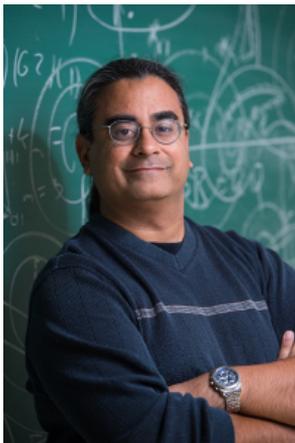




# Newsletter

Summer 2016

## Message from the Director



Greetings, my name is Sanjeev Seahra and I will be the Director of AARMS from 2016-2020. I assume this position as AARMS and the wider mathematical community find themselves on the cusp of an exciting new era of fundamental science inquiry in Canada. I am very much looking forward to assisting the mathematicians and statisticians of Atlantic Canada meet the challenges and exploit the opportunities

on the horizon.

I was born and raised near Toronto and obtained my undergraduate and doctoral degree from the University of Waterloo in theoretical physics. I then spent approximately seven years in the United Kingdom as a postdoctoral fellow at the Institute of Cosmology and Gravitation at the University of Portsmouth. I first came to Atlantic Canada as a postdoc at the University of New Brunswick in 2007, and I am currently an Associate Professor in the Department of Mathematics and Statistics.

I am a theoretical physicist with a keen interest in gravitation and cosmology. I primarily study the interface between Einstein's geometrical theory of gravitation, general relativity, and quantum mechanics. An overriding theme of my research has been obtaining predictions of quantum gravity that stand some chance of being tested by astronomical observations. Such phenomena usually involve early universe cosmology or black holes. The latter are the main focus of the AARMS Collaborative Research Group "The mathematical and physical aspects of black holes" of which I am currently a member.

In the future, I will work to ensure that AARMS has the resources to maintain and expand its already quite successful initiatives. This involves securing stable and direct funding from universities and all levels of government. Active collaboration and cooperation with Canada's other mathematical and

statistical institutes will be a key component in achieving this goal: Our voices are much louder and effective when coupled together.

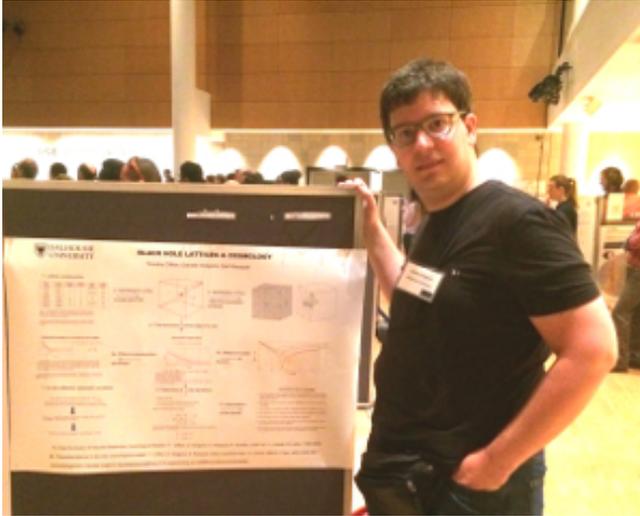
Outreach activities have been occupying an increasingly large part of the Association's portfolio, and I believe that this trend should continue. AARMS currently supports a number of innovative and effective provincial programs in Atlantic Canada, and the Association can clearly play a useful role in expanding these offerings to the entire region. There is also room for growth in number and quality of collaborations between mathematical scientists and local industry, and nurturing these relationships will be an important part of our future activities. Of course, the Association's crucial support for basic research in Atlantic Canada will not be neglected even as its outreach and industrial collaboration activities ramp up.

Let me conclude by acknowledging the exceptional service offered to our organization by its outgoing Director: Jeannette Janssen. Her stewardship of the Association saw significant increases in the scope of its activities, its level of support, and its national influence. We all wish her the best in her new job as the Chair of the Department of Mathematics and Statistics at Dalhousie University.

