



**Atlantic Association for  
Research in the  
Mathematical Sciences**

# Annual Report 2014

[www.aarms.math.ca](http://www.aarms.math.ca)

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## *Message from the Director*



In the year 2014, AARMS reaped the rewards of concerted efforts to draw attention to the successes of the mathematical community in Atlantic Canada, and to garner support for AARMS so that this community can continue to thrive. In April, AARMS was notified of the outcome of the joint application of the Institutes to the NSERC-CTRMS program. The reports we received from the review committees contained ample praise for AARMS and strongly recommended continued funding for AARMS through the CTRMS grants to CRM, Fields and PIMS. Shortly after that, we received news that our application to the Research Development Corporation (RDC) of Newfoundland & Labrador had been successful. The RDC will support AARMS for an amount of \$300K over the next five years. There was also a positive response to our request for renewal of funding from the province of Nova Scotia. The provincial government substantially increased their contribution, awarding \$85K to AARMS for 2014, while the previous annual amount was \$50K.

The increased funds were immediately used for an increase in our activities. In particular, we have expanded our post-doctoral program, our collaborative research group (CRG) program, and our funding for scientific and outreach events. We also saw the development of several new outreach initiatives, some of which are specifically aimed at under-represented groups. AARMS aims to take a stronger coordinating role in Math Outreach, and we started to assume this role with a "fact-finding" meeting of organizers of outreach activities, held in June.

The joint application process for the NSERC-CTRMS program led to increased collaboration with CRM, Fields, PIMS and CANSSI. With Fields, the main area of collaboration was in Algebra. With CANSSI, there was collaboration on Big Data. With PIMS, there is great synergy in the field of Dynamical Systems and Mathematical Biology. The directors of the five institutes communicate regularly, and we continue to explore new ideas for joint projects.

The summer school moved to Dalhousie in 2014, and will remain there for three years. The themes this year were Commutative Algebra and Statistics. Judging from the feedback through the survey we administered, the students were very pleased with the school. I attended the final event, and thus had the opportunity to judge that the students had cemented a strong bond over the four weeks of the school, both with each other and with the instructors and organizers.

Each year, we thank David Langstroth for his service to AARMS. This year I want to put special emphasis on my gratitude. The new funding opportunities all come with their own application, review and reporting requirements; keeping track and making sense of all the details is a daunting task, but one which David performs with grace and good humour. 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  
April, 2015

## ***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 2014 the second generation of AARMS CRGs completed their first year and begun the second year of their two-year term. They were: The Atlantic Collaborative Research Group in Numerical Analysis and Scientific Computing, Statistical Modeling of Complexly Correlated Data, and Graphs and Games.

### ***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)

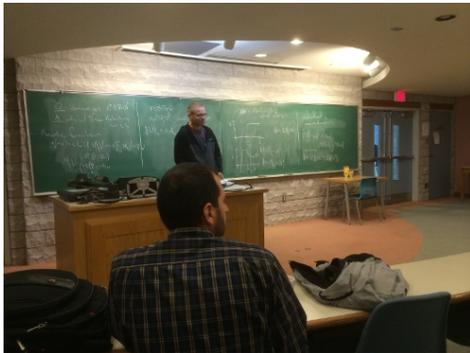
Weizhang Huang (Kansas)  
 Colin Farquharson (Memorial)  
 Shaohua Chen (Cape Breton)  
 Jahrul Alam (Memorial)  
 Richard Karsten (Acadia)

The 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 adaptive methods for PDEs, held in August of 2014. Another activity undertaken by the CRG was an outreach project, held in July of 2014, known as a Software Carpentry bootcamp. One member of the CRG (Brunner) has been involved in the organization of two graduate courses in the area of Numerical Analysis and Scientific Computing that will make 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.

### *Recent Developments in the Adaptive Solution of PDEs*

A workshop titled “Recent Developments in the Adaptive Solution of PDEs”, organized by the CRG, was held at Memorial University of Newfoundland, St. John's, Newfoundland, Aug. 17-22, 2014. This workshop received funding from AARMS, the CRM, the NSF, the Memorial University Conference Fund, and the Department of Mathematics and Statistics of Memorial University. The workshop was well attended with approximately 45 participants involved, including B.Sc., M.Sc., Ph.D. students and researchers from Canada, the United States, China, the United Kingdom and Columbia. There were four invited plenary speakers, 11 faculty members, three post-docs, and 27 undergraduate and graduate students; 32 of the participants were from outside the province. This workshop consisted of three primary parts. The first part was a two-day short course on adaptive methods for PDEs, given by Dr. Weizhang Huang of the University of Kansas, a leading expert in this area. This short course outlined PDE based adaptive mesh generation and concluded with research level questions concerning anisotropic mesh generation. Each day included approximately five hours of lectures given by Dr. Huang, and concluded with a hands-on computer lab session, led by Dr. Lennard Kamenski of the Weierstrass Institute for Applied Analysis and Stochastic (WIAS), in which participants got an opportunity to learn about software implementations (primarily in Matlab) 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 second part of the workshop consisted of four invited research level talks given by Mark Ainsworth (Brown),



A session from “Recent Developments in the Adaptive Solution of PDEs” in St. John's.

The workshop then transitioned to its third part with four applied problem presentations from Colin Farquharson (MUN). These speakers nicely outlined problems in their primary research area that would benefit from the use of adaptive numerical techniques. The last day and a half of the workshop included breakout sessions which partnered applied problem presenters, adaptivity experts and other workshop participants, as well as several contributed talks in which participants talked about applications in which adaptive methods for PDEs were employed. 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.

### ***Software Carpentry Bootcamp***

An outreach activity, called a Software Carpentry Bootcamp, that contributed to the training of graduate students in the area of Scientific Computing was organized by the CRG and took place, July 2-3, 2014, at Saint Mary's University. This activity was supported by an organization known as the Software Carpentry Project, which is a volunteer organization, founded in 1998, that runs short, intensive workshops (called bootcamps) that teach a core set of skills that enhance the efficiency and reliability of computer-based workflow for anyone who uses a computer as a significant component in their research.

The Saint Mary's University Software Carpentry Bootcamp was led by Dr. Dhavide Aruliah, an experienced Software Carpentry Bootcamp instructor, from the University of Ontario Institute of Technology. Stephanie Gagne (Dalhousie University) served as a second instructor for the bootcamp. Additional technical support was provided by Ross Dickson (ACENET), Andrew Valencik (Saint Marys University), and Jack Pew (Saint Marys University).

The bootcamp consisted of short tutorials alternating with hands-on practical exercises.

### ***Graduate student support***

This past year the CRG has partially funded a Ph.D. student Mr. Khaled Mohammad, who is currently being supervised by Dr. Ronald Haynes at Memorial University of Newfoundland. His thesis topic is multirate accelerated Schwarz waveform relaxation methods.

### ***Publications***

#### **Published/Accepted**

Haynes, R.D. and Howse, A.J.M, Alternating Schwarz Methods for partial differential equation-based mesh generation, *Int. J. Comput. Math.*, Taylor & Francis, Published Online April 09, 2014, DOI: 10.1080/00207160.2014.891733 PDF

Bihlo, A. and Haynes, R.D., A stochastic domain decomposition method for time dependent mesh generation, *Accepted Springer Lecture Notes in Computational Sciences and Engineering*, May 2014. Arxiv

Bihlo, A., and Haynes, R.D., Stochastic Methods for grid generation using domain decomposition, *Computers and Mathematics with Applications*, accepted July 2014, DOI: 10.1016/j.camwa.2014.07.017. PDF Arxiv

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 PDF

Humphries, 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*. Arxiv

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

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

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

S. Friedhoff and S. MacLachlan, A generalized predictive analysis tool for multigrid methods, *Numer. Linear Alg. Appl.*, 2015.

M. Hodes, L. Steigerwalt Lam, A. Cowley, S. MacLachlan, and R. Enright, Effect of evaporation and condensation at menisci on apparent thermal slip, *Journal of Heat Transfer*, 2015.

Carter-McAuslan, A., P.G. Lelièvre, and C.G. Farquharson, A study of fuzzy c-means coupling for joint inversion, using seismic tomography and gravity data test scenarios, *Geophysics*, 80, W1-W15. (DOI: 10.1190/geo2014-0056.1), 2015.

Jahandari, H., and C.G. Farquharson A finite-volume solution to the geophysical electromagnetic forward problem using unstructured grids, *Geophysics*, 79, E287-E302. (DOI: 10.1190/geo2013-0312.1), 2014.

Ansari, S., and C.G. Farquharson 3D finite-element forward modeling of electromagnetic data using vector and scalar potentials and unstructured grids, *Geophysics*, 79, E149-E165. (DOI: 10.1190/geo2013-0172.1), 2014.

P.H. Muir and J. Pew, Recent Advances in Error Control B-spline Gaussian Collocation Software for PDEs, *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, 2014.

J. Pew, P.H. Muir, J. Wang, T. Frasier, related: an R package for analysing pairwise relatedness from codominant molecular markers, *Mol. Ecol. Resour.*, 2014.

J. Ivanoff, R. Blagdon, S. Feener, M. McNeil, P.H. Muir, On the temporal dynamics of spatial stimulus response transfer between spatial incompatibility and Simon tasks, *Front. Neurosci.*, 8, 2014, Article 243.

H. Brunner, On Volterra integral operators with highly oscillatory kernels, *Discrete Contin. Dyn. Syst.*, 34 (2014), 903-914.

H. Brunner, H.D. Han, and D.S. Yin, Numerical solution of time-fractional diffusion-wave equations on two-dimensional unbounded domains, *J. Comput. Phys.*, 276 (2014), 541-562.

H. Brunner and Z.W. Yang, Quenching analysis for nonlinear Volterra integral equations, *Dyn. Contin. Discrete Impuls. Syst. Ser. A Math. Anal.*, accepted 16 December 2014.

