AARMS

Atlantic Association for Research in the Mathematical Sciences

2022-23 Annual Report

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2022/23 Annual Report

1 Director's Message

The 2022-23 year has been successful for AARMS, with our core programs functioning smoothly and our newer programs maturing nicely. We are currently in the second year of our five year grant from NSERC, and are enjoying the stable federal funding environment. Throughout this document you can find an accounting of most of the Institute's activities in the 2022-23 fiscal year. Below, I give a few personal highlights and some details of current and future activities.

In the 2022 postdoctoral competition we awarded four new fellowships with the goal of maintaining a steady state of roughly eight AARMS postdocs at any given time. You can read more about the current and incoming AARMS postdocs in section 3.2 below. The five Collaborative Research Groups (CRGs) active in 2022-23 have all come to an end in September 2023. We held a competition for new CRGs earlier in the year and are pleased to announce three new collaborations, starting in September 2023:

- Advances in Statistical Modeling of Fisheries Data (2023-2025)
  Administered by Asokan Mulayath Variyath (MUN)
- Applications of Commutative Algebra (2023-2025)
  Administered by Sara Faridi (Dalhousie)
- Games & Graph Searching in Atlantic Canada (2023-2025)
  Administered by Danielle Cox (MSVU)

Two of our highly-qualified personnel training programs have recently made their return. After several years, the AARMS Summer School returned in 2023. It was organized by Amy Hurford at Memorial University and focussed on the mathematical modeling of infectious diseases. This year's school received significant support from several of NSERC's Emerging Infectious Disease Modelling (EIDM) networks. We look forward to providing a complete report on the school in a future Annual Report. Another returning initiative is the AARMS Advanced Course program. This program was initiated during COVID in order to allow Atlantic Universities to share online graduate and advanced undergraduate courses. Post-pandemic, it was unclear what the appetite would be for continuing these courses given the return to in-person activities, so the program did not run in the 2022-23 academic year. However, it is now apparent that there is a significant

interest from both instructors and students for this kind of activity, and I am pleased to say that several AARMS Advanced Courses will be offered in Winter 2024. I would like to thank a former Director and Board Chair of AARMS, Jeannette Janssen, for all of her efforts to bring this program back.

Several recent new initiatives of AARMS are particularly noteworthy: For example, our new Junior Researcher Travel Support program has had a very successful first year of operation. The community has responded enthusiastically, and the first year of funding has been fully utilized. Following on from an external review of our equity, diversity and inclusion (EDI) practices, AARMS now has a standing EDI committee tasked with the careful and deliberate assessment and improvement of all the institute's activities utilizing an EDI lens. Finally, AARMS has entered into a new long term collaboration with CRM and PIMS to sponsor a special session at the Joint Mathematics Meetings, perhaps the largest annual meeting in the mathematical sciences. The first of these sessions will be in January 2024.

Lastly, I will mention one more activity that occurred just after the formal reporting period of this document: the 2023 Bridges Conference on Mathematics and Art. This was organized by AARMS in July 2023 at Dalhousie. The conference was a huge success with record high attendance for this series. There were several excellent public events including a lecture by Craig Kaplan on the recent discovery of aperiodic monotiles and a Math + Art family day at the Halifax Public Library. The cover of this year's annual report features a work of art from the conference's exhibition. A full report on the conference will appear in next year's annual report.

In conclusion, I would like to express my appreciation to the AARMS Executive, AARMS Board, AARMS Scientific Review Panel, and wider Atlantic mathematical sciences community for their sustained efforts in driving all of our programs and initiatives. AARMS is grateful for the continued support of a number of organizations, including AARMS's member universities. Special recognition is due to David Langstroth for expert administrative efforts and his chairing of AARMS's new committee on Equity, Diversity and Inclusion. I would also like to thank PIMS, Fields, CRM, BIRS and CANSSI for their ongoing and valued collaboration. Finally, I would like to thank NSERC for their strong support for the mathematical sciences in Atlantic Canada.

Sanjeev Seahra
AARMS Director
October 2023

2 Report on Funding

The year was uneventful in terms of funding issues. We received the first installment of our 5-year NSERC Discovery Institutes Support Grant.

3 Report on Activities

3.1 AARMS Collaborative Research Groups (CRGs) Program

AARMS supported 5 Collaborative Research Groups in the 2022/23 academic year. Highlights from the reports from these groups are included below.

3.1.1 Developing General Dynamic Modelling Systems & Spatiotemporal Models for Omics Data

3.1.1.1 Members

Academic Administrator: Hong Gu, Mathematics & Statistics, Dalhousie University

Other Researchers from AARMS Member Universities:

- Joe Bielawski Biology, Dalhousie University
- Zoe Finkel Oceanography, Dalhousie University
- Graham Gagnon Architecture and planning, Dalhousie University
- Andrew Irwin Mathematics & Statistics, Dalhousie University
- Toby Kenney Mathematics & Statistics, Dalhousie University
- Janice Lawrence Biology, UNB
- Adrian Reyes-Prieto Biology, UNB
- Nanwei Wang Mathematics & Statistics, UNB

Other CRG Members:

- Jesse Shapiro Microbial Evolutionary Genomics, McGill University
- David Walsh Microbial Ecology and Genomics, Concordia University
- Ximing Xu Mathematics & Statistics, Nankai University, China

3.1.1.2 Activities

Collaborative research in developing methodologies to deal with omics data and study of the dynamic models has been continued in the second year of the funding period. There are several different topics being developed with different PhD students and supervisors involved. Paul Bjorndahl (PhD candidate, co-supervised by Joe Bielawski, Graham Gagnon and Hong Gu) Paul has led the following projects:

- Community Assembly and Interactions of Complex Heterotroph-Phototroph Microbial Co-existence during the Spring Bloom in the Gulf of Aqaba, Red Sea. A manuscript is under revision. It includes a comparison of NMF, BioMiCo, and STM for inferring subcommunity structure as well as ecological interpretation of subcommunity dynamics from the NMF 'basis features' with respect to cyano blooms. Manuscript to be submitted.
- Comparing Prediction of CyanoHABs from Microbiome Feature Extraction and Selection in Freshwater Lakes. This is based on the ATRAAP data collected and processed by Shapiro's group (McGill Univ.). These data include a large time series of microbiome and toxicity samples collected daily from a number of key locations in Quebec. The testing for comparing prediction of microcystin toxin using different statistical methods (PPCA, NMF, and SuRF) developed by our own research group has been finished.
- Beyond bar charts: A water researcher's guide to microbial community investigation and water quality interpretation. A review paper surveying all our groups work and methods is being written up.
- Exploring decadal changes of natural organic matter quality in a browning drinking water supply using a novel long-term fluorescence dataset. This is a project using multi-source data analysis methods to analyze drinking water fluorescent spectroscopy data and genomics data. This involves some methodology development for joint analysis of ultra high dimensional data from different sources.
- Sarah Organ (PhD candidate, co-supervised by Amina Stoddart, Joe Bielawski and Hong Gu). Sarah's research has focused on the study of microbiome communities and their important roles in the wastewater treatment process. We have proposed novel applications of statistical methods, through an integrative analysis of wastewater microbial communities using Poisson measurement error corrected PCA (PPCA) and Generalized Common Factors, for studying the microbiome of a municipal wastewater plant as a whole and at separate subsets of the different treatment stages of the plant in wastewater treatment. Our study of the Timberlea wastewater treatment plant showed significant evidence of a difference in the microbiome communities corresponding to the treatment process stages. In addition, we were able to identify that across the treatment stages, there are common factors influencing the separation of ammonia. Manuscript to be submitted.
- Shanglun Li (PhD candidate, co-supervised by Toby Kenney and Hong Gu). Shanglun has been researching the application of OU models with measurement error for modelling Microbiome dynamics. He has studied the one-dimensional case, and has written a first draft of a paper that applies the models to microbiome data, yielding important insights into the dynamics of microbial communities. In the coming year, he will extend this to a multidimensional case where multiple microbes follow the same dynamics and there are dynamics on multiple time scales. Manuscript to be submitted.