## AARMS Postdoc: Daniele Gregoris

The "General Relativity & Cosmology" group is a cornerstone of the Mathematics department at Dalhousie University in Halifax. General relativity is the theory of gravitation formulated by Einstein one century ago as an improvement of the previous Newtonian theory, while Cosmology deals with the study of the characteristics and evolution of our Universe. I joined this research group as a postdoctoral fellow under the supervision of Prof. Alan Coley on June 1st 2015 within the Atlantic Association for Research in the Mathematical Sciences (AARMS) network. Before moving to Canada I did my undergraduate and graduate studies in Italy (which is the country I come from) in Trieste and Rome "La Sapienza" respectively, and my Ph.D. at the Stockholm University (Sweden) within the European Erasmus Mundus framework, where I defended my thesis in Theoretical Physics in November 2014.

# News



My past and current research interests are applications of general relativity to the modelling of the Universe we live in. In fact the current standard model of cosmology predicts the existence of an exotic fluid named dark energy that no one has detected so far and also its physical properties and features are mysterious and not at all known. Thus I have been working with my Ph.D. supervisors on two parallel avenues trying to propose a model compatible with observations without dark energy, but with a nontrivial geometry, and on the other hand another model picturing dark energy in terms of a nonideal fluid with asymptotic freedom. As a complementary topic I have also investigated the motion of massive bodies in general relativity subject to a frictional force. More recently as part of my postdoc I have been studying a method for generating new exact inhomogeneous solutions to the famous Einstein field equations of general relativity which exhibit a spiky behavior.

During my first year at Dalhousie University I also taught two courses of Mathematics, one addressed to students of the Engineering program and a second for the students in commerce. In June I also gave the introductory lectures about general relativity and black holes during the workshop organized by AARMS as a collaborative meeting with the scientists of all Atlantic Canada held this year at Dalhousie. Recently I received the opportunity to discuss my research results also at St. Francis Xavier University in Antigonish (NS) and at the GR21 conference, one of the largest worldwide meeting in my field, at Columbia University in New York.

As I said, all my educational background is in Physics and I switched to Mathematics only when I started this latter experience. Thus this postdoc is providing me the opportunity to get a more formal and complete training on the "language in which the book of Nature is written" that I will have the opportunity to use all along my future scientific career.

- Daniele Gregoris

## GRASCan 2016

The 5th Graph Searching in Canada Workshop (GRASCan 2016) was held July 20-21 at Dalhousie University. The workshop brought together researchers interested in graph searching for two days of talks and collaboration. The workshop continued its tradition of holding plenary and contributed talks in the mornings, with the afternoons free for discussion, networking, and collaboration.

The plenary speaker on the first day was Geňa Hahn from l'Université de Montréal. His talk "A survey of cops and robbers on infinite graphs" was very well received; it introduced new researchers to the wealth of knowledge on the subject, but also shared some very recent advances on the subject. The plenary speaker on the second day was Paweł Prałat from Ryerson University. His talk "Intersection of Graph Searching and Probability" presented several graph searching problems where deterministic results were obtained using probabilistic methods. Six contributed talks were also given in the mornings. In the afternoons, small groups formed and participants shared ideas and some new research collaborations were born.

The workshop was made possible through generous funding from the Atlantic Association for Research in the Mathematical Sciences (AARMS), the Dalhousie University Dean of Science, and the Dalhousie University Mathematics and Statistics Department.

- M.E. Messinger



## Iterated Function Systems (IFS), Fractals, Invariant Measures and Applications Conference

The AARMS CRG Iterated Function Systems (IFS), Fractals, Invariant Measures and Applications, held our first conference June 10-12, 2016 at Dalhousie University. This meeting was made possible through the generous support of AARMS. There were approximately 20 participants at this first meeting, including a few students and postdocs.

