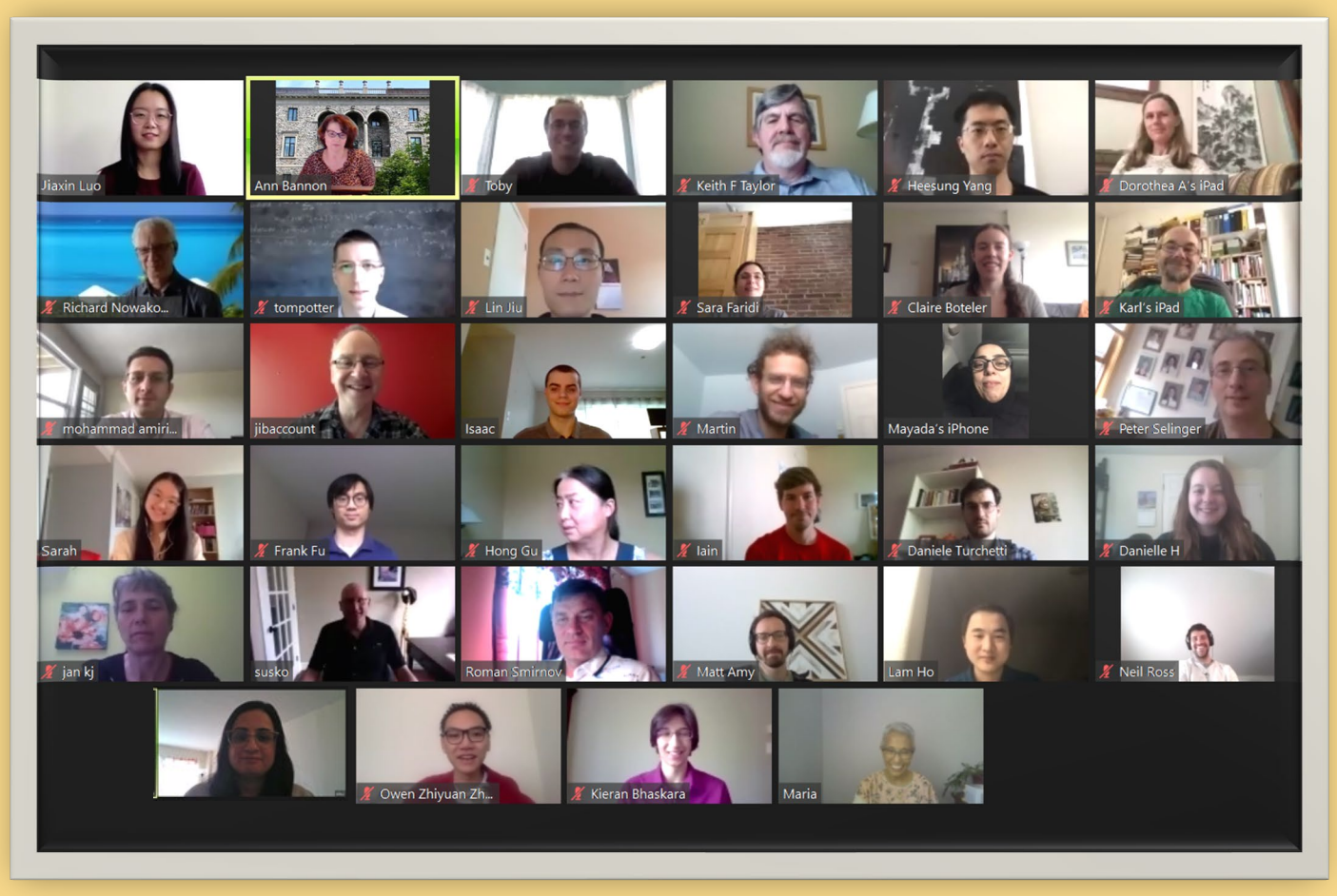


CHASE ANNUAL REPORT

Department of Mathematics and Statistics

Faculty of Science

2020 EDITION

DALHOUSIE UNIVERSITY

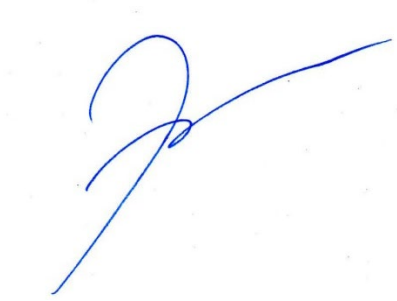
dal.ca/mathstat

Message from the Department Chair

At the end of this academic year, we are finding ourselves in exceptional circumstances. Normally, I would at this moment have attended Dalhousie's graduation ceremony to see our graduates cross the stage, and to congratulate them in person (maybe even with a handshake.) We would have held our awards ceremony, where we would have personally recognized our award winners, and given all graduating students the opportunity to say good-bye to their professors. The pandemic has caused a change of plans, and the recognition of our graduates and award winners will, out of necessity, lack the personal touch.

We are no less proud of our graduating class. To complete a degree in mathematics, statistics or actuarial science requires talent and perseverance. Congratulations, graduates! You are now embarking on a new adventure. I hope you find fulfillment in your chosen career, and I hope we prepared you well. Please join the alumni community, stay in touch, and stop by when you have a chance

Congratulations also to our award winners, and to all that received honours and scholarships. You have shown exceptional promise. I hope you take a moment to celebrate your achievement.



Jeannette Janssen
Department Chair

Congratulations & Welcome to Our Alumni Family

Congratulations to all our graduates from the fall of 2019 and spring of 2020! We look forward to hearing from you. Please feel welcome to either drop us a line when you have a chance or stop in to say hello next time you are on campus.

GRADUATES & NEWEST ALUMNI

We are pleased to present the names of everyone who convocated this academic year. Graduates, who are now members of our alumni family, are listed by spring 2020 and fall 2019. Each list is sorted by surname.

SPRING 2020

First Name	Surname(s)	Program
Abdullah	Al-Shaghay	Doctor of Philosophy, Mathematics
Kelu	An	Bachelor of Science Major in Statistics and Economics
Paul	Bjorndahl	Master of Science, Statistics
Maggie	Bowman	Bachelor of Science Major in Mathematics and Statistics
Cecilia	Chen	Bachelor of Science Major in Statistics and Psychology
Keigan	Davis	Bachelor of Science Major in Actuarial Science
Corey	DeGagne	Doctor of Philosophy, Mathematics
Xin	Deng	Bachelor of Science in Statistics
Kimberly	Franklin	Bachelor of Science Honours Co-operative in Marine Biology and Mathematics
Yuejia	Gao	Bachelor of Science Major in Statistics
Han	Geng	Bachelor of Science Major in Economics and Statistics
Charlie	Gerrie	Bachelor of Science Honours in Mathematics
Stefan	Hadley	Bachelor of Science Major in Mathematics and Statistics
Chris	Harding	Bachelor of Science Major in Actuarial Science
Shapeng	Hou	Bachelor of Science Major in Actuarial Science
Zhouzi	Hu	Bachelor of Science Major in Mathematics
David	Iruegas	Bachelor of Science Major in Statistics and Economics
Sydney	Johns	Bachelor of Science Major in Mathematics
Shaoming	Kang	Bachelor of Science Honours in Statistics and Actuarial Science
Arman	Kerimbek	Bachelor of Science Honours in Statistics
Nancy	Khalil	Doctor of Philosophy, Mathematics
Kerry-Joy	Kiefte	Bachelor of Science in Mathematics
Yuqi	Kong	Bachelor of Science Major in Statistics and Economics
Matthew	Leighton	Bachelor of Science Honours in Physics and Mathematics
Anny	Li	Bachelor of Science Major in Economics and Statistics
Su	Li	Bachelor of Science Major in Economics and Statistics
Carol	Liu	Bachelor of Science Major in Economics and Statistics
Cecelia	Liu	Bachelor of Science Major in Economics and Statistics
Haochen	Liu	Bachelor of Science Major in Statistics
Shuman	Liu	Bachelor of Science Major in Psychology and Statistics
Xinyuan	Liu	Bachelor of Science Honours in Actuarial Science

First Name	Surname(s)	Program
Zhenming	Liu	Bachelor of Science Major in Statistics and Economics
Adam	Lucas	Bachelor of Science Honours in Mathematics
Junyu	Luo	Bachelor of Science Major in Economics and Statistics
Pengyu	Lyu	Bachelor of Science Major in Statistics and Economics
Todd	Mullen	Doctor of Philosophy, Mathematics
Yuno	Nakanishi	Bachelor of Science Major in Marine Biology and Statistics
Brandon	Nuttall	Bachelor of Science Major in Mathematics and Chemistry
Victor	Obeid	Bachelor of Science Major in Statistics
Liam	Orovec	Bachelor of Science Honours in Mathematics
Wei	Pan	Bachelor of Science Major in Economics and Statistics
Renjie	Peng	Bachelor of Science Honours in Statistics
Jessica	Perkins	Bachelor of Science Major in Statistics
Jeremy	Peters	Bachelor of Science Honours in Mathematics and Physics
Alexander	Poulton	Bachelor of Science Major in Actuarial Science
Tina	Ren	Bachelor of Science Major in Mathematics and Statistics
Christy	Sabu Zacharia	Bachelor of Science Honours in Mathematics
Fatma	Sarhan	Bachelor of Science Honours in Statistics
Sen	Shan	Bachelor of Science Major in Statistics
Zhengyang	Shang	Bachelor of Science Major in Economics and Mathematics
Asmita	Sodhi	Doctor of Philosophy, Mathematics
Vishal	Sood	Master of Science, Statistics
Mutian	Sui	Bachelor of Science Major in Economics and Mathematics
Chang	Sun	Bachelor of Science Major in Mathematics
Edison	Wang	Bachelor of Science Major in Economics and Mathematics
Kunpeng	Wang	Doctor of Philosophy, Mathematics
Lei	Wang	Bachelor of Science Major in Mathematics
Mengyao	Wang	Bachelor of Science Major in Psychology and Statistics
Sarah	Woodside	Bachelor of Science Major in Chemistry and Mathematics
Yuan	Wu	Bachelor of Science Honours in Statistics and Economics
Yuxuan	Xiao	Bachelor of Science Major in Psychology and Statistics
Jinhao	Yang	Bachelor of Science Major in Statistics
Zhixian	Yang	Bachelor of Science Honours in Statistics
Bohan	Yu	Bachelor of Science Major in Actuarial Science
Jaelene	Zhang	Bachelor of Science Major in Chemistry and Statistics
Kan Yu	Zhang	Bachelor of Science Major in Economics and Statistics
Tingyu	Zhang	Bachelor of Science Honours in Mathematics
Wang	Zhang	Bachelor of Science Major in Economics and Statistics
Wenyi	Zhang	Bachelor of Science Major in Statistics
Xueying	Zhang	Bachelor of Science Major in Economics and Statistics
Yikun	Zhang	Bachelor of Science Major in Statistics
Yunzheng	Zhang	Bachelor of Science Honours in Actuarial Science and Statistics
Xiaohang	Zhou	Bachelor of Science Honours in Statistics
Yuye	Zhou	Bachelor of Science Major in Statistics
Ryan	Zigrossi	Bachelor of Science in Mathematics