- Shangming Yang (PhD candidate, co-supervised by Toby Kenney and Hong Gu). Shangming has been researching methods for fitting non-linear stochastic differential equations to microbiome data. While linear SDEs like the OU process can give us insights into the dynamics of microbial communities, they are too simple to reflect the complicated dynamics of the real communities. However, when we study non-linear SDEs, the likelihood of observed data no longer has a closed form, making it impossible to estimate parameters exactly. There are a number of approximate methods that can be used, but developing a method that works well enough for microbiome data with irregular sampling and relatively small datasets will be a serious challenge. He has reviewed a number of state-of-the-art methods which will be compared before deciding on the most promising approach for further development.
- Xinyue Zhang (PhD candidate, co-supervised by Toby Kenney and Hong Gu, in collaboration with Andrew Irwin). Xinyue has developed a non-parametric model-based spatial clustering method for spatial data and applied it to satellite measurements of ocean data. One paper draft has been written and is being revised for submission. The spatial patterns developed by this method can be further incorporated into spatio-temporal dynamic models for omics data. Manuscript to be submitted.

3.1.2 Graph Searching in Atlantic Canada

3.1.2.1 Members

Academic Administrator: Danielle Cox (Mount Saint Vincent University)

Steering Committee Members

- Nancy Clarke: Acadia University
- Danielle Cox: Mount Saint Vincent University
- Danny Dyer: Memorial University of Newfoundland
- Art Finbow: Saint Mary's University
- Stephen Finbow: St. Francis Xavier University
- Shannon Fitzpatrick (Chair of committee): University of Prince Edward Island
- Jared Howell: Memorial University Of Newfoundland, Grenfell Campus
- Melissa Huggan, Vancouver Island University, Nanaimo, BC
- Margaret-Ellen Messinger: Mount Allison University

National Collaborators

- David Pike, Memorial University of Newfoundland, NL
- Rebecca Milley, Memorial University of Newfoundland Grenfell Campus, NL
- Art Finbow & Dr. Bert Hartnell, Saint Mary's University˜, NS
- Richard Nowakowski & Dr. Jeannette Janssen, Dalhousie University˜, NS

- Andrea Burgess, University of New Brunswick Saint John˜, NB
- Geňa Hahn & Dr. Ben Seamone, Université de Montréal, QC
- Paweł Prałat & Dr. Anthony Bonato, Toronto Metropolitan University, ON
- Karen Gunderson, University of Manitoba, MB
- Boting Yang, University of Saskatchewan, SK
- Bojan Mohar & Dr. Ladislav Stacho, Simon Fraser University, BC
- Gary MacGillivray, University of Victoria, BC

International Collaborators

- Dariusz Dereniowski, Gdańsk University of Technology, Gdańsk, Poland
- Christopher Duffy, University of Melbourne, Melbourne, Australia
- Jessica Enright, University of Glasgow, Glasgow, Scotland
- Bill Kinnersley, University of Rhode Island, South Kingstown, USA
- Kerry Ojakian, The City University of New York, New York, USA
- Öznur Yaşar Diner, Kadir Has University, Istanbul, Turkey

3.1.2.2 Activities

Winter GSAC research meeting
This event took place on Friday, January 28, 2023, via Zoom. Our speakers were Dr. Kerry Ojakian (City University of New York), who spoke on Two-Color Percolation; Dr. Mohamed Omar (Harvey Mudd College), who spoke on a Counterexample to the Burning Number Conjecture; Dr. Andrea Burgess (University of New Brunswick, Saint John˜), who spoke on the Deduction Number; Dr. Paweł Prałat (Toronto Metropolitan University), who spoke on the Semi-random Process. We had 22 attendees from across Canada and the globe. The attendees ranged from well established researchers to graduate students and postdoctoral fellows of GSAC members. The workshop consisted of four 20-minute talks highlighting open problems in different areas of graph searching. There were then breakout groups related to each topic. These breakout groups resulted in ongoing collaborations between GSAC members and will result in the publication of peer-reviewed journal articles.

Introduction to Research in Graph Searching Student Workshop
Dr. Todd Mullen of the University of Prince Edward Island led the student workshop hosted by GSAC. The workshop took place on May 9, 2023, at Acadia University. Eight students participated: five undergraduate students and three graduate students.

East Coast Combinatorics Conference (ECCC)

The ECCC was co-organized by Dr. Nancy Clarke and Dr. Iain Beaton of Acadia University. The conference itself was held entirely in-person with 24 attendees. Of the attendees, there were five undergraduate students, four graduate students and two postdocs. Moreover, 21 of the attendees were from Atlantic Canada, and three were from other regions of Canada. Speakers included Danny Dyer (Memorial University of Newfoundland), An introduction to cat herding; Jared Howell (Memorial University of Newfoundland, Grenfell Campus), The watchman's walk on Cayley graphs; Jeanette Janssen (Dalhousie University), Graph signal processing using a graphon Model; Peter Collier (Dalhousie University), Zero forcing; William Kellough (Memorial University of Newfoundland), An adversarial graph burning model; John Marcoux (Toronto Metropolitan University), Distance-restricted firefighting on finite graphs; Dylan Pearson (Mount Allison University), Modelling virus containment with self Disseminating.

Canadian Mathematical Society Combined Games Session
Melissa Huggan and Rebecca Milley were two of the co-organizers of this session, held at the Summer 2023 CMS meeting in Ottawa, Ontario. The session highlighted research in both combinatorial game theory and pursuit-evasion games in graph theory. The session had 14 speakers, of which five were students. There were approximately 25 people in attendance. Several GSAC members and their students participated, including Melissa Huggan (Vancouver Island University), The damage number of the product of graphs; Danny Dyer (Memorial University of Newfoundland), The cheating robot on graph products; Anthony Bonato (Toronto Metropolitan University), The Localization Game; Rebecca Milley (Memorial University of Newfoundland - Grenfell Campus), Progress on misere dicots; Dylan Pearson (Mount Allison University), Slow Localization; Rylo Ashmore (Memorial University of Newfoundland), Herding cats stuck in trees.

CanaDAM Pursuit-Evasion Games on Graphs Session
The 2023 CanaDAM Conference was held June 5-8, 2023, in Winnipeg, Manitoba. The session on Pursuit Evasion Graphs was organized by JD Nir (PostDoc), Brittany Pittman (PhD student), and Trent Marbach (PostDoc), all of Toronto Metropolitan University. (All of whom are supervised by Dr. Anthony Bonato.) A number of GSAC members and their students spoke in the session, including Stephen Finbow (St Francis Xavier University), Hyperopic cops and robber; Jared Howell (Memorial University of Newfoundland, Grenfell Campus), The watchman's walk problem on Cayley graphs; Andrea Burgess (University of New Brunswick), Firefighting with a distance-based restriction; Kerry Ojakian (Bronx Community (CUNY)), A variety of graph surrounding games; John Marcoux (Toronto Metropolitan University), k-Visibility localization; Michael Molnar (Toronto Metropolitan University), The one-visibility Localization game; William Kellough (Memorial University of Newfoundland), A two player graph burning Game; Caleb Jones (Memorial University of Newfoundland), Extending graph burning to hypergraphs; Rylo Ashmore (Memorial University of Newfoundlandˇ), Herding cats stuck in trees.; Virgélot Virgile (University of Victoria), Complexity of Eternal Domination.