There were two excellent plenary talks. The first one, on Saturday, was given by Dr. Michael Barnsley who spoke on IFS Theory: inside out and inverse limits. Dr. Barnsley was his usual enthusiastic self and inspired all with an overview of iterated function systems (IFS) and their connections with planar tilings. Dr. Barnsley is one of the “fathers” of IFS theory and its applications, notably to image compression and processing (he founded a very successful company in this area). The second plenary talk, on Sunday, was given by Dr. Robert Devaney who spoke on Cantor and Sierpinski, Julia and Fatou: Crazy Fractal topology in Complex Dynamics. Dr. Devaney gave a striking birds-eye view of complex analytic dynamics, showing both the depth of the mathematics as well as the beauty of the resulting images. Dr. Devaney is one of the best-known researchers in dynamical systems and his book on this topic is one of the standard textbooks.

In addition, we had 9 contributed talks and an “open problems/brainstorming” session. The contributed talks ranged from image compression using fractal methods, dimension theory of fractals, invariant measures of dynamical systems, fractals arising from the classification of tricycloids, multidimensional radix representations, and the connections between Martin boundary theory and multi-dimensional wavelets. The brainstorming session was lead by Dr. Barnsley and featured a lively discussion of a selection of problems and directions for further research. The conference also inspired new connections and allowed researchers with existing collaborations to work together.

- Franklin Mendivil



## Call for Proposals

The next deadline for proposals for workshops, conferences and outreach events is September 15, 2016. Please submit proposals to our online system.

## ECCC 2016

The 11th East Coast Combinatorics Conference was held July 18-19 at Mount Saint Vincent University in Halifax, Nova Scotia. Over 40 researchers, graduate and undergraduate students from the east coast, and beyond gathered for two days of presentations. Our plenary speaker the first day was Dr. Matej Sajna from the University of Ottawa who spoke about “Eulerian properties of hypergraphs and triple systems”. This talk was very well received and exposed the undergraduate students who attended to the generalized versions of results they learned about in their introductory graph theory class. Dr. Anthony Bonato of Ryerson University was our second plenary speaker and his talk was entitled “The new world of infinite random geometric graphs”. It introduced new researchers to the study of infinite random geometric graphs and was enjoyed by all. We also had 14 contributed talks which covered variety of topics, such as combinatorial game theory, graph drawing software design, graph searching and design theory.

- Danielle Cox

## 2016 UPEI Integration Tournament

The 2016 UPEI Integration Tournament was held on the evening of March 14, 2016 in conjunction with other Pi day festivities. In the month leading up to the tournament, it was announced in all Math classes that students who wished to participate could sign up. Over 30 students signed up, so on March 7 a Qualifying Quiz was held and based on the results of that Quiz, 16 students were selected to participate in the Integration Tournament. Eight were first-year students and eight were upper-year students. All 16 participant received School of Mathematical and Computational Sciences T-shirts. In addition, the top four finishers received a top hat and a monetary prize.

The First-year runner-up was Stephanie Cairns, who was awarded \$50. The Upper-year runner-up was Nikita Volodin, who was awarded \$50. The First-year Champion was Samantha Begin, who was awarded \$150. The Upper-year Champion was Cameron Hastie, who was also the overall Champion, who was awarded \$250 plus the title of Magnificent.

I acted as moderator for the event. Chris Vessey was technical support. Professors Justin Gulati and Shafiqul Islam were judges along with Morgan Erskine, who was the reigning Magnificent champion.

As mentioned earlier, this was part of our Pi day festivities, which also included a Mathematical and Computational Sciences Trivia Contest (about Math, Stats & CS in movies, songs, TV shows and other areas of popular culture) and the eating of Pie. Total attendance at the event was approximately 50 students and faculty.

- Gordon MacDonald

## Postdoctoral Fellowship Awards

Our annual postdoctoral fellowship award program will be opening for applications in November. Visit our website or watch out for announcements.

