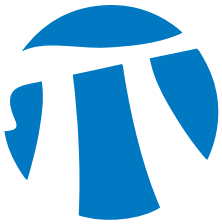

Pacific Institute *for the* Mathematical Sciences

Annual Report 2023

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ANNUAL PROGRESS REPORT

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Pacific Institute for the Mathematical Sciences

January 1–December 31, 2023

HIGHLIGHTS

Jupyter Hub

PIMS has developed expertise in cloud computing and, in partnership with Digital Research Alliance and Cybera, launched Jupyter Hub services for researchers and students in Canada and at the University of Washington. The Syzygy project enables staff, students and faculty members at Canadian higher education institutions to acess Jupyter using their existing institutional credentials. Jupyter is a powerful open-source web application that facilitates collaboration on live code, equations, visualizations and narrative text.

M2PI Workshop

In 2023, PIMS' Math to Power Industry (M2PI) program was green-themed. This annual professional development program featured workshop problems involving clean energy, clean tech, problems related to climate change and othert problems in the realm of climate resistance. As a result of the 2023 program, six products, processes, services or technologies were developed or improved.

PIMS Action on Climate Thematic Summer (PIMS ACTS)

PIMS designated the summer of 2023 as the "PIMS Action on Climate Thematic Summer". Tackling Climate Change and the Just Tansition to Renewable Energy was jointly organized by PIMS and the French Embassy in Vancouver as part of the French-Ameri-Can Climate Talks (FACTS) that have been held throughout North America in the past decade. The FACT event was attended by over 120 people and consisted of three-hour individual talks, a two-hour discussion panel, and a one-hour "Meet the Panelists" session. All sessions were open to the general public.

Mathemalchemy

Between April 1 and October 31, 2023, PIMS hosted the Mathemalchemy exhibit at the Beaty Museum at UBC. Created by Ingrid Daubechies, a prominent world leading mathematician, and Dominique Ehrman, a Canadian fiber artist, in collaboration with a team of mover than 20 other artists and scientists, Mathemalchemy was a unique and collaborative art exhibit exploring the beauty of mathematics.

Women in Math Day

The 2023 Women in Math Day Celebration involved a Women's Luncheon and short talks on the lives and careers of prominent women mathematicians both past and present.

WHAT'S NEW

PIMS Emergent Research Seminar Series
The PIMS Emergent Research Seminar Series showcases the research of PIMS Postdoctoral Fellows. This series is a network-wide event offered virtually via Zoom. In 2023, twelve PIMS PDFs presented their research.

CRM-Fields-PIMS Prize
In 2023, Christian Genest from McGill University was awarded the CRM-Fields-PIMS Prize. As part of the prize, Profesor Genest presented a lecture titled "Drawing inference without directly relevant data".

CRGs and PRNs
In 2023, PIMS started a new Collaborative Research Group: Forecasting and Mathematical Modeling for Renewable Energy. Organized by professors at the University of Victoria, University of Calgary and Acadia University, this CRG aims to develop meso, submeso, and mirco scale forecast methods for wind and solar power and create quantitative tools to support a wide range of decision-making problems related to wind and solar power systems and their integration to the power grid and electricity markets.

First Nations University
First Nations University (FNUniv) has joined PIMS as an Affiliated Member. FNUniv is dedicated to enhancing the quality of life and preserving, protecting, and interpreting the history, culture and artistic heritage of First Nations.

ICMS Partnership
PIMS has formed a partnership with the International Centre for Mathematical Sciences (ICMS) at the University of Edinburgh. We will facilitate the exchange of researchers between the UK and Canada via available visitor programs, collaboration programs, and workshops.

CRM-PIMS-AARMS Partnership
CRM, PIMS and AARMS have signed a joint long-term partnership agreement with the American Mathematical Society to organize a plenary address and an associated special session at the Joint Mathematics Meeting. The first CRM-PIMS-AARMS invited address will be given by Henri Darmon (McGill University) at JMM 2024.