Graph Searching in America (GRASAm) Workshop
The Graph Searching in America (GRASAm) workshop was held Aug 3-4, 2023, at the CUNY Graduate Center in New York City. This was the 11th workshop in the Graph Searching series and was attended by faculty and students from across Canada and the United States. The workshop was co-organized by Dr. Kerry Ojakian. Speakers included Anthony Bonato (Toronto Metropolitan University), Progress on Pursuit-Evasion Games on Graphs (plenary talk); Danny Dyer (Memorial University of Newfoundland), An introduction to cat herding. Jessica Enright (University of Glasgow), Multilayer cops-and-robbers; John Marcoux (Toronto Metropolitan University), k-Visibility Localization (Part 1); Trent Marbach (Toronto Metropolitan University), k-Visibility Localization (Part 2); Niko Townsend (University of Rhode Island), High-Speed Cops and Robbers. Other GSAC members in attendance were Margaret-Ellen Messinger, Nancy Clarke, and Bill Kinnersley.

Atlantic Graph Theory Seminar
The Atlantic Graph Theory Seminar was organized by Dr. Jeanette Janssen and was held regularly between November 2022 and March 2023. Ten seminars were delivered using a hybrid format of in-person and Zoom. Talks were given by national and international researchers, including both faculty and graduate students.

Teaching Seminars
On June 21, 2023, an online teaching workshop, The 4th Annual Calculus Instruction in Atlantic Canada Workshop, took place online via Zoom. This workshop is aimed at university and high school educators teaching upper-level mathematics. The workshop was co-organized by Danielle Cox. There were 52 registered participants, of which 23 were high school teachers and the remaining were university instructors. It was a successful workshop and well-received by participants. On August 31, 2023, an online workshop, Best Practices in Teaching Introductory Discrete Mathematics, will be held. The workshop was organized by Dr. Shannon Fitzpatrick and will take place via Zoom. The workshop will provide a forum for instructors to discuss curriculum, student engagement and assessment practices.

Outreach
Dr. Danielle Cox presented for Nova Scotia Math Circles and co-organized the MSVU Science Circles program. She also visited five Humber Park Elementary School classrooms for math enrichment activities.

3.1.3 Groups, Rings, Lie and Hopf Algebras

3.1.3.1 Members

Academic Administrator: Mikhail Kotchetov
Collaborators from AARMS member universities:

- Yuri Bakhturin (Memorial University, St. John's)
- Tom Baird (Memorial University, St. John's)
- John Irving (Saint Mary's University, Halifax)
- Yorck Sommerhäuser (Memorial University, St. John's)
- Eduardo Martinez-Pedroza (Memorial University, St. John's)
- Mitja Mastnak (Saint Mary's University, Halifax)
- Braham Rangipour (University of New Brunswick, Fredericton)
- Peter Selinger (Dalhousie University, Halifax)
- Roman Smirnov (Dalhousie University, Halifax)
- Nicholas Touikan (University of New Brunswick, Fredericton)
- Yiqiang Zhou (Memorial University, St. John's)

Collaborators from other institutions:

- Nicholás Andruskiewitsch (University Nacional de Córdoba)
- Georgia Benkart (University of Wisconsin, Madison)
- Alberto Elduque (University of Zaragoza)
- Jörg Feldvoss (University of South Alabama, Mobile)
- Terry Gannon (University of Alberta, Edmonton)
- Yevgenia Kashina (DePaul University, Chicago)
- Simon Lentner (university of Hamburg)
- Susan Montgomery (University of Southern California, Los Angeles)
- Alexander Olshanskiy (Venderbilt University, Nashville)
- Alexander Premet (University of Manchester)
- Christoph Schweigert (University of Hamburg)
- Kirill Zainoulline (University of Ottawa)

3.1.3.2 Activities

The first activity organized by the CRG in this period was the **mini course Polynomial Identities, Representation Theory and Growth Functions**, by Antonio Giambruno from the University of Palermo, Italy. From September 19 to 23, 2022, Professor Giambruno delivered 3 lectures at Memorial University, presenting a combinatorial approach to the study of the polynomial identities satisfied by an algebra (in characteristic zero) through the use of the representation theory of the symmetric or general linear groups. These lectures were attended in person by local faculty and graduate students and were also broadcast via Webex. More details are available at https://www.mun.ca/aac/mini-courses-2016--/antonio-giambruno/

The second **mini course Group Graded Azumaya Algebras and Generic Constructions**, by Eli Aljadeff from Technion University, Israel, was delivered at Memorial University from February 17 to 22, 2023, and broadcast via Webex. The first lecture motivated the study of group gradings on algebras by recalling some classical topics such as division algebras, Brauer groups, crossed products and Galois cohomology. In the second and third lectures, graded polynomial identities were used to construct generic graded algebras, which were then applied to the problem of existence of a graded division form for a given finitedimensional graded simple algebra. More details can be found at https://www.mun.ca/aac/mini-courses-2016--/eli-aljadeff/

The third **mini course Automorphisms and Derivations in Affine Algebraic Geometry** took place at Memorial University from March 13 to 17, 2023, and was also broadcast via Webex. It was delivered by Leonid Makar-Limanov from Wayne University, USA, and consisted of 3 lectures, presenting new and simplified proofs (using modern tools such as locally nilpotent derivations) of several classical theorems in affine algebraic geometry. More information and course notes are available at https://www.mun.ca/aac/mini-courses-2016--/leonid-makar-limanov/

At the **CMS Summer Meeting in Ottawa** (2-5 June 2023), members of the CRG co-organized 4 sessions: Group Symmetries and Equivariance in Algebra, Descent, Geometry, and Topology (Dorette Pronk), Hopf Algebras and Related Topics (Yevgenia Kashina, Mitja Mastnak, Mikhail Kotchetov and Yorck Sommerhäuser), Equivariant Schubert calculus and beyond and Quadratic forms and Linear algebraic groups (Kirill Zaynullin).