### **Submitted**

Haynes, R.D. and Kwok, F., Discrete analysis of Domain Decomposition Algorithms for Grid

Generation via the Equidistribution Principle, June 2014. PDF

Haynes, R.D., Ladd, K., and Ong, B. W., A OpenMP Parallel in Time Wrapper for the Solution of Time Dependent PDEs, August 2014. Arxiv

Carosio, G., Haynes, R.D. and Farquharson, C., A Closer Look at Differential Evolution for the optimal well placement problem, February 2015.

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

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

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

S. Friedhoff and S. MacLachlan, A generalized predictive analysis tool for multigrid methods, *Numer. Linear Alg. Appl.*, 2015.

M. Hodes, L. Steigerwalt Lam, A. Cowley, S. MacLachlan, and R. Enright, Effect of evaporation and condensation at menisci on apparent thermal slip, *Journal of Heat Transfer*, 2015.

J. H. Adler, T. J. Atherton, D. B. Emerson, and S. P. MacLachlan, An energy-minimization finite-element approach for the Frank-Oseen model of nematic liquid crystals, *SIAM J. Numer. Analysis*, 2014.

J. H. Adler, T. J. Atherton, T. R. Benson, D. B. Emerson, and S. P. MacLachlan, Energy minimization for liquid crystal equilibrium with electric and flexoelectric effects, *SIAM J. Sci. Comput.*, 2015.

J. Adler, S. MacLachlan, and N. Madden,, A first-order system Petrov-Galerkin discretisation for a reaction-diffusion problem on a fitted mesh, *IMA J. Numer. Analysis*, 2014

J. H. Adler, D. B. Emerson, S. P. MacLachlan, and T. A. Manteuffel, Constrained optimization for liquid crystal equilibria, SIAM J. Sci. Comput., 2014

J. Pew, P.H. Muir, Z. Li, Collocation software for 1D Parabolic PDEs with Interpolation-based Error Estimation, ACM Trans. Math. Softw., 2014.

## ***Statistical Modelling of Complexly Correlated Data with Applications***

Members:

Renjun Ma (UNB)

M. Tariqul Hasan (UNB)

Guohua Yan (UNB)

Jeff Picka (UNB)

Claire Goggin (St. Thomas)

Zhaozhi Fan (Memorial)

Ying Zhang (Acadia)

Gary Sneddon (Mount St Vincent)

Henrik Stryhn (UPEI)

Yanqing Yi (Memorial)

The CRG in Statistical Modelling of Complexly Correlated Data with Applications was created in August 2013 to provide a unique and important opportunity to bring Atlantic researchers from different areas together as a team to address challenging issues in the analysis of complexly correlated data.

There have been two workshops in the first year as planned. For each workshop, the CRG also invited some researchers outside of the group based on the workshop theme. The first workshop was held August 9-10, 2013 to get familiar with each other, to identify emerging issues and to explore collaboration opportunities. There were fifteen oral and six poster presentations by researchers, graduate students and postdoctoral fellows from statistics, biology, forestry, geology and veterinary epidemiology. In particular, two free-style open discussion sessions were held to stimulate collaborative research on challenging and emerging issues in the interdisciplinary areas.

The second workshop was held June 16-17, 2014 to communicate the research progress and new projects. There were sixteen oral presentations. New collaborative research projects between statistics and applied researchers have just started last year and are still underway; therefore, the participants to this second workshop were mainly statisticians and their HQPs. One distinctive feature of this workshop was a much stronger presence of graduate students, postdoctoral fellows, collaborators and non-group members. An extended student session was held to promote student participation.

New collaborative research projects have arisen from this CRG initiative in the areas of statistical modelling of biological, geological and veterinary data. There are also new collaborative research projects among statisticians. More detailed information about our research topics and two workshops can be found under the link below:  
<http://www.math.unb.ca/~renjun/CRG/index.html>

## **Publications**

Collaborative research papers involving two or more CRG group members:  
(Note: the members are underlined. The HQPs are boldfaced.)

### 1) Published/accepted:

Hasan, MT, Yan, G. and Ma, R. (2014). Analysis of periodic patterns of daily precipitation through simultaneous modeling of its serially observed occurrence and amount. Environmental and Ecological Statistics. Vol. 21, No. 4, 811-824.

Hasan, MT, Huda, S. and Sneddon, G. (2014). A Comparative Study of Observation- and Parameter-driven Zero-Inflated Poisson Models for Longitudinal Count Data. Communications in Statistics - Simulation and Computation. (accepted on July 2014).

Liu, J., Liu, W., Wu, L. and Yan, G. (2015). A flexible approach for multivariate mixed-effects models with nonignorable missing values. Journal of Statistical Computation and Simulation. (accepted 2015).

### 2) Submitted:

**Nadeem, K.** Moore, J. Zhang, Y. and Chipman, H. (2015). Integrating distance sampling data and population dynamics models: A hierarchical state-space modeling approach. (under review).

Yan, G., Hasan, MT, and Ma, R. (2015). Analysis of clustered multinomial data with random cluster sizes. (under review).

Zhu, R., El-Shaarawi, AH, **Duan, X.** Wang, Z. and Ma, R. (2015). Assessing annual trends, and monthly fluctuations and spatial patterns of sulphate deposition in the Turkey Lakes Watershed in the presence of strong spatial and temporal dependence. (under review).

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 review).

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

### 3) Papers involving only one CRG group member:

Yanqing Yi, Xuan Li. The most powerful test and the order of error probabilities for response adaptive designs. Electronic Journal of Statistics. Submitted on Dec.1 2013.

Yanqing Yi, Xikui Wang. Statistical inference following response-adaptive randomization. Modern Adaptive Randomized Clinical Trials: Statistical, Operational, and Regulatory Aspects. Edited by Oleksandr Sverdlov. Chapman & Hall/CRC Press. Accepted on Aug 2014.

Selvakkadunko Selvaratnam, Yanqing Yi, Alwell J. Oyet, Veeresh Gadag. Estimation of a Generalized Linear Mixed Model for Response Adaptive Designs of Multi-Center Clinical Trials. In the process of submission.

## *Graphs and Games*

Members:

Richard Nowakowski (Dal)  
 Suzanne Seager (Mount St Vincent)  
 Margaret-Ellen Messinger (Mt Allison)  
 Jeannette Janssen (Dal)  
 Bert Hartnell (St Marys)  
 Shannon Fitzpatrick (UPEI)

Stephen Finbow (STFX)  
 Art Finbow (St Marys)  
 Danny Dyer (Memorial)  
 Nancy Clarke (Acadia)  
 Jason Brown (Dal)

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:

Specifically, there have been two events, and third was postponed to September.

1: Short Course on the 2-Coloring Number, May 26-28, 2014, Dalhousie University. Organizers: Dr. M. E. Messinger, Dr R. J. Nowakowski.

Dr Hal Kierstead (Arizona State), a world's expert on the theory of colouring algorithms, gave six lectures. Except for the first lecture, the group spent 90 mins before each lecture going over 'work' that Dr Kierstead had assigned. Fourteen faculty, one Post-Doc, five graduate and two undergraduate students attended.



*Short course on the 2-Coloring Number*

2: Student Engagement Workshop, July 30-31st, 2014, St. Francis Xavier University.  
Organizers: Dr. S. Finbow, Dr. M. E. Messinger.

The workshop focussed on student engagement and provided an opportunity for students to present completed or in-progress engagement combinatorial research projects and also work collaboratively with faculty in problem sessions. The invited guest was Dr. Danny Dyer (MUN), who presented background, the state-of-the-art, and open problems for both “fast searching” and “the watchman’s walk” problems. Participants broke into two groups and worked on several questions that Dr. Dyer had posed. There were 8 student presentations and problem sessions and the workshop was attended by 15 participants; 6 faculty and 9 students.

3: Placement Games Workshop: September 20-21, 2014, Sir Wilfred Grenfell College.  
Organizers: Dr. R. Milley, Dr R. J. Nowakowski.

The Invertibility Conjecture for Placement Games was the focus of this workshop. Excitingly, Invertibility Conjecture for Misere Dicot Games was recently (August 2014) solved by Renault and independently by Larsson, Nowakowski and Santos but in a more general setting.

### Research:

#### 1: Papers.

The synergy, and just plain energy, that AARMS brings to the researchers of the region, through the Collaborative grant and other activities, is most evident in the papers of Dr Pike (noted by \* in the list of Research Papers).. Horsley was an AARMS PDF and Bryant and Pralat were at Memorial University as AARMS Summer School instructors. Francetic was here as an AARMS Summer School attendee. Although members of the group published many papers, we list only the papers and manuscripts that came about through collaboration in the region.

#### 2: New Research.

The communication engendered by the group has formed new partnerships. Existing partnerships continued, as evident in the papers. Drs. Brown (UPEI) and Fitzpatrick (Dal); Drs. Fitzpatrick (UPEI), Messinger (MtA), and Pike (MUN); and Drs. Larsson, Milley and Nowakowski, all started new collaborations.

### Participants at the Short Course on the 2-Coloring Number.

Dr. J. Brown (Dal) (undergrad) D. DesRoches (Acadia)  
Dr. N. Clarke (Acadia) (PhD) A. Erey (Dal)  
Dr. D. Cox (Dal) (PhD) S. Huntemann (Dal)  
Dr. A. Finbow (SMU) (PhD) N. McKay (Dal)  
Dr. S. Finbow (StFX) (PhD) L. Mol (Dal)  
Dr. S. Fitzpatrick (UPEI) (PhD) E. Roshanbin (Dal)  
Dr. B. Hartnell (SMU) (post-doc) A. Sanaei (Acadia)  
Dr. J. Janssen (Dal) (undergrad) M. Trace (Acadia)  
Dr. N. Kalyaniwalla (Dal)  
Dr. U. Larsson (Dal)  
Dr. M.E. Messinger (MtA)

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Dr. R. Milley (SWGCG)  
Dr. R. J. Nowakowski (Dal)  
Dr. D. Pike (MUN)

Participants, Student Engagement Workshop.