IMPACT OF RESEARCH ACTIVITIES

Creation, curation, sharing or reuse of data sets

- PIMS has been collecting demographic data for our postdoctoral competition since 2018. These data are specific to academic employment in the mathematical sciences, and broad enough to include more than one academic employer. Thus, we believe that the data can be used to give a snapshot of the population of early career researchers in the mathematical sciences.

Development of tools, including software, for use by researchers or by others in the public or private domain

- PIMS has developed expertise in cloud computing and, in partnership with Digital Research Alliance and Cybera, launched Jupyter Hub services for researchers and students in Canada and at the University of Washington. The Syzygy project enables staff, students and faculty members at Canadian higher education institutions to access Jupyter using their existing institutional credentials. Jupyter is a powerful open-source web application that facilitates collaboration on live code, equations, visualizations and narrative text. Syzygy is deployed at 26 Canadian universities and University of Washington. Syzygy has been used by over 46,000 people and continues to be used by thousands every day. Individual users are given a curated computational environment customizable to research, teaching and training needs. By developing and making these computational resources accessible, PIMS has positively impacted the infrastructure for the mathematical sciences. While primarily intended for research, Syzygy has also been used by instructors of undergraduate and graduate courses nationwide.
- The Callysto project, created by PIMS in partnership with Cybera and funded by Cancode, uses the same architecture as Syzygy augmented with a rich set of interactive learning resources focused on training teachers and K-12 students in data science and computational thinking. Callysto has been used by over 80,000 students and 3,000 teachers and the resources created are used and updated via an open-source model. The theme of the activities in 2023 was “Developing Responsible Digital Citizens”.

Publications (selected key publications (from PIMS PDFs and CRGs):

- J. Males and A. Mono, Local MaaB forms and Eichler-Selberg type relations for negative weight vector-valued mock modular forms, Pac. J. Math., 322-2 (2023),381-406
- A. Nagy, S. Rayan, On the hyperbolic Block transform, Ann. Henri Poincare (2023): 10,1007/s00023-023-01336-8
- M.N. Shirazi, An extension of the Erdos-Ko-Rado theorem to se-wise2-intersecting families of perfect matchings, published in Discrete Mathematics, 346 (2023), 113444
- K Gunderson, K. Meagher, J. Morris, V.R.T. Pantangi, Induced forests in some distance-regular graphs, accepted by Discrete Applied Mathematics, 6 December 2023
- G-J. Huizing, M. Deutschmann, G. Peyre and L. Cantini, Paired single-cell multi-omics data integration with Mowgli, Nature Communications, 2023
- M. Faulhuber and S. Steinberger, Maximal polarization for periodic configurations on the real line, IMRN, accepted

- A. Tajmir Riahl, G. Woolard, F. Poitevin, A. Condon, K. Dao Duc (2023), AlignOT: An optimal transport-based algorithm for fast 3D alignment with applications to cryogenic electron microscopy density maps. IEEE/ACM Transactions in Computational Biology and Bioinformatics, DOI:10.1109/TCBB.2023.3327633
- The fourth discrete moment of the Riemann zeta function by Kubra Benli, Fatma Cicek, Ertan Elma, Alia Hamieh and Nathan Ng (53 pages, preprint)
- Fan, Y., Henry, M., Pass, B. and Rivero, J. Lorenz map, inequality ordering and curves based on multidimensional rearrangements (preprint)

Non-technical publications

- PIMS Annual Reports are available on our website.
- PIMS Connection and Year in Review are also available on our sebsite.
- In December 2023, Steven Rayan from the Quantum Topology CRG, was featured in Scientific American in an article about his efforts to turn quantum mathematical research conducted with the CRG into a musical suite and performance, which has premiered at the University of Saskatchewan CRG hub in September 2023.
- Research by Quantum Topology CRG students Tarah Teixeira (BSc) and Christopher Mahadeo (PhD) was featured in 2023 in the Globe and Mail and the Saskatoon StarPhoenix, respectively.