Our final activity of the academic year 2022-23 was the **international workshop Groups, Rings, Lie and Hopf Algebras. V**, from August 21 to 25, 2023. Our original plan was to organize a meeting at the Bonne Bay Marine Station of Memorial University, but it was not available this year, so we changed the venue to the Harlow campus of Memorial University, located in Harlow, UK. On the one hand, this workshop was a follow-up to the previous workshop with the same title, which was held in June 2022 at the St. John's campus of Memorial University, and indeed some of the participants of that workshop now reported their progress since last year. On the other hand, we had quite a few new participants, especially from European universities, due to the low cost of travel to Harlow from many locations in Europe. The organizers (Yuri Bahturin, Mikhail Kochetov, Alexander Premet, and Kirill Zaynullin) expect that this interaction of researchers from Canada and Europe will have a positive impact on their future work thanks to the exchange of new ideas, directions and techniques. The workshop ran for five days (Monday – Friday, with Wednesday afternoon reserved for excursions and informal discussions) and attracted 38 participants from 11 countries (Belgium, Canada, Germany, Israel, Italy, Jordan, Romania, Spain, Sweden, UK, and USA). There were 13 participants from Canada, 8 of which were from Atlantic Canada. The total number of students and postdoctoral fellows was 9. In total, 32 talks were presented (19 research lectures and 13 shorter communications), six by students and postdoctoral

fellows. Three speakers at the workshop were women, even though the organizers reached out to many more. This is the same number as last year, so we may need to adopt new strategies to increase diversity if we organize similar events in the future. More details about the workshop are available at https://www.mun.ca/aac/workshops/future-and-recent-workshops/

3.1.4 Mathematical Foundations and Applications of Scientific Machine Learning

3.1.4.1 Members

Academic Administrator: Alex Bihlo
Collaborators from AARMS member universities

- Jahrul Alam (Mathematics and Statistics, Memorial University)
- Alex Bihlo (Mathematics and Statistics, Memorial University) Academic coordinator
- Stijn De Baerdemacker (Chemistry, University of New Brunswick)
- Ronald Haynes (Mathematics and Statistics, Memorial University)
- Viqar Husain (Mathematics and Statistics, University of New Brunswick)
- Theodore Kolokolnikov (Mathematics and Statistics, Dalhousie University)
- Peter Lelievre (Mathematics and Computer Science, Mount Allison University)
- JC Loredo-Osti (Mathematics and Statistics, Memorial University)
- Scott MacLachlan (Mathematics and Statistics, Memorial University)
- Dr. Alison Malcolm (Earth Sciences, Memorial University) Equity, Diversity & Inclusion coordinator
- Paul Muir (Mathematics and Computing Science, St. Mary's University)
- Jeffrey Picka (Mathematics and Statistics, University of New Brunswick)
- Jiju Poovvancheri (Mathematics and Computing Science, St.\ Mary's University)
- Nicholas Touikan (Mathematics and Statistics, University of New Brunswick)
- Hamid Usefi (Mathematics and Statistics, Memorial University)
- Asokan Variyath (Mathematics and Statistics, Memorial University)
- Nanwei Wang (Mathematics and Statistics, University of New Brunswick)

Collaborators from other institutions

- Leopold Haimberger (Meteorology and Geophysics, University of Vienna)
- Luke Olson (Computer Science, University of Illinois)
- Roman O. Popovych (Mathematics, University of Vienna)
- Francis Valiquette (Mathematics, Monmouth University)
- Andy Wan (Mathematics and Statistics, University of Northern British Columbia)
- Justin Wan (Computer Science, University of Waterloo)
- Matt West (Mechanical Science and Engineering, University of Illinois)

3.1.4.2 Activities

CRG workshop at University of New Brunswick. The 2nd workshop of the CRG was held on Mon Jul 31 & Tue Aug 01 on the Fredericton Campus of the University of New Brunswick in a hybrid format in which remote participants could join in and contribute via MSTeams. The local organizing committee consisted of Dr. Viqar Husain, Dr. Nicholas Touikan, and Dr. Stijn De Baerdemacker. The program consisted of four blocks (Mon/Tue AM/PM), each with a different theme.

- Mon AM: Physics-inspired machine learning models.
- Mon PM: Scientific machine learning in industry, including a panel discussion with industry partners on best practices for educators and graduates to pursue successful careers as machine learner in industry.
- Tue AM: Scientific machine learning models in chemistry.
- Tue PM: General topics in scientific machine learning.

A call was given by the local organizers to the CRG to suggest for invited speakers, after which the following speakers accepted our invitation: from academia Dr. Paul Cook (UNB), Dr. Jon Sensinger (UNB), Dr. Augusto Gerolin (uOttawa), Dr. Rodrigo Vargas-Hernandez (MacMaster), and Dr. Moulay Akhloufi (UdeM); from industry Colin West (BlueSky data), and Max Hennick (TrojAI). Dr. Lena Simini (McGill) declined our invitation. Partners in the CRG were encouraged to present their work, with an emphasis on ECR. There were 27 in-person participants, of which 14 gave presentations (7 invited), and 21 participants joined in remotely. All presentations were recorded. All presentations were of high scientific quality, particularly those from ECR in the network. The presentations were scheduled on a 50+10 min (25+5 min) format, allowing for plenty of time for discussion between, which was well used. The large coffee and lunch breaks allowed for plenty of networking opportunities between the partners

Short-term scientific visits.

A total of three short-term scientific visits were carried out in the course of the second year of this CRG, in particular:

1. Alex Bihlo (Memorial University) and Francis Valiquette (Monmouth University) met at McGill University (June 5, 2023)
2. Alex Bihlo (Memorial University) visited Stijn De Baerdemacker at University of New Brunswick (June 12–13, 2023)
3. Alex Bihlo (Memorial University) visited Peter Lelievre at Mount Allison University (June 14, 2023).
4. Peter Lelievre and his postdoc Saeed Vatankhah (Mount Alison University) visited Alex Bihlo, Ron Haynes, JC Loredo-Osti Scott MacLachlan at Memorial University (June 26–30, 2023).

All these research visits provided ample time to discuss current and potential new collaborative projects, and new ideas for teaching of concepts of scientific machine learning. Alex Bihlo and Saeed Vatankhah have also given presentations at University of New Brunswick and Memorial University, respectively.

Student support. A key component of this CRG was student support, through which the collaboration among CRG members should be fostered.

3.1.5 Numerical Solution of Geophysical Inverse Problems

3.1.5.1 Members

Academic Administrator: Peter Lelièvre, Mount Allison University
Collaborating faculty from AARMS Member Universities

- Alex Bihlo (MUN)
- Karl Butler (UNB)
- Colin Farquharson (MUN)
- Ronald Haynes (MUN)
- Nathan Johnston (MtA)
- Peter Lelievre (MtA) `
- Scott MacLachlan (MUN)
- Dr. Alison Malcolm (MUN)

Collaborating faculty and research staff from other universities:

- Andrew Binley (Lancaster)
- Nathan Church (NTNU)
- Karl Fabian (NTNU)
- Suzanne McEnroe (NTNU)
- Rosemarie Renaut (Arizona State University)
- Florian Wagner (RWTH Aachen University)
- Shunguo Wang (NTNU)
- Florian Wellmann (RWTH Aachen University)

3.1.5.2 Activities

HQP Support and Supervision

Several students and PDFs were co-supervised by CRG participants over the second year:

- Jianbo Long worked on the surface geometry inverse problem. Long transitioned as a PDF between CRG universities, from MtA to NTNU. Our activities in year two, particularly

the scientific visit to NTNU, has encouraged further connection between CRG participants at MUN, MtA and NTNU.

- Xushan Lu, PDF at MtA, then MUN, now back at MtA, was officially co-supervised by Lelievre (MtA) and Farquharson (MUN). He worked on the surface geometry inverse problem, and research related to numerical modelling of electromagnetic phenomena.
- Rocelle Mendoza began her MSc study at UNB with co-supervision by CRG participants at UNB and MtA. She continues to work on the more applied side of the CRG research, applying new numerical methods to a specific geophysical problem of interest to several of the CRG participants.
- Lopsii Olagoke worked as computer programmer to directly serve the research groups of both Lelievre and Farquharson. Olagoke developed the software through which new numerical methods are researched, designed and tested.
- Saeed Vatankhah began his PDF position at MtA in November, 2023. Vatankhah has been investigating the numerical behaviour of surface-geometry inverse problems, one of the important geophysical inverse problems identified for this CRG research.

