 - 25, 2010
5. [\*Social Networks Workshop\*](#), Whistler, BC, June 26 – 27, 2010
6. *Visitors*: Francesca Dominici and Giovanni Parmigiani (Biostatistics, Harvard), April, 2010

## **Postdoctoral Fellows:**

Ben Marlin (UBC)

Francois Caron (UBC)

**Status:** This CRG ended in 2010.

# CRG 19: Partial Differential Equations 2008 - 2010

**CRG Leader:** Nassif Ghoussoub (UBC)

**Abstract:** Partial Differential Equations is a large subject with a history that dates back to Newton and Leibniz. They form the basis for many mathematical models in the sciences and in economics, yielding such famous examples as Euler's, Schrodinger's and Einstein's equations. Moreover, the subject is far more than just a mathematical tool to address physical and economic phenomena; PDE's have guided and created the fields of nonlinear functional analysis, harmonic analysis, optimization and the modern calculus of variations, and have had a major impact on the field of geometry. This CRG focused on several key areas:

- Geometry and analysis of dispersive equations
- Regularity for solutions of certain fundamental equations (Navier-Stokes, harmonic measures, the infinity Laplacian)
- The role of hyperbolic problems in traffic flow, kinetic theory, and the material sciences
- Modern approaches to asymptotic analysis in the calculus of variations and applications
- General variational principles
- Universal inequalities in relevant function spaces
- The role of game theory and stochastic methods in certain elliptic and parabolic equations

## Events:

1. [\*Workshop on Variational Methods and Nash-Moser\*](#), UBC, June 16 - 22, 2008
2. [\*8th Pacific Northwest PDE Meeting\*](#), UBC, January 17, 2009.
3. [\*Workshop on "Theory and Applications of Classical and Quantum Kinetic Theory"\*](#), BIRS, June 21 -26, 2009
4. [\*Workshop on "Topics in Kinetic Theory."\*](#) University of Victoria, June 29 - July 3, 2009
5. [\*Workshop on "Asymptotic analysis in the calculus of variations and PDEs."\*](#) UBC, July 6 -10, 2009
6. [\*Workshop on "Multiscale Analysis of Self Organization in Biology."\*](#) BIRS, July 12 -17, 2009
7. [\*Workshop on "Analysis of Nonlinear PDEs and Free boundary Problems: Applications to Homogenization."\*](#) UBC, July 20 - 24, 2009
8. [\*Workshop on "New Connections Between Differential and Random Turn Games, PDE's and Image Processing."\*](#) UBC, July 27- 31, 2009
9. [\*Workshop on "Regularity Problems in Hydrodynamics."\*](#) UBC, August 3-7, 2009
10. [\*Analysis of Nonlinear Wave Equations and Applications in Engineering\*](#), BIRS, August 10 - 14, 2009
11. [\*Workshop on "Nonlinear Dispersive and Geometric Evolution Problems: Singularities and Asymptotics."\*](#) UBC, August 17 - 21, 2009
12. [\*Mini-symposium in PDE\*](#), UBC, November 12 - 13, 2009
13. [\*Second PRIMA-PARC-PIMS Meeting on PDEs\*](#), Seoul National University, August 25 - 2, 2011

## Postdoctoral Fellows:

Yves van Gennip (SFU)  
Mohammad El Smaili (UBC)  
Ian Zwiars (UBC)  
Vianney Combet (UBC)  
Jun Kitigawa (UBC)

**Status:** This CRG ended in 2011.

# CRG 20: Operator Algebras and Non-Commutative Geometry 2009 - 2012

**CRG Leaders:** Douglas Farenick (University of Regina)

Marcelo Laca (UVic)

Anthony Lau (UA)

Ian Putnam (UVic)

**Abstract:** The subject of operator algebras has its origins in the work of Murray and von Neumann concerning mathematical models for quantum mechanical systems. During the last thirty years, the scope of the subject has broadened in a spectacular way and now has serious and deep interactions with many other branches of mathematics: geometry, topology, number theory, harmonic analysis and dynamical systems.