Co-creation or transfer of products, technology, processes, services or advice useful to specific organizations (in the private, public or non-profit sectors), communities or society

- Developed by PIMS, Math to Power Industry (M2PI) is an annual professional development program positioned to benefit the Canadian economy and industry by linking highly trained personnel to career opportunities outside academia. Following an intensive training workshop, teams of graduate students work with mentors from industry and academia to solve a challenge coming from government or industry. The 2023 program was green-themed. Workshop problems involved clean energy, clean tech, problems related to climate change and other problems in the realm of climate resilience. As a result of the 2023 program, 6 products, processes, services or technologies were developed or improved. The Awesense team analyzed synthetic electrical consumption data contributing to improved performance of Awesense's Energy Data Model (EDM) product. The group working with Cenovus Inc. produced a model of feedstock sources that can be used in the production of biofuel. The students working with Innovatree Carbon Group assessed feasibility of using slash-pile burning for biofuel, and a tool to predict monetary gains from carbon credit and power generation (to be used to incentivize companies who may be considering using this). The Ioto International team produced a data dashboard visualizing and analyzing over 74,000 parliamentary speeches for prevalence of specific topics, especially those related to climate policy. The Multiverse Computing team produced a tensorized convolutional neural net which analyzes deforestation data in the Amazon rainforest basin. The resulting product has improved performance over classical methods. The students working with North Coast Skeena First Nations Stewardship Society analyzed biological sampling practices and produced a recommendation for new practices to improve the accuracy of salmon population estimates in the Chathan Sound area.
- Syzygy.ca is a project of PIMS, Digital Research Alliance and Cybera to bring Jupyter notebooks to researchers, educators and innovators across Canada. Jupyter is an interactive computing environment, built for collaboration, where research tools such as Julia, Python and R are accessed via browser. It is integrated with single sign-on systems at postsecondary institutions. Digital Research Alliance extended their support though 2023.

- PIMS and Cybera created Callysto which is a free, online learning tool that helps Grades 5-12 students and teachers learn and apply in-demand data science skills including data analysis and visualization, coding and computational thinking. Our interactive learning modules and lesson plans are available in a variety of subjects-from math to history-and are aligned with existing curriculum. An example of one of the 2023 modules is "Elementary Climate Change" where students investigate climate change through sea ice, ocean levels, and forest fires. Another 2023 module was "Great Gatsby Data Science" which involved natural language processing and data analytics from the text of the novel The Great Gatsby.

Advances to equity, diversity, inclusion and accessibility in the research ecosystem

- The Pacific Institute for the Mathematical Sciences (PIMS) believes that equity, diversity and inclusion (EDI) strengthen the mathematical community by increasing the impact and relevance of research; widening the pool of qualified potential participants; and enhancing the integrity of the programs. Our programs support inclusivity at all stages from early education to graduate study to research activity.
- The PIMS EDI Committee (EDIC) includes faculty, students and postdoctoral fellows (PDFs) from across the PIMS network. The purpose of the EDIC is to develop implementable, explicit strategies to monitor and improve equity, diversity and inclusivity of the Institute and its activities, and potentially impact the wider mathematical sciences community. Within the mandate we consider inequities faced by women, Indigenous Peoples, persons with disabilities, members of visible minorities and diverse sexual orientation and gender identities. The EDIC helps PIMS develop programs that celebrate diverse communities and their contributions to the mathematical sciences.
- Increasing Diversity in Mathematical and Related Sciences, an annual summer school, was established to enhance diversity in mathematics and related sciences, specifically targeting underrepresented groups. The program seeks to prepare and motivate undergraduate students for advanced degrees by offering instruction in foundational subjects relevant to graduate studies, mentorship, and the establishment of a supportive community.
- PIMS is studying the demographics of its PDF applicant pool to work to diversity future pools. PIMS created a recruitment fund to provide supplemental salary to help make competitive offers to PDF applicants from diverse backgrounds. We recognize that many candidates face additional barriers in academia and seek to address those inequities and develop and recognize their mathematical excellence.
- PIMS has established an Indigenous Engagement Committee designed to identify and support Indigenous-led initiatives in the mathematical sciences. This committee consists of distinguished Indigenous mathematical scientists in academia and industry from across North America and the Pacific Rim. With guidance from this committee, we strive to ensure that PIMS fulfills its commitment to listening to Indigenous voices and ensuring the PIMS community is welcoming, respectful and supportive to Indigenous, First Nations, Inuit and Metis students and researchers.
- PIMS has launched two new programs specifically targeting EDI goals. The PIMS/BIRS Team UP! Pathways to Inclusive Research is a joint program with the Banff International Research Station (BIRS). It provides opportunities for in-person collaboration to teams of mathematical scientists, targeting researchers whose research may have been disproportionately affected by various obstacles like family obligations, professional isolation, access to funding and the COVID-19 pandemic. This includes women, gender expansive and minority groups, Indigenous scholars, individuals with visible/invisible challenges and early-career researchers with limited resources. Participants receive lodging and meals at either the Banff or Kelowna BIRS site, as well as reimbursement of travel expenses. A key goal of this program is for researchers with caregiving responsibilities