Conference Attendance. We had hoped to send Vatankhah to various conferences this year so that he could meet with other CRG participants and have him develop and continue those ties, and to allow him to take a more active role coordinating the CRG. This was challenging because of travel visa issues, but we did manage to send Vatankhah to a more local conference, one scientific visit, and other local meetings with collaborators. Lelievre attended other conferences in Vatankhah's place.

- Lelievre and Lu attended the European Geosciences Union (EGU) General Assembly in Vienna, Austria, in April 2023. Lelievre in person, Lu remotely. One presentation given by Lu, Discussions with Malcolm, Wagner and Wellmann on site. Lelievre convened two sessions, both on topics covered by this CRG:
  – Advancements in Magnetic Field Studies and Natural Resources Exploration, M. Fedi, M. Milano, P. Lelievre and S. Liu, EGU General Assembly 2023, Session EMRP2.8, April 2023, Vienna, Austria.
  – 3-D Geological Models as Scientific Tools for Joint Inversion, Uncertainty Quantification, and Machine Learn□ing, F. Wellmann, P. Lelievre, S. Devriese, C. Farquharson and C. Bond, ` EGU General Assembly 2023, Session TS8.1, April 2023, Vienna, Austria.
- Lelievre attended the (IAMG) in Trondheim, Norway, in August 2023. One presentation given.
- Lelievre and Vatankhah attended the workshop put on by the AARMS-CRG "Mathematical Foundations of Scientific Machine Learning Workshop" in July/August. One presentation given, That CRG and this one have some intersection related to geophysical methods. The two CRGs shared costs for the involvement of Lelievre and Vatankhah.

Scientific Visits

- Bihlo visited Lelievre and Vatankhah at MtA in June 2023. Bihlo was in Fredericton for the Canadian Applied and Industrial Mathematics Society (CAIMS) Annual Meeting and stopped in Sackville for the day to meet with Lelievre and Vatankhah to discuss research topics related to this CRG and that organized by Bihlo.
- Renault visited Lelievre and Vatankhah at MtA in June 2023. This week long visit included presentations and discussions on current and future directions of collaborative research between the two academic groups.
- Lelievre and Vatankhah visited Butler and Mendoza at UNB in July 2023. This involved two days of presentations and discussions on current and future directions of collaborative research between the two academic groups.
- Lelievre and Vatankhah visited Bihlo, Farquharson, Haynes at MUN in July 2023. This involved five days of presentations and discussions on current and future directions of collaborative research between the various academic groups. This visit was financially supported 50% by this CRG and 50% by that organized by Bihlo.
- Lelievre visited Church, Fabian, Lee, Long, McEnroe and Wang at NTNU in August 2023. This involved three days of presentations and discussions on current and future directions of collaborative research between the four academic research groups headed by Fabian, Lelievre, McEnroe and Wang.

Ongoing Collaborative Activities

This AARMS CRG has been critical in establishing and supporting ongoing research collaborations:

- Butler and Lelievre continue to investigate the application of various geophysical methods for imaging dams, dykes and other flood barriers. This year, as planned, we began co-supervision of MSc student Mendoza.
- Farquharson and Lelievre continue to collaborate on many geophysical numerical modelling problems related to this CRG, and to co-supervise HQP involved in this work. This year, as planned, we have began to involve other CRG participants more in this work, including Haynes and MacLachlan.
- Lelievre and McEnroe continue to investigate the application of constrained magnetic inversion of micromagnetic microscopy, and are identifying aspects of this application that relate to the specific topics of this CRG. As planned, the scientific visit to NTNU helped to continue this collaboration and we are planning to co-apply for future grants and co-supervise HQP.
- Farquharson, Gunther, Lelievre and Wagner intend to collaborate on computer science and software development aspects of this CRG. We had hoped that with Olagoke hired as a computer programmer, and with the meetings between researchers at conferences, that

the level of collaboration would increase. This has not happened as quickly as we'd like but Lelievre and Wagner met at the EGU meeting and there is still interest on all sides to collaborate in future. It may require a dedicated scientific visit in the future to move this forward.

- Farquharson and Lelievre are in the process of organizing a consortium of industry companies to further support longer-term research on numerical methods for modelling electrical and electromagnetic phenomena, which is a topic of interest to this CRG. This work will likely involve Haynes and MacLauchlan, or other mathematicians at AARMS universities. The consortium project is expected to provide positions to several HQP and bring other researchers into the fold of this CRG. Exact details and HQP/supervisors are still to be determined. We hope and expect this consortium to move forward by the close of 2023. Much of the impetus for this consortium has come from the recent work efforts of Lu and Long, both HQP in this CRG.

3.2 AARMS Postdoctoral Fellowship Program

Each year AARMS conducts a competition to award Postdoctoral Fellowships to highly qualified personnel who received their PhD within the last 4 years. AARMS provides a portion of the funding for these positions, which must be at least matched by other research funding from the host university. The program is successful in attracting highly qualified young researchers to universities in New Brunswick and the rest of the Atlantic region. AARMS also makes available a travel grant of $1,500/year for each postdoc.

3.2.1 Postdoctoral Fellow Biographies

The following postdoctoral fellows have been supported by AARMS in the 2022/23 fiscal year:

Pranabesh Das received his Ph.D. from the Indian Statistical Institute in 2018. After completing his doctorate degree, he joined the University of Waterloo, Canada as a postdoctoral fellow with Cam Stewart where he stayed for the next three years. In July 2021 he joined Dalhousie University as a postdoc working with Karl Dilcher. His research interests lie in number theory, more specifically in Diophantine equations, Diophantine approximations, number sequences, and transcendence.

Dipanjan Dey completed his Ph.D. in Physics at the Indian Institute of Technology, Kanpur, India in 2019 under the supervision of Professor Kaushik Bhattacharya. In his Ph.D., Dipanjan primarily investigated the gravitational collapse of compact objects in different cosmological scenarios. He then joined the International Center for Cosmology, CHARUSAT, India as a postdoctoral fellow under the supervision of Professor Pankaj S. Joshi. During his first postdoc, he was primarily interested in the causal structure of a singularity formed in a continual gravitational collapse of a compact object and the possible physical signatures of a non-spacelike singularity. In October 2022, Dipanjan joined Dalhousie university as an AARMS postdoctoral fellow under the supervision of Professor Alan A. Coley. Now, his goal is to investigate the causal structure of the singularity in a coordinate-independent way and to understand the spinor structure of the spacetime manifold of a collapsing compact object.

Melissa Huggan completed her PhD in 2019 at Dalhousie University. She then joined Ryerson University as an NSERC postdoctoral fellow working under the supervision of Anthony Bonato. She has been working as an AARMS postdoctoral fellow under the supervision of Margaret-Ellen Messinger at Mount Allison University. Melissa's research interests are in combinatorial game theory, graph theory, and pursuit-evasion games.

Blake Keeler completed his Ph.D. in 2021 at the University of North Carolina at Chapel Hill under the supervision of Yaiza Canzani. His thesis work was on the subject of high-frequency spectral asymptotics on Riemannian manifolds. His other research interests include energy decay for the damped wave equation and dispersive estimates for operators on manifolds with conic singularities. Blake is currently dividing his time between McGill University as a CRM-ISM postdoctoral fellow and Dalhousie University as an AARMS postdoctoral fellow. His current research goals are centered around applying

techniquesfrom microlocal analysis and Riemannian geometry to understand Laplace eigenfunctions in a variety of geometric settings.