FALL 2019

First Name	Surname(s)	Program
Zainab	Albandari	Bachelor of Science Major in Neuroscience and Mathematics
Junqiu	Gao	Master of Science, Statistics
Morgan	Garnier	Bachelor of Science Major in Mathematics
Joey	Hartling	Master of Science, Statistics
Melissa	Huggan	Doctor of Philosophy, Mathematics
Dinggu	Jiang	Bachelor of Science in Mathematics
Feng	Jiang	Bachelor of Science Major in Mathematics
Anne	Johnson	Master of Science, Mathematics
Maayan	Johnston	Bachelor of Science Major in Mathematics
Christopher	Jones	Doctor of Philosophy, Statistics
Michael	Lambert	Doctor of Philosophy, Mathematics
Ge	Meng	Bachelor of Science Major in Psychology and Statistics
Giuseppe	Pasqualino	Master of Science, Mathematics
Becca	Ryan	Master of Science, Mathematics
Xiao	Tan	Bachelor of Science Major in Statistics and Economics
Guoyu	Wang	Bachelor of Science Major in Mathematics and Computer Science
Ziyuan	Wang	Bachelor of Science Major in Statistics and Economics
Xinrui	Zhao	Bachelor of Science Major in Statistics and Economics

KEITH TAYLOR'S CONVOCATION ADDRESS

A small silver lining in this COVID cloud for those of you graduating in 2020 is that you will have a story to tell your grandchildren in 2070. You can probably tell that I am a Boomer. I did my undergraduate studies in the late 1960s and 70s. Those were truly turbulent times on university campuses. In fact, I lost the last few weeks of classroom time in my senior year as well. It was not because of some pandemic; but because we students went on strike and closed the university. The issue seems incredibly silly now. However, to us it was a matter of principle and we did learn some things from that experience. I also gained a story to tell in 2020.

These past few months have made it clearer than it has ever been how important economics, psychology, the natural sciences, mathematics, and statistics are for the function of modern society. They will continue to be vital throughout your careers and I look forward to watching you all make the world a better place.

Department Awards

Congratulations to our 2019 – 2020 award earners! The names of this year's recipients are presented below along with some information about each of the 17 awards.

Sir William Young Gold Medal in Mathematics

This medal is awarded at convocation to the student who stands first among those taking 1st class honours in Mathematics. It is also known as the University Medal in Mathematics.

Recipient: **Jeremy Peters.**

University Medal in Statistics

This medal is awarded at convocation to the student who stands first among those taking 1st class honours in Statistics.

Recipient: **Renjie Peng**

University Medal in Actuarial Science

This medal is awarded at convocation to the student who stands first among those taking 1st class honours in Actuarial Science.

Recipient: **Yunzheng Zhang**

Barry Ward Fawcett Memorial Prize

This monetary award goes to the student who has achieved the highest grade in MATH/CSCI 2113 (Discrete Structures II).

Recipient: **Xiaoyu Jia**

Bernoulli Prize

This monetary award goes to the student registered in the Co-op Mathematics Program who has the best cumulative academic record, subject to the restrictions that the prize can be awarded only once to a given individual, and that the winner must have performed acceptably in all work term assignments.

Recipient: **Haomu Liu**

The Ellen McCaughin McFarlane Prize

This award is in the memory of Ellen McCaughin McFarlane, class of 1927 and goes to the student who has achieved the highest standing after completing year one of the honours program. This prize is a monetary award.

Recipient: **James Munday**

The Dr. Emil and Mrs. Stella Blum Prize in Mathematics

This monetary prize is awarded to an Advanced Major or Honours Mathematics student who achieves the highest grade in second year Calculus.

Recipient: **James Munday**

Erma Geddes Filmore Memorial Scholarship

This scholarship is awarded to a full-time BSc undergraduate student with the highest grade point average entering the second year of their degree with a declared major in Mathematics or Statistics. This scholarship is in memory of Erma Geddes Fillmore (Dalhousie BA, 1924) and was established by her family.

Recipient: **Bridget Solomon**

Field Prize in Statistics

This monetary prize is awarded to the student with the highest academic standing who has completed their 3rd year of studies in Statistics. This award was endowed by Dr. Christopher Field and Mrs. Harriet Field.

Recipient: **Yeping (Kyle) Wang**

Heller-Smith Foundation Graduate Scholarship in Mathematics & Statistics

This scholarship is awarded based on academic achievement. The scholarship was established to provide financial support and recognition to a graduate student.

Recipient: **Fahimeh Bayeh**

The Katherine M. Buttenshaw Prize

This monetary prize is awarded to the student standing highest in the advanced Mathematics courses.

Recipient: **Caroline Barton**

Ken Dunn Memorial Prize

This cash prize is awarded to a student who has completed the third year of an Honours program in Mathematics or Statistics, or a combined Honours program in Mathematics and Statistics.

Recipient: **Owen Bennett-Gibbs**

The Peter and Anne-Ellen Fillmore Scholarship

This scholarship is awarded to a graduating math honours or major student from the Maritimes who plans to become a high school math teacher.

Recipient: **Sarah Woodsideen**

Professor Michael Edelstein Memorial Graduate Prize

This prize is awarded to a graduate student who shows great promise in the mathematical sciences.

Recipient: **Chunyi Gai**

R.P. & Kamla Gupta Scholarship in Statistics

This scholarship is to recognize excellence in Statistics by providing one or more scholarships to undergraduate students enrolled in Honours Statistics.

Recipient: **Ziwei Wang**

The Ralph and Frances Lewis Jeffery Scholarship

This scholarship is awarded to two students who have each completed an honours degree in Mathematics, and who have maintained at least 2nd class standing during the first 3 years.

Recipients: **Jeremy Peters** and **Christy Sabu Zacharia**

Waverley Prize

This award goes to the student with the highest standing in MATH 1010 (Differential and Integral Calculus II).

Recipients: **Lucy Pennyfather**

Reports, Reflections & News to Note

CHAIR'S REPORT

By Jeannette Janssen

This academic year saw several new developments in our department. Suresh Eshwarathasan joined our department in a tenure track position. He fills a position created to increase the diversity of the Dalhousie community. Suresh joined us from a previous appointment at the University of Cardiff. He studied at the University of Rochester and held post-doctoral appointments at McGill and IHES in France. Suresh has started an Analysis seminar series, which was off to a lively start before it was cut short by the pandemic. He also recently secured his first NSERC Discovery grant. Congratulations!

Asmita Sodhi successfully defended her PhD in March, under the supervision of Keith Johnson, and just a few weeks later started a position as instructor and learning center director in our department. She replaces Sarah Chisholm during her maternity leave: Sarah, husband Chris and daughter Paige welcomed baby Quinn in April; baby and family are doing well.

Danielle Hill joined the office staff in January, replacing Kasia Wolkowicz, who left to take up another position. Danielle divides her time equally between our department and the department of Chemistry. She has been a tremendous help in making sure all financial transactions and payments are processed quickly and efficiently.

During the calendar year 2019 I enjoyed a sabbatical, catching up on research. Bruce Smith was acting Chair; thanks to Bruce for steering the ship during this time. Bruce made sure some important initiatives came to fruition, and he successfully argued for a new tenure track position in our department, with focus on data science. Bruce has since been appointed to a position as Associate Dean, Faculty Development (part-time). In the current academic year, he also served as the president of the Statistical Society.

In December, we finalized a 2+2 agreement in Actuarial Science with Bermuda College. Bermuda College offers a two-year Associateship in Actuarial Science, with students from that program often going elsewhere to complete a degree. There have been a number of Bermuda College students that finished their degrees at Dalhousie in the past, including some in our department. Given these existing ties, and the fundamental role that the financial industry plays in the economy of Bermuda, we believe that the new agreement will be a real boost to our Actuarial Science program.

In March, we received positive news about an important initiative that has been over a year in preparation. A direct entry 2+2 program in Statistics with the Shandong University of Finance and Economics (SDUFE) was approved by the Chinese government. Thanks to Barry Lesser, Professor Emeritus of Economics, and to Shannon Peng, China program coordinator (and wife of Theo), to help make this program a reality. We currently have 2+2 agreements in Statistics, Mathematics, and Actuarial Science with SDUFE, but the new program makes it easier for Chinese students to choose the top two years at Dalhousie, and we expect many more students to come to our department through this program. It should be noted that this

year's winners of the University Medals in Actuarial Science and Statistics were both students that came to our department through a 2+2 program with SDUFE. Congratulations, Yunzheng and Renjie!

Joanna Mills-Flemming is championing the creation of CANSSI Atlantic, a regional centre of the Canadian Statistical Sciences Institute (CANSSI). The centre will be housed at Dalhousie. Like its parent organization, CANSSI Atlantic will foster the development, application, and communication of cutting-edge statistical and data science research and training.

Two department members have announced their retirement from July. Keith Taylor came to our department after he served a term as Dean of the Faculty of Science. Before that, he was a professor and administrator at the University of Saskatchewan. Keith Thompson holds a joint appointment in our department and the department of Oceanography. He came to Dalhousie as one of the first Canada Research Chairs. More about both elsewhere in the Chase report. Unfortunately, due to the pandemic it will not be possible to hold the customary retirement party. We hope to be able to honour and thank the two Keiths with a party next summer.

Finally, I want to recognize the great flexibility and considerable effort required from students and instructors to make the sudden change to temporary teaching in the midst of the winter semester. Through your efforts, the change went smoothly, learning outcomes were met, and graduating students were not held back by circumstance. We all learned a lot about on-line teaching and remote communication. Let's hope this will benefit us in the future.

I would like to single out three grad students: Asmita Sodhi, Leila Mohammadi and Maryam Ehya Jahromi, who, after some training from the Faculty of Science, helped instructors understand the intricacies of working with Brightspace, Panopto, Collaborate, and other tools involved in moving the content of a course online. Their help made the transition smoother.

Last but not least, I want to recognize our support staff. The pandemic has made it clear how much we depend on them. Angela Myers is keeping our workspace clean, and thus is keeping us safe from pathogens. Balagopal Pillai keeps our computer equipment in good shape, making sure we have the means of continuing our tasks from home. Maria Fe Elder, Ellen Lynch and Danielle Hill have made a seamless change to working from home, and they continue to support the department and the Chair with many different administrative tasks.

I want to end this report with a special note of thanks to Ann Bannon, the department administrator. She has been my rock in these turbulent times. Her thoroughness, efficiency, and knowledge of university procedures make the Chair's job easier, and her good ideas and compassionate nature make it a pleasure to work with her.

GRADUATE PROGRAM

GRADUATE STUDENT SOCIETY REPORT

Submitted by Catherine Antwi

The Association's General Meeting elected the following officials for the 2019/2020 academic year:

Catherine Antwi - President
Molly Hayes - Vice President External
Mia Parenteau - Vice President Internal
Vishal Sood - MSc Statistics
Claire Boteler - PhD Statistics
Fahimeh Bayeh - MSc Mathematics

As part of the year, several events were earmarked to be celebrated but not all were done due to the COVID-19. The following programs were done:

- The Monthly Coffee and Timbits were organized every first week of October 2019 to March 2020. The patronage for this has been great.
- The fall end of term dinner was also held at the Wooden Monkey. We also organized the PI Day and the Chinese New Year as part of our food events and also celebrating the diversity among our members.
- The exam review for the fall exams was also organized to help students prepare for the exams as well as raise funds.

