Atlantic Association for Research in the Mathematical Sciences

AARMS

Annual Report 2015

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Message from the Director

The year 2015 brought further positive developments for AARMS. Several of our programs expanded, and new initiatives took off. Continued collaboration with the other Math Institutes led to several significant joint activities, and we pursued new international collaborations. Visibility of AARMS continues to increase, and our voice is more clearly heard on the national stage.

The AARMS summer school was held at Dalhousie again, and led by Theodore Kolokolnikov. The theme in 2015 was Differential Equations and Numerical Analysis. Three workshops related to the school were held concurrently, making this a summer of extraordinary activity in this research area. This conformed to our goal of developing the summer school into a short thematic program, where the presence of expert lecturers and eager students is used to create a focused program of research activity.

This year, the province of Nova Scotia increased its funding for AARMS to 100K annually, with the expectation that this level of funding will continue in future years. This funding has allowed us to create the position of AARMS Outreach coordinator. This position is filled by a post-doctoral fellow, and thus contributes to the research objectives of AARMS as well. Also, a number of new Outreach activities took off this year. There are new or expanded school visit programs in Nova Scotia, PEI and New Brunswick, and a new math challenge club with a special focus on female students.

There was a new CRG competition this year. Two new CRGs were started, in Iterated Function Systems, and in the Mathematical and Physical Aspects of Black Holes. The highly succesful CRG in Numerical Analysis and Scientific Computing was renewed for a second term. It is worth mentioned that this CRG is pursuing collaborations with industry. The group held a workshop where industrial representatives were invited to present real-life problems, and is now investigating the possibility of taking advantage of NSERC's collaborative opportunities.

In addition to the workshops already mentioned, AARMS supported a variety of events this year. By sponsoring a large number of sessions, AARMS was an active partner in the 2015 CMS meeting, which was held in PEI. In addition, AARMS sponsored a number of focussed research meetings, and also contributed to other events with high significance for our region. Also, we sharpened the focus of our event funding by adopting a new policy which clearly distinguishes AARMS workshops, which are targeted meetings of high quality, with 40-60 participants, from other events. AARMS workshops are favoured, since such events are felt to have the highest impact.

Finally, in 2015, five new post-doctoral fellows were chosen in the competition; in addition the Outreach coordinator and Director's PDF led to an increase of our PDF program.

In June, I will hand over the directorship. I have enjoyed leading AARMS over the last five years. It was a great opportunity to get to know the mathematical community in our region, and the rest of Canada, and learn about the excellent work that is being done

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here. I would like to thank the members of that community for their enthusiasm and energy, which is what makes our programs great. Thanks to the AARMS Executive and to the Board, and a special thanks to David Langstroth. It has always been a pleasure working with David, and his efficiency made the job an easy one. Finally, thanks to the provinces of Nova Scotia, New Brunswick, Newfoundland and Labrador, CRM, Fields, and PIMS (and indirectly NSERC), and our member universities for their continued support.

Jeannette Janssen
AARMS Director
March, 2016

Use and Access to the Resource

Most of AARMS' programs are accessed through an open proposal system. Funding for collaborative research groups, postdoctoral fellowships, workshops and conferences and outreach programs all require the submission of a proposal outining plans for the proposed project, the quality of the proposed project and a detailed budget. Such proposals are evaluated in a competitive process either by the AARMS Executive, or the AARMS Scientific Review Panel, or a combination of the two. The exception to this process is the AARMS Summer School. In Atlantic Canada an event of this magnitude cannot be efficiently organized at the smaller universities within the available budget and so far we have rotated the event between Memorial University, Dalhousie University and the University of New Brunswick. Our practice has been to allocate the summer school for three years to one host and then move it to the next. At the end of the three-year allocation we do invite other universities to propose hosting the event. UPEI has shown an interest in hosting for 2017 but may not be able to provide accommodation at a reasonable rate. These discussions are ongoing. Lecturers at the summer schools are invited by the summer school Directors and students apply by providing a transcript and a letter of reference from their department head or supervisor.

Together in all programs there were over 1600 users. This compares to over 3000 users in 2014. However, these total numbers are not very meaningful. The higher number in 2014 is mainly due to some outreach events, such as the NB Mathematics Competition which involved 1247 students, as well as some other outreach projects with high numbers. In 2015 the NB Mathematics competition found funds from other sources and didn't apply for AARMS funding. If we look at our other activities then the number of users was higher across the board in 2015. Workshops and conferences, had over 1100 users in 2015 compared to 680 in 2014. We supported 10 postdoctoral fellows in 2015, compared to 4 in 2014, and our summer school involved 10 lecturers and TAs, compared to 5 in 2014. The numbers for workshops and conferences, however, are also reasonably volatile from year to year as the figure depends ultimately on how many very large meetings were supported by AARMS in a given year.

AARMS is a distributed organization, with Executive members and users spread throughout the region. Although there is one part time adminstrator based at Dalhousie there is no host institution in any meaningful way. Therefore we do not collect data on how many users come from within or without the host institution. All of our users are academic, with the exception of our outreach programs which involve children, their teachers, and sometimes their parents.

In 2016 we anticipate that the number of users will remain at a similar level to 2015 as we will continue to maintain our programs within the limits of our budget. The actual number may fluctuate depending on how larger events may skew this figure upwards or downwards.

We address communications to all faculty in mathematics, statistics, engineering and computer science in Atlantic Canada through our email list, which also includes our Executive, our Board, our Scientific review panel and other people who have been involved in AARMS in the past. Through this list we announce calls for proposals and other significant AARMS events or news. We also produce a newsletter three times a year which is distributed electronically and we maintain a website at www.aarms.math.ca. Twice a year we distribute a poster to departments of mathematics and statistics across Canada giving information on AARMS events,

AARMS programs and the AARMS Summer School. We organize an annual meeting in Nova Scotia for people interested in outreach and our postdoctoral fellow who coordinates outreach also attends an annual teachers conference in Nova Scotia to make contacts with teachers.

Research Activities

There are four main programs of research activity which are described in detail later in this report: Collaborative Research Groups, Postdoctoral Fellowship Support, AARMS Summer School, and Workshop and Conference Support. The AARMS Summer School is included in this category as there is a research component to the courses offered, and the Summer School brings together international and local experts in a given field for a period of four weeks, facilitating collaborations through the workshops which are organized in association with the summer school, and through more informal interactions between the people involved. Details on all of these programs are given later in this report. Activities to keep abreast of scientific and technical advances include all of these research activities, each focused either narrowly or broadly on different fields of mathematical science. Scientific contributions are described in terms of publications specifically in relation to the Collaborative Research Group Program.

Training and development of HQP

In 2015 we supported 10 postdoctoral fellowships through our Postdoctoral fellowship program, although not all concurrently. Some fellowships finished and then others began. Details are given in our postdoctoral fellowship program. This represents a significant increase from 2014 in which we supported 4 fellowships. The increase is due to increases in funding from provincial sources which created a surplus going into 2015 and enabled a temporary boost to the budget for this particular program. We expect to reduce somewhat in 2016 to a more sustainable level. Six graduate students and one undergraduate research position were supported through the Collaborative Research Group in Numerical Analysis and Scientific Computing, and the Collaborative Research Group in Statistical Modelling of Complexly Correlated Data with Applications. We have not collected enough consistent information concerning the use of AARMS programs by students and postdocs for 2015 to create a reliable summary figure but there is some information on student and postdoc participation in many of the detailed reports provided for workshops and conferences. We intend to collect this information more consistently going forward.

Partnerships and Interactions

AARMS has taken an active role in collaborating with the Institutes on a number of activities where we have identified common interests of our respective communities as listed below. The following events are from 2014 and 2015 as well as planned collaborations in 2016:

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Collaborations with Fields
- AARMS Summer School 2014 $6000
- Combinatorial Algebra meets Algebraic Combinatorics 2014 $3000
- Workshop in Enveloping Algebras and Representation Theory 2014 $10,000
- Connecting Women in Mathematics Across Canada 2014 $2000
- Combinatorial Algebra Meets Algebraic Combinatorics 2015 $4500
- Statistical and Computational Analytics for Big Data 2015 $4235
- Statistical Society of Canada (SSC) Annual Meeting 2015 $2500
- Domain Decomposition Methods for the Parallel Solution of Partial Differential Equations 2015 $5000
- Algebraic Groups and Lie Algebras 2015 $5000
- AHA 2015 $3000
- Workshop on Homotopy Type Theory 2016 $2000
- AARMS-Fields workshop Hopf Algebras, Algebraic Groups and Related Structures 2016 $7500
- Outreach Project on Data Science Analytics in Fredericton 2016 $3800

Collaborations with CRM
- Recent developments in the adaptive solution of PDEs 2014 $4200
- Connecting Women in Mathematics Across Canada 2014 $2000
- Domain Decomposition Methods for the Parallel Solution of Partial Differential Equations 2015 $5000
- Statistical Society of Canada (SSC) Annual Meeting 2015 $2500
- AARMS Workshop on Numerical Analysis of Singularly Perturbed Differential Equations 2016   TBA

Collaborations with PIMS
- Connecting Women in Mathematics Across Canada 2014 $2000
- AARMS/PIMS Summer School 2015 $20,000
- Statistical Society of Canada (SSC) Annual Meeting 2015 $2500

Collaborations with CANSSI
- Statistical and Computational Analytics for Big Data 2015 $6000
- International Symposium on Statistics 2015 $8500
- Statistical Society of Canada (SSC) Annual Meeting 2015 $2500

AARMS has also collaborated with the Canadian Mathematical Society for the funding of Math Camps in all provinces of the Atlantic Region and is an active agent in attempting to foster collaboration across the diverse field of outreach actors through hosting annual meetings and through the coordinating activities of our new outreach coordinator.

In 2016 AARMS has entered into new collaborative relationships with the African Institute of Mathematical Sciences (AIMS) which will provide a limited number of places in our annual summer school for promising African students as well as the opportunity for Atlantic Canadian faculty to lecture at African Institutions on a short term basis.

Finally, AARMS is also entering into membership of MSRI, a cost which would not be feasible for any of our member universities, but through which we can facilitate the benefits of MSRI membership to any AARMS universities. These benefits include support for students to attend MSRI workshops, BIRS workshops and support for resident experts to come to the Atlantic region for seminars and collaboration.

Management and Budget

AARMS charges member universities an annual fee, ranging from $1000 for the smallest universities to $30,000 for the largest. Individual users are not charged. Details of our budget and management structure are given later in this report.

Consultation Mechanisms and Collaborative Activities

Regular phone conferences between the Directors of AARMS, CANSSI and the Institutes facilitate discussion and collaboration, as well as the participation of the AARMS Director in strategic meetings of a national importance. In addition the Directors of the Institutes have an ex officio position on the AARMS Board so long as they continue to be major funders of AARMS.

Collaborative Research Groups

AARMS Collaborative Research Groups consist of Atlantic Province University researchers with common research interests who wish to collaboratively develop their research programs. Members of a CRG typically organize intensive workshops, share PDF appointments, coordinate graduate training programs, propose and assist in AARMS summer school programs, jointly supervise graduate students, and carry out other activities supporting their research programs.

AARMS believes that groups of researchers with common research interests can benefit from sharing resources and coordinating activities. Furthermore, CRGs offer young researchers a larger community for growing their research program. AARMS also believes that the critical mass achieved by CRGs will help the Atlantic Provinces to recruit and retain faculty in mathematical sciences, to attract post-doctoral fellows and offer enhanced training programs attracting more graduate students.

In 2015 the second generation of AARMS CRGs completed their second year. They were: The Atlantic Collaborative Research Group in Numerical Analysis and Scientific Computing, Statistical Modeling of Complexly Correlated Data, and Graphs and Games. We report on these below.

In September 2015 the third generation of AARMS CRGs were funded and began operating. These include The Atlantic Collaborative Research Group in Numerical Analysis and Scientific Computing (a second term) under the leadership of Ron Haynes; Mathematical and Physical Aspects of Black Holes, under the leadership of Sanjeev Seahra; and Iterated Function Systems, Fractals, Invariant Measures and Applications, under the leadership of Shafiqul Islam. The first reports on their activities will be included in the 2016 Annual Report

The Atlantic Collaborative Research Group in Numerical Analysis and Scientific Computing

Members:
Ronald Haynes (Memorial)
Paul Muir (St. Marys)
Hermann Brunner (Memorial)
Hans de Sterck (Waterloo)
Jean-Christophe Nave (McGill)
Martin Gander (Geneva)

Weizhang Huang (Kansas)
Colin Farquharson (Memorial)
Shaohua Chen (Cape Breton)
Jahrul Alam (Memorial)
Richard Karsten (Acadia)

The AARMS CRG in Numerical Analysis and Scientific Computing was formed as of September 1, 2013. This note gives a summary of the activities for the second year of the CRG, from 2014 - 2015. Note, the CRG was awarded funding for an additional two years, from 2015 – 2017.

Summary of Activities

The executive of the CRG (Haynes, Brunner, Muir) met on a regular basis to plan and carry out the activities of the CRG. The primary activity organized by the CRG was a workshop on domain decomposition methods for PDEs, held in August of 2015. Members of the CRG were involved with the organization of the 2015 IFIP Working Group 2.5 on Numerical Software and the Bluenose Numerical Analsyis and Applied Math Day. One member of the CRG (Brunner) was involved in the organization of two graduate courses in the area of Numerical Analysis and Scientific Computing that made up half of the course offerings for the AARMS 2015 Summer School. As well, the members of the CRG have been involved in a number of research projects related to the CRG and in the supervision of students working on these projects. Below we provide further details on the activities undertaken by the CRG over the last 12 months.

Workshop on Domain Decomposition Methods for PDEs

A workshop titled Domain Decomposition Methods for PDEs, organized by the CRG, was held at Dalhousie University, Halifax, Nova Scotia, Aug. 3-8, 2015. This workshop received funding from AARMS, the CRM, the Fields Institute, the NSF, the Memorial University Conference Fund, and the Department of Mathematics and Statistics of Memorial University. Administrative support was provided by the Department of Mathematics and Computer Science at Saint Mary's and the Department of Mathematics and Statistics at Dalhousie University.