Alain Connes' program of non-commutative geometry is based on the fact that any commutative  $C^*$ -algebra is isomorphic to an algebra of continuous functions on some space. The aim of the program is to develop the tools of geometry in the setting where a commutative algebra of functions is replaced by a non-commutative algebra of operators.

## Events:

1. [\*37th Canadian Operator Symposium\*](#), University of Regina, May 26 - 30, 2009
2. [\*KMS States and Non-Commutative Geometry\*](#), UVic, June 29 - July 10, 2009
3. [\*Northwest Functional Analysis Seminar\*](#), Banff, Alberta, October 16 - 18, 2009
4. [\*Workshop on Non-commutative Dynamics and Quantum Probability\*](#), University of Regina, May 14 -17, 2010
5. [\*Summer School on Operator Algebras and Non-commutative Geometry\*](#), UVic, June 14 - 25, 2010
6. [\*Conference on Selected Topics in Non-commutative Geometry\*](#), UVic, June 27 - July 2, 2010
7. *Distinguished Chair: Joachim Cuntz* (U. Munster), UVic, November, 2010
8. [\*Canadian Operator Symposium\*](#), University of Victoria, May 24 - 28, 2011
9. *PIMS Distinguished Lecturer: Jean Bellissard* (Georgia Institute of Technology), UVic, October, 2011
10. *PIMS Distinguished Lecturer: Vern Paulsen* (U of Houston), University of Regina, March, 2012
11. *Visitors* (2010): Astrid an Huef and Iain Raeburn (University of Otago, June 26 - July 9), Jerry Kaminker (Indiana U. - Purdue U. Indianapolis, June 26- July 9, 2010)
12. *Visitors* (2011): A. an Huef & I. Raeburn (U of Otago, September), J. Kellendonk (U de Lyon, October), J. Savinien (Georgia Institute of Technology, October), M. Ramirez-Solano (U of Copenhagen, January-August)
13. *Visitors* (2012): Chris Skau (Trondheim, Spring), and Klaus Thomsen (Aarhus, Spring)

## Postdoctoral Fellows:

Antoine Julien (UVic), Bogdan Nica (UVic), Michael Yin Hei Cheng (UA)

**Highlights:** The *Operator Algebras* CRG has led to a great increase in activity around  $C^*$ -algebras from number theoretic systems. In particular it motivated a focused workshop which took place in Münster in December, 2011, an Oberwolfach work-shop on the subject to be held in April, 2012, and a workshop at BIRS taking place in November, 2013. A paper by D. Farenick and V. Paulsen offered potential new approaches to the Connes Embedding Problem. Research by J. Cuntz, C. Deninger, and M. Laca has already had a significant impact and sparked research in several directions in the area of  $C^*$ -algebras of Toeplitz type.

**Status:** This CRG ended in 2012.



# CRG 21: L-functions & Number Theory

## 2010 - 2013

**CRG Leader:** M. Greenberg (UC)

**Abstract:** 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. We feel the time is ripe to bring all of these mathematicians together, again under the umbrella of a PIMS CRG.