The following programs were however not organized due to the COVID-19:

- Relaxing activities near exams like painting and crafty activity at the Clay Café.
- Persian New Year, STAT 1060 and MATH 1010 Reviews, Skating and End of Term Dinner winter.

Notwithstanding, the improvement needed to the graduate handbook is still ongoing.

STATISTICS GRADUATE COORDINATOR NOTES

Contributed by Joanna Mills-Flemming

MSc student **Abe Adeeb** put a tremendous amount of work into organizing a Hockey Hackathon in our department, only to have it cancelled due to COVID-19. PhD **Jonathan Babyn** returned to our department from DFO Newfoundland following his internship. MSc student **Jiaxin Luo** has been awarded funding from the Atlantic Halibut Council to complete her thesis. Joanna Mills Flemming, along with MSc student **Raphael McDonald**, PhD student **Ethan Lawler** and PDF **Sofie (Yuan) Yan**, organized and attended a workshop at The International Council for the Exploration of the Sea (ICES), in Spring 2019. ICES is an intergovernmental marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.

UNDERGRADUATE PROGRAM

DALHOUSIE UNDERGRADUATE MATHEMATICS AND STATISTICS SOCIETY (DUMASS)

by Kieran Bhaskara

2019/2020 Executive Council members:

President: **Kieran Bhaskara**
Vice President: **Maddie Torres**
Treasurer: **Aeriana Narbonne**
Secretary: **Christy Zacharia**
Communications: **Eniola Bakare**
DSS Rep: **Adam Lucas**

The Dalhousie Undergraduate Mathematics and Statistics Society is comprised of a group of dedicated students who volunteer their time to enhance the university experience of students in mathematical science programs. Over the past year, we planned several events for students to be able to socialize and meet others in the department.

In September, we had our annual Meet and Greet, where we helped introduce students to each other and the department. Later in the fall, and again in the winter, we held a pizza party in the Colloquium room. These events were very well attended, including appearances by both faculty members and first-year students, which is always exciting to see. Due to the university's closure in March, we were unable to host some of our previously planned events, including our annual Wine and Cheese, which is normally our biggest event of the year. Despite this disappointment, we hope that everyone enjoyed this year's events!

This year's executive would like to congratulate all those students who are graduating this spring, and wish them all the best with their future endeavors. We would also like to thank everyone who attended our social events this year for their support. Due to this year's extraordinary events, the executive members for next year are yet to be determined. But we plan to organize on-campus events for students as soon as it is possible to do so. Thanks again to everyone who helped make it a great year. We hope to see you all soon!

Kieran Bhaskar
President, DUMASS

HONOURS PROGRAM

This year we had a total of 16 honours students in our three programs. Each student, their project and their supervisor is noted below.

MATHEMATHICS

Jeremy Peters, An Overview of Geometric Algebra and its Applications to Physics and Relativity, Supervisor: Alan Coley

Vaughn Menchions, Symmetries and the Geometrization of Ordinary Differential Equations, Supervisor: Rob Milson

Adam Lucas, A Tale of Two Chordalities, Supervisor: Sara Faridi

Tingyu Zhang, Analyzing Music via Graph Theory and Statistics, Supervisor: Jason Brown

Christy Sabu Zacharia, Quantum Magic Games: An Extension of the Mermin-Peres Magic Square, Supervisor: Julien Ross

Charlie Gerrie, Amenable Groups, Supervisor: Keith Taylor

Liam Orovec, On Menon's Identity, Supervisor: Karl Dilcher

STATISTICS

Shaoming Kang, D-optimal design for linear regression, Supervisor: Lam Ho

Arman Kerimbek, Data Analysis for Epileptic Seizure Prediction, Supervisor: Bruce Smith

Renjie Peng, Maximum Likelihood Etimation of Parameters in the Matern Covariance Function, Supervisor: Bruce Smith

Fatma Sarhan, Bootstrapping and Survival Analysis, Supervisor: Edward Susko

Yuan Wu, Detection of Genes Associated with the Survival Rate of Breast Cancer Patients, Supervisor: Lam Ho

Zhixian Yang, Evaluation and comparison of using maximum likelihood estimation and cross-validation to estimate the correct tree in phylogentics, Supervisor: Edward Susko

Xiaohang Zhou, An investigation of binning strategies in goodness of fit testing, Supervisor: Edward Susko

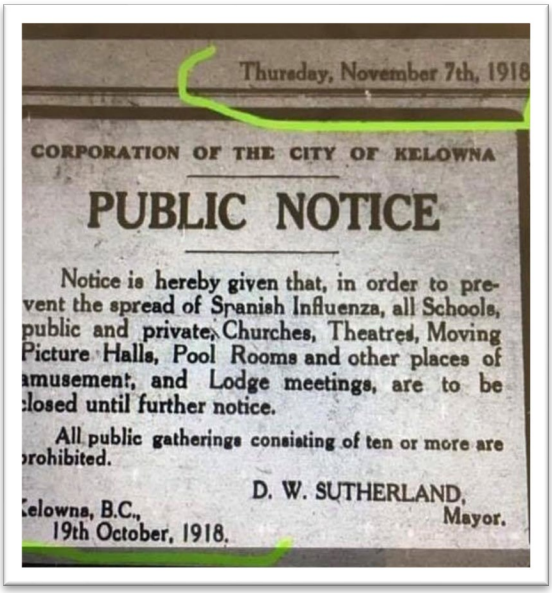
ACTUARIAL SCIENCE

Yunzheng Zhang: Modelling Changes in Mortality: Supervisor: Toby Kenney

Xinyuan Liu: Effects of Regulation Limitation on Modified Hotelling Model in Health Insurance Market: Supervisor: Toby Kenney

MATHEMATICS DIVISION REPORT

By Roman Smirnov, Director



Thursday, November 7th, 1918

CORPORATION OF THE CITY OF KELOWNA

PUBLIC NOTICE

Notice is hereby given that, in order to prevent the spread of Spanish Influenza, all Schools, public and private, Churches, Theatres, Moving Picture Halls, Pool Rooms and other places of amusement, and Lodge meetings, are to be closed until further notice.

All public gatherings consisting of ten or more are prohibited.

D. W. SUTHERLAND,
Mayor.

Kelowna, B.C.,
19th October, 1918.

Photo: A newspaper clipping that was published in the Kelowna Record in 1918 as the world fought to prevent the spread of the H1N1 virus, commonly called the "Spanish Flu." Source: "Did Cities Close Schools, Businesses During the 1918 Pandemic?" by Dan E

It has been a very interesting, eventful, and challenging year for the Mathematics Division. Many exciting things have happened over the last year. Our faculty, postdoctoral fellows, students, and staff have been actively engaged in teaching and learning, scholarly work that included research published in peer-reviewed journals, conference presentations, participation in seminars, administrative and service duties. We were lucky to be able to welcome new faculty members, introduce new courses, and participate in many extracurricular events and projects.

Mathematics continues to be a very important subject of study and is now arguably one of the most popular at Dalhousie University, where it is given high priority in curricula across the campus. In fact, apart from our department, mathematics is also taught, for instance, in the Faculties of Agriculture and Engineering, the Department of Physics and Atmospheric Science, the Department of Economics. Lately, the Faculty of Computer Science has been investing much of its resources into the development of new mathematics and statistics courses of their own that are replicas of the corresponding courses taught in the Department of Mathematics and Statistics (e.g., CSCI1300 is a computer science version of MATH1000 – a calculus course that has been taught in our department for years).

Up until March it looked like ``business as usual'' for us, when the COVID-19 pandemic changed the world in the course of one week. For the teaching and learning process at Dalhousie, as well as on every other university campus across the nation, this meant the cancelling of in-person exams, meetings, and co-op placements, the moving of classes to an online format and the shutting down of university buildings. Working under these adverse conditions, we did our best to make sure that all of our winter semester courses finished on

time, online versions of our summer courses were developed, and the Department continued in full force all of its functions in an online format.

We wish to thank all of the faculty, instructors, staff, and graduate students who have been working, often literally around the clock, to ensure a seamless transition from in-person to online teaching. We are very proud of our students, who managed to complete their courses performing under strenuous and stressful conditions of working and living in isolation.

Pandemics come and go, but no matter what happens next, we are sure that our team is poised to emerge from this pandemic stronger than ever. ``We shall overcome.''

STATISTICS DIVISION REPORT

By Hong Gu, Acting Director

Firstly, I am happy to report that student numbers in our division continue to grow, owing largely to the popularity of data science and artificial intelligence in this data dominated world. According to the statistics from faculty of science, there are 68 current Statistics majors and 37 Actuarial Science majors, for a total of 105 students. In addition, as always, there are even more students with their second major in Statistics or Actuarial Science. This has been reflected in our third-year classes where there are close to 100 students or more in each class. With only eight full time faculty members between statistics and actuarial science, we have successfully maintained a full suite of statistics and actuarial science programs, plus a large successful graduate program (with 17 current PhD students and 10 MSc students). Needless to say, all our faculty members have worked extremely hard to deliver the best programs and maintain the strict quality control for the excellence of our programs.

The division is greatly diminished by the coming retirement of Prof. Keith Thompson, who has served the division for many years (in a joint appointment with Oceanography). During his time here, he has supervised and co-supervised many graduate students in statistics and taught many courses. He was also appointed a Tier 1 Canada research chair in Marine Prediction and Environmental Statistics. We will greatly miss his presence in the department, both for his outstanding service to the department, and for his helpful and cheerful attitude. We wish him a happy and long retirement.

Dr. Orla Murphy has accepted our offer of a tenure track position in statistics and data science. She received her BSc in mathematics from St. F. X. University in 2011, MSc in Statistics from McGill university in 2013 and PhD in statistics from McGill University in 2018. She is currently a postdoc fellow in McMaster University. She will join us on July 1, 2021.

We also have several new graduate students. Students starting in fall 2019 include Wang, Mengyao (MSc candidate), Zhang, Wensha (PhD candidate) and Bjorndahl, Paul (PhD candidate). The incoming graduate students starting in fall 2020 include Haldoupis, Danielle (MSc candidate) and Kerimbek, Arman (MSc candidate). There are two incoming postdoctoral fellows: Krainski, Elias who started in Sept 2019, and Star, Shahideh, who started in early 2020 with funding from Mitacs. PhD student Jonathan Babyn returned to our department from DFO Newfoundland following his internship. MSc student Jiaxin Luo has

been awarded funding from the Atlantic Halibut Council to complete her thesis. MSc student Mia Parenteau has been funded by Mitacs-Accelerate to finish her thesis on the topic of Detection of Fights in Crowd Video. PhD student Xinyue Zhang has been funded by Mitacs accelerate fellowship for full four years for developing methods for artificial intelligence and data science in property valuation problems. MSc student Abe Adeeb put a tremendous amount of work into organizing a Hockey Hackathon in our department, only to have it cancelled due to COVID-19.