The workshop was well attended with approximately 40 participants involved, including B.Sc., M.Sc., Ph.D. students and researchers from Canada, the United States, Turkey, Switzerland, China and the United Kingdom. There were four invited plenary speakers, 15 faculty members, 1 post-docs, 20 undergraduate and graduate students and 4 industry representatives.

This workshop consisted of three primary parts. The first part was a two-day short course on domain decomposition methods for PDEs, given by Dr. Martin Gander of the University of Geneve, a leading expert in this area. Each day included approximately five hours of lectures given by Dr. Gander, and concluded with a hands-on computer lab session, led by Dr. Victorita Dolean of the University of Stratclyde opportunity to learn

about software implementations of some of the algorithms discussed in the lectures. An important feature of the short course and computer lab sessions was the degree of interaction between the instructors and the participants; questions were frequent and often added important insight into the material being presented.

The workshop then transistioned to four plenary talks. David Keyes (KAUST) gave a visionary talk entitled \Scalable Nonlinearly Implicit Methods for Multiscale Science and Engineering Applications". Victorita Dolean (Strathclyde) spoke on Robust Coarse Spaces via Generalised Eigenproblems: the GenEO method. Felix Kwok (HKBU), gave a nice talk with the title Schwarz Methods for the Time-Parallel Solution of Parabolic Control Problems. The last plenary talk was given by Martin Gander (Geneva) who gave a beautiful overview on Five Decades of Time Parallel Time Integration. These talks were all very well prepared; it was a valuable experience for all in attendance to get a summary of the latest results in the field from these adaptivity experts.

The final phase of the workshop began with applied talks by Tom Jonsthovel (Schlumberger), Hansong Tang (City College of New York, CUNY), and Rick Link and Derrick Alexander (Lloyd's Register Technology Group (ATG)). These speakers nicely outlined problems in their primary research area that would benefit from the use of domain decomposition techniques. These talks were followed by one and a half days of breakout sessions, which allowed interested participants the opportunity to pair with these applied researchers and domain decomposition experts to explore the applied problems in greater detail. The breakout sessions represented a novel part of the workshop and were very well received. These sessions were quite successful in forging future collaborations and introducing potential M.Sc. and Ph.D. students to researchers at the forefront of their fields.

Organization of Two 2015 AARMS Summer School Courses
One of the members of the CRG executive (Brunner) was the organizer of the two graduate courses in Numerical Analysis/Scientic Computing that made up two of the four courses offered during the AARMS Summer School held in July 2015 at Dalhousie University. One of the courses was titled Structure-preserving Discretizations of Di erential Equations, and was taught by Elena Celledoni and Brynjulf Owren (Norwegian University of Science and Technology). The other course, Numerical Analysis of Singularly Perturbed ODEs and PDES, was taught by Martin Stynes (National University of Ireland and Beijing Computational Science Research Center).

Bluenose Workshop/Working Group 2.5 on Numerical Software meeting
A meeting of the IFIP Working Group 2.5 on Numerical Software with an associated workshop that followed the long running series of regional meetings in NA/SC known as the Bluenose Applied and Computational Mathematics Days was held at Saint Mary's on July 9-12. The meeting and the workshop were organized by Paul Muir, Wayne Enright, and Richard Karsten. Muir and Karsten are active CRG members.

IFIP was established under the auspices of UNESCO in 1960 to promote international cooperation in the field of information processing. IFIP does its work through a collection of 13 Technical Committees (TCs) and some 100 working groups. Working Group 2.5 on Numerical Software (WG 2.5), which is part of TC2 on Software Theory and Practice, works to improve the quality of scientic computation by promoting the development and availability of sound numerical software. WG 2.5 members come from all over the world and are elected both in recognition of the substantial

contributions that they have already made to the field, but also for their commitment to actively participate in WG 2.5 projects. There are currently about 30 active members, along with a similar number of affiliated members. WG 2.5 members take turns hosting the yearly meeting at their home institutions. At these meetings, members discuss the latest developments associated with topics that the group has decided to formally track, as well as crafting plans for joint projects. In addition, each WG 2.5 meeting is paired with a local workshop to foster exchange of information between the Working Group and local students and researchers with an interest in the design and effective use of numerical software. These workshops provide an excellent opportunity for local researchers involved in numerical analysis scientific computing to meet experts who are developing and implementing useful and reliable software tools that can be applied in a variety of application areas. As well, the members of the Working Group get a chance to find out about projects that are being undertaken by researchers who are local to the area where the WG 2.5 meeting is held. In recent years these meetings have been held in Toronto, Canada, Raleigh, USA, Leuven, Belgium, Boulder, USA, Santander, Spain, Shanghai, China, and Vienna, Austria.

The program featured 12 speakers and 8 student poster presentations, with additional participation from faculty and students who did not present, for a total of about 36 participants. We did not organize a conference proceedings for this event; thus there are no immediate publications resulting from this event. However this event did provide a unique opportunity to bring together a number of experts from the area of Numerical Software Development (members of the IFIP WG 2.5 on Numerical Software as well as local experts) with a number of experts in Applied Mathematics Application Areas (AARMS Summer School Instructors as well as local experts) where numerical software is widely used as a key component of the research process. The presentations by these experts gave insight into cutting-edge research results in a variety of important topics in numerical software andapplied mathematics. The workshop featured talks by eight experts in numerical software or applied mathematics who were from various places around the world including Norway, China, New Zealand, the US, and other parts of Canada. The workshop gave these two groups the opportunity to hear about each other's work and to network on potential future collaborative research efforts. The workshop was also of substantial benefit to the many students who attended - both students from the AARMS Summer School as well as regional students. And the students who participated in the workshop's poster session had a chance to gain useful feedback on their work from the numerical software and applied mathematics experts who viewed their posters.

The 2015 Bluenose Applied and Computational Math meeting represented the 12th such meeting in this series. The first meeting was held at Acadia University in 2000. Subsequent meetings have been held, in 2001 at Saint Mary's University, in 2002 at Dalhousie University, in 2003 at Saint Mary's University, in 2004 at Acadia University, in 2005 at Cape Breton University, in 2006 at St. Francis Xavier University, in 2007 at Saint Mary's University, in 2008 at Dalhousie University, in 2009 at Acadia University, and in 2011 at Saint Mary's University. This meeting series is well known to AARMS since many of the meetings have received financial support from AARMS. Participants at these events have typically included a mix of researchers in application domains and researchers who specialize in numerical analysis and scientific computing, as well as many students who are working with these researchers. Participants typically come from academia but over the years there have also been a number of speakers from industry

and government labs. As well, there have often been talks by students: typically graduate students or post-docs but occasionally undergraduate research students. All past meetings have been one day in length and have usually featured mostly regional participation, with at most one or two speakers from outside the region participating.

Group member publications 2014{2015

Hermann Brunner:

1. (with H. Han and D. Yin) Artificial boundary conditions for a time-fractional di usion-wave equation on a two-dimensional unbounded spatial domain, J. Comput. Phys., 276 (2014), 541-562.
2. (with Z. Yang) Quenching analysis for nonlinear Volterra integral equations, Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal., 21 (2014), 507-529.
3. (with H. Han and D. Yin) The maximum principle for time-fractional di usion equations and its applications, Numer. Funct. Anal. Optim., 36 (2015), 1307-1321.
4. (with S. Seyedallaei and Z. Yang) Existence, uniqueness and regularity of solutions for a class of third-kind Volterra integral equations, J. Integral Equations Appl., 27 (2015), 325-342.
5. (with Q. Huang and X. Xu) Continuous Galerkin methods on quasi-geometric meshes for delay di erential equations of pantograph type, Discrete Contin. Dyn. Syst. A, accepted 2 December 2015.

Other activities:

1. 2015 AARMS Summer School (Dalhousie University, 6-31 July): Co-Director.
2. CRG Workshop on Domain Decomposition and Parallel Methods for PDEs (St. Mary's University, 4-8 August 2015): Co-Organizer.

Ronald Haynes

1. Bihlo, A., and Haynes, R.D., Parallel Stochastic Methods for PDE based grid generation, Computers and Mathematics with Applications, accepted July 2014, Vol. 68, Iss. 8, pages 804-820, Oct. 2014 DOI: 10.1016/j.camwa.2014.07.017.
2. Belliveau, Patrick, Colin Farquharson, and Ronald Haynes, 2014, ArjunAir: Updating and parallelizing an existing time domain electromagnetic inversion program. SEG Technical Program Expanded Abstracts 2014: pp. 875-880. doi: 10.1190/segam2014-1433.1
3. Humprhies, T.D. and Haynes, R.D., T.D., Joint optimization of well placement and control for nonconventional well types, Submitted July 2014, accepted December 2014, Journal of Petroleum Science and Engineering, 126 (2015), pp. 242-253.
4. Grazieli Luiza Costa Carosio, Thomas Donald Humphries, Ronald Dale Haynes, and Colin Glennie Farquharson. 2015. A Closer Look At Di fferential Evolution For The Optimal Well Placement Problem. In Proceedings of the 2015 on Genetic and Evolutionary Computation Conference (GECCO '15), Sara Silva (Ed.). ACM, New York, NY, USA, 1191-1198. DOI=10.1145/2739480.2754772
5. Bihlo, A., Haynes, R.D. and Walsh, Emily J., Stochastic domain decomposition for time dependent adaptive mesh generation, J. Math. Study, Vol. 48, No. 2, pp. 106-124, 2015. doi:10.4208/jms.v48n2.15.02
6. Haynes, Ronald D. and Huang, Weizhang, Preface Adaptive Moving Mesh Methods, J. Math. Study, Vol. 48, No. 2, pp. i{iii, 2015.

7. Haynes, R.D. and Kwok, F., Discrete analysis of Domain Decomposition Algorithms for Grid Generation via the Equidistribution Principle, Submitted June 2014, Revised Spring 2015, Accepted AMS Mathematics of Computation, July 14 2015.

8. Haynes, R.D., Ladd, K., and Ong, B. W., A OpenMP Parallel in Time Wrapper for the Solution of Time Dependent PDEs, Accepted Transactions on Mathematical Software, December 2015.

David Iron

1. Logarithmic Expansions and the Stability of Periodic Patterns of Localized Spots for Reaction-Diffusion Systems in R2, D Iron, J Rumsey, MJ Ward, J Wei, Journal of Nonlinear Science 24 (5), 857-912

2. Dynamics and stability of a three-dimensional model of cell signal transduction with delay, accepted nonlinearity

Scott MacLachlan

1. Energy minimization for liquid crystal equilibrium with electric and exoelectric e ects, J. H. Adler, T. J. Atherton, T. R. Benson, D. B. Emerson, and S. P. MacLachlan, to appear, SIAM J. Sci. Comp., 2015.

2. A first-order system Petrov-Galerkin discretisation for a reaction-diffusion problem on a fitted mesh, J. Adler, S. MacLachlan, and N. Madden, published online, IMA J. Numer. Anal., 2015

3. An energy-minimization finite-element approach for the Frank-Oseen model of nematic liquid crystals, J. H. Adler, T. J. Atherton, D. B. Emerson, and S. P. MacLachlan, SIAM J. Numer. Anal., 53(5):2225-2254, 2015.

4. A generalized predictive analysis tool for multigrid methods, S. Friedho
 and S. MacLachlan, Numer. Linear Alg. Appl., 22:618-647, 2015.

5. Effect of evaporation and condensation at menisci on apparent thermal slip, M. Hodes, L. Steigerwalt Lam, A. Cowley, S. MacLachlan, and R. Enright, Journal of Heat Transfer, 137(7):071502, 2015

6. Implied volatility and the risk-free rate of return in options markets, M. Bianconi, S. MacLachlan, and M. Sammon, North American Journal of Economics and Finance, 31:1-26, 2015.

7. Parallel time integration with multigrid, R.D. Falgout, S. Friedhoff, Tz.V. Kolev, S.P. MacLachlan, and J.B. Schroder, SIAM J. Sci. Comput., 36:C625-C661, 2014.

8. Mathematical and computational models of incompressible materials subject to shear, J.H. Adler, L. Dorfmann, D. Han, S. MacLachlan, and C. Paetsch, IMA Journal of Applied Mathematics, 79(5):889-914, 2014.

9. Theoretical bounds for algebraic multigrid performance: review and analysis, S. MacLachlan and L. Olson, Numer. Linear Alg. Appl., 21(2):194-220, 2014.

Paul Muir

1. P.H. Muir, J. Pew, An Analysis of the Reliability of Error Control B-spline Gaussian Collocation PDE Software, to appear in Mathematical and Computational Approaches in Advancing Modern Science and Engineering, Eds. J. Belair, I. Frigaard, H. Kunze, R. Makarov, R. Melnik, R. Spiteri, Springer, 2015.

2. J. Pew, P.H. Muir, Z. Li, Algorithm xxx: BACOLI: B-spline Adaptive Collocation Software for PDEs with Interpolation-based Spatial Error Control, to appear in ACM Trans. on Math. Softw., 2015.

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3. P.H. Muir, J.Pew, Recent Advances in Error Control B-spline Gaussian Collocation Software for PDEs, in Interdisciplinary Topics in Applied Mathematics, Modeling and Computational Science, Springer Proceedings in Mathematics & Statistics, 117, Cojocaru, M., Kotsireas, I.S., Makarov, R., Melnik, R., Shodiev, H. (Eds.), Springer, 2015.

Statistical Modelling of Complexly Correlated Data with Applications

Members:

Renjun Ma (UNB)
M. Tariqul Hasan (UNB)
Guohua Yan (UNB)
Jeff Picka (UNB)
Zhaozhi Fan (Memorial)

Ying Zhang (Acadia)
Gary Sneddon (Mount St Vincent)
Henrik Stryhn (UPEI)
Yanqing Yi (Memorial)

The primary research activities of our CRG in the second year evolved into several emerging areas of statistical research: analysis of spatial, and spatiotemporal data, modelling correlated data with excess zeros, and modelling of serially correlated multivariate non-normal data. The distinctive feature of this year was the strong emphasis on promoting the research and training of highly qualified personnels (HQPs) as planned in our proposal. Undergraduate, graduate students, postdoctoral fellows were exposed to new ideas and research directions through our third workshop and visitors. This was especially beneficial to our HQPs since the graduate programs in statistics are usually small in the Atlantic universities. Our CRG provided valuable opportunities for HQPs to interact with other researchers and to work together. The most of our CRG funding this year was devoted to HQPs to partially support their research activities and dissemination of knowledge at our CRG workshop and the annual meeting of the Statistical Society of Canada (SSC).