## UPEI Mathematics Achievement Program (UPEI MAP)

The UPEI Mathematics Achievement Program was set up to deliver free day-camps to elementary students in PEI. The goal of this initiative was to create excitement about Mathematics and to help remove the fear and feelings of inadequacy that is often associated with learning math. Ideally, the program's goal was to show that mathematics does not have to be scary, but can be both challenging and fun. MAP strived to assist and motivate students who struggle with mathematics, while providing job opportunities for UPEI Mathematics Society members and pre-service teachers to develop and hone skills which will be relevant to their career path. The pilot phase of MAP involved the participation of students from six elementary schools in the Charlottetown area. MAP camp days ran on PD Days at either the Sherwood Elementary School or the Royalty Centre throughout the 2015-2016 school year.

The MAP Director and Coordinator worked closely with the Executive Director of the PEI Literacy Alliance and the UPEI Dean of Education, and to coordinate all aspects of the program, develop program evaluations and launch the program. This required many hours of dedicated work and ongoing communication with local elementary schools, the Department of Education, and the English Language School Board. All staff were trained in CPR and First aid and attended an instructional training day with the Department of Education. The program was supposed to begin on October 22, however, delays in the referral process meant the opening day had to be pushed back to November 20. The program had seven successful camps between November 20 and May 6 on the topics of Shapes, Forces and Friction, Fractions, Finance, Patterns, Probability, and a final day to bring all of the themes together.

## In Memoriam: Jon Borwein



Jonathan Michael Borwein, Laureate Professor at the University of Newcastle, NSW, Australia, passed away suddenly in the early morning hours of August 2nd, towards the end of a four-month term as Distinguished Scholar in Residence at Western University in London, Ontario.

Jonathan Borwein was born in St. Andrews, Scotland, on May 20, 1951. He moved with his parents, both academics, to London, Ontario, where he completed an Honours Mathematics degree at UWO in 1971. He received his Ph.D. in Mathematics from Oxford University (1974) as an Ontario Rhodes Scholar. Jonathan started his academic career at Dalhousie, first as a postdoctoral fellow (1974-1976), and then quickly moving through the ranks to Full Professor (1984) in what was then the Department of Mathematics, Statistics, and Computing Science.

With the exception of two years at Carnegie-Mellon University (1980-1982), Jonathan stayed at Dalhousie until

1991, when he moved to the University of Waterloo (1991-1993). In 1993, Dr. Borwein became the Shrum Professor of Science and founded the Centre for Experimental and Constructive Mathematics (CECM) at Simon Fraser University. He later served as a Canada Research Chair in Information Technology (2001-2004) at SFU before returning to Dalhousie as a Canada Research Chair in Distributed and Collaborative Research in the Faculty of Computer Science, with a cross-appointment in the Department of Mathematics and Statistics (2004-2009). During this time he also held an appointment as Director of the Atlantic Association for Research in the Mathematical Sciences.

In 2009, Jonathan and his family moved to Australia, where he accepted the position of Laureate Professor of the School of Mathematical and Physical Sciences at the University of Newcastle. He also became the founding director of CARMA, a Priority Research Centre at the University of Newcastle, devoted to Computer-Assisted Research Mathematics and its Applications.

While in Australia, Jonathan maintained professional and personal connections with Dalhousie, where he still held an adjunct appointment in the Department of Mathematics and Statistics. Only a month before his untimely death, he and his wife Judith visited Dalhousie, where he gave a Colloquium talk on visualization in mathematics, one of his research areas.

Jonathan Borwein was an innovative and prolific mathematician of international renown. Among numerous other honours, he was elected Fellow of the Royal Society of Canada (1994) and of the Australian Academy of Science (2010), and he received two honorary doctorates. He was also elected Fellow of several professional associations and won various top research awards throughout his career.

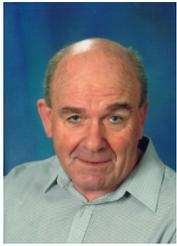
Jonathan was active in numerous administrative and editorial roles nationally (in Canada and Australia) and internationally. In particular, over several decades he held important Executive and Committee appointments with the Canadian Mathematical Society (CMS), including CMS President (2000-2002). A press release by the CMS states that "Dr. Borwein was passionate about promoting the advancement, discovery, learning and application of mathematics at both the local, national and global levels", and "Jon was an extraordinarily productive and diverse researcher, widely recognized as one of the world's foremost practitioners of Experimental Mathematics," said CMS President Michael Bennett (UBC).