In Oct. 2019 convocation, we have Christopher Jones (PhD, co-supervised by Joe Bielawski and Ed Susko), Junqiu Gao (MSc, co-supervised by Hong Gu and Toby Kenney) and Joey Hartling (MSc, supervised by Mike Dowd). We have 3 students with first major in statistics and 2 students with second major in statistics graduated.

In May 2020 convocation, we have Paul Bjorndahl (MSc, co-supervised by Joe Bielawski and Hong Gu) and Vishal Sood (MSc, supervised by Ammar Sarhan). We have 7 students with concentrated Honours or combined Honours with first subject in statistics, we have 16 students either major in statistics or double major with the first subject in statistics and 19 students in double major with the second subject in statistics.

MSc student Molly Hayes (supervised by Hong Gu) has successfully defended her thesis in early May.

Congratulations goes to Andrew Irwin who has received four years of funding from the Simons Foundation (New York) as part of a multi-university research collaboration known as SCOPE (Simons Collaboration on Ocean Processes and Ecology) – Gradients. At Dalhousie, researchers working on this project will have the opportunity to collaborate with Zoe Finkel (Oceanography) and her research group, which is separately funded by this program. International collaborations at U Washington, Hawaii, MIT will provide a rich scientific environment for HQP to gain experience on a multidisciplinary project. The vision for the SCOPE-Gradients collaboration is to mechanistically predict ocean ecosystem structure and function. At Dalhousie the focus will be on developing and testing new models of microbial growth and stoichiometry using a multi-compartment model of cellular composition and function. Andrew also has recruited a new PhD student, Mohammad Amirian Matlob (MSc Tarbiat Modares University, Iran), who arrived in January 2020 to begin a PhD in applied mathematics on phytoplankton modeling of growth, community composition, and biogeography.

Joanna Mills Flemming has been working to establish CANSSI Atlantic, a regional node of CANSSI, based at DAL. She is hopeful the grand opening will be in early fall. Joanna, along with MSc student Raphael McDonald, PhD student Ethan Lawler and PDF Sofie (Yuan) Yan, organized and attended a workshop at The International Council for the Exploration of the Sea (ICES), in Spring 2019. ICES is an intergovernmental marine science organization, meeting societal needs for impartial evidence on the state and sustainable use of our seas and oceans.

I co-organized a 5-day workshop titled "workshop on Emerging Statistical Challenges and Methods for Analysis of Human Microbiome Data" at the Banff International Research Station in Sep. 2019 during my sabbatical leave. This workshop aimed to address some of the

main challenges in dealing with the microbiome data. The workshop brought together a number of investigators with different perspectives and different backgrounds that ranged from practitioners and users, to developers of statistical approaches for studying microbial communities. Topics and presentations ranged from highly theoretical to entirely practical. The workshop was a big success.

ACTUARIAL SCIENCE

The Actuarial Science program continues to grow, with another 3 honours students and 5 major students graduating this year. With student enrolment continuing to increase, particularly in the higher-level classes, we expect the number of graduates will continue to grow.

Another 2+2 program has been approved with Bermuda College, taking effect on 1st July. Bermuda College is a community college, so they do not have the facilities to teach the higher-level Actuarial Science courses. Meanwhile, insurance is an important industry in Bermuda, so we hope this will be a good source of students for our program.

REFLECTIONS

FROM THE CHASE REPORT OF 10 YEARS AGO

Dug up by Karl Dilcher

JOHNSON'S LAW

Mathematics is full of rules and laws, such as Cramer's Rule, Pythagoras' Law, and many others. Perhaps a little less known is Johnson's Law, named after Professor Keith Johnson of this department who postulated more than 20 years ago that there has to be snow on the day of the Calculus exam in April. This can take the form of significant accumulation, or just a few flakes in the air, but year after year this law proved to be correct. Until finally this year, when we had an unusually mild early Spring and the law appeared to be broken at last. However, on the day of the big exam, Thursday, April 16, the temperature started to drop, and finally, when your law-abiding department chair went outside at around 11 p.m., there was indeed a wet snow shower. So, Johnson's Law remained valid for yet another year. -kd

Update: Even though this year the MATH 1010 exam was written remotely, with the 400 students distributed all over the world from British Columbia in the West to Japan in the Far East, and even though Keith Johnson retired last July, Johnson's Law proved to be true again this April 18th.

THE BALCONY SCENE

As every department member knows, one of the nicest features of the Chase Building is our balcony. In fact, last year it served as the backdrop for wedding photos for at least two couples who had connections with our department.

But now the balcony has also been discovered by the Dalhousie Theatre Department. On March 31st a group of three theatre students asked for permission to use our balcony as a stage for a class project. Obviously, permission was granted, and rehearsals began immediately. On that day and the next, April 1st, our balcony presented quite a spectacle, and occasionally it got rather loud.

And no, it was NOT Romeo and Juliet, nor was this an April Fool's joke, as at least one department member of little faith had conjectured.

A DOUBLE ANNIVERSARY

This coming Fall and Winter mark a double anniversary for our department: The construction of the Provincial Archives Building (now the Chase Building) was completed 80 years ago, in 1930, and the formal opening took place on January 14, 1931. Secondly, the then Department of Mathematics, Statistics and Computing Science moved into the newly renovated (but not quite finished) building for the Fall term of 1985. The careful planning that preceded the move was chaired by Tony Thompson, in collaboration with the University Architect at the time, and with the help of many staff and faculty.

AN ALMOST PERFECT TRACK RECORD

By Karl Dilcher

While reading the Chase Report of 20 years ago, I came across a list of eight graduate students who received their M.Sc. or Ph.D. degrees in the October 1999, Convocation. I immediately recognized four of them as current faculty members in as many universities in Atlantic Canada. That already would have been an excellent record, but it is even better: Three of the remaining four graduates, whose names I only vaguely remembered, also have faculty positions in the US and in China!

The seven graduates in question are, along with their supervisors:

- Nancy Clarke (M.Sc. Math., Richard Nowakowski), Professor of Mathematics, Acadia University
- Stephen Finbow (M.Sc. Math., Richard Nowakowski), Professor and Chair, St. Francis Xavier University
- J Concepcion Loredo-Osti (Ph.D. Stats., Bruce Smith), Professor of Statistics and Department Head, MUN
- Annik Martin (M.Sc. Math., Shigui Ruan), Senior Lecturer, Idaho State University
- Mitja Mastnak (M.Sc. Math., Luzius Grunenfelder), Professor of Mathematics, St. Mary's University
- Rong Wang (M.Sc. Math., Pat Keast), Associate Professor, Southern University of Science and Technology, Shenzhen, China
- Changchun Xie (M.Sc. Stats., Bruce Smith), Professor of Biostatistics, University of Cincinnati

NEWS TO NOTE

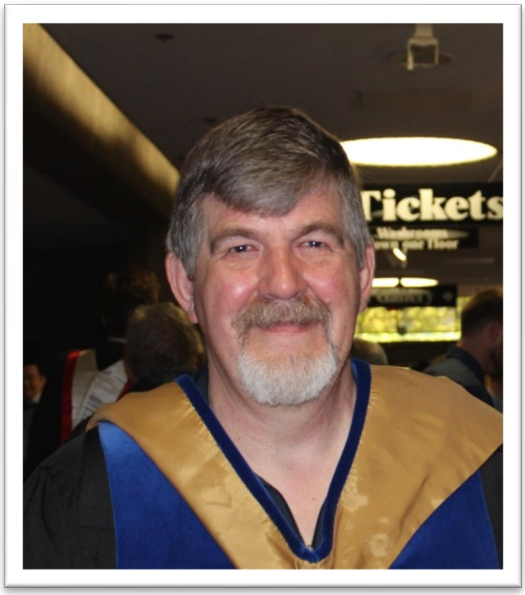
YEARS OF SERVICE AWARDS

Jason Brown was acknowledged by Dalhousie for his 25 years of service.

Roman Smirnov was acknowledged by Dalhousie for his 15 years of service.

FACULTY RETIREMENTS

This year two faculty members have retired: **Keith Taylor** and **Keith Thompson**.



Keith Taylor

KEITH TAYLOR RETIRES

Provided by Karl Dilcher

After 17 years at Dalhousie, Keith Taylor is going to officially retire as of June 30, 2020.

When Keith arrived at Dalhousie in July of 2003 as Dean of Science, he was no stranger to our department. In fact, he wrote in the 2004 Chase Report, "Twenty years ago I spent a sabbatical year at Dalhousie University visiting the research group in operator theory headed up by Professors Fillmore and Radjavi. It was a year that had a major impact on the rest of my career as I was able to initiate two new lines of enquiry that both turned out to be fruitful. Moreover, my wife, Julia, and I established some lifelong friendships here in Halifax. This fondness we had for Dalhousie and the city made us susceptible when the search consultants contacted me in Saskatoon in late 2002 to encourage me to apply for the position of Dean of Science at Dalhousie University. To be truthful, it was an extremely hard decision to leave the University of Saskatchewan where I had spent 26 enjoyable years and Dalhousie

was pretty much the only place I would have moved to. So I let my name stand and, to my astonishment, I was selected."

Keith grew up in Nova Scotia, on a farm in Antigonish County. He earned his first degree at St. Francis Xavier, a university of which he has always been a proud and loyal alumnus. He then moved West, and received his Ph.D. at the University of Alberta in 1975, as the first of Tony Lau's numerous students. Soon afterwards he joined the University of Saskatchewan, as mentioned above.

In addition to being an excellent teacher and researcher, Keith's whole career was dominated by a sense of service to the community, in fact to several communities within and outside his two universities. This is best summarized by the citation for his 2018 Graham Wright Award for Distinguished Service (quoted, in part, already in last year's Chase Report):

"Praised by his colleagues as being an 'excellent role model for a well-rounded mathematician', Dr. Taylor's career, spanning more than four decades, has truly exemplified what this award represents, not just because of his excellent record of research and mentorship, but also through his academic work as Associate Dean, Dean and Associate Vice President at two Universities and through years of fundamental service to the CMS, including a term as President (2012-2014).

Indeed, just to list his CMS committee work and appointments takes a full page on his vitae! Past President and Chair of the CMS Distinguished Awards Selection Committee Dr. Michael Bennett (UBC) asserts "Taylor's real contribution to Canadian mathematics goes far beyond a few lines on his CV. It lies more in his continued striving for educational excellence, in award-winning teaching, and through remarkable and continuing commitment to outreach.

"Dr. Taylor`s later outreach work focusses on developing pathways to mathematical literacy for underrepresented groups in Saskatchewan and Nova Scotia, and consistently supporting and championing disadvantaged communities. Among his many honours are the Master Teacher Award from the University of Saskatchewan in 2001 where he also championed the "The Math Readiness Project" aimed at bridging the gap between high school and college/university mathematics, especially for students in remote areas. In 1996, Taylor was awarded the President's Educational Site Award for the MRC web course at the University of Saskatchewan. The following year, Dr. Taylor received the Student Union Teaching Excellence Award."

During his 10 years as Dean of Science and Associate Vice President here at Dalhousie, Keith regularly taught a course in our department, and remained active in research. After taking an accumulated and well-deserved administrative leave, Keith became a full-time member of our department for the last few years. Knowing Keith, he will not rest on his laurels, and will contribute to the community, relieved of some of the day-to-day duties.