### Events:

1. *West End Number Theory Seminar*, University of Calgary, March 6, 2010
2. [\*PIMS Calgary CRG Launch 2010\*](#), University of Calgary, April 6, 2010
3. [\*Alberta Number Theory Days\*](#), Banff, April 3 - May 2, 2010
4. Visitors: Hugo Chapdelaine (U. Laval), December 14 -19, 2010
5. [\*Alberta Number Theory Days\*](#), Banff, June 17-19, 2011
6. *UBC-SFU Number Theory Seminars*, 2011-2013
7. [\*Analytic Aspects of L-functions and Applications to Number Theory\*](#), UC, May 29 - June 3, 2011
8. [\*Special Session in Number Theory\*](#), CMS Summer Meeting, UA, June 3 – 5, 2011
9. [\*L-packets\*](#), Banff, June 26 - July 1, 2011
10. [\*Workshop on “Cycles on Modular Varieties.”\*](#) Banff, October 30 - November 4, 2011
11. [\*WIN2: Women in Numbers\*](#), Banff, November 6 – 11, 2012
12. Visitors: Noam Elkies (Harvard), David Roe (Harvard), Pierre Charollois (Jussieu), Cameron Franc (McGill), Paul Mezo (Ottawa), Hadi Salmasian (Ottawa), Pramod Achar (LSU), Samit Dasgupta (UCSC), 2011
13. [\*12th Canadian Number Theory Association Meeting \(CNTA XII\)\*](#), U Lethbridge, June 17- 22, 2012
14. *West End Number Theory Seminas*, 2012-2013
15. Visitors: N. Elkies (Harvard), P. Charollois (Jussieu), C. Franc (McGill), P. Mezo (Ottawa), H. Salmasian, (Ottawa), P. Achar (LSU), S. Dasgupta (UCSC), 2012
16. [\*Sage Days 36: p-adics in Sage\*](#), UC San Diego, February 19 – 23, 2013

### Postdoctoral Fellows:

Johnson Jia (UBC), Christopher Marks (UA), Bian Ce (UC), David Roe (UC)

**Highlights:** The L-functions and Number Theory CRG had a full slate of focused activities in 2011, coordinating workshops at Calgary with previously scheduled workshops at BIRS, as well as a special session at the Canadian Mathematical Society Summer Meeting in Edmonton. The Calgary meeting featured lecture series by three top number theorists: B. Conrey (AIM), R. Murty (Queens), and K. Soundararajan (Stanford). The workshop on L-Packets featured several invited lectures by J. Arthur, who took this opportunity to announce a new major result in the full local Langlands correspondence. From June 17 through June 22, 2012, the CRG hosted its premiere event - the 12th Meeting of the Canadian Number Theory Association (CNTA 12) at the University of Lethbridge.

**Status:** This CRG ended in 2013.

## CRG 22: The Mathematics of Quantum Information 2010 - 2013

**CRG Leaders:** Barry Sanders (UC)

Robert Raussendorf (UBC)

Petr Lisonek (SFU)

Dave Bacon/Aram Harrow (UW)

### Abstract:

Quantum information science is an interdisciplinary research endeavour that brings together computer scientists, mathematicians, physicists, chemists, and engineers to develop revolutionary information processing and communication technologies that are infeasible without exploiting the principles of quantum mechanics. The importance of quantum information was first widely recognized in 1982 when Feynman conjectured that a quantum computer would efficiently simulate quantum systems, and a universal Turing machine (“classical computer”) could not. Quantum cryptography has since become commercial technology that can enable information-theoretic security over public channels.

### Events:

1. [\*10th Canadian Summer School on Quantum Information\*](#), UBC, July 17 - 30, 2010
2. [\*Workshop on “Quantum Algorithms, Computational Models, and Foundations of Quantum Mechanics.”\*](#) UBC, July 23 - 25, 2010
3. *Quantum Information Seminar Series* (multiple dates), UC, 2010 -2013
4. [\*13th Canadian Summer School on Quantum Information\*](#), UC, June 17 - 21, 2013
5. [\*Canadian Quantum Information Students' Conference\*](#), UC, June 24 -28, 2013
6. [\*Quantum Information and Foundations of Quantum Mechanics\*](#), UBC, July 2 - 5, 2013

### Postdoctoral Fellows:

R. Dridi (UC)

V. Gheorghiu (UC)

M. Hernandez (UBC)

N. Lovett (UC)

V. Singh (SFU)

C. Trail (UC)

Y. Wang (UC)

**Highlights:** Two key breakthroughs came in 2010. One, due to B. Sanders and collaborators at UC, elucidated the metabolic process of electron transfer between proteins and was published in the *Proceedings of the National Academy of Sciences*. On the experimental side, long-distance quantum communication took a leap forward with W. Tittel’s group’s demonstration of entangled light storage and release using solid state systems. This work was published in *Nature*. To top things off, A. Lvovsky, one of the CRG faculty members, was given the *International Quantum Communication Award*. 2011 advances include the non-randomized construction of highly entangled subspaces, and a proof that the Affleck-Kennedy-Lieb-Tasaki states in condensed matter physics are a universal resource for quantum computation. Much progress was also made on quantum error correction. The CRG helped attract new faculty in experimental quantum information to UW (P. Barclay). In 2012, quantum simulation commenced for open quantum systems.