The main event organized by our CRG this year was the third workshop held June 12-13, 2015 at University of Prince Edward Island. As a tradition, we also invited some researchers outside of our group based on the workshop theme to facilitate exchange of ideas and problems. This year, some statistical researchers from Ontario, Quebec, Saskatchewan, Greece and applied researchers from Prince Edward Island and New Brunswick joined us. There were sixteen oral presentations from undergraduate, graduate students, postdoctoral fellows, university and government researchers. In particular, a free-style open discussion session was held to stimulate collaborative research on challenging and emerging issues. This workshop provided participants valuable opportunity to communicate the research progress and discuss future research directions.

Publications
(Only those papers with explicit acknowledgement of AARMS CRG support are listed here.)

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Accepted

Yan, G., Hasan, MT, and Ma, R. (2015). Analysis of clustered multinomial data with random cluster sizes. (accepted). Journal of Applied Statistics.

Zhu, R., El-Shaarawi, AH, Duan, X., Wang, Z. and Ma, R. (2016). Assessing annual trends, monthly fluctuations and between-station relationship of sulphate deposition in the Turkey Lakes Watershed (accepted). Envoronmetrics.

Under Revision

Hasan, MT, Sneddon, G. and Ma, R. (2015). Simultaneous Modelling clustered marginal counts and multinomial proportions with zero-inflation with application to analysis of osteoporotic fractures data. (under revision).

Hasan, MT, Sneddon, G. and Ma, R. (2015). Modelling distance-specific binomial counts and event probabilities (under revision).

Submitted

Pellegrini, R. Hasan, MT, and Ma, R. (2015). Analysis of paired semi-continuous data with application to comparative environmental and ecological studies. (under review).

Graphs and Games

Members:

Richard Nowakowski (Dal)   Stephen Finbow (STFX)
Suzanne Seager (Mount St Vincent) Art Finbow (St Marys)
Margaret-Ellen Messinger (Mt Allison)   Danny Dyer (Memorial)
Jeannette Janssen (Dal)   Nancy Clarke (Acadia)
Bert Hartnell (St Marys)   Jason Brown (Dal)
Shannon Fitzpatrick (UPEI)

Atlantic Canada has many Universities that do not have graduate programs yet which have excellent researchers and excellent students. The lack of a graduate program makes it very difficult for these researchers to obtain NSERC grants, indeed many no longer have grants, consequently their research program suffers and also the students are not exposed to other researchers nor to active research programs. The Collaboration Grant from AARMS has been instrumental in redressing these problems for our extended group.

The main theme for the group is: discrete systems on graphs. There is no underlying theory, as there is in the continuous cases. Being exposed to new ideas is paramount for the well-being of a research program and to stimulate both undergraduate and graduate students. The Collaboration Grant has formed the base funding, allowing the extended group to use both small departmental funds and NSERC grants judiciously and efficiently.

Events:
1. ***Post ECCC Student Friendly Mini-Workshop***, July 29, 2015, Mount Allison University. Organizer: Dr. M.E. Messinger.

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The morning began with a problems sessions where participants presented accessible open problems. Break-out groups then formed and the groups separated into different rooms to work on their problems. The break-out groups reconvened after lunch and later provided a progress report on their work mid-afternoon. The workshop provided a venue for undergraduate students to give short talks on their in-progress summer research. Four undergraduate students gave talks in the afternoon.
Participants:

    Dr. M. Messinger (MtA)
    (undergrad) S. Guzman Pro (Dal/Mexico)
    Dr. S. Finbow (StFX)
    (undergrad) G. Power (MtA)
    Dr. J. Howell (SWGC)
    (undergrad) F. Lidbetter (MtA)
    Dr. D. Cox (MSVU)
    (PhD) C. van Bommel (UVic/Waterloo)
    Dr. M van Bommel (StFX)
    (undergrad) J. O'Connor (UNBSJ)
    Dr. S. Fitzpatrick (UPEI)
    (undergrad) A. Angeli (MtA)
    (PhD) L. Mol (Dal)
    (undergrad) Jennie Newman (SMU)
    (MSc) T. Mullen (Dal)
    (undergrad) E. Bardeau (MtA)

2: *Games-at-Dal* *August 11-14, 2015,* Dalhousie University, Organizer: Dr. R. J. Nowakowski

   The first day consisted of talks. The subsequent days were a workshop on the games of Subversion, Distance Games, Leap-Frog and MEM. These led to the manuscript by Fisher, Larsson, McKay, Nowakowski, Ottaway and Santos "Subversion" and submitted paper by Burke, Hueback, Huggan, Huntemann, "When keeping your distance is hard".

Talks:
1) Alda Carvalho, C. Santos, (Portugal): Oak, ordinal sums and the generalized mex function;
2) A. Fraenkel, Lior Goldberg (Israel): Extensions of the results of Duchene, Fraenkel, Nowakowski and Rigo (Extensions and restrictions of "Wythoff's game preserving its P-positions") to Generalized Wythoff (| k-\ell | < t, t > a fixed integer).
3) Neil McKay* (Canada): Sums of Hackenbush Stalks
4) Gabriel Renault (Belgium): Invertibility modulo dead-ending no-P-universes
5) Simon Rubinstein-Salzedo (USA): Multi-pile Fibonacci nim.
6) Craig Tennenhouse (USA): New Bogus Nim variants

Workshop:
    In particular, four problems caught the attention of subgroups. People wandered between subgroups and joined in the conversations. This allowed the students to interact with all the international participants. Each day concluded with the leader of each group giving a synopsis.

A: Atomic Weights are an approximation that are very useful but the approximations are hard to calculate. The group proved that in a game where, at each stage, at most one player has a non-terminal option then the nim-dimension is at most 2. The canonical forms can be complicated but it was discovered that the Atomic Weights are restricted to being integral, -/12, 1/2, and a switch of the form { -2 | x } or { x | 2 }. The subsequent conjecture, *if the game has finite nim-dimension then the Atomic Weights will also be restricted*, has attracted international attention. A paper is now in preparation, with authors: Fisher, Mckay*, Nowakowski, Ottaway, Santos.

B: Complexity of Placement Games: A placement game has players placing pieces which then cannot be moved or removed from the board. Studying the underlying simplicial complexes has proved fruitful. The group however considered the complexity of placement games. Although not solved in general, the case for "Distance Games", for example COL and SNORT, was shown to be NP-complete. A paper has been submitted, with authors Burke, Heuback, Huggan* and Huntemann*.

C: Global Fibonacci Nim: This is a game introduced by Whinihan (1963) but was only solved for 1 heap. Larsson and Rubinstein-Salzedo, using Zeckendorf representations and fibonacci words, solved the two heap case and made inroads on the multi-heap case. A paper has been submitted, see arXiv:1509.08527

D: MEM games: originally proposed by Conway (see Winning Ways 1982 edition). Very little progress has been made until this Workshop. Larsson, McKay*, Rubinstein-Salzedo and both Siegels
all worked on this and the results have been presented in conferences at MSRI and Israel. A paper is now in preparation.

Other Problems that were considered.

E: Blocking games. To convert a game to a blocking game allow the option for the previous player to forbid a particular option on the next turn. This led to an ongoing discussion of cellular automata generated by combinatorial games. In particular, Blocking Hex. Carvalho, Isenor*, Fisher, Larsson, Renault.

F: Many variants of Leapfrog: these arose out of a question raised by Richard K. Guy. Intriguing conjectures were obtained but no definitive progress as of yet. Everybody in the group joined in at some point.

3: ***One-Visibility Cops and Robber Workshop***, Dec 5-6, 2015, Acadia University. Organizer: Dr. N.E. Clarke.

This intense 2-day workshop focussed on a pursuit-evasion game on a graph. Dr. Dyer (MUN) recently published two articles on the Zero-Visibilty model and proposed this natural variant as a problem to study. The participants have an on-going collaboration on this problem. Participants:

Dr. N.E. Clarke (Acadia)
Dr. S. Finbow (StFX)
Dr. C. Duffy (Dal)
Dr. D. Cox (MSVU)
Dr. M. Messinger (MtA)
Dr. D. Dyer (MUN)
Dr. S. Fitzpatrick (UPEI)

Research Papers

CRG members in **bold**, students in *italics*

<u>Accepted or Appeared.</u>
S. Bard, **C. Duffy**, M. Edwards, G. MacGillivray, F. Yang. Eternal Domination of Split Graphs, to appear in Journal of Combinatorial Mathematics and Combinatorial Computing.

J.I. Brown, **D. Cox**, Inflection Points of All-Terminal Reliability Polynomials are Dense in [0,1], to appear in Networks.

N.E. Clarke, **S. Finbow**, **S. Fitzpatrick**, **M.E. Messinger, R. Milley, R.J. Nowakowski,** Grundy Number and Graph Products, *Discrete Applied Mathematics* 202 (2016) 1-7.

D. Dereniowski, **D. Dyer**, R. Tifenbach, B. Yang, Zero-visibility cops and robber and the pathwidth of graph. *J. Comb. Optim.* 29 (2015), no. 3, pp. 541–564.

C. Duffy, G. MacGillivray, An Analysis of the Weighted Firefighter Problem, Journal of Combinatorial Mathematics and Combinatorial Computing 94:167-175 (2015).

A. Finbow, **B. Hartnell**, J. Young, The complexity of monitoring a network with both watchers and listeners, accepted subject to revisions by Networks.

S. Finbow, M.E. Messinger, M. van Bommel, Eternal domination on 3 x n grid graphs, Australasian Journal of Combinatorics (61)2 (2015) 156-174.

S.L. Fitzpatrick, J. Howell, **M.E. Messinger**, **D.A. Pike**, A Deterministic Version of the Game of Zombies and Survivors on Graphs, accepted subject to revisions by Discrete Applied Mathematics.

U. Larsson, R. J. Nowakowski, C. Santos, Scoring Games: When Waiting moves you, to appear in International Journal of Game Theory.

B. Hartnell, **J. Newman**, Equi-b-matchable Graphs, to appear in Bulletin of the I.C.A.

J.T. LeGrow, **D.A. Pike** and J. Poulin, Hamiltonicity and cycle extensions in 0-block-intersection graphs of balanced incomplete block designs. to appear in Designs, Codes and Cryptography.

M. Huggan, **R. J. Nowakowski**, Conjoined games: Go-Cut and Sno-Go. To appear Games of No Chance 5.

R.D. Luther and **D.A. Pike**, Cycle extensions in PBD block-intersection graphs, to appear in Ars Combinatoria.

R.D. Luther and **D.A. Pike**, Equitably colored balanced incomplete block designs, to appear in Journal of Combinatorial Designs.

M.E. Messinger, A.Z. Delaney, Closing the Gap: Eternal domination on 3 x n Grids, to appear in Contributions to Discrete Mathematics.

D.A. Pike, *A. Sanaei* and N. Shalaby, Pseudo-Skolem Sequences and Graph Skolem Labelling, to appear in Mathematica Scandinavica.

<u>Papers submitted this year</u>
B. Bresar, **B. Hartnell**, D. Rall, Uniformly Dissociated Graphs.

K. Burke, S. Hueback, *M. Huggan*, *S. Huntemann*, When keeping your distance is hard.

D. **Dyer**, E. Martinez-Pedroza, B. Thorne, The Coarse Geometry of Hartnell's Firefighter Problem on Infinite Graphs.

D. **Dyer**, **J. Howell**, The watchman's walk of Steiner triple system block intersection graphs.

A. Finbow, **B. Hartnell**, M. Plummer, On well-covered pentagonalizations of the plane.

W. F. Klostermeyer, **M.E. Messinger**, A. Angeli Ayello, An Eternal Domination Problem in Grids.
S. Finbow, S. Gaspers, **M.E. Messinger,** P. Ottaway, A Note on the Eternal Dominating Set Problem.

Manuscripts
N.E. Clarke, *M. Creighton*, *P. Murray* and **A. Sanaei**, Ambush Cops and Robbers.
N.E. Clarke and **A. Sanaei**, Skolem Labellings of Generalised Dutch Windmills.
N.E. Clarke and **R.P. Gallant**, On 2-Limited Packings of Complete Grid Graphs.
S. Faridi, *S. Huntemann*, **R. J. Nowakowski**, Flag Complexes.
M. Fisher, **U. Larsson**, *N. McKay*, **R. J. Nowakowski**, P. Ottaway and C. Santos, Subversion.
M. Huggan, **R. J. Nowakowski**, Thinning Thickets.

AARMS Summer School

The fourteenth AARMS Summer School took place at Dalhousie University from July 6 -31, 2015 under the direction of Theodore Kolokolnikov and Hermann Brunner. As usual, four courses at the beginning graduate level were offered; in 2015 the theme was Differential Equations:

- **Waves and patterns in nonlinear systems**
  Dr. Andrea Bertozzi, UCLA and Dr. Ricardo Carrettero, San Diego State
- **Topics in Reaction-Diffusion Systems: Theory and Applications**
  Dr. Michael Ward, UBC and Dr. Juncheng Wei, UBC
- **Structure-preserving discretization of differential equationsInstructors**:
  Drs. Elena Celledoni, Norwegian University of Science and Technology and Brynjulf Owren, Norwegian University of Science and Technology
- **Numerical analysis of singularly perturbed ODEs and PDESInstructor**:
  Dr. Martin Stynes, University College Cork, Ireland

Concurrently with the summer school, there were three associated workshops in differential equations that the school participants were also invited to attend:

- Bluenose Workshop (July 11-12).
- Workshop on Pattern Formation in Differential Equations (July 18-19).
- Workshop on Domain Decomposition methods for PDEs **(**Aug 4-8).