In another scientific tribute, Jonathan Borwein's closest and longest-term collaborator writes, "Jon was a mentor par excellence, having guided 30 graduate students and 42 post-doctoral scholars. Working with Jon is not easy — he is a demanding colleague (as the present author will attest), but for those willing to apply themselves, the rewards have been great, as they become first-hand partners in ground-breaking work."

Jonathan Borwein is survived by his parents, Bessie and David Borwein of London; his wife Judith, three daughters Naomi, Rachel, and Tova; five grandchildren Jakob Joseph, Noah Erasmus, Skye, Zoe and Taj; siblings Sarah and Peter; sister-in-law Jennifer Moore.

- Karl Dilcher

## In Memoriam: Pat Keast



Patrick (Pat) Keast, retired professor, Department of Mathematics and Statistics, Dalhousie University, passed away suddenly at his home in Halifax on Monday, July 25, 2016, at the age of 73. He is survived by his wife Kathleen, whom he met in high school, and sons Liam (Brenda) and James (Stephanie) and his grandchildren, Isaac, Kate and Ella.

Pat was born in Broxburn, Scotland, on August 2nd, 1942. In 1960, upon leaving St. Mary's Academy in the neighboring town of Bathgate as dux of his class, he entered the University of Edinburgh, and began an outstanding undergraduate career. In 1964, he graduated with a first class honours degree in mathematics and received the Napier Medal and Gangadhar Balwant Gadgil Prize in Mathematics awarded to the most distinguished student in Mathematics in the Final Honours examination. He then joined the Mathematics Department at St. Andrews University and while an assistant lecturer there completed a Ph.D. in Mathematics in 1967 under the supervision of Andrew (Ron) Mitchell.

Pat spent the academic year 1968-1969 at the University of Toronto (U of T) as a visitor in the Computer Science Department. In 1970, he immigrated to Canada to take up a regular faculty position at U of T, splitting his time between teaching in the undergraduate program at the U of T Scarborough College campus, and teaching graduate courses and supervising graduate students at the U of T St. George campus.

In 1983, Pat moved to Dalhousie University (Dal) where he joined the newly established Division of Computing Science in the Mathematics, Statistics, and Computer Science Department. He completed his career in the Mathematics and Statistics Department at Dal, retiring in 2007. During his 24 years at Dal, he taught many undergraduate students, supervised numerous graduate students in both mathematics and computer science, and held several administrative positions, including Department Chair. Pat was a highly respected teacher; former students have spoken of the outstanding attention that he gave to his teaching and to his students.

Throughout his career, Pat maintained an active research program in numerical analysis and scientific computing supported by NSERC grants. His Ph.D. thesis and earliest publications focused on numerical methods for solving partial differential equations, an area that he revisited later in his career. After his move to Toronto, he spent several summers at Argonne National Laboratory which led to his work on multidimensional quadrature with James Lyness. In 1985, Pat directed a NATO Advanced Research Workshop on Numerical Integration at Dalhousie University in which many of the leading researchers in the area of numerical quadrature from around the world participated.

From the early eighties, a central aspect of Pat's research was the development of robust numerical software packages, which he accomplished with colleagues and graduate students. His early achievements in this area were in the formulation and implementation of efficient methods for the solution of a class of

structured linear systems known as almost block diagonal (ABD). Such systems arise in all well-known methods for solving boundary value ordinary differential equations (BVODEs) and in certain spline collocation techniques for solving partial differential equations (PDEs). He then embedded these solvers in commonly used packages for solving BVODEs and time-dependent PDEs in one space dimension with resulting efficiencies.