Keith, we wish you many more years of good health and good mathematics!

Keith Thompson

RETIREMENT: KEITH THOMPSON

Provided by Mike Dowd

Keith Thompson is retiring on July 1, 2020. He was educated in the UK, and came to Dalhousie first as a post-doc, and then as a faculty member. Keith held a joint appointment in the Depts of Mathematics&Statistics and Oceanography.

His research involved the use and development of advanced statistical methods for oceanographic problems, using a fusion of spatio-temporal statistics with the theory of ocean dynamics. These were "big data" problems in the days before they were recognized as such. He notably had a longstanding interest in the development of operational ocean forecasting systems through data assimilation. He pioneered coastal forecasting for Canadian waters, with one important focus being a sea-level or storm surge prediction that is now being used operationally.

Keith always strove for excellence and constant improvement in his teaching. He had a special talent for crafting clever examples to illustrate key concepts. He regularly taught many of our graduate courses (Time Series Analysis, Multivariate Analysis), as well as being a dedicated, long-time instructor for first year Introductory Statistics. His success in teaching was evident, and many people considered him as their best instructor.

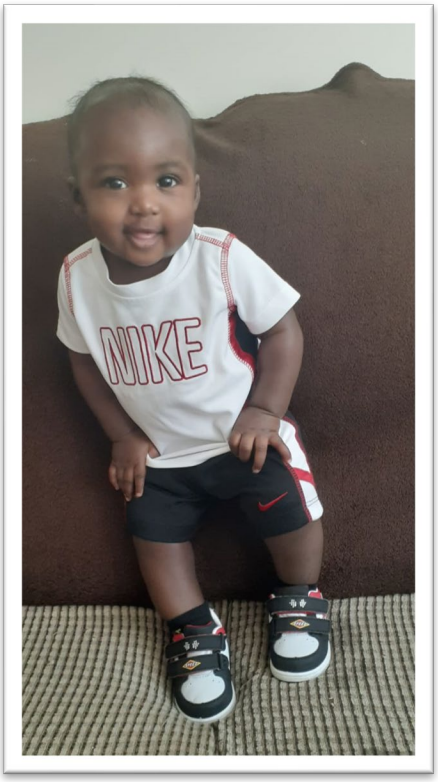
Keith held a CRC Tier 1 research chair for many years and as part of this helped establish the Environmental Statistics program of the Statistics division. During his career, he trained many graduate students and post-docs, and left a real legacy in passing on his research approach resulting in many of his students now holding prominent positions at universities and in government. In fact, three of Keith's PhD students have become faculty members at Dalhousie (Mike Dowd, Math&Stats; Eric Oliver, Oceanography; Swarna Weerasinghe, Community Health and Epidemiology).

NEW ADDITIONS

Department members welcomed several new additions to their families this year.

Ryan Ahmadi - Maryam Ehya Jahromi welcomed her son Ryan Ahmadi, born on May 17th, 2020.

Daniele Turchetti and his wife welcomed Cosimo Turchetti on December 12, 2019.



Catherine Antwi and her husband welcomed Eliel Kwame Boakye on October 26, 2019.

Sarah Chisholm and her family welcomed Quinn in the spring of 2020.

POST-DOCTORAL FELLOWS

Dr. Shahideh Star commenced early in 2020. Joanna Mills F has a new MITACS funded PDF Shahideh Star, being co-supervised with Bruce Martin of Jasco.

Dr. Martin Szyld started in February of this year as a postdoc with Dorette Pronk and is working with her on double categories and other 2-dimensional structures. He completed his PhD in 2015 from the University of Buenos Aires, Argentina, where he also worked as a postdoctoral fellow with Eduardo Dubuc. His main research interests are in topos theory and in higher category theory.

Dr. Lin Jiu joined our department at the end of August of 2017 as a Killam PDF, and has been working with Karl Dilcher. After completing his Ph.D. at Tulane University, he had previous postdoctoral positions in Linz, Austria. For three years now, Lin has been the organizer of a very active Number Theory Seminar, followed by a Reading Seminar on Special Functions. After the completion of his two years as a Killam PDF, Lin has stayed on as a Research Associate.

VISITING FACULTY

Christophe Vignat of the Université Orsay (France) and Tulane University visited the department again from June 11 to September 14, 2019. He was here to work with Karl Dilcher and Lin Jiu. This was Christophe's fifth visit to Dalhousie.

It is no longer accurate to list **George Beck** as a visitor. He did indeed visit Karl Dilcher in the Summer of 2019, but then moved permanently to Halifax from Comox, BC, in the Fall of 2019. George joined Wolfram Research in Champaign, IL, in 1993 as a technical writer, and he continued working on Mathematica Demonstrations and as Editor of the Mathematica Journal after his return to Canada in 2007. George is interested in various aspects of partitions, and his work has caught the attention of experts in the field, such as George Andrews. Here at Dalhousie George has been a regular attendee (and participant) of various seminars, and audited some advanced courses.

BOOKS WANTED AND FOR SALE

by Karl Dilcher

As I mention every year in the Chase Report, I keep, and have catalogued, a large number of surplus books that have been donated over the years by current and retired faculty members, alumni and departing students. Over the last few years, around 1,500 volumes were sold to mathematicians around the country and dozens more around the world. I was able to donate the sizeable income from these sales back to our department and to the CMS.

Almost 2,000 volumes still remain; they are catalogued at:

http://www.mathstat.dal.ca/~dilcher/oldb ooks.html.

As always, I welcome further donations of mathematics, statistics and related books, including textbooks of any kind. Anything that is deemed suitable for the library will be placed there. In my experience, eventually most of the books find a good home and as an extra bonus, two good causes will be supported. I thank all those who have donated their books.

A related initiative is what I informally call the Calculus Textbook Preservation Project. I'm keeping one copy of each edition of each calculus textbook that I can get my hands on; they are hidden in the basement. Quite surprisingly, without much effort on my part, this collection has grown to about 500 volumes. For this initiative too, I welcome any further volumes, once circumstances make book donations easier.

SUMMARY OF COLLOQUIA& SEMINARS

MATHEMATICS COLLOQUIA

Organizer: Sara Faridi

Sep 19 - Heydar Radjavi (University of Waterloo): Operators With Compatible Corners

Sep 26 - Colin Macdonald (UBC Vanvoucer): Numerical computation on surfaces and applications involving anisotropic diffusion

Oct 21 - Hermann Brunner (Hong Kong Baptist University): Recent developments in the numerical analysis of Volterra integral equations

Oct 24 - Theo Johnson-Freyd (Perimeter Institute): Bott periodicity from quantum Hamiltonian reduction

Dec 2 - Scott Rodney (Cape Breton University): Regularity estimates for PDE with data in non-standard spaces

Dec 5 - Chunhua Ou (MUN): Speed of the traveling wave for a bistable Lotka-Volterra competition model

Dec 10 - Michael Filaseta (Univ. of South Carolina): 495986669891512260981042445129 18

Jan 13 - Leandro Vendramin (University of Buenos Aires): Algebra with GAP

Jan 23 - Susan Cooper (University of Manitoba): Exploiting Collinearity

Jan 27 - S. Ahmad Mojallal (GERAD, HEC Montreal): On the difference of energies of a graph and its complement graph

Feb 27 - Suresh Eswarathasan (Dalhousie University): Restrictions of eigenfunctions to general subsets of surfaces

Mar 12 - Keith Johnson (Dalhousie University): Rational Polynomials which Preserve the Ring of Integer nxn Matrices

Links to each talk are available at these sites:

https://mathstat.dal.ca/~faridi/colloquium/Fall-2019.html

https://mathstat.dal.ca/~faridi/colloquium/Winter-2020.html

STATISTICS SEMINARS

Organizer: Lam Ho

October 3, 2019 (Joint with CGEB Seminar) - Marc Suchard (Departments of Biomathematics, Biostatistics and Human Genetics, UCLA): "Gradients do grow on trees: linear-time gradients for high-dimensional phylogenetics"

October 10, 2019 - Elias T. Krainski (Departments of Mathematics and Statistics, Dalhousie University): "Spacetime models using the SPDE approach"

October 31, 2019 - Andrew Rutenberg (Department of Physics, Dalhousie University): "The physics of human aging"

November 21, 2019 - Roman Smirnov & Kunpeng Wang (Department of Mathematics and Statistics, Dalhousie University): "On mathematical and statistical tools for data analysis "

November 28, 2019 - Arnold Mitnitski (Department of Medicine, Dalhousie University) "Measuring and modeling health and aging"

March 2, 2020 - Eric Pedersen (Department of Biology, Concordia University): "Hierarchical Generalized Additive Models in ecology"

March 5, 2020 - Orla Murphy (McMaster University): "Applications in extreme value analysis and current work" Abstract

March 9, 2020 - Neil Spencer (Carnegie Mellon University): "A new framework for modeling sparse networks that makes sense (and can actually be fit!)" Abstract

Abstracts for each talk are available:

https://www.mathstat.dal.ca/~lho/seminar/2019_2020.html

ATCAT SEMINAR 2019-2020

Organizer: Julien Ross

September 3rd, 2019.
Robert Paré (Dalhousie University): Kleisli Double Categories I

September 17th, 2019.
Robert Paré (Dalhousie University): Kleisli Double Categories II

September 24th, 2019.
Geoffrey Cruttwell (Mount Allison University): Vector Fields and Flows, Categorically I

October 1st, 2019.
Geoffrey Cruttwell (Mount Allison University): Vector Fields and Flows, Categorically II

October 8th, 2019.
Geoffrey Cruttwell (Mount Allison University): Vector Fields and Flows, Categorically III

October 22nd, 2019.
Theo Johnson-Freyd (Perimeter Institute): Condensation and Idempotent Completion

October 29th, 2019.
Frank Fu (Dalhousie University): Interpreting a Simple Dependent Type System in a Locally Cartesian Closed Category

November 5th, 2019.
Jeff Egger: On the Naturality of Fourier-Stieltjes Transforms I

November 26th, 2019.
Jeff Egger: On the Naturality of Fourier-Stieltjes Transforms II

January 7th, 2020.
Toby Kenney (Dalhousie University): Euclidean Convexity Spaces

January 28th, 2020.
Lisa Nicklasson (Stockholm University): Ideals with Linear Powers

February 4th, 2020.
Matthew Amy (Dalhousie University): Path Integrals and Symbolic Quantum Computing

February 25th, 2020.
Jeff Egger: An Element-Free Description of the Mix Structure on Ban

March 3rd, 2020.
Martin Szyld (Dalhousie University): Sigma limits in 2-categories and applications

March 10th, 2020.
Toby Kenney (Dalhousie University): Euclidean Topological Convexity Spaces

NUMBER THEORY SEMINAR

Organizer: Lin Jiu

Sept. 11, 2019 Christophe Vignat
A Probabilistic Approach to Some Elliptic Functions

Sept. 16, 2019 Lin Jiu
On b-ary Binomial Coefficients

Sept. 23, 2019 Lin Jiu
Examples on Several Integration Methods

Sept. 30, 2019 Karl Dilcher
Infinite Products Involving Dirichlet Characters and Cyclotomic Polynomials

Oct. 7, 2019 Keith Johnson
Integer Valued Polynomials and Division Algebras

Oct. 21, 2019 Manar Benoumhani
Additive decomposition of polynomials over unique factorization domains

Oct. 28, 2019 Daniele Turchetti
Lifting automorphisms of power series from characteristic p to characteristic 0

Nov. 4, 2019 Asmita Sodhi
Integer-Valued Polynomials over $p\times p$ Matrices

Nov. 20, 2019 Abdullah Al-Shaghay
Some Classes of Generalized Cyclotomic Polynomials

Nov. 25, 2019 Heesung Yang
Variant of a theorem of Erdos on the sum-of-proper-divisors function

Dec. 2, 2019 George Beck
Distinct and Complete Integer Partitions

Dec. 20, 2019 J.C. Saunders
Diophantine Equations Involving the Euler Totient Function

In the Winter Term of 2020, the Number Theory Seminar was replaced by the "Reading Seminar on Special Functions, Orthogonal Polynomials, and Partitions", partly based on the book "Special Functions" by G. Andrews, R. Askey and R. Roy.