Unlike previous years, we made a decision not to subsidize food for students. It was felt that the money would be better spent on instructurs and TA's instead. Moreover, many students found additional sources of funding from their home institutions. We gave all instructors a choice of either a at all-inclusive honorarium rate, or an honorarium plus airfare plus housing. Several instructors chose the all-inclusive rate, which can be advantageous particularly for non-Canadians, because they can get taxes back from

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CRA. On the other hand, for Canadians the all-inclusive honorarium was less attractive because of tax implications.

We hired three TA's: one TA for course 1 and two for course 2 (one each for Ward and Wei's parts). Course 1 had the largest enrollment and also had a computer lab component. The TA for course 1 helped students with the lab and graded their homework. She lived in the student residence and was able to help the students in the evenings as well. It was definitely worth the investment.

A facebook group page was useful for both students and instructors. Various announcements were done through this page. Additionally, students often self-organized for dinners, trivia nights etc.

We hired a socal events planner/organizer, Shannon Peng and Tianze Kong. They run the China 2+2 program at Economics department and have a wealth of experience with organizing social activities. This was a worthwhile investment not only from the point of view of saving the organizers time, but also because they have good connections to food services, bus companies and so on, which allowed them to save money overall. Here is the list of social activities:

- Welcome reception
- Lobster boil in Point Pleasant park
- A day-trip to Lunenburg
- Harbour Hopper
- Farewell dinner

Participants at the 2015 AARMS Summer School

List of Students

Alhasanats, Ahmad Salman	Memorial University of Newfoundland
Ali, Iftikhar	King Fahd University of Petroleum and Minerals, Saudi Arabia
Broome, Michael	Montana State University
Burhoe, Simon	University of Massachusetts Amherst
Chen, Tongzhou	School of Math at Georgia Institute of Technology
Ciesielski, Danielle	Montana State University

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Cisneros, Pedro	University of Peru
DiPietro, Kelsey	University of Notre Dame
Dostalik, Mark Charles	University in Prague Czech Repubic
Dowdall, James	University of Ottawa
Draskovic, Dragana	University of Novi Sad, Serbia
Dunlap, Alexander	Chicago
Gai, Chunyi	Dalhousie University
Gomez, Daniel	University of BC
Grant, Zachary	University of Massachusetts Dartmouth
Hguyen, Hieu	University of Texas Austin
Huang, Chih-Chiang	Department of Mathematics-National Taiwan University
Huang, Robert	University of New Brunswick
Jain, Sonal	Malaviya National Inst of Technology
Keegan Kirk	UPEI
Koo, Ja-Keoung	Chuang-ang University
Koopaei, Javad Rastegari	Western University
Lin, Kuan-Yu	University of Minnesota. Twin Cities
Mavric, Bostjan	University of Nova Gorica
Nino, Guancarlo	GSSI, Italy
Ohm, Laurel	Washington
Pancaldi, Francesco	University of Notre Dame
Portaluri, Tommaso	University of Turin
Qu, Zhaonan	Princeton University
Shiliang Shan	Dalhousie
Sierra, Trinidad	UC Riverside
Smith-Roberge, Julien	Dalhousie
Spies, Lukas	Memorial University of Newfoundland
Steyer, Andrew J.	University of Kansas
SunKula, Mahesh	University of Oklahoma
Tao, Tianyu	University of Minnesota
Tristan Guest	Dalhousie
Varatharajan, N	Centre for Theoretical Studies
Virissimo, Francisco	University of Bath
Xie, Shuangquan	Dalhousie
Xu, Feifei	Florida State University
Yu, Polly Wing Yan	University of Waterloo
Zaytseva, Sofya	College of William and Mary
Zitin, Ari	Berkley

In a survey of participants taken after the summer school had finished, respondents gave scores to the four different courses. Average scores ranged between 68% and 96%. Ratings of lecturers ranged between 77% and 97%. When asked whether they would recommend the summer school to a friend or colleague, 90% or respondents said that they would. There were a few comments about the need for greater background information on the courses. For example:

> *"I would have benefitted from more information ahead of time as to what background the classes expected"*

> *"An outline of the requirements of knowledge to come into the class already knowing would have been very helpful"*

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But the general tone of comments was positive:

"overall it is a great experience"

The fifteenth annual Summer School will be held July 11- Aug 5, 2016 at Dalhousie University. We will be offering the following courses:

- **Higher Category Theory and Categorical Logic**
   Drs. Michael Shulman, University of San Diego, and Peter Lumsdaine,   Stockholm University
- **Categories, Quantum Computation and Topology**
   Dr. Jamie Vicary, University of Oxford
- **Stable polynomials: with applications to graphs, matrices, and probability**
   Dr. David Wagner, University of Waterloo
- **An Introduction to Special Functions and WZ Theory**
   Dr. Armin Straub, University of South Alabama

AARMS Postdoctoral Fellowship Program

AARMS awarded seven new Postdoctoral Fellowships in 2015:
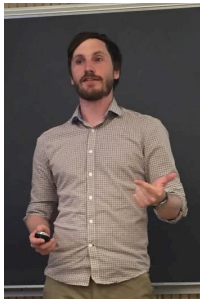
Christopher Duffy received his PhD (2015) from the University of Victoria and the University of Bordeaux. His research interests are graph homomorphisms and discrete time processes on graphs. He is currently working at Dalhousie University under the supervision of Jeannette Janssen and is the AARMS outreach coordinator postdoctoral fellow.

Daniele Gregoris received his PhD (2014) from Stockholm University within the Erasmus Mundus framework. His research interests are general relativity, cosmology and geometry and is currently working at Dalhousie University under the supervision of prof. Alan Coley.

Nathan Grieve received his PhD (2013) from Queen's University. His research interests include algebraic, complex, and differential geometry and is currently working at the University of New Brunswick under the supervision of Colin Ingalls.

Rory Lucyshyn-Wright received his PhD from York University in 2013 and was an NSERC Postdoctoral Fellow at the University of Ottawa and the University of Cambridge from 2013 to 2015. As an AARMS Postdoctoral Fellow he is currently working at Mount Allison University under the supervision of Geoffrey Cruttwell and Robert Rosebrugh.
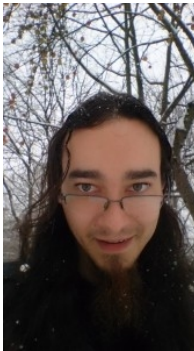
Israel Rocha received his PhD (2015) in applied mathematics from Federal University of Rio Grande do Sul. His research interests includes spectral graph theory focusing on partitioning, clustering and connectivity problems. He is currently working at Dalhousie University under the supervision of Jeannette Janssen as the AARMS Director Postdoctoral Fellow.

Peng Zhou received his PhD in 2015 in mathematics from Shanghai Jiao Tong University, Shanghai, China. As an AARMS postdoctoral fellow he is currently working at Memorial University under supervision of Prof. Xiaoqiang Zhao. His research interests lie in Nonlinear PDEs with application to mathematical biology.
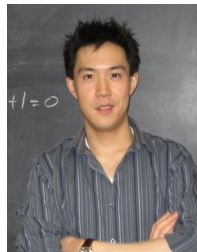

Baocheng Zhu received his PhD in 2014 from Southwest University, Chongqing, China. He is currently working at Memorial University under the supervision of Dr. Deping Ye. His research interests are in convex geometric Analysis.

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Other ongoing AARMS Postdoctoral Fellowships in 2015:

Jonathan Ziprick received his PhD (2014) from the University of Waterloo. He is currently working with Jack Gegenberg, Viqar Husain and Sanjeev Seahra at the University of New Brunswick. His research goes toward finding a quantum theory of general relativity.

Justin Tzou received his PhD in 2012 in Applied Mathematics from Northwestern University. He currently works at Dalhousie University under the supervision of Theodore Kolokolnikov. His research is in the formation and stability of patterns in different regimes of reaction-diffusion equations using weakly nonlinear, asymptotic, and numerical methods.

Yuzhao Wang received his PhD (2010) in Pure Mathematics from Peking University, Beijing, China. As an AARMS postdoctoral fellow, he is currently working at Memorial University under the supervision of Prof. Jie Xiao. His research interests lie in Harmonic Analysis and Partial Differential Equations.

The competition for 2016 positions opened in November 2015 with final decisions on awards made in spring 2016.

Past holders of AARMS Postdoctoral Fellowships have gone on in many cases to continue in successful careers in mathematics.

Past Postdoctoral Fellows:

Evgeny Chibrikov, Memorial 2009-11 – Currently working in industry in St. John's
Alin Ciuperca, *UNB 2009-11* – Currently working in the Financial sector in Toronto
Kia Dalili, *Dalhousie 2005-07* - Currently working at the Stevens Institute of Technology in Hoboken,New Jersey
Mahya Ghandehari, *Dalhousie 2010-12* - Currently Assistant Professor, U. of Delaware
Alexei Gordienko, *Memorial 2010-12* - Currently working as a Marie Curie Postdoctoral Fellow at Vrije Universiteit in Brussels
Thomas Guedenon, *Mount Allison 2003-05* – no information
Rebecca Hammond, *Acadia 2007-09* - no information

Sigbjorn Hervik, *Dalhousie 2005-06* - Currently a full professor at the University of Stavanger in Norway.

Daniel Horsley, *Memorial 2008-10* – Currently ARC DECRA Research Fellow in the School of Mathematical Sciences at Monash University

Golam Hossain, *University of New Brunswick 2008-10* – Currently Assistant professor at the Indian Institute of Science and Education in Kolkata.

Tobey Kenney, *Dalhousie 2006-08* - Currently Professor of mathematics at Dalhousie

Dawood Kothawala, *University of New Brunswick 2010-12* – Currently Assistant professor at the Indian Institute of Techology (IIT) in Madras.

Peter LeFanu Lumsdaine, *Dalhousie 2010-12* - Currently holds a postdoctoral position at Stockholm University

Rogers Mathew, *Dalhousie 2012-13* - is now a faculty member at IIT Karaghpur in India

Ping Wong Ng, *University of New Brunswick 2003-05* – Currently Assistant professor in the Mathematics Department at the University of Louisiana at Lafayette

Rui Peng, *Memorial 2010-12* - Currently is a postdoc in the Institute of Math. and its Applications,University of Minnesota.

Ryan Tifenbach, *Memorial 2012-14* – is a postdoctoral fellow at the University of Regina

Francis Valiquette, *Dallhousie 2011-13* - is an assistant professor at SUNY New Paltz

Michael A. Warren, *Dalhousie 2010-11* - Currently holds a postdoctoral position at the Institute of Advanced Studies in Princeton

Oliver Winkler, *University of New Brunswick 2004-06* - Currently Strategic Analyst with Siemens Canada

Dansheng Yu, *Saint Francis Xavier 2006-08* – Currently Associate Professor, Hangzhou Normal University, China

Conferences and Workshops

In 2015 AARMS funded or partially funded the following workshops conferences and events. These involved over 1100 participants, more than 750 of whom were from outside Atlantic Canada:

Combinatorial Algebra Meets Algebraic Combinatorics
Organizer: Hugh Thomas
Location: Queen's University, Kingston
Date: January 23-25, 2015

This conference, the eleventh in its annual series, was held at Queen's University in Kingston, Ontario. The conference included 16 talks over three days. The conference had forty participants, with five of them being from Atlantic Canada (2 faculty members and 3 graduate students). Topics included some familiar from other years, such as Hopf algebras (as in the contributed talks by Amy Pang and Yannic Vargas), and some less familiar ones, such as Schubert calculus (which appeared in the invited talk of Cristian Lenart as well as contributed talks by Dominic Searles and Anna Bertiger). The talk by Patricia Hersh, discussing her recent paper in Inventiones, on regular cell complexes and total positivity, was a highlight. We were also happy to welcome Mats Boij back as an invited speaker again; one of the founders of Boij-Söderberg theory, and a faculty member at KTH in Stockholm, he has attended the conference several times.
Also funded by Fields, Queens University and the University of New Brunswick

Atlantic General Relativity 2015
Organizer: Sanjeev Seahra and Viqar Husain
Location: University of New Brunswick
Date: May 6-7, 2015

The Atlantic General Relativity Meeting 2015 (AGR15) was the latest in an annual series of meetings covering all aspects of classical and quantum gravity. There were 28 participants in AGR15 and 20 talks. 21 participants were from the Atlantic region (i.e., from UNB, Dalhousie or Memorial), four from elsewhere in Canada, and three from outside Canada. The principal invited speaker for the conference was Jorma Louko (Nottingham), who gave two talks. We also invited Walter Craig (Fields Institute and McMaster), who gave one talk. Topics covered included quantum fields in curved space and the recent controversial firewall proposal, quantum gravity, wave propagation in curved space, exotic classical solutions of the Einstein equation, and alternative gravity models.

On the evening of May 6, we held a public talk delivered by Sanjeev Seahra (UNB) and panel discussion to celebrate the centenary of the Einstein field equations. The panel consisted of Masooma Ali (UNB), Hari Kunduri (Memorial), Steve Turner (UNB) and Jon Ziprick (UNB). We estimate & 100 members of the public were in attendance.

ACCESS 2015
Organizer: Remy Rochette, Myriam Barbeau, James Watmough
Location: Huntsman Marine Science Centre, St. Andrews, New Brunswick
Date: May 10-12, 2015

This conference was organized by the labs of Drs. Myriam Barbeau, Rémy Rochette and Heather Hunt from the Departments of Biology in Fredericton and Saint John, with assistance from the lab of Dr. James Watmough from the Department of Math/Stats. The event included a workshop on Spatial Analysis and a Symposium on "Spatial Analysis in Coastal Systems" by Dr. Marie-Josee Fortin (University of Toronto), who is a world-leader in spatial analysis. There were 48 speakers, of which 31 were graduate students and 3 undergraduate students. Participants included academics from Atlantic Canadian and Quebec Universities, researchers from government research labs (DFO, BIO), representatives from industry and conservation societies and some international visitors. AARMS funds were used as travel awards for students in mathematics and statistics interested in modelling and analysis of problems in spatial ecology.
Also funded by the University of New Brunswick

Applied Mathematics in Environmental sciences
Organizer: Salah El Adlouni
Location: Rimouski, QC
Date: May 26, 2015

Twelve conferences selected for this symposium focused on a variety of subjects with great interest for modeling environmental phenomena. The speakers came from different Canadian and international universities (2 regional, 9 national and 1 international). More than fifty people attended this conference and participated to discussions that follow each presentation. The main developments were related to:

- Resolution of the convection-diffusion problems by the approaches of stabilized finite elements;
- New approaches to the non-crossing problems for the quantile regression;
- Combinatorial approaches in the field of non-ideal gas;
- Methods of network rationalization for water temperature measures;
- Numerical methods for atmospheric modeling;
- Directional Statistics to model animal movements;
- Spatio-temporal model for air pollution studies.