A fundamental limitation of the early 1D PDE collocation packages was that only the temporal error was controlled. From the late nineties until the end of his research career, the development of high quality numerical software for the error controlled numerical solution of 1D PDEs became a central theme in Pat's work. Along with colleagues, he developed the first software package implementing a collocation solver that computed both spatial and temporal error controlled numerical solutions of general classes of systems of 1D PDEs. Subsequently he contributed to the development of refinements of this package which is now in its third edition. All of the numerical software packages in which Pat was involved are available in the highly respected Collected Algorithms of the Association for Computing Machinery. Moreover, codes based on the ABD solvers appear in the NAG software library.

It was not all work and no play with Pat. He was a devoted family man and greatly enjoyed having his sons, both of whom are computer scientists, and their families living in close proximity to his home. He was very active in the church communities of St. Pius X and St. Benedict's in Halifax especially through his work with the St. Vincent de Paul Society. Throughout his life, he was passionate about cycling. While at U of T, he regularly cycled between U of T Scarborough and U of T St. George, and subsequently he cycled around much of Nova Scotia in addition to commuting to Dal by bike. On summer vacations to visit family in Scotland, his bike accompanied him and he thoroughly enjoyed cycling in central Scotland with his two brothers. It also accompanied him to Argonne where he had more than one mishap that took him to an emergency room.

Many will long remember Pat's delightful sense of humour, oft described by family members as "quirky". Not as well-known was his uncanny ability to create limericks with remarkable ease. Several years ago, he considered writing a book, each chapter of which would begin with a limerick, an example of which is the following.

A simple eigenvalue named psi  
Was perturbed by a small amount, phi.  
The change was sufficient  
To make its eigenvector deficient  
And the condition of the matrix quite high.

Unfortunately the book did not get past the limerick stage. :)

Pat will be greatly missed by family, friends and the communities of which he was a vital part.

- Graeme Fairweather and Paul Muir,  
with contributions from Ronnie Keast

# Recent and Upcoming Events

## AARMS Workshops and Minicourses

### **Graphs and Combinatorics (ECCC/GRASCan)**

Organizers: S. Seager, D. Cox, M. Messinger, A. Bonato  
Location: Mount St. Vincent University and Dalhousie University, Halifax  
Date: July 18-21, 2016

### **Numerical Analysis of Singularly Perturbed Differential Equations**

Organizers: S. MacLachlan, R. Haynes, H. Brunner, P. Muir, D. Iron, T. Kolokolnikov  
Location: Saint Mary's University, Halifax  
Date: July 25-29, 2016

### **International Category Theory Conference**

Organizers: R. Blute, R. Cockett, P. Hofstra, R. Dawson, D. Pronk  
Location: Dalhousie University and Saint Mary's University, Halifax  
Date: August 7-13, 2016

### **Games at Dal 2016**

Organizers: Richard Nowakowski and Urban Larsson  
Location: Dalhousie University, Halifax  
Date: August 9-23, 2016

### **Partial Differential Equations and Numerical Analysis at Atlantic Universities Conference**

Organizers: George Chen et al  
Location: Cape Breton University, Sydney  
Date: October 16, 2016

### **Fifth Parallel-in-time Integration Workshop**

Organizers: M. Emmett, M. Minion, M. Gander, R. Haynes, R. Krause  
Location: Banff International Research Station  
Date: November 27 – December 2, 2016

## AARMS-Sponsored Events

### **Conference on Selected Areas in Cryptography and SAC Summer School**

Organizer: Howard Heys et al  
Location: Memorial University, St. John's  
Date: August 8-12, 2016

### **PIMS Grad Math Modeling in Industry Workshop**

Organizers: Michael Lamoureux  
Location: UBC Vancouver  
Date: August 8-13, 2016

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*David Wolfe (QRA Halifax)*

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## **AARMS Scientific Review Panel**

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*Darryn Bryant (Queensland)*

*Stephen Cantrell (Miami)*

*Steven Carlip (UC Davis)*

*Richard Cook (Waterloo)*

*Chantal David (Concordia)*

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*"The study of mathematics, like the Nile, begins in minuteness but ends in magnificence.*

*- Charles Caleb Colton*