The presentations were as follows:

Jan. 13, 2020 Lin Jiu
Gamma Function (Chpt. 1)

Jan. 27, 2020 Lin Jiu
Hypergeometric Function (Chpt. 2--3)

Feb. 24, 2020 Daniele Turchetti
Topics on Hypergeometric Functions (Chpt. 3--4)

Mar. 9, 2020 Xiaoyu Jia
Orthogonal Polynomials (Chpt. 5--6)

Unfortunately, the two remaining talks by Heesung Yang: q-Series (Chpt. 10) and George Beck: Partitions (Chpt. 11) had to be cancelled. Slides and/or notes of the talks can be found at https://chase.mathstat.dal.ca/~ljiu/readingseminar/SFOPP.html

TALKS GIVEN BY OUR FACULTY ELSEWHERE

JULIEN ROSS:

- January 2020 : Number-Theoretic Perspectives on Fault-Tolerant Quantum Circuits (Invited Lecture, Joint Center for Quantum Information and Computer Science Five-Year Anniver-sary Symposium, University of Maryland)
- October 2019 : The ZX-calculus (Invited Lecture, AARMS Session on Hopf Algebras and Tensor Categories, 2019 Science Atlantic Conference for Mathematics, Satistics, and Computer Science, Halifax)
- June 2019 : A Characterization of Integral, Real, and Gaussian Clifford+T Operators (Invited Lecture, The Mathematics Behind Quantum Information Science, CMS Summer Meeting, University of Regina)
- June 2019 : Number-Theoretic Methods in Quantum Compiling (Invited Lecture, Mathematical Techniques for Analysing Quantum Structures and Materials, CMS Summer Meeting, University of Regina)

JASON BROWN:

- February 12, 2020 : “Independence Polynomials and Their Roots”, Department of Mathematics , University of Central Florida
- February 14, 2020 : “Independence Polynomials and Their Roots”, Department of Mathematics and Statistics, University of South Florida
- February 17, 2020 : “All You Need is Math”, public lecture, University of South Florida

DORETTE PRONK:

- "Weakening of the Conditions for a Bicategory of Fractions", at the 27th Workshop on Foundational Methods in Computer Science, University of Calgary, June 1, 2019
- "Nice Properties of the Bicategory of Orbigroupoids", in the Special Session on "Categorical Approaches to Topology and Geometry" during the 2019 Summer Meeting of the Canadian Mathematical Society, June 9, 2019
- "Left Cancellative Categories and Ordered Groupoids", at the International Conference on Category Theory 2019 at the University of Edinburgh, July 11, 2019

ROMAN SMIRNOV:

- In search of a new economic model determined by logistic growth in the Special Session on Applications of Dynamical Systems and Differential Equations. The V AMMCS International Conference, Waterloo, Ontario, Canada, August 18-23, 2019.
- A Hamiltonian framework for the problems of economic growth theory in the Minisimposium on Applied Analysis & Inverse Problems. The V AMMCS International Conference, Waterloo, Ontario, Canada, August 18-23, 2019.

KARL DILCHER:

- Infinite products involving Dirichlet characters and cyclotomic polynomials, Ramanujan Conference, Urbana, IL, June 8, 2019.
- Infinite products involving cyclotomic polynomials, CMS Winter Meeting, Toronto, Dec. 8, 2019.
- Solutions of certain polynomial Diophantine equations, CMS Winter Meeting, Toronto, Dec. 8, 2019.
- Short course on Analytic Number Theory
- Abdus Salam School of Mathematical Science, Lahore, Pakistan, February 2020.

DISTINGUISHED SPEAKER SERIES

ALMOST 20 YEARS

by Karl Dilcher

This is a good opportunity to look back to the first Distinguished Lecture, which took place almost 20 years ago. A driving force behind the establishment of the lecture series was Dr. R.P. Gupta, now Professor Emeritus and a former Department Chair. Here is an excerpt from the 2001 Chase Report:

"The first Distinguished Lecture in the Department of Mathematics and Statistics was given on March 19, 2001, by Gregory J. Chaitin of the Thomas J. Watson Research Center in New York. Gregory was invited to write the first volume in the Cambridge University Press series on theoretical computer science, his 1987 monograph "Algorithmic Information Theory". In addition, three volumes of his papers have been published by World Scientific. His three most recent books, all published by Springer-Verlag, are "The Limits of Mathematics", "The Unknowable", and his most recent book is "Exploring Randomness". 220 people attended the lecture which was well received by the audience."

FALL 2019 DISTINGUISHED SPEAKER

by Karl Dilcher

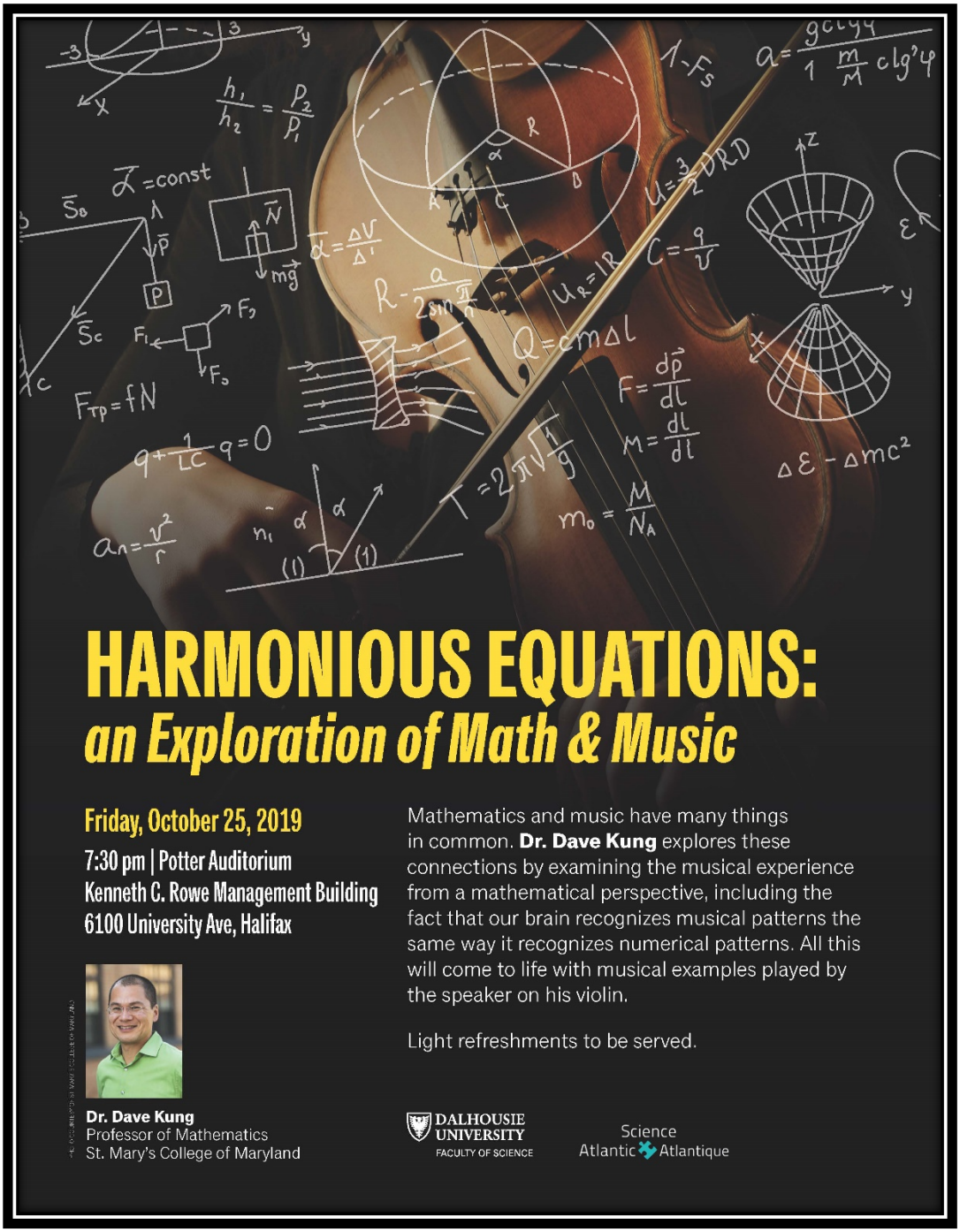
Last Fall's talk in the Department's Distinguished Speaker Series took place on Friday, October 25, 2019 in the Potter Auditorium, one of the largest lecture halls on campus. The speaker was Dr. Dave Kung of St. Mary's College of Maryland, and the title of the talk was "Harmonious Equations: an Exploration of Math & Music". The lecture was very well attended, and as always, it was followed by a reception.

Below is a summary of this fascinating talk which as interesting to the general audience as it was to a professional mathematician.

"Mathematics and music seem to come from different spheres (arts and sciences), yet they share an amazing array of commonalities. We will explore these connections by examining the musical experience from a mathematical perspective. The mathematical study of a single vibrating string unlocks a world of musical overtones and harmonics, and even explains why a clarinet plays so much lower than its similar-sized cousin the flute. Calculus, and the related field of differential equations, shows us how our ears hear differences between two instruments - what musicians call timbre - even when they play the same note at the same loudness. Finally, abstract algebra gives modern language to the structures beneath the surface of Bach's magnificent canons and fugues. Throughout the talk, mathematical concepts will come to life with musical examples played by the speaker, an amateur violinist."

Here is a short biography of the speaker: Dave Kung fell in love with both mathematics and music at a very early age. More successful with one than the other, he completed three degrees from the University of Wisconsin - Madison, none in music, before joining the faculty at St. Mary's College of Maryland. He enjoys playing violin with students, in the local community orchestra, and with his daughter. He has authored a variety of articles on topics in harmonic analysis and mathematics education, and is the recipient of numerous awards including the 2006 Teaching Award and 2017 Service Award from the MD/VA/DC section of

the MAA. His Great Courses lectures, How Music and Mathematics Relate, have quickly become a top Math & Science seller for the Teaching Company. He serves as director of MAA Project NExT, a professional development program for new faculty in the mathematical sciences.