**Status:** This CRG will shut down at the end of March, 2014.

## CRG 23: Applied and Computational Harmonic Analysis 2010 - 2014

**CRG Leaders:** Bin Han (UA)

Rong-Qing Jia (UA)

Elena Braverman (UC)

Ozgur Yilmaz (UBC)

### **Abstract:**

This CRG is concerned with the applied and computational aspects of harmonic analysis and approximation theory. Emphasis is placed on wavelet analysis, time-frequency analysis, redundant representations, and their applications in areas such as signal/image processing, computer graphics, and numerical algorithms in scientific computing. An important goal is to develop and study various mathematical multi-scale based methods that can represent and approximate a given set of functions/signals/data efficiently and sparsely with fast algorithms.

### **Events:**

1. [\*International Conference on Applied Harmonic Analysis and Multiscale Computing\*](#), UA, July 25 - 28, 2011
2. [\*Summer School on Applied and Computational Harmonic Analysis\*](#), UA, July 29 - 31, 2011
3. [\*Alberta-British Columbia Seminar in Harmonic Analysis\*](#), UBC, August 7 - 10, 2012
4. [\*Alberta-British Columbia Seminar in Harmonic Analysis\*](#), UC, August 26 - 30, 2013
5. [\*PIMS-BIRS Workshop: Recent Progress on Applied and Computational Harmonic Analysis\*](#), Banff, August 30 - September 1, 2013

### **Postdoctoral Fellows:**

E. Au-Yeung (UBC)

K. Wang (UA)

Yi Shen (UA)

**Highlights:** The 2011 events above have enabled the CRG to attract the interest of and establish connections with the research groups on machine learning at the Department of Computing Sciences and signal processing at the Department of Physics at UA. At this meeting O. Yilmaz and E. Au-Yeung presented an important result on recovery guarantees in compressed sensing when “jitter sampling”-based Fourier sampler matrices are used for collecting measurements. In addition, Fields Medalist S. Smale lectured on the theory of learning.

In 2012, the CRG focused on the development of numerical algorithms in scientific computing based on spectral methods with grids defined by nonclassical polynomials as well as with Fourier series, splines and wavelets.

**Status:** This CRG is ongoing.

# CRG 24: Optimization Theory, Methods and Applications 2012 - 2015

**CRG Leaders:** Heinz H. Bauschke (UBC-O)

Michael Friedlander (UBC)

Yuriy Zinchenko (UC)

## Abstract:

Optimization is an interdisciplinary area of mathematics and computer science that amounts to choosing the best element from some set of available alternatives and studying its properties. Optimization has become ubiquitous to numerous theoretical and applied research directions of modern mathematics. Here, we understand optimization in its broad sense as a discipline that spans many areas including nonsmooth and convex analysis, numerical analysis, computational complexity theory, and the theory of algorithms. However, despite recent theoretical breakthroughs and the dramatic increase in our computational capacities, there is an urgent need to push the boundaries of our knowledge even further. This urgency is driven not by just our own curiosity but also by many challenging real-world applications such as to classical and biomedical engineering, optimal robust “green” energy dispatch, scheduling, economics and finance, to name but a few.