Dr. D. Dyer (MUN) (MSc) K. Barnetson (MUN)  
Dr. S. Finbow (StFX) (undergrad) A. Douthwright (StFX)  
Dr. M. Messinger (MtA) (undergrad) Thomas Faour (StFX)  
Dr. J. Preen (CBU) (MSc) S. Haghshenas (MUN)  
Dr. M. van Bommel (StFX) (PhD) N. MacKay (Dal)  
Dr. P. Wang (StFX) (PhD) Lucas Mol (Dal)  
(undergrad) J. Newman (SMU)  
(undergrad) J. Poulin (MUN)  
(MSc) M. Sullivan (MUN)

Participants, Placement Games Workshop.

Dr. U. Larsson (Dal) (PhD) S. Huntemann (Dal)  
Dr. R. Milley (SWGCG) (PhD) N. McKay (Dal)  
Dr. R. J. Nowakowski (Dal)  
On-line Attendees:  
Dr. P. Ottaway (Vancouver)  
Dr. G. Renault (Taiwan)  
Dr. C. Santos (Portugal)

Research Papers

(i) Accepted or appeared.

A. Bonato, N.E. Clarke, S. Finbow, S.L. Fitzpatrick, M.E. Messinger, "A note on bounds for the cop number using tree decompositions", accepted for publication in Contributions to Discrete Mathematics.

J. I. Brown, A. Erey (student), J. Li (student), "Extremal Restraints for Graph Colourings", accepted for publication in Journal of Combinatorial Mathematics and Combinatorial Computing.

J. I. Brown, D. Cox, R. Ehrenborg, "The Average Reliability of a Graph", Discrete Applied Mathematics 117 (2014) 19--33.

J. I. Brown, D. Cox, "On the Non-Existence of Optimal Graphs for All Terminal Reliability", Networks 62 (2014) 146--153.

J. I. Brown, A. Erey (student), "A note on the real part of chromatic roots", Discrete Mathematics 328 (2014) 96--101.

J. I. Brown, J. Tufts (student) "On the Roots of Domination Polynomials", Graphs and Combinatorics 30 (2014) 527--547.

\* D. Bryant, N. Francetic, P. Gordinowicz, D.A. Pike and P. Pralat, "Brushing without capacity restrictions", Discrete Applied Mathematics, 170 (2014) 33--45.

N.E. Clarke, S. Finbow, G. MacGillivray, "A simple method of computing the catch time", *Ars Mathematica Contemporanea* 7 (2014) 353--359.

D. Dereniowski, D. Dyer, R. Tifenbach, B. Yang, "Zero-visibility cops and robber and the path width of a graph", accepted for publications in *Journal of Combinatorial Optimization*.

D. Dereniowski, D. Dyer, R. Tifenbach, B. Yang, "The complexity of zero-visibility Cops and Robber", *FAW2014, LNCS 8497* (2014) 60--70.

D. Dereniowski, D. Dyer, R. Tifenbach, B. Yang, "Zero-visibility cops & robber game on a graph", *FAW-AAIM 2013, LNCS 7924* (2013) 520--532.

A. Finbow, B. Hartnell, R. J. Nowakowski and M. Plummer, "Well-covered triangulations: Part IV" (with A. Finbow, and M. Plummer), accepted (August, 2014) subject to revisions.

A. Finbow, B. Hartnell and M. Plummer, "On well-covered quadrangulations of the plane", *J. of Combinatorial Mathematics and Combinatorial Computing* 85 (2013), 287-297.

\* D. Horsley and D.A. Pike, "On balanced incomplete block designs with specified weak chromatic number", *J. Combin. Theory -- Series A*, 123 (2014) 123--153.

R. Milley, G. Renault, "Dead ends in misere play: the misere monoid of canonical numbers", *Discrete Mathematics* 313 (2013) 2223—2231.

(ii) Papers were submitted this year:

A. Bonato, J. Janssen, E. Roshanbin (student), "Burning a graph as a model of social contagion", submitted to *WAW 2014*. Conference paper.

A. Bonato, J. Janssen, E. Roshanbin (student), "Burning a graph is hard", submitted to *ANALCO 2015*. Conference paper.

M. Hurshman (student), J. Janssen, "On the continuity of graph parameters", accepted to *Discrete Applied Math*.

J. Janssen, C. Vautour (student), "Finding strategies for competitive diffusion on trees", *Internet Mathematics*, accepted subject to revision.

J. Janssen, P. Pralat and R. Wilson (student), "Asymmetric Distribution of Nodes in the Spatial Preferred Attachment Model", *Proceedings of WAW 2013*. Conference paper. Full paper in preparation.

J. Janssen, R. Mathew, D. Rajendraprasad, "Partial list colouring of certain graphs", *proceedings of International Colloquium of Graph Theory and Combinatorics (ICGTC)*, France, 2014. Conference paper. Full paper submitted to *Electronic Journal of Combinatorics*.

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J. I. Brown, D. Cox, "k-Clique Reliability of a Graph".

J. I. Brown, A. Erey (student), "On the roots of s-Polynomials".

J. I. Brown, D. Cox, A. Hoefel, N. McKay (student), R. Milley, R. J. Nowakowski, A. A. Siegel, "Polynomial Profiles of Placement Games".

B. Cameron (student) and S. L. Fitzpatrick, "Edge Contraction and Cop-win Critical Graphs".

N.E. Clarke, R.P. Gallant, "On 2-Limited Packings of Complete Grid Graphs".

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

A. Finbow, B. Hartnell, and J. Young (student), "The complexity of monitoring a network with both watchers and listeners".

S. Finbow, M.E. Messinger, M. van Bommel, "Eternal domination on  $3 \times n$  grid graphs".

R.D. Luther and D.A. Pike, "Cycle extensions in PBD block-intersection graphs".

D.A. Pike, A. Sanaei and N. Shalaby, "Pseudo-Skolem Sequences and Graph Skolem Labelling".

(iii) Manuscripts:

A. Z. Delaney (student) and M.E. Messinger, "Closing the Gap: Eternal Domination on  $3 \times n$  Grids".

B. Hartnell and J. Newman (student), "Equi-b-matchable graphs".

J. Howell, S. Fitzpatrick, M.E. Messinger, D. Pike, "Zombies and Survivors: a pursuit evasion game played on a graph".

U. Larsson, R. J. Nowakowski, and C. Santos, "Scoring Games: When Waiting moves you".

U. Larsson, R. J. Nowakowski, and C. Santos, "Dicot Misere Games: the Relationship between their Monoids, their Partial Orders and the Invertibility Conjecture."

U. Larsson, R. J. Nowakowski, and C. Santos, "Spaces of Combinatorial Games".

## ***AARMS Summer School***

The thirteenth AARMS Summer School took place at Dalhousie University from July 21 to August 15, 2014 under the direction of Sara Faridi and Hong Gu. As usual, four courses at the beginning graduate level were offered; in 2014 the themes were Algebra and Statistics:

- **Gröbner Bases in Commutative Algebra**  
Dr. Giulio Caviglia, Purdue University, USA
- **Homological Conjectures in Commutative Algebra**  
Dr. Hailong Dao, University of Kansas, USA
- **Statistical Learning with Big Data**  
Dr. Hugh Chipman (Acadia) and Dr. Xu Wang (STFX)
- **Spatial Statistics**  
Dr. Julie Horrocks, University of Guelph

Students attended from 13 different countries, each bringing with them their expertise and experiences. There were 25 Algebra students (including 5 from Dalhousie and 5 from other Maritime universities) and 20 Statistics students (including 1 from Dalhousie and 5 from other Maritime universities) .

The four weeks were spent in intense study along with homework, tutorials and problem sessions. The lectures were engaging, covering a broad range of topics: from classic questions in Algebra that motivated decades of research to some of the most contemporary lines of thought in the field; from the most popular and powerful statistical and machine learning tools to Statistical Models for Spatial data arising in many fields, including geography, epidemiology, public health, ecology and climatology.

There were supplementary lectures in the algebra program by Jay Schweig of Oklahoma State University and Russ Woodroffe from Mississippi State University. They each stayed at the school for a week or more.

All reports indicate that it was a successful School. More than 86% of the students found the level of the courses were suitable for them, and more than 80% of the graduate students' thought the courses were relevant to their research.

There was a welcome barbeque held in the courtyard of the Mini Rez houses to welcome the students from out of town and provide a chance for everyone to start to know each other. Also, a catered dance evening was held at St. Mary's Boat Club where the students could relax and enjoy some down time.

The students were treated to several outings showcasing various aspects of Nova Scotia. They went to the Kejimikujik National Park Seaside Adjunct. On the way there they stopped in Liverpool and on the way back had a chance to try some traditional fare at Lanes Privateer Inn. A glimpse of the Annapolis Valley was available on another weekend when they went to Annapolis Royal to tour the town and then stopped in Hall's Harbour for a traditional Lobster Dinner, tour of a lobster pound and a chance to see the spectacular view of the Bay of Fundy at low tide.