DEPARTMENT HOSTED MEETINGS & COMPETITIONS

Submitted by Dorette Pronk

The **William Lowell Putnam Mathematical Competition** is the preeminent undergraduate mathematics competition in Canada and the United States. Each year on the first Saturday in December, more than 4,000 students spend two 3-hour sessions solving 12 problems. We congratulate Xiaoyu Jia who scored 25 points and ranked in place 371.5 among the 4,229 students at 570 institutions that participated in the competition.

The session on "Categorical Approaches to Topology and Geometry" was co-organized by Dorette Pronk (with Marzieh Bayeh and Darien DeWolf).

The 2019 Science Atlantic Undergraduate Conference in Mathematics, Statistics and Computer Science was held on October 25-27, 2019, and hosted by Dalhousie University. The organizers were Vlado Keselj from Computer Science and Julien Ross and Dorette Pronk from Mathematics. We are also very grateful for the large number of volunteers that helped us make this possible. For our department, we want to acknowledge Asmita Sodhi and Fahimeh Bayeh who worked through the submitted abstracts and created the program for the meeting, as well as Daniele Turchetti, Finlay Rankin, and Owen Zhang who seemed to know very well when they were needed in any particular spot during the conference. Thanks to all of you and the army of volunteers from computer science everything went very smoothly. We received 220 registrations from students and faculty from all Atlantic universities. The conference started on Friday afternoon with a programming competition in computer science and a problem-solving competition in mathematics with a record number of teams participating in both. Our department was well-represented by our students: the problem-solving team consisting of Xiaoyu Jia and Vaughn Menchions won the shared second place in the problem-solving contest (shared with a team from Memorial University, after the first place team from UNB, Fredericton) and Jeremy Peters won the first place Best Oral Presentation Research Award for his research presentation on "Geometric Algebra for Relativity" (supervisor: Alan Coley). Congratulations! Other students from our department who spoke at the conference were: Kieran Bhaskara (Fractions with a Twist: Continued Fractions and Polynomial Pell Equations; supervisor: Karl Dilcher), Sarah Li (Towards a Finite Presentation of Unitary Dyadic Operators; supervisor: Julien Ross), Adam Lucas (A Look at Distributed Computing and Modal Logic; supervisor: Kohei Kishida), Charlie Gerrie (Multi-block Analysis of Unixcrypt; supervisor: Peter Selinger).

The named lectures for this meeting were:

- Blundon Lecture (Math): Dr David Kung (University of Maryland) – Harmonious Equations: an Exploration of Math and Music
- Sedgwick Lecture (Computer Science): Dr Jeffrey Shallit (University of Waterloo) – Additive Number Theory via Automata
- Fields Lecture (Statistics): Dr Michael Newton (University of Wisconsin) – Bayesian Inference by Example in Computational Biology

Both Dr Kung's lecture and Dr Shallit's lecture were part of the university's distinguished lecture series and we are grateful for the support from the appropriate funds to invite these speakers.

With the support of AARMS we were able to host a research session on Hopf Algebras and Tensor Categories on Sunday morning that was co-organized by Yorck Sommerhäuser from Memorial University and Julien Ross and Peter Selinger from Dalhousie.

Further financial support was gratefully received from our department, from the Faculty of Computer Science, the Faculty of Science, CGI, ShiftKey Labs and Morneau Shepell Ltd.

We also thank the office staff in both computer science and our department for all the support received, and in particular Ann Bannon for all the work she has done to make the Distinguished Lecture by David Kung with its reception on Friday night a huge success.

Affiliated Organizations & Societies Updates

CANADIAN MATHEMATICAL SOCIETY (CMS)

CMS PRESS RELEASE EUROPEAN GIRLS' MATHEMATICAL OLYMPIAD

submitted by Dorette Pronk

This year the CMS issued a media release regarding the Canadian Girls' Math Team winning two medals and an honourable mention at the European Girls' Mathematical Olympiad (EGMO). The full press release is available here:

https://cms.math.ca/MediaReleases/2020/EGMO2020Results

THE CMS WINTER MEETING 2019

by Karl Dilcher

The last Winter Meeting took place in downtown Toronto, December 6-9. With 650 participants it was one of the larger meetings in the Society's history, also as far as the number of sessions (33) was concerned. A recent feature of the CMS meetings is the minicourses which are run on the first day. These are intended to familiarize mathematicians, in a few hours, to a topic of current interest. To take advantage of these minicourses one does not need to participate in the whole meeting.

Once again, there was good Dalhousie participation in the CMS meeting. The following current department members were involved in the scientific program:

Sara Faridi was a co-organizer of the Session on "Commutative Algebra", and **Mayada Shahada** spoke in this session.

Richard Nowakowski gave a talk in the session "Graph Searching".

Rob Milson and **Karl Dilcher** gave talks in the session "Special Functions and Their Applications". The latter also spoke in "Analytic Number Theory".

Once again, our graduates, from honours B.Sc. to Ph.D., were well represented. The following is an alphabetic list, with the sessions they co-organized or in which they gave a talk:

- Ali Alilooee (Bradley University): Commutative Algebra.
- Peter Crooks (Northeastern University): Algebraic Geometry and Representation Theory.
- Nancy Clarke (Acadia): Graph Searching.
- Adam Clay (Manitoba): Topology.
- Robert Dawson (SMU): Interplay between Discrete Geometry, Analysis and Combinatorics.

- Stephen Finbow (St. Francis Xavier): Graph Searching.
- Wendy Finbow-Singh (SMU): Interplay between Discrete Geometry, Analysis and Combinatorics.
- Melissa Huggan (Ryerson): Graph Searching.
- Colin Ingalls (Carleton): Combinatorial Algebraic Geometry.
- Margaret-Ellen Messinger (Mt. Allison): Graph Searching.
- Jamie Mingo (Queen's): Operator Algebras.
- Shigui Ruan (University of Miami; former faculty member): Modeling Population Dynamics: Applications and Recent Developments.

Apart from this meeting, members of this department remain strongly involved with the CMS, for instance, Sara Faridi currently serves as VP Atlantic, and the following serve on various committees: Asmita Sodhi (Student and Education Committees); Jeannette Janssen (International Affairs), Dorette Pronk (Mathematical Competitions -- Chair, and IMO Committee); Keith Johnson (Nominating Committee); Sara Faridi (Research); and Keith Taylor and Karl Dilcher are Editors-in-Chief of the CMS Book series.

In other CMS news: The 75th Anniversary meeting, which was supposed to be held this June in Ottawa, was postponed for a year. As a consequence, the CMS Summer Meeting, which had been scheduled to be held here at Dalhousie in June of 2021, will be postponed to a later date; Suresh Eswarathasan is chairing the local committee.

Let me finish with an appeal from Sara who writes as our VP: "The success of the CMS rests upon the support of the Canadian mathematical community. The Toronto meeting and the postponed anniversary meeting in Ottawa were some of the largest and most mathematically diverse in recent years. Thank you for supporting your society!"

ATLANTIC ASSOCIATION FOR RESEARCH IN THE MATHEMATICAL SCIENCES (AARMS)

Submitted by David Langstroth

AARMS has had a busy year. On the research side, as well as supporting numerous conferences and workshops we are proud to award funding to two new Collaborative Research Groups:

- Computational Aspects in Finance and Insurance, administered by Kai Liu (UPEI)
- Groups, Rings, Lie and Hopf Algebras, administered by Yorck Sommerhäuser (MUN)

The 18th AARMS Summer School in 2019 was held at UPEI and focussed on various topics from the theory of differential equations. Several students were able to attend this year's School under the Memorandum of Understanding between AARMS and the African Institute of Mathematical Sciences.

Two newer AARMS initiatives had their second incarnation in the summer of 2019. The first is the AARMS-Girl Guides outreach event "All SySTEMs Go". This year's camp saw over 500 girls aged 9-17 visit Dalhousie and St Mary's universities for a weekend of STEM based learning with a mathematical sciences flavour.

The other event held for the second time in 2019 was the AARMS Industrial Problem Solving Workshop (IPSW). Presenters included a number of organizations interested in health data analytics such as the Government of New Brunswick and the New Brunswick Health Council.

And in 2019 we provided funding for a new postdoctoral fellowship for Dr. Abraham Westerbaan who will be working at Dalhousie under the supervision of Dr. Peter Selinger.

Finally, like every other institute in the world, COVID-19 will play a huge role in shaping our 2020 activities. All of the AARMS-organized signature events for the summer have been cancelled, and many of the activities we have agreed to support will not happen. Conversely, the coronavirus pandemic has allowed us to forge new relationships with national and provincial funding bodies to support research in mathematical modelling. To this end, a consortium of Canada's mathematical sciences institutes have received funding from Canada's Institutes for Health Research (CIHR) for infectious disease research. AARMS has received further matching funding from the New Brunswick Health Research Foundation (NBHRF) to specifically support research in Atlantic Canada.

CANADIAN STATISTICAL SCIENCES INSTITUTE (CANSSI)

Joanna Mills Flemming has been working to establish CANSSI Atlantic, a regional node of CANSSI, right here at DAL. She is hopeful the grand opening will be in early fall.

Community Outreach

CMS MATH CAMP (JULY 14 - 19, 2019)

By Roman Smirnov

During the second week of July, the Department of Mathematics and Statistics at Dalhousie University hosted the annual math camp for high school students, whose goals were to identify, stimulate and encourage mathematical talent among Nova Scotia high school students. To select the participants, we sent invitations to all of the schools in the province asking them to nominate two top students from each school. We then selected the 20 best students from this pool of qualified nominees, based on the letters of recommendations from their respective math teachers, math competition results, as well as their school grades. The camp was jointly sponsored by Dalhousie University, the Canadian Mathematical Society and AARMS. It consisted of lectures and problem-solving sessions conducted by faculty members and graduate students from Dalhousie, Mount Saint Vincent and Acadia Universities and also included extracurricular activities. There were 20 students (10 girls and 10 boys) from Grades 10 and 11 participating in the math camp, which was organized by Roman Smirnov (Dalhousie) and Asmita Sodhi (Dalhousie). The speakers at the camp this year were Marzieh Bayeh, Karl Dilcher, Lam Ho, Julien Ross, Chelluri Sastri, Daniele Turchetti, Asmita Sodhi (all from Dalhousie), Danielle Cox (MSVU), and David Wolfe. Over the years many of the former math camp participants came to Dalhousie to study mathematics and/or other STEM subjects, doing very well in the process. For example, Dan Abarbanel, who came to Dal first as a high school student to participate in one of our summer math camps, later graduated from Dalhousie with a combined honours degree in mathematics and physics. He is working now on his PhD thesis in physics at McGill University. Another former participant of our math camps that we would like to mention is Dr. Neil Spencer, who has recently obtained his PhD in Statistics and Machine Learning from the Carnegie Mellon University.

The COVID-19 pandemic has altered our plans for this year's math camp. It may be organized at a later time and in a different format, but we are sure that the program will continue to attract our most brilliant students from around Nova Scotia for many years to come. Please talk to my esteemed colleagues Prof. Suresh Eswarathasan and Dr. Asmita Sodhi, who are organizing the camp this year, if you wish to contribute to the camp as a volunteer speaker.