Alexandre Landry completed in 2020 at the Université de Montreal his PhD in theoretical physics under the supervision of Fayçal Hammad. The subject of the work was on the interaction of quantum particles with gravitation. In 2021, Alex continued to work with Fayçal Hammad. These early works make extensive use of Quantum Mechanics and General Relativity. Now Alex is a Post-Doc Fellow at Dalhousie University under the supervision of Alan A. Coley. Alex's main interests are alternative theories in gravity: Teleparallel Gravity and Teleparallel Geometry of Spacetimes. The goal is to explain the teleparallel structures of spacetime. Then, the goal is also to better explain the structures of universes by taking into account antisymmetric fields.

Luca Marchetti completed his cotutelle PhD at the University of Pisa and at LMU Munich in 2022. He is now working as a postdoctoral fellow under the supervision of Daniele Oriti at LMU Munich, and he will join the gravity group at the University of New Brunswick at the beginning of 2023. Luca's main research interest is the extraction of continuum physics from quantum gravity, focusing in particular on the emergence of cosmological and black hole spacetimes. He is also interested in renormalization and in the definition of physical notions of localization and evolution through the relational strategy, both issues being central to study and describe emergent continuum physics within quantum gravity.

Juan Margalef completed his Ph.D. in mathematical physics in 2018 under the supervision of Fernando Barbero and Eduardo Villaseñor. He did his first postdoc at Penn State University with Abhay Ashtekar. Currently, he is a postdoc at MUN with Ivan Booth and Hari Kunduri. His work revolves around the mathematical aspects of General Relativity and Field Theories. His main achievement is the development of the relative bicomplex framework, an essential generalization of the standard covariant phase space in the presence of boundaries, which has been used by him and his collaborators to solve several long-lasting problems. His goal now is to apply these techniques to some horizons problems in which the group of MUN is a world-leading expert. Juan Margalef is also passionate about science communication and outreach.

Geoffrey Vooys completed his PhD at the University of Calgary in Summer 2021 specializing in arithmetic geometry and category theory. He was working as a postdoctoral fellow under the supervision of Dorette Pronk at Dalhousie. Geoff's main research interests primarily include equivariant geometry, arithmetic geometry, (higher) category theory, descent theory, and applications of geometry and category theory to the Langlands Programme for p-adic groups.

Nomaan X completed his PhD at the Raman research institute in April 2021 working on various aspects of quantum field theory on causal sets. He is going to join the gravity group at the University of New Brunswick. Nomaan's research interests include causal sets, discrete geometry and more broadly, computational methods in quantum gravity. He is also interested in classical and semi-classical general relativity.

Fanheng Xu, under the supervision of Sun Yuhua, received his PhD in pure mathematics from Nankai University in 2019. His doctoral dissertation is on Liouville-type Principles for Elliptic Equations and Inequalities on Riemannian Manifolds. He continued his academic research as a postdoctoral fellow at Sun Yat-Sen University from 2019 to 2022. He is now an AARMS postdoctoral fellow at Memorial University of Newfoundland, working under the supervision of Prof. Xiao Jie. His main research interests focus on Applied Geometric Analysis and Partial Differential Equations.

Shuwen Xue completed her Phd in August 2021 at Auburn University under the supervision of Dr. Wenxian Shen. She was working as an AARMS postdoctoral fellow at Memorial University of Newfoundland with Dr. Xiaoqiang Zhao. Her research interests are in partial differential equations, dynamical systems and mathematical biology. More specifically, she works on population dynamics under the influence of chemotaxis and/or climate change.

3.2.2 Incoming Postdoctoral Fellows

We held our annual postdoctoral fellowship competition in the autumn of 2022. Four new postdoctoral fellows were appointed to start in the autumn of 2023: **John Maxwell Campbell**, who will work at Dalhousie under the supervision of Karl Dilcher; **Luuk Daniël Stehouwer**, who will work at Dalhousie under the supervision of Theo Johnson-Freyd; **Dharm Veer**, who will work at Dalhousie under the supervision of Sara Faridi; and **Qi Xiong,** who will work at Memorial under the supervision of Jie Xiao;

All of these postdoctoral fellowships starting in the autumn of 2023 will be funded by AARMS at the level of $25,000/year. Matching funds are provided by their supervisor and host university. AARMS also makes available a travel fund of $1500/year for each postdoc.

3.3 AARMS Summer School

During a four week period every summer AARMS invites highly regarded faculty from around the world to deliver graduate courses in the mathematical sciences and their applications. In 2022 the lingering pandemic made it too risky to plan for an in-person Summer School. However, planning was put in place to host the first post-pandemic Summer School on the topic of Emerging Infectious Diseases Modelling, to be held at Memorial University in August 2023.

3.4 Workshops and Conferences

This year we saw a return to many in-person events, However, it appears that the use of videoconferencing technology has become a familiar and useful tool for many research groups who continued to make use of the AARMS ZOOM license for seminars, meetings and other distributed interactions. The list of events for the year is given below.

Dalhousie-AARMS AAMP Seminar: Erick Schulz (ETH Zürich)
Dalhousie University
March 31, 2023 @ 4:00 pm - 5:00 pm

Atlantic Graph Theory Seminar: Calum MacRury, University of Toronto
Online via Zoom
March 29, 2023 @ 3:30 pm - 4:30 pm

Atlantic Graph Theory Seminar: Mohammad Salavatipour, U. Alberta
Online via Zoom
March 22, 2023 @ 3:30 pm - 4:30 pm

Dalhousie-AARMS AAMP Seminar: Milivoje Lukic (Rice U.)
Dalhousie University
March 17, 2023 @ 4:00 pm - 5:00 pm

Atlantic Graph Theory Seminar: Caleb Jones and Rylo Ashmore (Memorial University)
Online via Zoom
March 15, 2023 @ 3:30 pm - 4:30 pm

Automorphisms And Derivations In Affine Algebraic Geometry
Memorial University (St. John's Campus)
March 13, 2023 - March 17, 2023

Dalhousie-AARMS AAMP Seminar: Katrina Morgan (Northwestern University)
Dalhousie University
March 10, 2023 @ 4:00 pm - 5:00 pm

Atlantic Graph Theory Seminar: Lucas Mol, Thomson Rivers University
Online via Zoom
March 8, 2023 @ 3:30 pm - 4:30 pm

Atlantic Graph Theory Seminar: Isaac McMullin and Ian George, Dalhousie University
Online via Zoom
March 1, 2023 @ 3:30 pm - 4:30 pm

Minicourse: Group Graded Azumaya Algebras and Generic Constructions
Memorial University (St. John's Campus)
February 17, 2023 @ 11:00 am - February 22, 2023 @ 12:00 pm

Atlantic Graph Theory Seminar: Jérémie Turcotte, Université de Montréal
Online via Zoom
February 15, 2023 @ 3:30 pm - 4:30 pm

Dalhousie-AARMS AAMP Seminar: Victor Ivrii (U. Toronto)
Dalhousie University
February 10, 2023 @ 4:00 pm - 5:00 pm

Atlantic Graph Theory Seminar: Jason Brown, Dalhousie University
Online via Zoom
February 8, 2023 @ 3:30 pm - 4:30 pm

Dalhousie-AARMS AAMP Seminar: Alex Barnett (Flatiron Institute, NYC)
Dalhousie University
January 27, 2023 @ 4:00 pm - 5:00 pm