Participants at the 2014 AARMS Summer School

### List of Students

#### *Algebra Students*

Dalezios Georgios	University of Copenhagen	Denmark
William Sanders	University of Kansas	USA
Joao Pedro Martins dos Santos	Universidade de Lisboa	Portugal
Alessio D'Ali	Universita degli Studi di Genova	Italy
Ruqian Chen	Amherst College	USA
Alessandro Neri	University of Pisa	Italy
Monica Marinescu	Princeton University	USA
Greg Morre	University of New Mexico	USA
Marcus Webb	University of Nebraska – Lincoln	USA
George Shakan	University of Wyoming	USA
Asmita Sodhi	Mount Allison University	New Brunswick
Kaveh Mousavand	University of New Brunswick	New Brunswick
Amir Nasr	University of New Brunswick	New Brunswick
Fereshteh Yazdani	University of New Brunswick	New Brunswick
Matthew Lewis	University of New Brunswick	New Brunswick
Michael Lambert	University of Missouri	USA
Xiaoning Bian	Beihang University	China
Tomasz Miller	Warsaw University of Technology	Poland
Amor Haouaoui	Monastir University	Tunisia
Ben Hersey	Dalhousie University	Nova Scotia
Svenja Huntemann	Dalhousie University	Nova Scotia
Alanod Sibih	Dalhousie University	Nova Scotia
Ali Alilooee	Dalhousie University	Nova Scotia
Maryam Ehya	Dalhousie University	Nova Scotia
Nursel Erey	Dalhousie University	Nova Scotia

*Statistics Students*

Maria Alexandrova	Moscow State University	Russia
Jessica Barbosa	Inst. Tec. Autonomo de Mexico	Mexico
Krisztian Benyo Lorand Eotvos	University of Budapest	Hungary
Amiya Ranjan Bhowmick	Indian Statistical Institute	India
Daniel T. Braithwaite	University of Illinois at Chicago	USA
Blman Chakraborty	Indian Statistical Institute	India
Michael Akinwumi	University of Alberta	Alberta
Hao Hu	Fudan University	China
Emily Malcolm	University of Victoria	British Columbia
Soshi Mizutani	Brock University	Ontario
Giulio Morina	Universita di Torino	Italy
Onur Muharrem Orun	Bilkent University	Turkey
Tommaso Portaluri	University of Turin	Italy
Mengyin Wu (MITACS)	Zhejinag University	China
Easton R. White	University of Victoria	British Columbia
Qiuguang Sang	University of New Brunswick	New Brunswick
Jiejie Wang	University of New Brunswick	New Brunswick
Adeyinka Adedeji	Memorial University	Newfoundland
Mark Thomas	Acadia University	Nova Scotia
Mary (Zhouqin) He	St. Francis Xavier University	Nova Scotia
Lihui Liu	Dalhousie University	Nova Scotia

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 88%. Ratings of lecturers ranged between 70% and 96%. When asked whether they would recommend the summer school to a friend or colleague, 97% of respondents said that they would. There were a number of comments both positive and negative about the residence accommodations and Dalhousie facilities. For example:

*"I wish the kitchens in our dorms were better equipped."*

But the majority of comments on the academic curriculum were very positive:

*"The course on Homological Conjectures was amazing."*

*"The course was really good and many aspects of the subjects were covered."*

With one negative comment which was not further explained:

*"Did not like the spatial stats course."*

The fourteenth annual Summer School will be held July 6-31, 2015 at Dalhousie University. We will be offering the following courses:

- **Waves and patterns in nonlinear systems**  
Andrea Bertozzi (UCLA) and Ricardo Carrettero (San Diego State U.)

- **Topics in Reaction-Diffusion Systems: Theory and Applications**  
Michael Ward (UBC) and Juncheng Wei(UBC)
- **Structure-preserving discretization of differential equations**  
Elena Celledoni (Norwegian University of Science and Technology) and  
Brynjulf Owren, (Norwegian University of Science and Technology)
- **Numerical analysis of singularly perturbed ODEs and PDES**  
Dr. Martin Stynes (National University of Ireland)

### *AARMS Postdoctoral Fellowship Program*

In 2014 one new AARMS Postdoctoral Fellowships was awarded:



**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.

Other AARMS Postdoctoral Fellowships held in 2013:



**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.



**Charles Paquette** received his Ph.D. in 2010 at the Université de Sherbrooke, Quebec, Canada. As an AARMS postdoctoral fellow, he is working at the University of New Brunswick under the supervision of Drs Hugh Thomas and Eddy Campbell. His research interests focus on representation theory of associative algebras. His last projects dealt with Auslander-Reiten theory, representation theory of infinite quivers, homological conjectures and semi-invariants of quivers.

The competition for 2015 positions opened in November 2014 with final decisions on awards made in spring 2015. We have made offers to five candidates for fellowships in 2015.

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 Technology (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, *Dalhousie 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 2014 AARMS funded or partially funded the following workshops conferences and events. These involved over 680 participants, more than 300 of whom were from outside Atlantic Canada:

### **Combinatorial Algebra meets Algebraic Combinatorics**

Organizers: Sara Faridi, Hugh Thomas, Mike Zabrocki

Location: Dalhousie

Date: January 24-26, 2014

This annual conference series aims to promote connections between researchers in algebraic combinatorics and commutative algebra, and between Atlantic Canada, Eastern Canada, and the eastern seaboard of the United States. This year we had a lively and well-attended meeting, with many outstanding talks. Topics covered included some areas familiar from previous conferences, including simplicial complexes, symmetric functions and their generalizations, and varieties of commuting nilpotent matrices, and also some exciting new areas such as rational Catalan combinatorics. The invited speakers were:

Drew Armstrong (University of Miami)

Ezra Miller (Duke University)

Mike Roth (Queen's University)

Mark Skandera (Lehigh University)

Julianna Tymoczko (Smith College)

There were a further eleven contributed talks, with speakers coming from Canada, the United States, and Europe.

[Also funded by Fields, Dalhousie University and the University of New Brunswick](#)

### **Atlantic General Relativity 2014**

Organizers: Sanjeev Seahra, Jack Gegenberg

Location: University of New Brunswick (Fredericton)

Date: May 6-7, 2014

The Atlantic General Relativity Meeting 2014 (AGR14) was held from May 6-7 at the University of New Brunswick's Fredericton campus. It was the latest in an annual series of meetings covering all aspects of classical and quantum gravity. This year, the meeting was held in conjunction with the International Shape Dynamics Workshop from May 8-9, which was organized by Tim Koslowski (New Brunswick). The shape dynamics workshop attracted a large international contingent, which helped to make the 2014 incarnation of Atlantic General Relativity the largest one in the series to date. There were 41 participants in AGR14 and 19 talks. 27 participants were from the Atlantic region (i.e., from UNB, Dalhousie or Memorial), 6 from elsewhere in Canada, and 8 from outside Canada. The invited speaker for the conference was Bianca Dittrich (Perimeter), who gave two talks. Topics covered included recent advances in loop

quantum gravity, shape dynamics (a new theory of gravity), classification of spacetimes, mathematical relativity, and the effects of novel quantum theories on cosmology.

Also funded by [University of New Brunswick and FQXi](#)

### **Software Carpentry Bootcamp**

Organizer: Paul Muir

Location: St Mary's University

Date: July 2-3, 2014

The Software Carpentry Project (<http://software-carpentry.org/>) is a volunteer organization, founded in 1998, that runs short, intensive workshops (called bootcamps) that teach a core set of skills that enhance the efficiency and reliability of computer-based workflow for anyone who uses a computer as a significant component in their research. The Software Carpentry Project runs bootcamps all over the world, and also provides open access material for self-paced instruction.

On July 2-3, 2014, Saint Mary's University hosted a Software Carpentry Bootcamp, led by Dr. Dhavide Aruliah, an experienced Software Carpentry Bootcamp instructor, from the University of Ontario Institute of Technology. Stephanie Gagne, Dalhousie University, served as a second instructor for the bootcamp. Additional technical support was provided by Ross Dickson (ACENET), Andrew Valencik (Saint Mary's University), and Jack Pew (Saint Mary's University). The local organizers for the workshop were Paul Muir and Andrew Valencik, Saint Mary's University.

The bootcamp consisted of short tutorials alternating with hands-on practical exercises; learners worked on their own laptops and each had a working software environment by the time the bootcamp was completed. The primary areas covered by the bootcamp were the Unix shell (and how to automate repetitive tasks), Python (and how to grow a program in a modular, testable way), and Git and GitHub (version control software that allows one to track software or document development and share work efficiently). A pre-assessment survey of the registered learners, provided by Software Carpentry, allowed the teaching team to customize the material to the learning community.

The bootcamp had approximately 40 participants, with another 14 left on the wait list! The intense two day workshop featured hands-on learning by all participants, with enthusiastic participation from the instructors and the technical support team. A large fraction of the participants were graduate students from Saint Mary's and Dalhousie University, but the learning community also included some undergraduates, faculty, and a few industry participants, all local to the Halifax region, except for one undergraduate from Acadia University. There was of course no national/international participation as the point of this sort of outreach activity is to serve a regional base. (That is, other parts of Canada and many other parts of the world host their own bootcamps from time to time.)

Also funded by [Saint Mary's University](#)

### **Two weeks at WATERLOO - A Summer School for Women in Math**

Organizers: B. Csima, S. A. Campbell, K. Hare, M. Frigon, I. Laba, M. Lalin, L.

Pramanik, G. Wolkowicz

Location: University of Waterloo

Date: August 10-23, 2014

“Two weeks at Waterloo – A summer school for women in math” was a two week workshop, held at the University of Waterloo, from August 10-23, 2014, for outstanding female undergraduate mathematics students. The purpose of the workshop was to encourage and inspire talented women students to continue their studies in mathematics and to consider graduate work in mathematics.

Two mini-courses were offered, Kakeya sets, or, a handbook of parallel parking, taught by Prof. Malabika Pramanik (University of British Columbia) and Algorithmic learning theory, taught by Prof. Jennifer Chubb Reimann (University of San Francisco). As part of the courses, the students worked in small groups on a research project. Each course also had a female graduate student act as a TA and mentor for the students.

The students had the opportunity to meet with females with PhDs in mathematics, working in a variety of settings. A public lecture was given by Prof. Mary Lou Zeeman (Bowdoin College), and there were guest lectures given by Catherine Sulem (University of Toronto), Julia Viinikka (Sun Life Financial), and Megan Dewar (Tutte Institute). Tours were made to meet with female mathematicians in industry at IBM, Sun Life and Maplesoft. The students also visited the Fields Institute.

The program was advertised across Canada and 14 undergraduate women participated in the two week program. They came from 8 provinces and 12 different universities. Most were entering their final year of undergraduate studies. The travel and living costs of the students were covered.

The students reported that the school was a worthwhile experience. The majority indicated that they were more interested in graduate school now than they had been before. Many told us how much they enjoyed meeting and doing mathematics with other women students and instructors.