NS MATH CIRCLES

By Mayada Shahada

As the 2019/2020 school year draws to an end, Nova Scotia Math Circles remains busy with mathematics outreach in different levels and ways! Despite the difficult times we are all experienced together because of COVID-19 and the temporary suspension of our in-person services, this year has been a great success as we continue to increase the number of students we've presented to, creating new presentations and activities, and visit more new schools throughout the province.

For the 2019/2020 school year, the program has been run by Director Mayada Shahada, Assistant directors Asmita Sodhi and Maryam Ehya, and Teaching assistants Tom Potter, Justin Makary, Heesung Yang and Leila Mohammadi. This year, our program casual presenters were Rebecca Ryan, Mozhgan Saeidi, Daniele Turchetti and Giuseppe Pasqualino.

We started the year off strong by sending two teams to visit 9 new schools within Cape Breton-Victoria Regional Centre for Education. 1,313 students were visited, and 48 talks were given. During the same week, 12 homeschoolers from Sydney, enjoyed two talks given by Mayada Shahada in Sydney public library. During the first week of November, we ran a trip to 5 new schools within the Tri-County Regional Centre for Education. 745 students participated in 22 talks given by our teaching assistants.

Including the last visit done this year (on March 12th), we've visited 6378 students and gave 256 talks on day trips to schools in the counties of Halifax, Annapolis, Guysborough, Hants, Lunenburg and Kings. We also had the opportunity to visit several homeschooling groups and a group from the CBBC Career College. This year, we continued to grow our presence in the French community within Nova Scotia by offering presentations in two popular forums;

the French for the Future Forum and Bilingual Career Exploration Day, and in the French immerging program at several public schools.

Our monthly local events were popular as well! This year, six in-person events were given at Dalhousie Halifax Campus. Special thanks go out to Dr. Peter Selinger, Dr. Keith Taylor, Sarah Meng Li and Dr. Robert Milson from Dalhousie, Erick Lee from HRCE and Dr. Danielle Cox and Dr. Douglas Whitaker from MSVU. This June, Dr. Daniele Turchetti will give an online event to explore geometries via interactive activities.

The annual Math Teachers Conferences has been a great place to network; many new teachers were introduced to the program and enjoyed a sample of our activities. In regard to developing new material, we are adding 10 new presentations to our list and we are translating all our existed presentations to French.

Because of the great success and the huge growth our program has made over the past 5 years using Eastlink funding, Eastlink have decided to continue support the program for 5 more years (2021-2025). Thank you, Eastlink, for this generous gift! We can now continue to offer our fun outreach activities across the province, free of charge.

Thanks again to everyone who helped make this year a great success! Keep up to date with our events at www.nsmathcircles.com and via our Twitter account **@NSMathCircles**.

FUN MATH PROBLEMS:

SOLVE THE FOLLOWING ADDITION CRYPTARITHMS:

M A R S
M O O N
+ U R A N U S
_____
D E I M O S

SOLUTIONS ARE AT END OF THIS REPORT

DALHOUSIE MATH CLUBS

Submitted by Dorette Pronk

This year our department has continued to host two Math Clubs that are specifically focused on problem solving and math competitions. The senior club, for grades 7 and up, met on Mondays from 5:30 until 7:30 PM and the junior club, for grades 1-6, met on Wednesdays from 4:30 till 5:30 PM. The average attendance in the senior club was around 20 students a week, whereas the average attendance in the junior club was around 25 students. The interest in the junior club continued to increase over the semester as several extremely eager and bright students joined us, some travelling in all the way from New Glasgow.

Both clubs work on problems coming from various math competitions and go over the ways we approach these types of problems. Students then spend time solving problems in small group and present their solutions on the board. We are grateful to acknowledge that a large part of the funding that makes this possible comes from AARMS (the Atlantic Association for Research in the Mathematical Sciences). Most students participate primarily because they enjoy the challenge of solving math problems, but a good number of them also enjoys the challenge of national and international competitions. Our first contest was the Canadian Open Math Challenge organized by the Canadian Math Society.

Our students scored again extremely well: Robert Dumitru won the provincial Gold Award, Michael Lee won the provincial Silver Award and Mara Dumitru, Xingliang Li and Pratyush Makkar won the Provincial Honour Roll. Robert Dumitro won also the Gold Award for grade 12 and Xingliang Li won the Bronze Award for grade 12. Pratyush won the Gold Award for grade 10 and Nikifor Kiselev won the Silver Award for grade 10. Michael Lee won the Gold Award for grade 9 and was invited to write the Canadian Junior Math Olympiad (one of the "by invitation only" competitions). Maria Mihai won the Gold Award for students in grade 8 or under. The senior club students performed very well in the AMC 8, 10 and 12 competitions as well and Maria Mihai has been invited to write the AIME this year (the first invitational level competition organized by the MAA). Due to COVID-19 she has not yet been able to write this competition, but we just received news that she will be writing it online during the last week of May. The Math Kangaroo Contest, usually a highlight of the year for both math clubs, had to be postponed as well. We were all set up to hold it, but the original date was one week after we had to close down due to COVID-19 and the students will also be able to write this contest online during the last week of May. At the time of this writing I wish the students a very enjoyable contest.

COVID-19 also inspired some to create a new competition: the Global Quarantine Math Olympiad with participants from around the globe, ranging in age from 8 till 50. This competition was offered in two rounds: an easier round for the first weekend and a harder (Olympiad level) round the second weekend.

Both challenge clubs can only run because of the wonderful group of volunteers that help out each week. For the senior club, the AARMS outreach postdoc Daniele Turchetti has been a great partner in teaching and inspiring the students with new ways of looking at mathematics. Also, graduate students Asmita Sodhi and Fahimeh Bayeh have been invaluable in terms of both teaching and assisting with the administration of the club.

Undergraduate students Xiaoyu Jia and Benjamin Hatt have done a wonderful job in helping different groups of students work on specific questions. For the junior math club, we had an amazing group of undergraduate students engage the students in wonderful creative ways: Aeriana Narbonne, Annamieka Aerts, Kimberly Franklin, Maggie Bowman and Adam Lucas. During the fall semester, Aeriana, Annamieka and Kimberly created a large part of the curriculum for the club. During the fall semester, both clubs also benefited from the students in the MATH 3790 course: a course on mathematical problem solving that is part of the Science Leadership and Communication Program, hosted by the faculty of science. Students in the course are required to attend the math clubs a couple of times as assistants and lead the club twice. Our MATH 3790 students developed both leadership and communication skills through their participation in the math clubs. It was great to see some of them develop new ways of engaging the younger students with interactive games and logic puzzles where others took on the challenge of explaining some of their optimization problems to the upper level students. I want to take this opportunity to express a heartfelt thank you to all who have helped out with the math clubs this year and especially to the faithful volunteers who have been there every week to engage the students, keep them focused and spark their interest in challenging math problems.

HERE IS A PROBLEM FROM THE GLOBAL QUARANTINE MATH OLYMPIAD FOR YOU TO SOLVE:

Let n and k be positive integers such that $k \leq 2n$. Banana and Corona are playing the following variant of the guessing game. First, Banana secretly picks an integer x such that $1 \leq x \leq n$. Corona will attempt to determine x by asking some questions, which are described as follows. In each turn, Corona chooses k distinct subsets of $\{1,2,\cdots,n\}$ and, for each chosen set S, asks the question "Is x in the set S?" Banana picks one of these k questions and tells both the question and its answer to Corona, who can then start another turn. Find all pairs (n,k) such that, regardless of Banana's actions, Corona could determine x in finitely many turns with absolute certainty.

Proposed by Pitchayut Saengrungkongka, Thailand

SOLUTION AT END OF THIS REPORT

SOLUTIONS:

PUZZLE SOLUTION TO MATH CLUB PROBLEM:

The answer is: Corona wins if and only if $k \leq 2n-1$ or $(n,k) = (1,2)$. If $n=1$, then Corona wins without asking any questions. For the remainder of the solution, assume that $n>1$. We split the solution into two parts.

Part I: $k>2n-1$ implies Banana wins.

There are exactly $2n-1$ subsets S such that $S \cap \{1,2\}$ is either $\{1\}$ or $\{2\}$. Thus, Banana can always avoid those subsets, thus picking a question such that $S \cap \{1,2\}$ is either $\emptyset$ or $\{1, 2\}$. This way, the output will be exactly the same when $x = 1$ or $x = 2$. Thus Corona will never be able to distinguish between 1 and 2, hence he cannot guess x with certainty.

Part II: $k \leq 2n-1$ implies Corona wins.

We present two proofs for this part.

Method 1: (Pitchayut Saengrungkongka) In fact, we will prove that Corona wins in at most n turns. Let Ti denote the set of all possible candidates of x after the i-th turn (thus, $T0=\{1,2,...,n\}$).

Claim. Whenever $|Ti-1| \geq 2$, Corona could play in the i-th turn so that $|Ti| \leq |Ti-1| - 1$.

Proof. We set the i-th questions as follows. Let $r=|Ti|$. Note that there are $2n-2n-r+1 \geq 2n-1$ subsets S of $\{1,2,...,n\}$ such that $S \cap Ti-1$ is neither the empty set nor $Ti-1$. Thus we can select k of them and form a set of questions. This way, regardless of the question Banana has answered, some elements of $Ti-1$ are declared not to be x. Thus, Corona could eliminate at least one number in $Ti-1$ hence $|Ti| < |Ti-1|$ as claimed. □

Thus Corona can nail down the number of candidates from $n \to n-1 \to ... \to 2 \to 1$, eventually guessing the number.

Method 2: (Vincent Jugé)

The idea of this solution is the following claim.

Claim. Suppose that $a,b \in \{1,2,...,n\}$ where $a \neq b$. Then Corona can ensure that either a or b cannot be the value of x in a single turn.

Proof. There exist exactly $2n-1$ subsets S such that $S \cap \{a,b\}$ is either $\{a\}$ or $\{b\}$. Hence Corona can pick k of those subsets and form the questions using those subsets. This will ensure that Corona could eliminate either a or b, depending on which is not in the answered set S, thus achieving the claim's objective. □

Back to the main problem. Suppose that Corona applies the claim to all $(n2)$ pairs. Since he has applied the claim to the pair (i,x) where $i \neq x$, he has eliminated i for any $i \neq x$. Hence he is left with the only possibility for x.

PUZZLE SOLUTION TO MATH CIRCLES PROBLEM:

Solution: (9583+9667+185713=204963).

M O O N
+ S U N
_____
P L U T O

Solution: (9884+654=10538).

S A T U R N
T I T A N
+ T R I T O N
_____
E U R O P A

Solution: (613847+30317+340357=984521).

The Chase Annual Report is published for students, alumni and friends of the Department of Mathematics and Statistics, Dalhousie University.

Your suggestions and comments are welcomed for future issues.

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Cover Photo by Ann Bannon via Zoom

(The cover photo was taken on June 15, 2020 during the COVID-19 pandemic; a time when faculty, staff and students were all working remotely.)