Dalhousie-AARMS AAMP Seminar: Chamsol Park (Johns Hopkins University)
Dalhousie University
January 20, 2023 @ 4:00 pm - 5:00 pm

Atlantic Graph Theory Seminar: Jane (Pu) Gao, University of Waterloo
Online via Zoom
January 18, 2023 @ 3:30 pm - 4:30 pm

Dalhousie-AARMS AAMP Seminar: Andrea Bertozzi (UCLA)
Dalhousie University
January 13, 2023 @ 4:00 pm - 5:00 pm

Atlantic Graph Theory Seminar: Pawel Pralat, Metropolitan University of Toronto
Online via Zoom
January 11, 2023 @ 3:30 pm - 4:30 pm

The 19th Seminar on Commutative Algebra and related topics
Institute for Research in Fundamental Sciences (IPM) Tehran, Iran
January 7, 2023 - January 12, 2023

Student Poster Competition at the CMS Winter Meeting
Toronto, ON
December 3, 2022

Atlantic Graph Theory Seminar: Sebastian Cioaba, University of Delaware
Online via Zoom
November 30, 2022 @ 3:30 pm - 4:30 pm

University of New Brunswick Data Challenge 2022
University of New Brunswick (Fredericton Campus)
November 18, 2022

Science Atlantic Mathematics, Statistics, and Computer Science Conference
Mount Allison University
October 21, 2022 - October 22, 2022

34th Canadian Conference on Computational Geometry
Ryerson University
August 25, 2022 - August 27, 2022

East Coast Combinatorics Conference
University of Prince Edward Island
August 17, 2022 - August 18, 2022

Intersection of Microlocal Analysis, Harmonic Analysis, and Inverse Problems: A conference in honor of Allan Greenleaf
University of Rochester
August 15, 2022 - August 17, 2022

Symmetry, Invariants, and their Applications: A Celebration of Peter Olver's 70th Birthday
Halifax
August 3, 2022 - August 5, 2022

AARMS Geophysical Inverse Problems Discussion
Online via Zoom
July 29, 2022 @ 1:30 pm - 2:30 pm

AARMS Geophysical Inverse Problems Discussion
Zoom seminar
July 15, 2022 @ 1:30 pm - 2:30 pm

Canadian Undergraduate Mathematics Conference / Congrès canadien des étudiant(e)s en mathématiques
Université Laval
July 13, 2022 - July 17, 2022

Computational Aspects in Finance and Actuarial Sciences
University of Prince Edward Island
July 8, 2022 - July 9, 2022

AARMS Geophysical Inverse Problems Discussion
Zoom seminar
June 24, 2022 @ 1:30 pm - 2:30 pm

Stinson66 – New Advances in Designs, Codes and Cryptography
Fields Institute
June 13, 2022 - June 17, 2022

AARMS Geophysical Inverse Problems Discussion
Zoom seminar
June 10, 2022 @ 1:30 am - 2:30 pm

Applied and geometric analysis–A Session at the CMS Summer meeting
Memorial University (St. John's Campus)
June 6, 2022

Student Poster Competition at the CMS Summer Meeting
Memorial University (St. John's Campus)
June 4, 2022

Session on Design Theory and Graph Decompositions at the 2022 Summer Meeting of the Canadian Mathematical Society
Memorial University (St. John's Campus)
June 3, 2022 - June 6, 2022

Public Lecture: Dr. Ivan Shestakov
Memorial University (St. John's Campus)
June 1, 2022 @ 7:00 pm - 8:00 pm

Mathematical foundations of scientific machine learning
Memorial University (St. John's Campus)
June 1, 2022 - June 3, 2022

Groups, Rings, Lie and Hopf Algebras IV
Memorial University (St. John's Campus)
May 30, 2022 - June 2, 2022

Calculus Instruction in Atlantic Canada Conference 2022
Online via Zoom
May 28, 2022

AARMS Geophysical Inverse Problems Discussion
Online via Zoom
May 27, 2022 @ 1:30 pm - 2:30 pm

Combinatorial Algebra meets Algebraic Combinatorics 2023
University of Waterloo
May 26, 2022 @ 8:00 am - 5:00 pm

Atlantic General Relativity Meeting 2022

Online via Zoom

May 16, 2022 - May 19, 2022

AARMS Geophysical Inverse Problems Discussion Series

Zoom seminar

May 13, 2022 @ 1:30 pm - 2:30 pm

CMS-UPEI-AARMS Regional Math Camp

University of Prince Edward Island

May 6, 2022 - May 8, 2022

Atlantic Graph Theory Seminar: Aysel Erey (Gebze Technical University, Turkey)

Zoom seminar

April 13, 2022 @ 3:30 pm - 4:30 pm

AARMS Scientific Machine Learning Seminar: Michael W. Dunham (Department of Earth Sciences, Memorial University)

WebEx seminar

April 12, 2022 @ 11:00 am - 12:00 pm

Atlantic Graph Theory Seminar: John Engbers (Marquette University)

Zoom seminar

April 6, 2022 @ 3:30 pm - 4:30 pm

AARMS Scientific Machine Learning Seminar: Geoffrey McGregor (University of Northern British Columbia)

WebEx seminar

April 5, 2022 @ 11:30 am - 12:30 pm

3.5 Outreach

In 2022/23 outreach programs were still not as active as they had been pre-pandemic. However, the following activities were supported by AARMS:

UPEI-CMS-AARMS Regional Math Camp, held at UPEI between May 6 – May 8, 2022. The event hosted 25 of the most talented grade 10 and grade 11 math students from across the Island, offering students an opportunity to participate in challenging, intellectual activities with their peers, guided by the UPEI SMCS faculty members. The students, spent 2 nights in residence, and, with the help of several undergraduate math majors, and faculty members, participated in several educational, problem-solving and career sessions during the daytime, and recreational sessions during the evenings.

International Mathematical Olympiad Training Camp for Math Team Canada. Math Team Canada spent some time at UNB Fredericton preparing for the International Mathematical Olympiad in Oslo which started on the 9th of July, 2022. The camp was also open to welcome four local students for the first two days to join them in the training: the students from Atlantic Canada with the highest scores on the Canadian Open Math Challenge.

Jr. Math and Computer Science Camp, run by researchers at Acadia University. This week-long day camp is an opportunity for students entering grades 5 or 6 in the Annapolis Valley to participate in fun and enriching science-based activities with Acadia faculty and students to develop their curiosity and enjoyment of math and computer science. It represents an important piece of a multi-year plan to develop the science skills of young students in the Annapolis Valley by bringing young students into the Acadia University outreach program.

Connecting Math to Our Lives and Communities, run by researchers at St Francis Xavier University,is a focused in-community mathematics outreach program serving Mi'kmaw and African Nova Scotian youth in Eastern Nova Scotia. AARMS funding supported the continuation of this successful and requested program and also allowed for the enhancement of a new summer camp.

CMTOLC is run in partnership with local Mi'kmaw and African Nova Scotian communities to engage youth in meaningful, relevant, hands-on investigations of mathematics. For the 2022-2023 academic year, a StFX doctoral student was hired as a coordinator to manage the administrative and organizational aspects of the program. Twenty-one undergraduate and Bachelor of Education students were employed as community outreach facilitators, three of whom served as outreach leaders who provided peer mentorship in addition to their facilitation roles.