Also funded by l'Université de Moncton

Sessions at the CMS Summer Meeting
Location: UPEI, Charlottetown
Date: June 5-8, 2015

AARMS provided travel support to local researchers who wished to organize special sessions on a focused research area in association with the annual meeting of the Canadian Mathematical Society. Eleven such special sessions were funded by AARMS with support for travel of participants who otherwise would not have come to the CMS meeting. In total 90 researchers and guest speakers from across Canada, the USA, and other countries were enabled to attend the meeting and engage in these events with their collaborators in Atlantic Canada.   The special sessions were:

Dynamical Systems with Applications to Biology and Ecology
Number Theory
Rigorous computation for differential-equation problems
Games and Pursuit Games on Graphs
Interplay of Convexity and Geometric Analysis
Ergodic Theory, Dynamical Systems and Applications
Optimization and Nonlinear Analysis
Singularities and Phase Transitions in the Calculus of Variations and PDE
Graphs, Designs, and Hypergraphs
C*-algebra
Recent advances in the mathematics of electromagnetic and acoustic imaging

Also funded by the Canadian Mathematical Society and diverse NSERC Discovery Grants

Statistical and Computational Analytics for Big Data
Organizers: Hugh Chipman, Nancy Reid, Stan Matwin
Location: Dalhousie, Halifax
Date: June 12-13, 2015

This conference was part of the six month Fields Institute thematic program on "Statistical Inference, Learning, and Models for Big Data" with a number of allied activities at PIMS, CRM and AARMS. The conference gave an overview of highlights of the thematic program, and showcased research at IBDA on text mining, high performance computing, visualization, bioinformatics, and privacy. The conference consisted of 1.5 days of research presentations. Coffee breaks, lunch and a mixer on the evening of June 12 provided ample opportunity for networking and discussion. There were 71 participants (26 faculty, 2 government, 8 postdoc, 35 students). 16

students received partial support from the conference for travel ($500/person maximum). 68 participants were from Canada, 1 USA, 1 Brazil, 1 Germany. Of those from Canada, 40 were from Atlantic Canada.

A manuscript is in preparation summarizing the thematic program has been drafted and is currently under review.: "Statistical Inference, Learning and Models in Big Data" by Beate Franke, JeanFrançois Plante, Ribana Roscher, Annie Lee, Cathal Smyth, Armin Hatefi, Fuqi Chen, Einat Gil, Alex Schwing, Alessandro Selvitella, Michael M. Hoffman, Roger Grosse, Dieter Hendricks, Nancy Reid http://arxiv.org/abs/1509.02900

Talks presented by Chipman, Gil, Grosse, Plante, Lix and Shipp were overviews of the research presented at selected workshops during the thematic program on Statistical Inference, Learning and Models for Big Data. The other talks presented research at IBDA on text mining, highperformance computing, visualization, bioinformatics, and privacy. The event was wellattended by regional researchers and by statisticians from across Canada who were visiting Halifax for the annual meeting of the Statistical Society of Canada. As with the other events in the Big Data thematic program, the diversity of fields involved in Big Data research was evident at this conference. At the heart of nearly all the presentations was a substantive data science application. For example, Stephanie Shipp gave an interesting application involving data on first responder calls by fire departments, and the optimal allocation of services. Although the applications were quite varied, a number of common themes emerged. In this context, issues such as privacy of individuals represented in databases, feasibility of computation, including high performance computing, combination of different databases (e.g., in health policy research), including diverse data sources (geolocation, text, transactions, social media) and data visualization were discussed.In a panel discussion on education in data science participants Chipman, Gil, Reid, Matwin and Plante addressed a series of questions about the 'ideal' data science program:

- how traditional university degrees in statistics or computer science need to be modified to provide students with sufficient skills to work with big data
- the importance of soft skills such as data exploration, collaborative projects and communication in data science
- education of primary and secondarylevel students in data science
- crossdisciplinarity and partnering with subjectmatter experts in data science applications
- "data strategists" vs. "data scientists"
- Making room in a university curriculum for new topics: what should we be teaching less of?

One goal of the closing workshop was to 'introduce' researchers from the IBDA to the statistical sciences community, and vice versa. The second goal was to give a high level overview of the thematic program to interested researchers. We feel that both goals were successfully met with the workshop. The panel discussion was very helpful for the academic statisticians who participated, as many are involved in their institutions in introducing programs or courses in data science.

Statistical Society of Canada (SSC) 2015 Annual Meeting
Organizers: Ed Susko, Paul Gustafson, John Petkau
Location: Dalhousie, Halifax
Date: June 14-17, 2015

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The meeting attracted over 500 participants from educational, professional, scientific and public sectors. Registrants were mainly from Canada (335) and the United States (36), although there were registrants from countries such as China, France, Germany, Japan, Switzerland and others. There were 205 students and 43 recent graduate participants in attendance. On the first day of the conference, four concurrent full-day workshops were held: Biostatistics (44 participants), Probability (10 participants), Survey Methods (11 participants) and Statistical Education (23 participants). The second through fourth days of the conference consisted of scientific sessions. In total, there were 43 invited paper sessions, 27 contributed paper sessions, 1 case studies session and 1 poster session. The meeting featured 130 invited talks and 135 contributed oral presentations. Several awards were presented during the Meeting. The Gold Medal of the SSC was awarded to Richard Lockhart of Simon Fraser University, the Joint CRM-SSC award was presented to Matías Salibián-Barrera of the University of British Columbia, the Award for the Impact of Applied and Collaborative Statistics was given to Shelley Bull of the University of Toronto and the CJS (Canadian Journal of Statistics) award for the best paper of 2014 was given to a team of researchers: Douglas E. Schaubel (University of Michigan), Hui Zhang (U.S. Food and Drug Administration), John D. Kalbfleisch (University of Michigan), and Xu Shu (University of Michigan). In addition, John D. Kalbfleisch was given an Honorary Membership, Shirley Mills of Carleton University was given the Distinguished Service Award, and the Pierre Robilliard Award for the best PhD thesis in Statistics in 2014 was given to Ying Yan of the University of North Carolina at Chapel Hill, now at the University of Calgary.

Furthermore, the SSC presented awards for student research presentations and student research posters, best student presentation and best poster in probability, awards for the best analyses of each of two case-studies and an award for a bilingual abstract. In addition, 23 travel grants were provided to students presenting papers or posters.

And finally, several related events and activities were organized in conjunction with the meeting. The third SSC Student Conference was held on Saturday June 13 and was great success. It was held a day before the general meeting and involved 60 students in panel presentations and discussion. Business meetings were well attended. Social and information events provided networking opportunities.

Bluenose Applied and Computational Math Days
Organizers: Morven Gentleman, Wayne Enright, Paul Muir
Location: St. Mary's University, Halifax
Date: July 11-12, 2015

See the description in the report from the CRG on Numerical Analysis and Scientific Computing

Workshop on pattern formation in differential equations
Organizers: Theo Kolokolnikov, Michael Ward
Location: Dalhousie, Halifax
Date: July 18-19, 2015

Detailed report pending

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International Symposium in Statistics
Organizers: Brajendra Sutradhar et al
Location: Memorial University, St. John's
Date: July 20-22, 2015

This meeting covering five specialized research themes: Multi-dimensional data analysis in continuous setup; Multivariate analysis for longitudinal categorical data; Time series with financial and environmental applications; Spatial-temporal data analysis; and Familial longitudinal data analysis in semi-parametric setup, was attended by 46 delegates from many countries such as Brazil, France, India, Switzerland, USA and Canada, covering a large part of the globe. The meeting was a grand success with an excellent academic program complemented by two social events: the symposium banquet and a whale and puffin watching tour.

The symposium welcome address was given by Dr. Charmaine Dean, former President of the SSC (Statistical Society of Canada) and the current Dean of Science of the University of Western Ontario. There were four key note speeches in four different areas given by three speakers. Professor Anthony C. Davison from EPFL, Switzerland gave his key note address on Max-stable processes on river networks, under the theme of spatial-temporal data analysis. Professor Brajendra C. Sutradhar from Memorial University, Canada gave part 1 of his key note presentation on Advances and challenges in correlated data analysis in non-Gaussian multivariate setup; and part 2 of the presentation on Advances and challenges in analyzing ordinal categorical data in semi-parametric setup. The 3rd key note address was given by Professor Andrew Harvey from Cambridge University, UK., on New developments in modeling dynamic volatility. Nine special invited talks over three days of the symposium were given by professors Paul D. Sampson, University of Washington; Grace Y. Yi, University of Waterloo; Nairanjana Dasgupta, Washington State University; Roman Viveros-Aguilera, McMaster University; Julio M. Singer, Universidade de Sao Paulo; David E. Tyler, Rutgers- The State University of New Jersy; Refiq Soyer, The George Washington University, Charmaine Dean, The University of Western Ontario; and Richard J. Cook, University of Waterloo.The symposium had another two invited speakers, Drs. Alwell Oyet from Memorial University, and Ashis SenGupta from Indian Statistical Institute. Also contributed papers were presented by seven speakers including four graduate students. Furthermore, it is planned that a selected number of papers presented in the symposium will be published in the near future as lecture notes in the Springer's lecture note series.

East Coast Combinatorics Conference
Organizers: Margaret-Ellen Messinger, P. Danziger and W. Klostermeyer
Location: Mount Allison University, Sackville
Date: July 27-28, 2015

The ECCC is designed to bring together mathematicians and computer scientists interested in all aspects of combinatorics and the scope of the conference includes most areas of modern combinatorics, including but not limited to, graph theory, design theory, combinatorial optimization, and applications of combinatorics in computer science. This was the 10th year of the conference.

A plenary talk by Dr. Peter Danziger (Ryerson University) was given on the first day of the conference. Dr. Danziger is a well-respected researcher in both design theory and graph theory. He gave an interesting talk, entitled "Factoring into cycles", which focussed on the Oberwolfach and Hamilton-Waterloo problems and included the origins and history of the problems as well as recent results. The first day of the conference also included five talks given by faculty and graduate students. The second day of the conference included 6 talks given by faculty and graduate students, along with a full-hour long "open problems" session. A number of open problems were presented in a very collaborative and inclusive atmosphere. The movie "Codebreakers: lost heroes of Bletchley Park" was shown in the evening.

Along with the "open problems" session, the conference talks generated interesting discussions and new ideas; and also allowed researchers with existing collaborative projects an opportunity to come together to work on such projects. Immediately following the conference, on July 29th, the Graphs-and-Games Group (AARMS Collaborative Research Group) held a mini-workshop. Most ECCC participants also participated in the mini-workshop. The mini-workshop provided a forum for four undergraduate students to give short talks on their summer research, but the majority of the day was devoted to exploring new research problems in a collaborative atmosphere.

Domain Decomposition Methods for the Parallel Solution of Partial Differential Equations
Organizers: Ronald Haynes, David Iron, Hermann Brunner, Paul Muir
Location: Dalhousie University, Halifax
Date: August 4-9, 2015

See the description in the report from the CRG on Numerical Analysis and Scientific Computing

Conference on Selected Areas in Cryptography + SAC Summer School
Organizers: Liam Keliher and Orr Dunkelman
Location: Mount Allison University, Sackville
Date: August 10-14, 2015

Detailed report pending

Games at Dal VIII
Organizers: Urban Larsson and Richard Nowakowski
Location: Dalhousie University, Halifax
Date: August 11-14, 2015

see the CRG inGraphs and Games for a fuller description

Algebraic Groups and Lie Algebras
Organizers: Mikhail Kotchetov, Kirill Zainoulline and Yuri Bahturin
Location: Bonne Bay Marine Station of MUN, NL
Date: August 16-22, 2015

This workshop was organized in collaboration with the Network of Ontario Lie Theorists (NOLT). It was the second international workshop organized jointly by the Atlantic Algebra Centre and NOLT. Both groups also took an active part in the workshop "From Lie Algebras to Group Schemes" organized by the University of Ottawa and Carleton University in May 2015.

Algebraic groups are one of the cornerstones of modern mathematics. They are closely related to Lie groups and combine methods of Algebra, Algebraic Geometry, Topology, Functional Analysis, Lie Theory and other areas. Because of the richness of the subject, Algebraic groups find extensive applications in mathematics and natural sciences including applications in cryptography, Harmonic Anlalysis, Algebraic Topology, conservation laws in Physics, symmetries of molecules in chemistry, etc. One of the main tools in the theory of algebraic groups is the theory of Lie algebras. And, conversely, algebraic groups often serve as an important tool in the study of Lie algebras. This is why researchers usually study both subjects at the same time, which turns out to be very effective. There are hundreds of mathematicians in the world working in these areas. The theory has become very deep and has many specialized branches and many applications. In our workshop, we focused on the following areas: actions of algebraic groups by automorphisms of algebraic varieties, graded algebras and superalgebras, linear representations of groups and Lie algebras, and applications of algebraic groups to the structure theory of algebras including positive characteristics. Most of these areas are actively studied by the members of AAC and NOLT. There were 24 participants from seven countries: Brazil, Canada, Russia, Slovenia, Spain, Sweden and the UK.
Also funded by Fields, Memorial University, and the Atlantic Algebra Centre

AHA 2015
Organizers: Keith Taylor et al
Location: Dalhousie University, Halifax
Date: August 17-21, 2015

Many of the leading researchers in the area of abstract harmonic analysis gathered in Halifax from August 17 to August 21 for a scientific conference and workshop. There were 42 participants in the conference, distributed as follows: Canada (17), USA (2), UK (4), Germany (4), Spain (2), Sweden (2), France (1), Switzerland (1), Austria (2), Finland (1), Tunisia (1), Hong Kong (1), New Zealand (1), South Korea (1), South Africa (1), Poland (1). Of the 17 Canadian participants, 10 were students or post-docs. Thus it was very much an international conference.