## Events:

1. [\*West Coast Optimization Meeting\*](#), UW, May 4 - 5, 2012
2. [\*Workshop on Robust Optimization\*](#), Banff, May 25 - 27, 2012
3. [\*Optimization Workshop\*](#), UBC-O, July 9 - 11, 2012
4. [\*West Coast Optimization Meeting\*](#), UBC, October 6, 2012
5. [\*West Coast Optimization Meeting\*](#), UW, May 4, 2013
6. [\*Women Optimize in the West \(WOW\)\*](#), UC, June 13 - 14, 2013
7. [\*Optimization Summer School\*](#), UC, June 14 - 28, 2013
8. [\*PIMS Workshop on Numerical Linear Algebra and Optimization\*](#), UBC, August 8 - 10, 2013
9. [\*West Coast Optimization Meeting\*](#), UV, October 4 - 5, 2013

## Postdoctoral Fellows:

H. Phan (UBC-O)

N. Krislock (UBC)

Ting Kei Pong (UBC)

Nghia Tran (UBC-O)

**Highlights:** A “normal problem” associated with finding a zero of the sum of two maximally monotone operators is introduced. If the original problem admits solutions, then the normal problem returns this same set of solutions. The normal problem may yield solutions when the original problem does not admit any; furthermore, it has attractive variational and duality properties. A comprehensive study of parametrically prox-regular functions was initiated. In addition, probabilistic tail bounds were developed for the stochastic gradient method. The first series of computational validation of the newly proposed moment-based relaxation of the DVH constraints for radiotherapy treatment confirmed the expectations that this is indeed a viable computational approach.

Status: This CRG is ongoing.

## CRG 25: Algorithmic Theory of Networks 2012 - 2015

**CRG Leaders:** Funda Ergun (SFU)  
Petra Berenbrink (SFU)  
Valerie King (UVic)

### Abstract:

As networking technologies evolve, our understanding of computer (and other types of) networks changes in terms of their scale, structure, and functionality. Now, the scientific and technical community is faced with new networking paradigms which are complex, heterogeneous, and data-intensive. The resulting theoretical and practical problems are multifaceted, requiring a wide range of expertise from many fields. In this CRG we bring together researchers from four major universities in Western Canada (Simon Fraser University, University of Victoria, University of Calgary, and University of British Columbia), to investigate these problems. The collaboration will be on the modelling and algorithmic aspects of networks with special emphasis on sensor networks and probabilistic techniques.

The following scientific and technological challenges provide motivation for this work:

- Increased quantities of data
- New constraints on memory and power
- Heterogeneity and unpredictability of networks
- Social nature of networks
- New parallel programming paradigms

### Events:

1. [CRG Kickoff Meeting](#), Victoria, BC, October 9, 2012
2. *Research Meeting and Inaugural Distinguished Lecture*, UBC, December 4 - 5, 2012
3. [3rd Pacific Northwest Theory Days](#), UVic, May 4 - 5, 2013
4. *Summer School on "Randomized techniques for combinatorial algorithms,"* SFU, August 18 - 22, 2014
5. *Workshop on "Big data in networks and distributed systems,"* SFU, Oct 7 - 9, 2014

**Highlights:** CRG leader Valerie King (UVic) won the Best Paper Award at SODA 2013 for "Dynamic Graph Connectivity in Polylogarithmic Worst Case Time" with B. Kapron and B. Mountjoy. During 2012 the CRG researchers established ties and collaborations with UW, UT, U Paderborn, IBM, Dartmouth, UMass, Google and INRIA.

**Status:** This CRG is in progress.

## CRG 26: Geometry and Physics

**CRG Leader:** Chuck Doran (UA)

**Abstract:**

Pure mathematics and fundamental physics, historic partners for centuries, grew apart during the first half of the 20th century. This changed with the emergence of gauge theory in particle physics and, still more strikingly, the string-theoretic approach to quantum gravity. In the 21st century thus far, many of the great insights into geometry have come from physical models formulated in geometric terms.

During 2013-2015, the PIMS CRG in Geometry and Physics will bring hundreds of the world's best researchers in geometry and physics to Western Canada to continue to develop this rich interface.

**Events:**

1. *The Geometry and Physics Seminar Series*, UA & UBC, Fall 2013.
2. *Concentrated Graduate Course on Hodge Theory in String Theory*, The Fields Institute, November 11-15W, 2013.
3. *Workshop on Hodge Theory in String Theory*, The Fields Institute, November 18-22, 2013.

**Status:** This CRG was launched in 2013.