Topics for programming were derived from student interest and community input, and included natural disaster preparation and response in the wake of the impact of Hurricane Fiona which explored wind speeds and geometry in structural integrity, the mathematics of deforestation, water security particularly in historically marginalized communities in Canada, patterns and knots

in crafting and hunting, angles in sports, and understanding large quantities through space connected to cultural star stories.

Loosening health restrictions surrounding the COVID-19 pandemic allowed for a more fulsome return to in-community programming this year with the exception of one community whose previous partnership was unable to continue due to ongoing effects. Community visits took place biweekly through the 2022-2023 academic year, 33 in-community sessions were held, serving three Mi'kmaw (Paqtnkek, Pictou Landing, We'koqma'q) and three African Nova Scotian (Antigonish, Lincolnville, and Sunnyville) communities. Throughout these 33 sessions 252 students and youth (137 in Mi'maq communities, and 115 in African Nova Scotian communities) attended and participated, with most attendees being middle-school aged students. Youth participants returned regularly, demonstrating interest and engagement in the programming and also provided positive feedback after each visit.

Summer day camp programming was expanded in summer 2023, offering continued programming weekly in Paqtnkek, Pictou Landing, We'koqma'q, and Antigonish. Community embedded and culturally relevant explorations supported and encouraged youth to not only engage in mathematical activities, but also encouraged youth to participate in further studies in mathematics and science.

Four StFX students were hired to facilitate the summer programming which included school-based workshops in Paqtnkek and We'koqma'q in May and June reaching over 120 students, and weekly day camp visits in through July and August in each of Paqtnkek, Pictou Landing, We'koqma'q and Antigonish. This was done in partnership with communities' summer recreation staff and the African Nova Scotian Knowledge Seekers Summer Scholars camp,

deepening and expanding community relationships. Youth engaged in planning and planting community gardens, exploring the mathematics of sports with respect to the locally hosted North American Indigenous Games, investigating mazes and labyrinths and building courses to program coding tools to navigate those mazes. Additionally, CMTOLC supported the X-Project STEM camp through the development and facilitation of workshops and has begun to develop a partnership with X-Oceans.

University of New Brunswick Data Challenge 2022. The Data Challenge brought together three competitive events, Data Visualization (7th Annual), Data Analytics (3rd Annual), and Data Sprint (3rd Annual) on Nov. 18, 2022, in a hybrid format - virtually and in person! Participants and teams had the chance to showcase their ability to tell a story driven by data in three unique competitive formats. It is an ideal setting for citizens to get engaged, meet leaders in academia, government, and private organizations, and explore the world of data science.

AV Middle School Outreach
Acadia faculty and students offer math outreach activities to grades 7 and 8 at schools in the area. The format is hour-long sessions every 2 weeks.

Integration Tournament for UPEI Students. Modelled after a similar event held annually at MIT, students go head-to-head to complete integrals in a single-knockout tournament.

3.6 Scholarships and Awards

3.6.1 Graduate Student Scholarship

These scholarships aim to provide extra incentive to attract excellent students to Atlantic Canada, and will contribute to a healthy exchange of students and ideas between universities across Canada. In 2023 we awarded two prizes of $5,000 each to:

Irfan Javed, PhD student at the University of New Brunswick, supervised by Viqar Husain. Irfan Javed joined the quantum gravity group at UNB in Fall 2021. He graduated at the top of his class from the Lahore University of Management Science (Pakistan) in 2021 with two co-authored papers in quantum theory. In the relatively short time he has been at UNB, Irfan has demonstrated exceptional industry and research potential. A portion of Irfan's PhD work is already complete. This is a study of how a familiar physical system, a pendulum, interacts and evolves together with a

quantum system with spin, such as an electron. There are three distinct ways to describe this system; Irfan studied the corresponding equations to see how their dynamics differ. This work was published recently in Physical Review Letters, one the most prestigious journals in the field. Irfan is presently working on extending these results analytically and numerically.

Caleb Wellbourn Jones, Masters student at Memorial University, supervised by David Pike and Andrea Burgess (UNB). His research involves an abstract problem involving propagation of information among the nodes of hypergraph-based networks. Practical applications of this research include modelling dissemination within social networks and spread of malware within computer networks.

3.6.2 Doctoral Thesis Award

These awards will allow the Atlantic mathematical community to celebrate together the achievements of our students, and will also serve as a bridge between our research communities by promoting Atlantic Canadian research. In 2023 we made one award of $5000 to:

Dr. Abdalaziz Hamdan received his PhD from Memorial University in August, 2022, under the supervision of Dr. Scott MacLachlan, for a thesis entitled, *Finite-element methods for fourth-order problems and smectic A liquid crystals*. A key goal of applied mathematical research is to use mathematical tools to improve our understanding of physical and industrial processes in the world around us, particularly at scales where classical theoretical and experimental science fail to yield clear answers. Dr. Hamdan's thesis does just this for the class of "smectic" liquid crystals that possess a unique layering structure that has been hypothesized to be useful in assembling nano-scale devices, such as photonic crystals. While mathematical models of smectic liquid crystals were first proposed in the 1970's, much of their structure remains hidden to us, due to their extremely small length scales that can only be imaged indirectly. Dr. Hamdan's thesis focuses on the development of computational tools to accurately simulate the structure of smectic liquid crystals in equilibrium, allowing physicists and engineers to better understand these materials and how they can be used in physical and industrial processes.

3.7 New Programs

3.7.1 Junior Researcher Travel Support

In 2023 we initiated the Junior Researcher Travel Support Program with a budget of $20,000 to support graduate students and postdocs traveling to attend national and international conferences and workshops. The program has been well subscribed, helping HQP meet peers and find opportunities for collaboration and professional networking.

3.8 Equity, Diversity and Inclusion

In the 2022/23 academic year, the new EDI Committee met once a month to establish and create EDI policies and procedures to submit to the Executive Committee for approval. The following are now in place.

1. Permanent EDI Committee
2. Revised EDI Statement and Land Acknowledgment
3. Self-identification Questionnaire
4. Statistical Tracking
5. Guidelines for Boards and Committees
6. Guidelines for Event Organizers
7. Growing relationships with EDI Activist Groups

A new EDI committee is being convened for 2023/24. It will be tasked with making recommendations on:

1. Expanding Relationships with EDI Activist Groups
2. Creating programming for under-represented groups
3. Creating a dispute resolution process
4. Revising AARMS Statutes
5. Creating EDI Education/Training for the AARMS Community

4 Governance and Administration

There were no significant changes in governance and administration in 2022/23.

5 Accounts

See following page.

Income and Expenditure Account
April 1, 2022 - March 31, 2023

Income		2021-2022
Carried forward from previous year	170,264	280,326
Previous commitments written off	23,753	69,700
NSERC DIS	372,819	283,760
Mathematical Institutes	0	98,850
Universities	65,500	91,500
Provinces	0	35,000
NSERC other grants	30,000	0
Other Revenue	167	5,410
Total Income	**662,503**	**864,546**

Expenditure		
Bad Debts	0	6,000
Summer School	0	0
Workshops and Events (2)	28,528	114,500
Outreach (3)	10,501	30,556
PDF Program (4)	223,050	253,813
Collaborative Research Groups (5)	167,500	202,500
IPSW	0	13,878
Graduate Scholarships	10,000	10,000
Doctoral Thesis Award	5,000	0
Jr. Researcher Travel	662	0
EDI Consultant	0	5,000
Administration, travel and overheads	65,447	58,035
Total Expenditure	**510,688**	**694,282**
Surplus:	**151,815**	**170,264**