The scientific program was structured around 32 invited lectures with time set aside on Wednesday and Friday afternoons for small group discussions to foster collaborations. An excursion at 4:30 on Wednesday afternoon was followed by a conference dinner. . As reflects the importance of the Fourier A(G) and Fourier-Stieltjes algebra B(G) of a locally compact group G and the many significant advances in

understanding these algebras in recent years three of the eight sessions had a focus relating to these particular algebras. Monday, Wednesday and Friday morning sessions consisted of talks on A(G), B(G) or closely related Banach algebras.

Other sessions contained contributions to a variety of tools of harmonic analysis such as cohomology, Beurling algebras, Sidon sets, multiplier algebras, hypergroups, representation theory of Lie groups, group C*-algebras, quantum groups, spectral theory, and compactifications. In arranging the schedule, we also strove to intermix mature researchers with recent entrants into the field. It was gratifying that eight of the lectures were presented by current or recent doctoral students.

One of the highlights of the Fourier algebra sessions was Nico Spronk's announcement that the cohomological question of weak amenability of A(G) was now completely answered for Lie groups. (A(G) is weakly amenable if and only if the connected component of the identity in G is abelian.) This was joint work of Spronk with Lee, Ludwig and Samei (all of whom were at the conference) and built on recent break-through results of Choi and Ghandehari. Another highlight concerned the Herz-Figa-Talamanca algebras Ap(G); $1 < p < 1$ (note A2(G) = A(G)). Antoine Derighetti presented a brilliant and delicate construction giving an explicit extension of an element in Ap(H) to Ap(G) in the case where H is a closed amenable subgroup of G. This construction is new, and difficult, even when G = R and H = Z. The existence of such extensions will be very useful in establishing hereditary or inductive properties of Fourier algebras.

Arguably, one of the most exciting results presented at the conference was Jean Ludwig's talk on the group C*-algebra of a nilpotent Lie group. He and his co-authors have achieved an explicit description of C(G), when G is connected and simply connected, as particular sections of a C*-bundle over bG. The existence of such an explicit description has been sought since 1973 when Ian Brown showed that the Kirillov map from the topological space of coadjoint orbits in the dual of the Lie algebra of G onto bG is a homeomorphism. The greatest difficulties involve the behaviour at the singular point which is the constant 1 representation.

AHA 2015 was a scientific success with virtually all talks having good content and several presenting substantial and significant recent advances; but perhaps the greatest benefit of a conference such as this, which brings together the very active researchers in a relatively specialized area with graduate students and post-docs, is the wealth of new connections made, both mathematical and personal. In the evenings and during gaps in the program, many discussions take place, often stimulated by a talk. A number of new collaborations started during this week and we can look forward to continued vitality in the field.

Also funded by Fields, and Dalhousie University

Atlantic Math Stats and CS Conference 2015
Organizers: Daniel Silver et al
Location: Acadia University, Wolfville
Date: October 23-24, 2015

detailed report pending

Exploring Fractals: Topology, Dimension and Invariant Measures
Organizers: Shafiqul Islam, Franklin Mendivil and Tara Taylor
Location: Acadia University, Wolfville
Date: October 25, 2015

will be reported in detail in the 2016 report of the CRG in Iterated Function Systems (IFS), Fractals, Invariant Measures and Applications

Prizes

In 2015 AARMS also funded the student poster prize at the winter and summer meetings of the Candian Mathematical Society. And, AARMS funded annual algebra prizes awarded by the Atlantic Algebra Centre.

Outreach

In 2015 AARMS supported the following outreach programs:

Nova Scotia Math Outreach Discussion Meeting

The second annual Nova Scotia Math Outreach Discussion Meeting was held in June 2015. It included participants from across the province who were active in outreach and the goal was to produce a strategic plan for fostering and coordinating successful outreach activities in mathematics and statistics in Nova Scotia

Organizers of current outreach programs reported on their activities and their issues. These included

- Math Circles
- Nova Scotia Math League
- Black Educators Association Math Camp
- CMS Dalhousie Math Camp
- STFX projects reaching out to Aboriginal communities
- Introduction of the new Outreach Coordinator
- Mathematics Olympiad for Girls

A series of ideas for future development were produced:

Activities aimed at women and girls
Activities aimed at aboriginal groups and other under-represented groups
Involvement of undergraduate students in outreach
An enhanced role for AARMS in:
- Creating a new position of Outreach Coordinator in Nova Scotia
- Collecting and vetting online math resources
- Expanding awareness in the province of outreach opportunities
- Holding an annual Outreach Discussion meeting for practitioners

Participants:
Lisa Lunney Borden   School of Education, STFX
Danielle Cox   Math/Stats, Acadia Math Circles
R.P.Gupta   Dalhousie & Black Educators Ass. Math Camp
Eva Knoll   Faculty of Education, MSVU

Jeannette Janssen	Math/Stats, Dalhousie	Director of AARMS
David Langstroth	AARMS Executive Administrator	
Nancy Clarke	Math/Stats, Acadia	
Roman Smirnov	Math/Stats, Dalhousie	Dalhousie Math Camp
Jeff Hooper	Math/Stats, Acadia	
Erick Lee	Halifax Regional School Board	
Dorette Pronk	Math/Stats, Dalhousie	
Richard Nowakowski	Math/Stats, Dalhousie	
Matt Hebb	Dalhousie Assistant VP Government Relations	
Lois Murray	Biochemistry, Dalhousie	
Mary Ann Dufour	Kings Edgehill School	
Andrew Hare	Mathematics & CS, SMU	
John Irving	Mathematics & CS, SMU Math League	
John Grant McLoughlin	Faculty of Eductaion, UNB	
Preman Edwards	Aburn Drive HS & Black Educators Ass. Math Camp	
Karyn McLellan	Math/Stats/CS, STFX	
Chris Duffy	AARMS Outreach Coordinator	
Phillip MacEachern	Faculty of Education, MSVU	
Ben Cameron	Math/Stats, Dalhousie	
Tara Taylor	Math/Stats/CS, STFX	
Geneviève Boulet	Faculty of Education, MSVU	
Jean Hillman	Faculty of Education, MSVU	

Nova Scotia Math Circles:

Math Circles is a long-standing outreach program in Nova Scotia, dedicated to enriching the experiences of elementary, junior high and high school students in all areas of mathematics. Math Circles is delivered mainly by graduate students in Mathematics and Statistics, who travel across the Province giving interactive mathematical presentations in the classroom. In addition, monthly events for students, parents and teachers are held in the Mathematics and Statistics Department at Dalhousie University.

The program is very successful, and in high demand. A five-year grant (2014-2019) by *Eastlink* to Dalhousie, targeted to Math Circles, has enabled an expansion of activities to include younger students. The program started with visits to high schools, but now is expanding rapidly to junior high schools. In collaboration with the Education department of Mount Saint Vincent University, Math Circles has also expanded to elementary schools. For the delivery of the program, Math Circles enlists an increasing number of university students, including graduate students and undergraduate Honours students from Dalhousie and from other universities.

The rapid expansion of Math Circles is evident in the participation statistics. In 2014/2015 the program reached over 3700 students with 159 presentations across 28 schools in Nova Scotia. This represents nearly a ten-fold increase in students reached since 2009. Junior high school visits started in 2013, and now account for more than half of all visits.

AARMS aims to support Math Circles in its continued expansion through coordination, resource sharing and publicity. In particular, AARMS will support activities initiated from universities other than Dalhousie University. In 2014/15 the program began at Acadia University, and there is increasing interest in expanding to other Universities in Nova Scotia.

<u>Acadia Math Circles</u>

Based on the program at Dalhousie University, Acadia Math Circles provided students and teachers from the Annapolis Valley Regional School Board (AVRSB) with the opportunity to attend engaging mathematical workshops with a free pizza supper. These events were held 4 times during the academic year and took place in the Department of Mathematics & Statistics at Acadia University.

Math Circles #1:
Title: Math can be all Fun & Games!
Speaker: Dr. Danielle Cox (Acadia University)
Attendance: 23 students, teachers & community members.

Math Circles #2:
Title: Symmetry!
Speaker: Dr. Caroline Cochran (Acadia University)
Attendance: 17 students, teachers & community members.

Math Circles #3:
Title: Strategies that Stick!
Speaker: Jim Pulsifer (Acadia University)
Attendance: 17 students, teachers & community members.

Math Circles #4:
Title: Probability Puzzles & Games!
Speaker: Phil Munz (Acadia University)
Attendance: 21 students, teachers & community members.

During the 2014-2015 school year, several school outreach visits took place. The first classroom visits were to Northeast King's Education Centre. Over two days 85 students were outreached to. Three grade 9 classes were visited and one grade 11 class. Drs. Caroline Cochran and Danielle Cox, along with masters student Kanika Anaad and second year math student Kody Crowell gave workshops on polynomials.

Over the school year, there were 8 visits to each of Wolfville School and Evangeline Middle School. A group of approximately 20 students at each school were visited on a biweekly basis and provided mathematical enrichment. Workshops on topics such as game theory, graph theory, probability, Pascal's triangle and the math of origami were presented. Drs. Danielle Cox, Caroline Cochran, Eva Curry and Hugh Chipman, as well as several undergraduate mathematics students gave the workshops.

A class visit to Gaspereau Elementary School was planned, but unfortunately do to the poor winter weather, the trip was cancelled and unable to be rescheduled. We hope to visit the class next school year. Overall, with school visits 125 students were outreached to, with 40 of the students being visited on a biweekly basis during the school year.

"It reassured me that teaching math is what I want to do with my life"
– Kathleen MacPhee, 1st year math student

Also sponsored by Acadia University and Eastlink

The Big Dream:

Big Dream:
Empowering Girls To Pursue A Future In STEM
Movie Screening

Big Dream follows the intimate stories of seven young women who are breaking barriers and
overcoming personal challenges to follow their passion in science, math, computing & engineering.
From small town Iowa to the bustling streets of the Middle East, Big Dream immerses viewers in a
world designed by and for the inspiring next generation of girls.

Saturday, March 28th, 2015, 2:30pm
CIBC Auditorium, Goldberg Computer Science Building
Dalhousie University
6050 University Avenue, Halifax
Admission: Free

Co-hosted by:
NSERC Chair Women in Science and Engineering (WISEatlantic), MSVU
Atlantic Association for Research in the Mathematical Sciences
Faculty of Computer Science, Dalhousie University

Visit us at http://cs.dal.ca/bigdream

On March 28th, together with the Dalhousie Faculty of Computer Science and WISEatlantic, we facilitated the screening of Big Dream documentary movie for the first time in Canada. The Big Dream movie follows the intimate stories of seven young women who are breaking barriers and overcoming personal challenges to follow their passion in science, math, computing & engineering.

 Even though the weather was not cooperating with us, we had around 70 - 80 people attending the event! Also sponsored by Dalhousie University

STFX Integration Challenge

The Integration Challenge was a competition for solving integrals. Sixteen top-level first year math students (across science and engineering) from StFX participated. Two participants at a time competed head-to-head on a given question for up to 4 minutes, with the first to solve the problem correctly advancing, while the other was knocked out. The next round continued with all who were successful in the first round, and on until the final two participants remain (4 rounds in total). Problems were solved on the chalkboard to an audience of participating and non-participating students, and faculty. Integration questions were based on the typical skills covered in second-term calculus - integration by substitution, integration by parts, trigonometric substitution, and partial fractions, but increased in difficulty through progressive rounds. The final four students in the semi-finals all received certificates of distinction. The two winners of the semifinals competed in the final round. Participants: 16 students (plus additional audience members from students and faculty
Also sponsored by St. Francis Xavier University

STFX AARMS-CMS Math Camp:

This new camp is intended to be held annually in May each year and will be funded by a new collaboration between AARMS and the Canadian Mathematical Society. The goal of the Math Camps is to provide students in North-Eastern and Central Nova Scotia with opportunities for personal growth in the mathematical sciences within a supportive environment. It is hoped that some of the students will develop capacity to be future leaders in the scientific community of the province.

This year's camp was the second annual Math Camp to be held at StFX. These Camps are designed for grades 10 and 11 students. The camp consisted of lectures delivered by experienced instructors from StFX, and fun filled activities included: math relays, math trivia, problem solving, and games. The next camp will be planned for May 2016.

Number of participants: 24.
Number indicating increased interest in math, science or engineering: 17
Number considering math, science or engineering careers: 22

Other Students' Comments:

"I have been to other math camps, one that was much longer that this one, but this one was my
favorite. I loved the campus and I am very excited to hopefully come here in the near future."
"Thank you for selecting me to have this amazing experience here at StFX!"
"Very grateful for the opportunity. Hope to see it for many years to come"
"I didn't consider going to StFX before the Math Camp as it if far from my family. However, this
university is now a strong contender for my undergraduate degree"

Also sponsored by the St. Francis Xavier University

Nova Scotia Math League.

The Nova Scotia High School Math League is a competition run by the Dalhousie University Mathematics and Statistics Department designed to stimulate and challenge high school students across the province. The NSML is based on the very successful Newfoundland Math League which has been running since 1987. The first game was run in Halifax in 2002 by Richard Hoshino and Sarah McCurdy.

The NSML is an excellent venue for students to compete in a friendly manner and learn some mathematics in the process. Over the next years, we anticipate the NSML to expand to include additional regions and eventually encompass the entire province.

Also sponsored by Saint Mary's University

Math Camp for Black Students.

The annual Mathematics Camp for black students is held in the second week of July. Twenty-eight students (grade 6-7, aged 12-14 were selected by the Black Educators Assoc. of N.S. from Junior high schools from all over the province to attend this five-day camp at Dalhousie University.

This year the focus of the camp was logic. In the mathematics classroom students were taught via lectures, student-led discussions/activities, partner work, group work, games, and independent discovery. Throughout the week the students were introduced

to new topics as well as building on topics that they were introduced to throughout the school year.

In the classroom we introduced students to topics that they would later use to program and subsequently simulate or graph in the computer science classroom. These topics included playing the game 10 and NIM, where students discussed strategies on winning andlooked at the mathematics behind simple games that they play. Also, students were introduced to the Fibonnacci sequence via a hands on activity using the mating rituals of enclosed rabbits. These activities were well received by the students, they were interested in using math to "always win" in games. Thus allowing them to think about when they use mathematics in their everyday life and how the use of mathematics is important when thinking logically and solving problems.