[Also funded by University of Waterloo](#)

### **Recent developments in the adaptive solution of PDEs**

Organizers: Ronald Haynes, Paul Muir, Hermann Brunner

Location: Memorial University, St. John's

Date: August 17-22, 2014

The CRM-AARMS Workshop title "Recent Developments in the Adaptive Solution of PDEs", organized by the AARMS Atlantic Collaborative Research Group in Numerical Analysis and Scientific Computing, was held at Memorial University of Newfoundland, St. John's, Newfoundland, Aug. 17-22, 2014.

The workshop was well attended with approximately 45 participants involved, including BSc, Msc, PhD students and researchers from Canada, the United States, China, the United Kingdom and Columbia. There were 11 faculty members, 3 post-docs, 4 plenary speakers and 27 undergraduate and graduate students. 32 of these participants were from outside the province.

This workshop consisted of three primary parts. The first part was a two day short course on adaptive methods for PDEs, given by Dr. Weizhang Huang of the

University of Kansas, a leading expert in this area. This short course outlined PDE based adaptive mesh generation and concluded with research level questions concerning anisotropic mesh generation. Each day included approximately 5 hours of lectures given by Dr. Huang, and concluded with a hands-on computer lab session, led by Dr. Lennard Kamenski (Weierstrass Institute for Applied Analysis and Stochastic (WIAS), in which participants got an opportunity to learn about software implementations (primarily in Matlab) 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 second part of the workshop consisted of 4 plenary research level talks given by Mark Ainsworth (Brown) "A Synthesis of A Posteriori Error Estimation Techniques for Conforming, Non-Conforming, Mixed and Discontinuous Galerkin Finite Element Methods", Chris Budd (Bath) "Anisotropic mesh generation using optimal transport methods with applications to meteorology ", Lennard Kamenski (WIAS) "How a non-convergent Hessian recovery works in mesh adaptation", and Weizhang Huang "Adaptive and structure-preserving computation of anisotropic eigenvalue problems". These 4 talks were at very well prepared - it was a real treat to get a summary of the latest results in the field by 4 of our adaptivity experts.

The workshop then transitioned to its third part with 4 applied problem presentations from Colin Farquharson (MUN) "Exploration geophysics and synthesizing electromagnetic fields in the Earth", David Iron (Dalhousie) "Parabolic systems with multiple spatial and temporal scales", Scott MacLachlan (MUN) "Robust methods for singularly perturbed reaction-diffusion equations", and Hongmei Zhu (York) "Challenges with medical image de-noising and segmentation". These speakers nicely outlined problems in their primary research area which would benefit from the use of adaptive numerical technique. The last day and a half of the workshop included breakout sessions which partnered applied problem presenters, adaptivity experts and other workshop participants, as well as several contributed talks in which participants talked about applications in which adaptive methods for PDEs were employed. The breakout sessions that brought together applications experts and adaptivity experts represented a novel part of the workshop and were very well received. Although no papers were written in the last day and a half of the workshop, the sessions were quite successful in forging future collaborations.

[Also funded by CRM, Memorial University](#)

### **Enveloping Algebras and representation Theory**

Organizer: Yuri Bahturin,

Location: Memorial University, St. John's

Date: August 28 - Sept 1, 2014

Universal enveloping algebras of Lie algebras appeared more than a century ago as one of the major tools in Lie Theory. They find many applications in Differential Geometry and Mathematical Physics, and are indispensable to many directions of research in representation theory of Lie groups and algebras. With the increasing interest in infinite-dimensional representations, the role of enveloping algebras becomes even more significant. More recently, universal enveloping algebras have appeared in the theory of nonassociative algebras other than Lie (alternative, Jordan, Malcev and their super

analogues), which are of growing importance in the most advanced areas of mathematics and physics where traditional approaches fail to work. In addition, the Hopf algebra structure of universal enveloping algebras lends itself to quantization, leading to the celebrated Drinfeld - Jimbo "quantum groups". Far-going generalizations of the latter have recently appeared in the theory of Hopf Algebras in connection with the classification of pointed Hopf algebras. Thus, Enveloping Algebras is a vibrant area of research, with many mathematicians around the globe working and hundreds of papers published.

The aim of this workshop was to discuss the current state of research in the area of Enveloping Algebras and their applications, primarily in Representation Theory. We invited several prominent mathematicians to give lectures illuminating the main achievements in these areas and outline the prospects of further research. There were a number of longer research talks as well as some shorter research communications, in particular by graduate students and postdoctoral fellows.

The total number of participants was 38; 17 of them were students and postdoctoral fellows, primarily associated with AAC and NOLT, but also from other universities in Canada and abroad. The number of international participants was 14, from 7 countries. The total number of Canadian participants was 24, from outside of Atlantic Canada was 13.

The list of invited speakers included

1. Alberto Elduque (University of Zaragoza, Spain)
2. Vyacheslav Futorny (University of Sao Paulo, Brazil)
3. Antony Joseph (Weizmann Institute, Israel)
4. Victor Kac (Massachusetts Institute of Technology, USA)
5. Vladislav Kharchenko (Universidad Nacional Autónoma de México)
6. Vladimir Mazorchuk (University of Uppsala, Sweden)
7. Erhard Neher (University of Ottawa)
8. José María Pérez Izquierdo (University of La Rioja, Spain)
9. Alexander Premet (University of Manchester, UK)
10. Ivan Shestakov (University of Sao Paulo, Brazil)

Also funded by Fields, Memorial University, Atlantic Algebra Centre

### **AAC Minicourse on Branch Groups: Theory and Practice**

Organizers: Y. Bahturin, M. Kochetov, E. Martinez-Pedrosa, H. Usefi

Location: Memorial University, St. John's

Date: September 13-19, 2014

On September 13 – 19, 2014, Professor John Wilson of Oxford University visited the Atlantic Algebra Centre at St. John's campus of Memorial University of Newfoundland. Professor Wilson delivered a mini-course entitled "Branch groups: theory and practice". He also gave a Distinguished Colloquium "Non-standard finite simple groups". The lectures of the mini-course were at a level accessible to graduate and advanced undergraduate (honours) students. The Distinguished Colloquium was designed for a general mathematical audience.

Professor Wilson is a celebrated mathematician working primarily in the Theory of Groups. He is a founder and Editor-in-Chief of "Journal of Group Theory" published by De Gruyter.

From 1994 to 2003 he held the Mason Chair of Mathematics at the University of Birmingham and now holds an Honorary Visiting Professorship at Aston University. Professor Wilson has held visiting professorships and other appointments for various periods at a number of other universities around the globe, most recently at the Université de Genève (January - June 2002), the University of California at San Diego (January - March 2004), ETH Zürich (April - June 2007, May - June 2009), Berlin (September 2011). In October - March of 2015 he will be the Leibnitz Professor at the University of Leipzig.

From 2004 to 2010, he was Professor of Mathematics, Oxford University. On retirement from this position, he became a Departmental Research Fellow in the Mathematical Institute, Oxford. He is also a Fellow of Christ's College, Cambridge. Research interests of Professor John Wilson include profinite groups, finite and infinite soluble groups, model theory of groups, branch groups, word growth of groups, finitely presented groups, generation problems for finite simple groups.

The lectures of the mini-course by Professor Wilson took place on September 15, 17 and 19, 2014 in Auditorium A-1049, 3 – 4:30 pm. The total number of participants of the mini course was around 20 – 25 students and faculty members. Professor Wilson made himself available at other times during his visit for further questions and discussions at Atlantic Algebra Centre, including Algebra Elevenses on September 18. [Also funded by Memorial University, Atlantic Algebra Centre](#)

### **Connecting Women in Mathematics Across Canada**

Organizers: Sara Faridi et al

Location: Banff International Research Station

Date: October 3-5, 2014

This is an exciting time for women and visible minorities in the basic sciences. More and more women from diverse backgrounds continue to beat formidable odds and come to the forefront of their professions with spectacular achievements. For the first time in its distinguished history, the Fields medal has been awarded to a woman, Professor Maryam Mirzakhani. The presidents at the helm of the International Mathematical Union (IMU) and the Canadian Mathematical Society (CMS) are two other highly acclaimed female mathematicians, respectively Professors Ingrid Daubechies and Lia Bronsard. For the last decade or so, considerable effort has been invested in researching and ensuring gender equity, and we are beginning to see the gratifying repercussions of this heightened awareness. At the same time, this increase in diversity has not yet resulted in a representation of women and minorities in graduate and postgraduate programs or as university faculty at the rate or proportion one might expect. We are still looking for ways to support this pipeline.

The aim of the 2-day BIRS workshop was to target top female junior mathematicians from across the country, who are close to obtaining a Ph.D. or have just graduated. This is a time when researchers are faced with the challenges of job search in an increasingly tough academic environment. For graduate students, this may involve landing a coveted postdoctoral position. Postdocs on the other hand would be looking for tenure-track and/or instructorship positions after their term. Different job searches come with varying, often non-explicit, criteria. Preparing oneself for a largely unknown hiring process can be stressful. This is especially true for women, who are often a small

minority within their respective programs, and hence lack as extensive a support system as men. Also, women role models are much rarer, making it difficult for the junior women researchers to visualize themselves in senior academic roles.

The program made an effort to create a valuable experience for the participants within a limited timeframe. The highlights included:

- □ a collaborative and encouraging environment that facilitated interaction, as well as one-on-one mentorship,
- expert advice, general and personalized, related to research, teaching, giving talks and other facets of academic life,
- the presence of many role models.

We wanted the participating students to leave with the understanding that they are not alone (even though they may be among a mere handful of females in their respective programs), that women are being increasingly successful in challenging and rewarding careers and having a positive impact on their communities.

Given the limited amount of time we had, we broke the program into three parts. We made sure all junior participants were allowed time to present their work to the other attendees, as if they were giving a short job talk. We then had general discussion times built into the program as well as one on one meetings with assigned mentors so that the junior mathematicians could receive feedback on their presentations, as well as general career advice.