The math teachers also wanted to enhance the educational experience by giving the students information that would help them in the upcoming school year. For some students, algebra and subsequently rearranging equations were new concepts. So, explaining these ideas in a different manner gave several students more clarity for the following school year. Also, explaining different tricks on how to multiply or divide large numbers quickly and mentally was a lesson that we found would increase the confidence students needed for the following school year. We also introduced the students to ArithmeCodes and Sudokus allowing students to learn how we complete these puzzles and giving them opportunities to try on their own.

At the end of the week we found that the students were much more confident in the math classroom. Also, the students were given the tools to show that they are capable fo being leaders in the classroom when they return to their respectives schools in September.

There were also excursions to the Discovery Centre, the NS Museum of Natural History, a session on games and puzzles with Math Circles, some opportunities for sport and a final dinner with 150 participants including ex campers and ex chaperones. Mr Gerry Clarke and Dr. Chelluri Sastri and Dr. R. P. Gupta were presented a plaque for their services to the Math Camp. One of the highlights of the evening was a the creation of a bursary, starting September 2016 with funds donated by Dr. Nauzer Kalyaniwalla. Also sponsored by Dalhousie Universityand the Black Educators Association of Nova Scotia

Enhancing Our Appreciation of Mathematics Through Intentional Community Outreach

An ongoing program for developing public appreciation of mathematics: by creating a recreational mathematics exhibit, displayed in libraries; by implementing a public lecture series in the Fredericton Library; and by interactive visits to schools. Organized by John Grant McLoughlin (staffed by volunteers from the UNB Faculty of Education, UNB).

Several outreach events were carried out in 2015 including half/full day return visits to meet students in math outreach contexts at two rural locations: Nackawic Elementary School (K-5) and Keswick Valley Memorial School (K-8) in Nackawic and Burtts Corner respectively. Two other excursions were made, one to schools in the Miramichi area and another to

Moncton/Sackville. The Miramichi excursion included a visit to a First Nations school, an effort that had been cancelled in November 2014 due to snow and ice.

The outreach work is familiar to the AARMS people and the efforts are frequently acknowledged by local teachers. Indeed I make sure to acknowledge the support of AARMS in the various venues, and with colleagues at UNB when they ask about support. We get many invitations now to visit schools or drop in to classes. Any outreach that can be afforded financially and time-wise in the spring will be carried out.

Also sponsored by the University of New Brunswick

The Blundon Seminar - Math Camp

The W.J. Blundon Seminar is an annual three-day event organised by the Department of Mathematics and Statistics at Memorial University of Newfoundland, and held at its St. John's campus. Senior high school students from across Newfoundland and Labrador are invited to the Seminar based on their performance in the Euclid, Fermat and Cayley contests run by the University of Waterloo, as well as the Blundon contest administered by Memorial University. The Seminar runs for three days and two nights, during which students room together in a University residence. The goals of the Seminar are to expose Newfoundland and Labrador's best high school students to university-level mathematics and mathematical research; to help them hone their mathematical problem-solving skills; and to familiarise them with the University, with the Department, and with their peers. In addition to interacting with faculty from the Department, the students are also proctored by two senior undergraduate mathematics students (one male and one female), giving them the opportunity to gain insight into the university experience from individuals of a comparable age. The 2015 Math Camp and Seminar included 32 participants.

Also sponsored by the Province of Newfoundland, Newfoundland Power, CAIMS,MacMillan Publishing and the CMS

UPEI CMS-AARMS Math Camp

In 2015 AARMS awarded funds to support math camp at UPEI as a regular camp on an annual basis. In this year, due to the availability of increased support from other sources the AARMS funds were not needed.

Upcoming

Funds have also been committed, although not yet spent to support the following events starting up near the end of 2015, but continuing into the following year:

The Math Challenge Club:

We meet once a week (currently on Tuesday nights from 5 till 7 PM) to have fun with challenging math problems. Specifically, we teach the techniques needed to solve math contest problems and work on problems as a group. This year we are also working on creating sets of notes that could be used by trainers in other cities.

Some Background: Currently Canada does not have enough girls who are interested in math contests and perform at a high enough level to participate in a contest such as the European Girls Math Olympiad. So Dorette Pronk has started to form a network of instructors in various Canadian cities who want to lead math clubs for girls in order to train and inspire girls to be involved in mathematics competitions. This is one of

these clubs. However, as she started inviting girls, there was also a considerable interest from the boys to be involved. In order to keep the girls club girl-friendly we are planning to start two separate groups that meet at the same time and have pizza (and possibly one problem) together. We hope to see more students from Halifax participating in the international math competitions, such as the APMO (the Asian Pacific Math Olympiad), the European or Asian Girls Math Olympiad, and the IMO (the International Math Olympiad).

UPEI Mathematics Achievement Program:
 The members of the UPEI Mathematics Society and pre-service teachers in the Faculty of Education are interested in offering a Math program to PEI students. This goal of this initiative is to create excitement about Mathematics and help to remove the fear and anxiety that is often associated with learning math.
   This program will offer activity days at various island schools through the school year on professional development (PD) days. The target audience will be Grades 3-6 students, and the program will be delivered by students from the UPEI Mathematics and Statistics Society, as well as students from the UPEI Department of Education specializing in math education. Activities will focus on problem solving, games and puzzles, all with an emphasis on teamwork and active learning.

Administration and Governance

Jeannette Janssen, Director
Department of Mathematics and Statistics
Dalhousie University

Xiaoqiang Zhao, Deputy Director
Department of Mathematics and Statistics
Memorial University of Newfoundland

David Langstroth, Executive Administrator
Dalhousie University

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David Langstroth, Managing Editor (AARMS Executive Administrator)

AARMS is established through a set of statutes signed by the largest university in each Atlantic Province: Dalhousie University, Memorial University, University of New Brunswick and University of Prince Edward Island. These statutes define an organizational structure which includes a Board, an Executive Committee and a Scientific Review Panel.

The Director and Executive Administrator of AARMS are based at Dalhousie University, and the Deputy Director is based at Memorial. The other members of the Executive Committee are drawn from Acadia Dalhousie, Memorial, The University of New Brunswick and The University of Prince Edward Island, a distributed membership which includes large universities and small ones and enables AARMS to be in touch with current issues through Atlantic Canada and to be in dialogue with researchers in all provinces.

The Board is comprised of major sponsors of AARMS including Directors of the three Institutes and senior administrators from the universities; it also includes representatives of industry members of the Executive Committee and other mathematical scientists.

Our Scientific Review Panel is composed of mathematical scientists from Canada and abroad who are nationally and internationally respected in their fields. This panel assesses applications to our postdoctoral fellowship program, our collaborative research group program, and evaluates the larger requests for funding for workshops and converences. It provides scientific advice when requested.

The AARMS Board

Jacques Yves Guigné, Chair – serves as the Founder and President / Board Director of Intelligent Sciences Ltd. and Co-Founder, Director and Board member of PanGeo Subsea Inc. and of Acoustic Zoom Inc. (Jacques is the President and Chief Scientist/ Geophysicist for Acoustic Zoom Inc. and Executive Director and Chief Scientist/Geophysicist for PanGeo Subsea Inc.).

Mark Abrahams – a behavioural ecologist who studies the risk of predation and its impact upon aquatic ecosystems. This work is of fundamental importance to understanding how ecosystems operate, as well as having application to conservation ecology and invasion dynamics. He worked at the University of Manitoba for 18 years before moving to Memorial University where he is the Dean of Science

Martin Barlow – Acting Director of PIMS. Martin Barlow is a leading figure in probability and an expert in diffusion on fractals and other disordered media. His work has been important in such diverse fields as partial differential equations, including major progress on the De Giorgi conjecture, stochastic differential equations, the mathematical finance of electricity pricing, filtration enlargement and branching measure diffusions. Barlow's awards include the CRM-Fields-PIMS Prize, the Jeffery-Williams Prize of the Canadian Mathematical Society, the Rollo Davidson Prize from Cambridge University and the Junior Whitehead Prize from the London Mathematical Society. He has been a leader of the international probability community, an organizer of numerous conferences and editor of several probability journals. He is a Fellow of the Institute of Mathematical Statistics, The Royal Society of Canada, The Royal Society(London) and the American Mathematical Society.

David Bluteau – Branch Manager and Vice-President of National Bank Financial Wealth Management in Nova Scotia. He is responsible for the wealth management and estate planning for his physician clientele. He earned his Masters of Business Administration degree from Dalhousie University in 1987 and offers nearly 25 years as a financial advisor.

David Burns – Vice-President Research, UNB.

Hugh Chipman – Hugh Chipman is interested in computationally intensive statistical methods, including Bayesian computation, statistical and machine learning, and applications involving network data, drug discovery, and industrial statistics. He is a professor and Canada Research Chair at Acadia University's Department of Mathematics and Statistics. He received his doctorate at the University of Waterloo, and has held academic positions at Chicago and the University of Waterloo.

Robert Gilmour – currently is Vice President, Research at the University of Prince Edward Island. He formerly was a Professor of Physiology in the Department of Biomedical Sciences and Associate Dean for Research and Graduate Education at Cornell University, where he led a multidisciplinary group of investigators whose publications have appeared in both cardiovascular and physics journals. He also was a member of the Executive Committee for the IGERT-sponsored program in non-linear systems at Cornell and was a member of the Graduate Fields of Physiology, Pharmacology, Bioengineering and Computational Biology. His research interests are centered on theoretical and experimental studies of heart rhythm disorders.

Ian Hambleton – Director of The Fields Institute.

Viqar Husain – Professor in the Department of Mathematics and Statistics at the University of New Brunswick (Fredericton), and Affiliate Researcher at the Perimeter Institute since its founding. He received his PhD in theoretical physics from Yale University (1989). His fields of research are general relativity, cosmology, and quantum gravity. He has been Department Chair since 2007 and was Director of AARMS from 2008-2011.

Colin Ingalls – Professor, Department of Mathematics and Statistics, University of New Brunswick. He received hie Ph.D. in Pure Mathematics at the Massachusetts Institute of Technology in 1997. He works on interactions between noncommutative algebra and algebraic geometry.

Jeannette Janssen – **Director of AARMS**, Professor in the department of Mathematics & Statistics at Dalhousie University. She is a graph theorist, using techniques from probability and combinatorial optimization in her research. Her current interests focus on the modelling of complex networks, such as the networks of contacts formed through social media. She is one of the project leaders of the MITACS project: Modelling and Mining of Networked Information Spaces (MoMiNIS). Jeannette obtained her PhD in 1993

from Lehigh University in Pennsylvania, and her first graduate degree (doctoraal diploma) in 1988 from the Technical University Eindhoven in the Netherlands.

Richard Karsten – received his Bachelor's degree in Applied Mathematics in 1992 from the University of Waterloo and his PhD in Applied Mathematics in 1998 from the University of Alberta. He held a NSERC postdoctoral fellowship at M.I.T. from 1998 to 2001. He is currently a Professor (Mathematics and Statistics) at Acadia University in Nova Scotia. Dr. Karsten's research interests are in tidal energy, physical oceanography, fluid dynamics and computational mathematics.

John Newhook – Associate Vice-President Research, Dalhousie University. He is a Professor in the Department of Civil and Resource Engineering and the Director of the Centre for Innovation in Infrastructure. He obtained a PhD in Civil Engineering from Dalhousie in 1997. His research interests are in the areas of structural health monitoring, bridge engineering and analysis, soil-structure interaction and modelling, and the use of advanced composite materials in infrastructure.

Jason Powell – Engineering Site Director for Ping Identity, a Denver-based software company that offers technology to protect professional and personal identities, and is responsible for launching and leading Ping Identity's new Halifax-based software engineering Centre of Excellence.

Dorette Pronk – Associate Professor in the Department of Mathematics and Statistics at Dalhousie University. Dorette is a category theorist with a particular interest in higher category theory and in applications to the homotopy theory of orbifolds. She is part of the Atlantic Category Theory group with researchers at Dalhousie University, Saint Mary's University, Mount Allison University and Saint Francis Xavier University. Dorette is also involved in math outreach and in problem solving competitions such as the International Mathematical Olympiad. Dorette received her PhD in 1995 from Utrecht University in the Netherlands.

Nasser Saad – Professor, Department of Mathematics and Statistics, University of Prince Edward Island. He received his Ph.D. from Concordia University in 1998 (Mathematical Physics). Dr. Saad's research is in the area of special functions and their applications in mathematical and theoretical physics; his specialties include the asymptotic iterations method, Heun equation and supersymmetric quantum mechanics.

Henrik Stryhn – Professor in Biostatistics, Department of Health Management, Atlantic Veterinary College (AVC), University of PEI. He received his PhD from the Royal Veterinary and Agricultural University of Denmark (now part of the University of Copenhagen) in 1994. A statistician by training, he has been working extensively with applications of statistics in agriculture and veterinary science. Dr. Stryhn emigrated from his native Denmark to Canada in 2001 to take up a position at AVC. His research interests include a broad range of methods in statistics and epidemiology, in particular models involving random effects and other latent variables.

Luc Vinet – is Aisenstadt Professor of Physics at the Université de Montréal and the Director of the Centre de Recherches Mathématiques (CRM). Born in Montreal in 1953, he holds a doctorate (3rd cycle) from the Université Pierre et Marie Curie (Paris) and a PhD from the Université de Montréal, both in theoretical physics. After two years as a research associate at MIT, he was appointed as assistant professor in the Physics Department at the Université de Montréal in the early 1980's and promoted to full professorship in 1992. His research interests in Theoretical and Mathematical Physics include : exactly solvable problems, symmetries, algebraic structures, special functions and quantum information. Luc Vinet has sat on the board of many organizations. He is currently a Director of the National Institute for Nanotechnology and chairs the Fulbright Canada Board of Directors. He was a member of the Council of Canadian Academies' Expert Panel which assessed the State of Science and Technology in Canada in 2012. He holds an honorary doctorate from the Université Claude-Bernard (Lyon). He was made an Officer of the Ordre des Palmes académiques by the French Government and Knight of the Ordre de la Pléiade by the Parliamentary Assembly of the Francophonie. In 2009, the Government of Quebec awarded him the Armand-Frappier Prize in recognition of his outstanding research career and of his contributions to the creation and development of research institutions. In 2012, he received the CAP/CRM prize in Theoretical and Mathematical Physics as well as the Queen Elizabeth II Diamond Jubilee Medal recognizing his contribution to the establishment of Mitacs.