Finally, we had three (of the originally planned four) main invited lectures focusing on some major aspects of a mathematical career: Research, University Teaching, and Presenting Research in Conferences. These fantastic talks were interactive, and followed by passionate discussions.

There were 24 participants, all from Canada, as this was our target group.  
[Also funded by BIRS, PIMS, CRM, Fields, WISE chairs \(ON and Prairies\), CMS Women in Math Committee](#)

### **Atlantic Math/Stats/CS Conference**

Organizer: Mohammad Hamdan

Location: UNB Saint John

Date: October 3-5, 2014

The 37th Science Atlantic Math/Stat/CS Conference was held at the University of New Brunswick, Saint John, and initially scheduled for October 3-5, 2014. A Sunday session on Modelling and Simulation was initially scheduled, but we ended up accommodating all talks on Saturday, October 4, 2014.

The Conference attracted 171 participants (99 undergraduate students, 17 graduate students, 48 faculty members, 2 teachers and 5 retired faculty). The main focus of the conference is the encouragement of undergraduate students to present their research work under the guidance of faculty members, and writing team competitions. For the Mathematics and Statistics part of the conference, there were 18 official teams that participated in the Mathematics Problem Solving Competition. For the Computer Science part of the conference, there were 17 official teams that participated in the Programming Competition.

The 34 research talks at the conference included 4 undergraduate Statistics talks, 4 undergraduate Computer Science talks, and 15 undergraduate Mathematics

talks. There were 11 contributed talks, 4 of them were in Computer Science and 7 in Mathematics, Statistics (with 1 talk in Statistics Education). Conference schedule of talks, abstracts, and other details can be found in the conference booklet, appended to this report.

The following represented our invited speakers in Statistics, Mathematics and Computer Science, respectively:

1)Field's Lecture: Dr. Erica Moodie, Department of Epidemiology, Biostatistics, and Occupational Health, McGill University Title: Dynamic treatment regimens: Quantitative tools for the personalization of medicine

2)Blundon Lecture: Dr. John Grant McLoughlin, UNB-Fredericton, Faculty of Education

Title: Mathematical Problem Solving

3)Sedgewick Lecture: Dr. Manuela Veloso, (Herbert A. Simon Professor, Computer Science Department, Carnegie Mellon University, Title: Symbiotic Autonomy: Robots, Humans, and the Web

Also funded by Science Atlantic, CNSC, Innovatia, PearsonEd, CMS, Enterprise Saint John, Planet Hatch, NB Power, JD Irving, UNB, Maplesoft, Statistical Society of Canada, ACM.

### **2014 Fall Eastern Sectional Meeting of the American Mathematical Society**

Organizer: Peter Selinger

Location: Dalhousie, Halifax

Date: October 18-19, 2014

The 2014 Fall Eastern Sectional Meeting of the AMS was held at Dalhousie University on Oct 18–19, 2014. The scientific program consisted of four invited lectures by Sujatha Ramdorai (UBC), William M. Goldman (Maryland), Sourav Chatterjee (Stanford), and Francois Bergeron (UQAM). There were also 14 special sessions:

- Advances in Harmonic Analysis and Partial Differential Equations (D. Cruz-Uribe, S. Rodney)
- Combinatorial Representation Theory (C. Ballantine, R. Orellana, M. Rosas)
- Commutative Algebra and Its Interactions with Algebraic Geometry (S. M. Cooper, S. Faridi, W. Traves)
- Differential Geometry and Mathematical Physics (V. Charette, K. Melnick)
- Experimental Mathematics in Number Theory, Analysis, and Combinatorics (M. Chamberland, K. Dilcher)
- Games on Graphs (J. Brown, J. Janssen, R. Nowakowski)
- Generalized Catalan Algebraic Combinatorics (F. Bergeron, F. Saliola, H. Thomas, N. Williams)
- General Relativity (J. Gegenberg, A. Coley, I. Booth, H. Kunduri, S. Seahra, V. Husain)
- Hopf Algebras (Y. Bahturin, M. Beattie, M. Mastnak)
- New Directions in Category Theory (P. Hofstra, D. Pronk)
- $p$ -adic Methods in Arithmetic (H. Darmon, A. Iovita, S. Ramdorai)
- Sampling Theory (J. J. Benedetto, J.-P. Gabardo, O. Yilmaz)
- Special Functions and Their Applications (M. E. H. Ismail, N. Saad)
- Symbolic Dynamics and Combinatorics on Words (S. Brlek, R. Yassawi)

Many of the special sessions were at the cutting edge of their respective research areas. Among the scientific successes, let me highlight the special session on Sampling Theory. It was considered a great success, and was also connected to the invited lecture by Sourav Chatterjee, who was also an invited speaker at the recent ICM in Seoul. Dr. Chatterjee's lecture, which was on the probability of rare events, was very well received.

The conference had 243 registered participants. This included 66 from the Atlantic Region (43 from Nova Scotia, 14 from New Brunswick, 6 from Newfoundland, and 3 from Prince Edward Island) and 61 from the rest of Canada. There were also 97 participants from the U.S., as well as 19 participants from other countries (Argentina, Barbados, Belgium, Brazil, France, Germany, Great Britain, Italy, Mexico, and Spain). [Also funded by AMS, Dalhousie University.](#)

## ***Outreach***

In 2014 AARMS supported the following outreach programs:

### ***Nova Scotia Math Outreach Discussion Meeting***

The first annual Nova Scotia Math Outreach Discussion Meeting was held in June 2014. 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

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:**

Tamara Franz-Odendaal (Dept of Biology, MSVU and NSERC Atlantic Chair for Women in Science and Engineering )

Tara Taylor (Dept of Mathematics, Statistics and Computer Science, STFX)

John Irving (Dept of Mathematics and Computer Science, SMU and Math League Organizer)

Nancy Clarke (Dept of Mathematics and Statistics, Acadia)

Nauzer Kalyaniwalla (Faculty of Computer Science, Dalhousie)

Jeannette Janssen (Dept of Mathematics and Statistics, Dalhousie and AARMS Director)

Roman Smirnov (Dept of Mathematics and Statistics, Dalhousie; Dalhousie Math Camp organizer)

Svenja Huntemann (Dept of Mathematics and Statistics, Dalhousie)

Jeff Hooper (Dept of Mathematics and Statistics, Acadia)

John McLoughlin (Faculty of Education, UNB)

Alain Gamache (École secondaire du Sommet)

Paul Muir (Dept of Mathematics and Computer Science, SMU)

R.P. Gupta (Dept of Mathematics and Statistics, Dalhousie, Organizer Black Educators Association Math Camp)

Robert Dawson (Dept of Mathematics and Computer Science, SMU)

David Iron (Dept of Mathematics and Statistics, Dalhousie)

David Langstroth (AARMS Administrator, Dalhousie)

Preman Edwards (Auburn Drive High School; Black Educators Association Math Camp)

Danielle Cox (Program Director, Math Circles; Dalhousie)

Chelluri Sastri (Dept of Mathematics and Statistics, Dalhousie)

Huda Chuangpishit (Dept of Mathematics and Statistics, Dalhousie)

Eva Knoll (Faculty of Education, MSVU)

Richard Nowakowski (Dept of Mathematics and Statistics, Dalhousie)

**Regrets:**

Matt Hebb (VP Government Relations, Dalhousie)

John Newhook (Ass. VP Research, Dalhousie)

Lisa Lunney Borden (School of Education, STFX)

Joe Apaloo (Dept. of Mathematics and Statistics, STFX)

Bob Crane (Mi'kmaw Kina'matnewey)

Ms. Angelopoulos (Math On)

Robert Van den Hoogen (Dept. of Mathematics and Statistics, STFX)

Suzanne Seager (Dept. of Mathematics and Computer Science, MSVU)

***Nova Scotia Math Circles:***

NS Math Circles is a mathematics outreach program based out of the Department of Mathematics & Statistics at Dalhousie University. It began about a decade ago when two graduate students organized evening math events for local high school students. Graduate students or faculty members would give a 2 hour hands-on math presentation and a pizza supper would be provided for the students.

In June of 2014 Eastlink began a partnership with NS Math Circles. They will be donating \$500,000 to the program over the next 5 years. This will allow Math Circles to expand into junior high and elementary schools. This new funding partnership meant that Math Circles would be scrambling in 2014/15 to ramp up their activities and could not use another major funding initiative from AARMS in this year. From 2015/16 onwards we will be making resources available to Math Circles to further develop this successful program

However, in 2014 one of the founders of Math Circles, Danielle Cox, took up a position at Acadia University. AARMS funded her new initiatives with the Annapolis Valley Regional School Board to create a new pilot program: Acadia Math Circles. This aims to imitate the success of the provincial program in a specific school board region, supported by Acadia University.

And, also in 2014, AARMS funded a special trip by Math Circles to the Chignecto-Central School Board. A fuller report of this trip is included below.

The following schools were involved in the project:

**Amherst Regional High School**

79 Grade 10 Students

**Hants East Rural High School**

64 Grade 9 Students

**West Colchester Consolidated**

20 Grade 10 Students

12 Grade 8 Students

**Pugwash District High School**

40 Grade 9 Students

**Highland Consolidated Middle School**

20 Grade 9 Students

135 Grade 8 Students

40 Grade 7 Students

**River Hebert Rural High School**

15 Grade 8 students

**Oxford Regional High School**

15 Grade 11 students

20 Grade 10 students

**Northumberland Regional High School**

200 Grade 8 students

**Hants North Regional High School**

200 Grade 8 students





### Workshops Presented

Mathematic Problem Solving  
 Jury Duty  
 Tower of Hanoi  
 Toads & Frogs  
 Permutations & Combinations  
 Tessellations

From May 5-9 the NS Math Circles team visited the Chignecto-Central Regional School Board. Math Circles had visited schools in this region before, but this was their first major outreach visit to this board. This trip the main focus was to increase outreach to junior high students within the school board. Historically NS Math Circles has been a high school outreach program, but during the summer of 2013 workshops to take into junior high classes were developed. Some of the workshops had been tested in HRM junior high classes, but this was their second trip to take these presentations into classrooms outside of HRM.