Yuan Yuan – Professor at Memorial University of Newfoundland. She received her PhD in Applied Mathematics at the University of Western Ontario in 2002. Her research interests include Applied Dynamical Systems, Functional Differential Equations and Applications.

Xiaoqiang Zhao – Deputy Director of AARMS, University Research Professor at Memorial University of Newfoundland. He received his PhD in Applied Mathematics from Chinese Academy of Sciences in 1990. His research interests are Applied Dynamical Systems, Nonlinear Differential Equations, and Mathematical Biology.

The AARMS Scientific Review Panel

Xiaoqiang Zhao, Chair - Deputy Director of AARMS and University Research Professor at Memorial University of Newfoundland. He received his PhD in Applied Mathematics from Chinese Academy of Sciences in 1990. His research interests are Applied Dynamical Systems, Nonlinear Differential Equations, and Mathematical Biology.

Georgia Benkart - earned her B.S. degree from Ohio State University and her M.Phil. and Ph.D. degrees from Yale University. Her two-year post-doctoral position at the University of Wisconsin-Madison evolved into a career there, where she became E.B. Van Vleck Professor of Mathematics. Her research focuses on the structure and representation theory of Lie and associative algebras; combinatorial representation theory; and quantum groups and related structures. She gave the Noether Lecture at the Joint Mathematics Meetings in January 2014 and the International Mathematical Union's Emmy Noether Lecture at the International Congress of Mathematicians in Seoul, Korea in August 2014. From 2009 to 2011 she was President of the Association for Women in Mathematics. A Fellow of the American Mathematical Society (AMS), she currently serves as Associate Secretary of the AMS and is on the Board of Trustees of the Mathematical Sciences Research Institute in Berkeley.

Michael Bennett - is professor and head of the Department of Mathematics at the University of British Columbia, where he has been a faculty member since 2001, and from where he obtained his PhD in 1993. Previously, he held positions at the University of Waterloo, the University of Michigan, The Institute for Advanced Study, Princeton, and at the University of Illinois, Urbana-Champaign. He has served on the Board of Directors of the Canadian Mathematical Society as Vice President (West) and

currently serves on the board of the Number Theory Foundation. His main research interests are in Number Theory, where he has published extensively.

Darryn Bryant – is a Professor in Mathematics at the University of Queensland, where he obtained his Ph.D. under the supervision of Sheila Williams in 1993. He has held several Australian Research Council Fellowships, and has served on the Council of the Combinatorial Mathematics Society of Australasia since 2001. His research interests lie predominantly in graph theory and design theory, and he is a member of the editorial board for the Journal of Combinatorial Designs and the Australasian Jnl of Combinatorics.

Stephen Cantrell – is Professor and Chair of the Department of Mathematics at the University of Miami, where he joined the faculty in 1982, after earning his B.S. degree summa cum laude from Furman University in mathematics in 1976 and his Ph.D. from the University of Utah in 1981 under the supervision of Klaus Schmitt. His research interests lie at the interface of nonlinear analysis and partial differential equations with mathematical biology, particularly in relation to spatial ecology, epidemiology and evolutionary biology. He is the author or co-author of over 80 papers and the co-author (with Chris Cosner) of the book Spatial Ecology via Reaction-Diffusion Equations, and his work with Cosner at the interface of mathematics and biology has enjoyed continuous support from the US National Science Foundation since 1988.

Steven Carlip – is a professor of physics at the University of California at Davis, specializing in quantum gravity. He received an undergraduate degree in physics from Harvard in 1975, and after seven years as a printer, editor, and factory worker, returned to school at the University of Texas, where he earned his Ph.D. in 1987. Following a postdoctoral position at the Institute for Advanced Study, he joined the faculty at Davis in 1990. He is a Fellow of the American Physical Society and the Institute of Physics, has served on the editorial boards of four journals (including Physical Review Letters), and has reviewed grant proposals for the national science agencies of 14 countries. His particular research interests include lower dimensional quantum gravity, quantum black holes, numerical approaches to the Feynman path integral, quantum fluctuations of topology, and "spontaneous dimensional reduction" at short distances.

Richard Cook – is Professor of Statistics in the Department of Statistics and Actuarial Science at the University of Waterloo and Tier I Canada Research Chair in Statistical Methods for Health Research. He also holds a cross-appointment to the School of Public Health and Health Systems and is an Affiliate Scientist at the PROPEL Centre for Population Health Impact at the University of Waterloo. His research interests include the life history analysis, the design and analysis of clinical and epidemiological studies, and statistical methods for incomplete data. He is currently Associate Editor for Statistics in Medicine, Biometrics, and Statistics in Bioscience. He was the

recipient of the CRM–SSC Prize in 2007 and in 2008 was elected Fellow of the American Statistical Association.

Leslie Hogben – is Dio Lewis Holl Chair in Applied Mathematics and Professor of Mathematics at Iowa State University, and Associate Director for Diversity of the American Institute of Mathematics. She received her BA from Swarthmore College and her PhD from Yale University. Her research is in linear algebra, graph theory, and applications of linear algebra. She is the editor of the Handbook of Linear Algebra, associate editor of the journals Linear Algebra and its Applications and Electronic Journal of Linear Algebra, and is the Secretary/Treasurer of the International Linear Algebra Society.

Weizhang Huang – is a professor at the University of Kansas. He received his PhD degree from the Chinese Academy of Sciences in Beijing in 1989. His research interest is in numerical analysis and scientific computing with emphasis on the numerical solution of partial differential equations. Recent topics include mesh movement, mesh adaptation, anisotropic mesh generation, finite element analysis, collocation and spectral methods, geometric integration, and their applications.

Susan Niefield – earned her BA from Douglass College in 1974 and PhD from Rutgers University in 1978. Following a Killam postdoctoral fellowship at Dalhousie University, she joined the Department of Mathematics at Union College (Schenectady, NY) where she was named Professor Emerita in 2015. Her research interests include double categories, exponentiability, locales, quantales, and toposes.

Mary Pugh – received a BA in pure mathematics from U.c. Berkeley in 1986, and MS and PhD degrees in mathematics from the University of chicago in 1988 and 1993, respectively. From 1993 to 1997, she was a post-doc at the Courant Institute and at the Institute for Advanced Study. From 1997 to 2001, she was an assistant professor at The University of Pennsylvania. Since 2001, she has been an associate professor at the University of Toronto. Her research is largely on the modeling, analysis, and simulation of thin films of viscous liquids, with a broader interest in computational methods for partial differential equations.

Susan Sierra – received her Ph.D. in 2008 from the University of Michigan. After an NSF postdoctoral fellowship at the University of Washington and at Princeton, she began a lectureship at the University of Edinburgh in 2011. She is now a Senior Lecturer at the University of Edinburgh. Her research is in noncommutative ring theory; she is particularly interested in interactions with algebraic geometry and with infinite-dimensional Lie algebras.
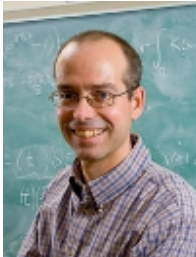
James Watmough – received his Bachelor's degree in Engineering Physics in 1989 and his PhD in Applied Mathematics in 1997: both from the University of British Columbia. He held a postdoctoral position at Virgina Tech and a NSERC postdoctoral fellowship at the University of Victoria. He is currently a Professor (Mathematics) at the University of New Brunswick, Fredericton. Dr. Watmough's research interests are in mathematical biology: specifically epidemiology and ecology.

Gail Wolkowicz – received her BSc and MSc degrees from McGill University and her PhD degree from the University of Alberta in 1984. Before joining the Department of Mathematics and Statistics at McMaster University in 1986, where she is currently a full professor, she obtained an NSERC postdoctoral fellowship which she held for one year at Emory University followed by one year at Brown University. She has served on the Board of Directors of the Canadian Mathematical Society. She was the recipient of the 2014 Krieger-Nelson prize and the 2015 Lord Robert May Prize for the best paper in the Journal of Biological Dynamics for 2013-2014. Her research interests are in dynamical systems and bifurcation theory with applications in biology and ecology.

Chen Greif, Javad Mashreghi, James A. Mingo, Michael Newton, Jungcheng Wei, and Xingfu Zou were also members of the Scientific Review Panel whose term ended in 2015.

AARMS Financial Statements

AARMS funds are held in accounts at Dalhousie University and The University of New Brunswick and are subject to the oversight and auditing of the Financial Services Departments of those universities. The following accounts are a view of the data compiled by Dalhousie and UNB.

The financial year is January 1 – December 31. The statements employ cash-flow accounting which is the method which records transactions when funds move, rather than when transactions are accrued. This is consistent with university statements but may create timing anomalies: if an event which occurs in 2014 is paid for in 2015 then it will show up in the 2015 accounts.

Income and Expenditure Account
2015

A A R M S

Income[1]	$	$	2014
Carried forward from previous year		190,875	61,775
Mathematical Institutes		110,000	105,000
Universities		129,000	92,000
Provinces		150,000	185,000
Other Revenue (1)		694	2,340
Total Income		**580,569.06**	**446,115**

Expenditure			
Summer School		75,496	82,548
Workshops and Events (5)		76,238	55,589
Outreach (5)		16,645	11,388
PDF Program (6)		70,000	35,000
Collaborative Research Groups (7)		75,920	24,000
Distinguished Lecturers		0	1,075
Book Series		0	0
Administrator Salary		31,762	29,327
AARMS Online system		14,369	394
Travel		1,962	0
Office Expenses		2,177	2,920
Dalhousie Overheads		13,000	13,000
Total Expenditure		**377,570.25**	**255,240**
Surplus: Income Less Expenditure		**202,998.81**	**190,875**

Notes

1. For a breakdown see Appendix 1
2. Travel, Accommodation and stipends of $5,000 each   -202998.81
3. Residence and Meals
4. Texts and course materials, promotion, secretarial, computing , hospitality

5. See Appendix 2
6. See Appendix 3
7. See Appendix 4

AARMS

Balance Sheet
31-12-2015

Assets

	$	$
Surplus from Operations (Income less expenditure)		202,999
Accounts Receivable[1]		
CRM	55,000	
Fields	30,000	
PIMS	30,000	
Acadia	5,000	
Cape Breton	2,000	
Dalhousie	30,000	
Memorial	30,000	
Moncton	1,000	
Mount Allison	1,000	
Mount Saint Vincent	2,000	
Saint Francis Xavier	2,000	
Saint Mary's	2,000	
UNB	60,000	
UPEI	1,000	
Province of Nova Scotia	85,000	
Province of New Brunswick	50,000	
Province of Newfoundland	60,000	
		446,000
Total Assets		**648,999**

Liabilities

	$	$
Accounts Payable[2]		
Summer School	116,714	
Postdoctoral Fellowships	192,500	
Scientific Activities[3]	95,440	
Outreach	76,610	
Collaborative Research Groups	75,920	
AARMS Book Series	0	
Administrator Salary[4]	31,000	
online development	9,200	
AARMS Poster	1,000	
Travel and Office expenses	4,000	
		602,384
Unallocated funds - for AARMS activities		46,615
Total Liabilities		**648,999**

Notes

1. Fees due to be collected in 2015

2. Funding Commitments in 2015

3. Workshops, Conferences, Meetings

Annual Accounts 2015

AARMS

Appendix 1

Revenue Breakdown

Provinces

New Brunswick	50,000	
Nova Scotia	100,000	
		150,000

Mathematical Institutes

CRM	15,000	
Fields	30,000	
PIMS	45,000	
PIMS Summer School support	20,000	
		110,000

Universities

Acadia	5,000	
Cape Breton	1,000	
Dalhousie	30,000	
Memorial	30,000	
Moncton	1,000	
Mount Allison	1,000	
Mount Saint Vincent	0	
Saint Francis Xavier	0	
Saint Mary's	0	
UNB	60,000	
UPEI	1,000	
		129,000

Other Revenue

book royalties	444	
Digby Sponsorship	250	
		694

total		**389,694.23**

Annual Accounts 2015

Appendix 2

Workshops and Scientific Events

Two Weeks at Waterloo	1,800
Adaptive Methods for PDEs	3,500
Fall Eastern AMS Meeting 2014	2,691
Combinatorial Algebra meets Algebraic Combinatorics	1,967
Atlantic Algebra Centre Graduate Prizes	1,000
CMS Poster Prize – Winter 2014	1,000
Connecting Women in Mathematics	2,000
CMS Poster Prize – Summer and Winter 2015	2,000
CCCG 2014	4,950
Special Sessions at CMS meeting in Charlottetown	21,648
Applied Mathematics in Environmental Sciences	2,000
East Coast Combinatorics Conference	2,111
International Statistics Symposium	7,500
Advanced Harmonic Analysis	7,500
Bluenose Workshop	3,571
Atlantic General Relativity Conference	4,000
Statistical Society of Canada 2015	2,500
Statistical Analytics for Big Data	4,500
total	**76,238**

Outreach

Big Dream Movie promotion	79
John McLoughlin outreach in NB	4,500
Integration Competition for 1st year calculus	500
Blundon Seminar Camp	2,500
AARMS Outreach Meeting catering	440
AARMS outreach Meeting Teacher sub fee	180
AARMS Outreach Meeting travel expenses	605
STFX Math Camp	3,294
Black Educators Math Camp	4,547
	16,645

Annual Accounts 2015

Appendix 3

Postdoctoral Fellowships

Justin Tzou	26,250
Yuzaho Wang	17,500
Jonathan Ziprick	17,500
Nathan Grieve	8,750
total	**70,000**

Appendix 4

Collaborative Research Groups

Numerical Analysis and Scientific Computing	24,000
Graphs and Games	12,000
Iterated Function Systems, Fractals	20,000
Black Holes	19,920
total	**75,920**