The presenters for the week were Julien Ross, Hoda Chaungpishit, Abdullah Al-Shaghay, graduate students within the Department of Mathematics & Statistics at Dalhousie University, as well as honours student Julia Tufts. Julien was the Presentation Lead. The trip was organized by Program Director, Danielle Cox. During the week the team visited 5 schools within the Chignecto-Central School Board. Another 4 schools were visited a week prior to the trip, as there were too many requests to fit into a one week visit.

Thanks to the funding from AARMS, this trip resulted in over 800 students being outreached to and allowed NS Math Circles to begin to build a presence within the junior highs in the CCRSB.

Some teacher comments:

“I would love to have a presentation every year!”  
-Julie North, Teacher at Hants East Rural High.

“Students were engaged and able to connect the presentation with their current outcomes” -Kelly Power, Teacher at Amherst Regional High School.

“Great to engage them mathematically” -Krista Brown, Teacher at Highland Consolidated Middle School.

“Students were able to see some different math concepts they otherwise wouldn’t have experienced this year” -Angela Vogels, Teacher at West Colchester Consolidated.



### ***STFX-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 inaugural camp was a two and a half day weekend camp to begin at 9:00 am on the Friday and end by 11:30 am on Sunday. There were seven sessions that were presented by faculty to expose the participants to exciting topics and applications in the mathematical sciences. In addition there were several sessions on math trivia, math relays, and team problem solving to help inspire the participants about the breadth and applicability of the mathematical sciences. It is anticipated that students who attend the camps will develop new friends, new ideas, and a new outlook on mathematics. Participants were 23 students in grades 10 and 11 from Pictou County to Cape Breton County and 2 university students as chaperones. Invitations were sent to all high schools in the area. The participants are self-selected with some evidence of strong aptitude for the mathematical sciences, There is a nominal fee which is waived in the case of students of need.

In an exit survey 18 students indicated increased interest in math science or engineering; and 21 student were considering math, science or engineering careers.

Other Students' Comments

"Increased interest in math, science and engineering"

-Yes it did. It opened up possible careers I could follow

-It increased my interest only in math

-I definitely increased my interest now that I am aware of all the opportunities and possibilities.

-Yes, this experience was absolutely awesome. My interest was always there for math/sciences but now it's definitely more apparent.

-Yes, it made my interest increase in math dramatically

"Are you considering a career in math, science, or engineering?"

-Yes I was considering a career in engineering but might look into other math/science careers

-I am considering a career only in math or science

The next camp will be planned for May 2015.

### ***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.

### ***Math Camp for Black Students.***

The annual Mathematics Camp for black students is held in the second week of July. Approximately 32 students (grade 6-7, aged 12-14) are selected by the Black Educators Assoc. of N.S. AARMS has committed \$4500 for the 2015 camp in a new partnership with this organization and we look forward to continuing to support their program in the years ahead.

### *Enhancing Our Appreciation of Mathematics Through Intentional Community Outreach*

A 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).



Sisters Madison and Samara enjoying math games in Fredericton

### *UNB-CMS Mathematics Camp, Grades 10-11*

The fifteenth edition of the UNB-CMS Math Camp at the University of New Brunswick, Fredericton, took place May 9-11, 2014. As these dates suggest, the camp is residential, so that accommodation and meals are by far our greatest expenses. We cover all weekend expenses, although students (their families, of course) are responsible for travel to and from Fredericton.

This year we had typical attendance, with twenty-four students selected by the organizers from high schools across the province of New Brunswick. Eight of the campers were young women; this proportion is stubbornly resistant to change. We are still struggling to find students outside the three larger cities in the province. Students from grades 10 and 11 are selected for the most part based on past success on the NB Mathematics Competition (grades 7-9) or in the COMC (Canadian Open Mathematics Competition). We see the Camp quite simply as an exercise in enrichment and an opportunity to recruit young people into mathematics and related fields. During the 52 or so hours that students were on site we had several problem sessions, beginning with a discussion of problems sent out before the camp. There were also several invited talks, mainly interactive but some more formal. Our contributors came from the UNB Departments of Mathematics and Statistics, Philosophy and Education. Of course, we have some downtime, including an evening of 'basketball math' at the gym. Invariably our student surveys at the end of the weekend ask for more time off but in that one area, we are reluctant to acquiesce.

### *The New Brunswick Mathematics Competition, Grades 7-9*

The Competition was held on Friday, May 9, 2014, simultaneously on the campuses of the University of New Brunswick at Fredericton and Saint John, and at l'Université de Moncton at their Moncton, Edmundston and Shippagan campuses.

The competition paper was available in both English and French at all locations. A total of **1247** students participated: 402 in Fredericton, 275 in Saint John, 322 in Moncton, 118 in Edmundston and 130 in Shippagan. (A few more ambitious students from lower grades participated informally.) The students represented 160 schools from all 7 school districts.

The awards ceremony at UNB-Fredericton was hosted by Dr. Eddy Campbell, mathematician and President of the University of New Brunswick. Prizes were presented to students by Kathy Hildebrand, Learning Specialist K-8, NB Department of Education and Early Childhood Development; Michael Freeze, Actuarial Analyst, Morneau Shepell, Fredericton; and Stephen Heard, Acting Dean of Science at UNBF.

All winners, including those finishing first in each of numerous subdistricts, received a mathematically themed T-shirt. This year's T-shirt featured the golden section  $\tau$ , one of the many appearances of which is the ratio of diagonal to edge in a regular pentagon. District winners for each grade received as well diplomas and either a book (English districts) or a magazine subscription (French districts). Pewter medals were given or mailed to the top three students in the province for each grade. The top three students in each grade, at each campus, will receive cheques. We thank our many sponsors for underwriting these and all other prizes.

Also sponsored by NB Department of Education and Early Childhood Development, Morneau Shepell - Fredericton, CIBC Wood Gundy - CMS, and the two host universities.

### ***The Blundon Math Camp and Seminar***

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 2014 Math Camp and Seminar was held on May 14-16 and included 36 participants.

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

Funds have also been committed, although not yet spent to support a postdoctoral coordinator of Math Outreach in Nova Scotia. The coordinator would act as a liaison between the various organizers, the schools, and the teachers. He or she would help with logistics and communications, and ideally be actively involved in at least one of the outreach activities. We propose that the coordinator should hold a post-doctoral position at Dalhousie University. He or she will spend a fraction of their time working on research with faculty members associated with AARMS in Nova Scotia, and rest of the time would be dedicated to coordinating AARMS outreach activities.

## ***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

### **The AARMS Executive Committee**

Jeannette Janssen (Dalhousie), Chair  
Jacques Allard (Moncton) [term ended in 2014]  
David Bremner (UNB) [term ended in 2014]  
Colin Ingalls (New Brunswick)  
Paul Muir (St. Mary's)  
Dorette Pronk (Dalhousie)  
Nasser Saad (UPEI)  
Yuan Yuan (Memorial)  
Xiaoqiang Zhao (Memorial)

### **The AARMS Editorial Board**

Yuri Bahturin (Memorial), Chair  
Robert Dawson (Saint Mary's)  
Theodore Kolokolnikov (Dalhousie)  
Lin Wang (New Brunswick)  
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 Dalhousie, Memorial, Saint Mary's, 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 conferences. 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.



**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 the University of Chicago and the University of Waterloo.



**Walter Craig** - is a Professor of Mathematics and the Canada Research Chair (Tier I) of Mathematical Analysis and its Applications at McMaster University. His doctorate is from the Courant Institute (1981), and he has held faculty positions at Caltech, Stanford University and Brown University, where he was department chair, before moving with his wife to McMaster in the year 2000. He is a prominent mathematical analyst, whose interests include partial differential equations, Hamiltonian dynamical systems, and their applications to the physical sciences. His contributions have been to theoretical aspects of these fields, as well as their applications to fundamental problems in physics; these include small divisor problems in Hamiltonian partial differential equations, microlocal propagation of singularities for the Schrodinger equation, advances in the mathematical theory of water waves and their modeling, and progress on the important issue of regularity for solutions of the Navier - Stokes equations. He has authored more than 100 research articles. He has organized several thematic programs at the Fields Institute, and has been a regular visiting member since his move to Canada. He served on the Fields Institute Scientific Advisory Panel (2000-2005), the Scientific Nominating Committee (2001-2005) and the Board of Directors (2009-2012). He has been awarded a Bantrell, a Sloan and a Killam Research Fellowships, and was elected as a Fellow of the Royal Society of Canada, of the AAAS and AMS, as well as a Fields Institute Fellow.



**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. .



**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 his 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.



**Paul Muir** - Professor, Department of Mathematics and Computing Science, Saint Mary's University. He received his Ph.D. from the University of Toronto in 1984 in Computer Science (Numerical Analysis). Dr. Muir's research is in the general area of numerical analysis; his specialties include the numerical solution of ordinary differential equations, with emphasis on boundary value ordinary differential equations and Runge-Kutta methods, and the adaptive method-of-lines solution of partial differential equations with collocation methods.



**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.

awaiting  
image

**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.

awaiting  
image

**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.



**Yuri Bahturin** - University Research Professor at the Department of Mathematics and Statistics, Memorial University of Newfoundland, Coordinator of the Atlantic Algebra Centre, and Chair of Higher Algebra at the faculty of Mechanics and Mathematics, Moscow State University. His main occupation is research, supervising and teaching in algebra. He has published more than 100 books and papers, supervised 15 PhDs and more than 20 MSc students.



**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.



**Chen Greif** - is a professor of computer science at the University of British Columbia, where he holds a faculty position since 2002. He received B.Sc. and M.Sc. degrees in applied mathematics from Tel Aviv University, and obtained his PhD (applied mathematics) from UBC in 1998. Before joining UBC as a faculty member he was a postdoctoral fellow at Stanford University (1998-2000) and a Senior Software Engineer at Parametric Technology Corporation (2000-2002). He is an Associate Editor with the SIAM Journal on Scientific Computing, and the Program Director of the SIAM Activity Group on Linear Algebra. His main area of interest is scientific computing, and in particular numerical linear algebra.



**Javad Mashreghi** - is a Professor of Mathematics at Laval University. He obtained his bachelor degree in electrical engineering from the University of Tehran, and his Ph.D. in pure mathematics from McGill University in 2001. He has served in the board of directors of the Canadian Mathematical Society (CMS) and Centre de Recherches Mathématiques (CRM), and faculty Council of the Faculty of Science and Engineering of Laval University. He has published 4 books and his main interests are complex analysis and operator theory.



**James A. Mingo** - James A. Mingo was a student at Dalhousie University where he completed his PhD under the supervision of Peter Fillmore in 1982. He was a visiting assistant professor at Purdue University and UCLA, and a NSERC University Research Fellow at the University of Toronto. Since 1987 he has been at Queen's University and a professor there since 1997. He has served on various committees of the Canadian Mathematical Society including a term as Vice-President (Ontario) and Chair of the Finance Committee. His research interests concern operator algebras, free probability and random matrices. In particular the application of combinatorics to the study of the eigenvalue distribution of large random matrices.



**Matthias Neufang** - is a graduate of France's Université de Lille 1. He received a Mathematics PhD in 2000 from the Universität des Saarlandes for his thesis entitled "Abstract Harmonic Analysis and Module Homomorphisms on von Neumann Algebras". He has taught at the University of Alberta and Carleton University. His principal work involves functional analysis and harmonic analysis,

investigating the links between abstract harmonic analysis and Banach and operator algebra theory. He is the author of over fifty research papers and has organized numerous research conferences and special sessions. Neufang served as Interim Deputy Director of the Fields Institute from January to June 2009. He also served as Director of the Ottawa-Carleton Institute of Mathematics and Statistics, and Associate Dean of the Faculty of Graduate Studies and Research at Carleton University. His service to the profession include the positions of member of the Board of Directors of the Canadian Mathematical Society, as well as chair of the Natural Sciences and Engineering Research Council Pure Mathematics Grant Selection Committee.



**Michael A. Newton** - Professor at the University of Wisconsin Madison, in the Departments of Statistics and of Biostatistics and Medical Informatics, where he has worked since completing his PhD in Statistics at the University of Washington in 1991. He earned his undergraduate degree in Mathematics and Statistics from Dalhousie University in 1986. Dr. Newton's research concerns the use of statistics in the biological sciences, especially inference problems in genomics and cancer biology. His service includes a term on the genome study section of the US National Institutes of Health, and a term as biological sciences editor of the *Annals of Applied Statistics*.



**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.



**Hugh Thomas** - University of New Brunswick. Associate Professor in the Department of Mathematics and Statistics at the University of New Brunswick. He received his Ph.D. in Mathematics from the University of Chicago in 2000. His research interests are in algebraic combinatorics, representation theory, and algebraic geometry. He presently serves on the board of the Canadian Mathematical Society.



**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 Virginia 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.



**Juncheng Wei** - Chair Professor at the Department of Mathematics, Chinese University of Hong Kong. He received his PhD from University of Minnesota in 1994. After one year postdoc at SISSA, he moved to Chinese University of Hong Kong. He was the recipient of Croucher Senior Fellowship (2005) and Morningside Silver Medal (2010). He is included in ISI Highly Cited (2010). His main research interests are Nonlinear Partial Differential Equations, Concentration Phenomena and Blow Ups, and Mathematical Biology.



**Xingfu Zou** - Professor of applied mathematics at the University of Western Ontario. He received his Ph. D from York University in 1997. Before joining UWO in January 2004, he pursued postdoctoral studies at the University of Victoria (Jan. 1997-July 1998) and Georgia Institute of Technology (July-Dec 1998), and was a faculty at Memorial University of Newfoundland (Jan 1999-Dec. 2005). His research interests are in applied dynamical systems including theories of ODEs, PDEs and FDEs and applications to various problems arising from biology and other fields.

Penny Haxell (Waterloo) and Peter Russell (McGill) were also members of the Scientific Review Panel whose term ended in 2014.

## ***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 in 2013 is paid for in 2014 then it will show up in the 2014 accounts.



# Income and Expenditure Account 2014

<b><u>Income</u></b> <sup>1</sup>	\$	\$	<u>2013</u>
Carried forward from previous year		61,775	100,970
Mathematical Institutes		105,000	75,000
Universities		92,000	82,000
Provinces		185,000	100,000
Other Revenue (1)		<u>2,340</u>	<u>141</u>
<b>Total Income</b>		<b>446,115</b>	<b>358,111</b>
<b><u>Expenditure</u></b>			
Summer School			
Instructors (2)	39,120		40,664
Students (3)	43,151		26,060
Other (4)	<u>277</u>		<u>3,357</u>
	82,548	<b>82,548</b>	<u>70,081</u>
Workshops and Events (5)		55,589	35,853
Outreach (5)		11,388	7,179
PDF Program (6)		35,000	101,780
Collaborative Research Groups (7)		24,000	36,000
Distinguished Lecturers		1,075	7,246
Book Series		0	0
Administrator Salary		29,327	29,250
AARMS Online system		394	5,395
Travel		0	2,302
Office Expenses		2,920	1,249
Dalhousie Overheads		<u>13,000</u>	<u>0</u>
<b>Total Expenditure</b>		<b>255,240</b>	<b>296,336</b>
<b>Surplus: Income Less Expenditure</b>		<b>190,875</b>	<b>61,775</b>

## Notes

- |   |   |
|---|---|
| <ol style="list-style-type: none"> <li>1. For a breakdown see Appendix 1</li> <li>2. Travel, Accommodation and stipends of \$5,000 each</li> <li>3. Residence and Meals</li> <li>4. Texts and course materials, promotion, secretarial, computing, hospitality</li> </ol> | <ol style="list-style-type: none"> <li>5. See Appendix 2</li> <li>6. See Appendix 3</li> <li>7. See Appendix 4</li> </ol> |
|---|---|



## Balance Sheet

31-12-2014

### **Assets**

	\$	\$
Surplus from Operations (Income less expenditure)		190,875
Accounts Receivable <sup>1</sup>		
CRM	30,000	
Fields	30,000	
PIMS	45,000	
Acadia	5,000	
Cape Breton	2,000	
Dalhousie	30,000	
Memorial	30,000	
Moncton	1,000	
Mount Allison	1,000	
Saint Francis Xavier	1,000	
Saint Mary's	1,000	
UNB	60,000	
UPEI	1,000	
Province of Nova Scotia	85,000	
Province of New Brunswick	50,000	
Province of Newfoundland	60,000	
	<hr/>	432,000
<b>Total Assets</b>		<b>622,875</b>

### **Liabilities**

Accounts Payable <sup>2</sup>		
Summer School	102,782	
Postdoctoral Fellowships	66,971	
Scientific Activities <sup>3</sup>	60,750	
Outreach	11,450	
Collaborative Research Groups	48,000	
AARMS Book Series	1,000	
Administrator Salary <sup>4</sup>	31,000	
online development	7,000	
AARMS Poster	1,000	
Travel and Office expenses	4,000	
	<hr/>	333,953
Unallocated funds - for AARMS activities		288,921
<b>Total Liabilities</b>		<b>622,875</b>

### **Notes**

1. Fees due to be collected in 2015
2. Funding Commitments in 2015
3. Workshops, Conferences, Meetings



# Annual Accounts 2014

## Appendix 1

### *Revenue Breakdown*

Provinces			
	New Brunswick	50,000	
	Nova Scotia	135,000	
			<b>185,000</b>
Mathematical Institutes			
	CRM	45,000	
	Fields	30,000	
	PIMS	30,000	
			<b>105,000</b>
Universities			
	Acadia	5,000	
	Cape Breton	1,000	
	Dalhousie	35,000	
	Memorial	30,000	
	Moncton	1,000	
	Mount Allison	1,000	
	Mount Saint Vincent	1,000	
	Saint Francis Xavier	1,000	
	Saint Mary's	1,000	
	UNB	15,000	
	UPEI	1,000	
			<b>92,000</b>
Other Revenue			
	book royalties	2,340	
			<b>2,340</b>
			<hr/>
	<b>total</b>		<b>384,340</b>



## Annual Accounts 2014

### Appendix 2

#### *Workshops and Scientific Events*

CMS poster session prize	3,000
CanADAM2013	6,000
Science Atlantic and Games&Graphs	6,500
Atlantic Algebra Centre Prizes	1,000
Foundational Methods in CS	3,500
2013 Math Biology Workshop	5,133
Combinatorial Algebra meets Algebraic Combinatorics	2,500
Software Bootcamp	2,350
Enveloping Algebras	7,500
Branch Groups, Theory and Practice	2,000
Sustainability of Aquatic Systems Networks	9,607
Atlantic General Relativity	2,500
Atlantic Math/Stats/CS Conference	4,000
	<hr/>
<b>total</b>	<b>55,589</b>

#### *Outreach*

John McLoughlin – NB Outreach program	2,000
Outreach Strategy meeting	988
Math Circles	2,500
UPEI Math Camp	1,000
STFX Math Camp	1,000
Blundon Seminar Camp	2,000
Math Circles and Math League at Acadia	1,900
	<hr/>
	<b>11,388</b>



## Annual Accounts 2014

### Appendix 3

#### *Postdoctoral Fellowships*

Douglas Stones	17,500
Justin Tzou	8,750
Jonathan Ziprick	8,750

**total** **35,000**

### Appendix 4

#### *Collaborative Research Groups*

Graphs and Games	12,000
Statistical Modelling of Complexly Correlated Data with Applications	12,000

**total** **24,000**