to fully participate in its scientific activities. Support may be offered for lodging and travel expenses for children and a caregiver accompanying the member. The second program, First Year Interest Groups (FYIG), aims to build community and networks for graduate students, especially benefitting early career researchers from underrepresented groups. Each group is led by a PIMS PDF and centers on an accessible subject for beginning graduate students.

- The Scientific Review Panel (SRP) and Postdoctoral Fellow Panel guidelines now have a strong emphasis on EDI. The PDF application includes an EDI statement, and guidelines for evaluating candidates have EDI in mind to ensure that equity deserving candidates receive fair consideration.
- PIMS supported the CanaDAM EDI luncheon which involved discussion about EDI initiatives that have been very helpful, or not helpful at all (or even harmful), as well as EDI initiatives that participants would like to see implemented at their schools. PIMS also supported the Women's Networking Luncheon at CanaDAM which was aimed towards women and non-binary researchers and industry professionals.
- The 2023 Women in Math Day Celebration involved a Women's Luncheon and short talks on the lives and careers of prominent women mathematicians both past and present.
- PIMS supported the Inclusive Paths in Explicit Number Theory summer school as part of the L-Function in Analytic Number Theory Collaborative Research Group (CRG). The CRG leaders simultaneously used this event to recruit a more diverse graduate student and postdoctoral fellow applicant pool for number theory researchers at PIMS Universities.

Communication of research results and knowledge translation to specialist or non-specialist audiences, including the public

- PIMS designated Summer 2023 as the "PIMS Action on Climate Thematic Summer" (or PIMS ACTS). This period culminated in a public panel on climate change. Tackling Climate Change and the Just Transition to Renewable Energy was jointly organized by PIMS and the French Embassy in Vancouver as part of the French-Ameri-Can Climate Talks (FACTS) that have been held throughout North America in the past decade. The FACTS event, which was attended by more than 120 people, consisted of three sessions: a three-hour session of individual talks by each of the panelists, followed by a two-hour panel discussion, and a one-hour "Meet the panelists" session. All sessions were open to the general public. Rene Aid from University of Paris-Dauphine presented "More electricity demand response for less carbon emissions". Gael Giraud from Georgetown University talked about "Macroeconomics and climate". Seth Klein, a public policy researcher and author, gave a talk on "Mobilizing Canada for the climate emergency". Judith Sayers, president of the Nuu-chah-nulth Tribal Council, spoke about "First Nations leadership in clean energy and climate action". Andrew Weaver from the University of Victoria presented "Privilege, agency, and the climate scientist's role in the global warming debate".
- Between April 1 and October 31 of 2023, PIMS hosted the Mathemalchemy exhibit at the Beaty Museum at UBC. Created by Ingrid Daubechies, a prominent, world leading mathematician, and Dominique Ehrman, a Canadian fiber artist, in collaboration with a team of more than 20 other artists and scientists, Mathemalchemy is a unique and collaborative art exhibit exploring the beauty of mathematics. We were happy to have Ingrid Daubechies and Dominique Ehrman join the opening event of Mathemalchemy, deliver a talk, and provide a tour of the exhibit.
- PIMS continues to showcase the diversity of the mathematical sciences community via the online Network Wide Colloquium. 2023 talks included "Surface sums and Yang-Mills gauge theory" by Scott Sheffield from MIT and "Understanding form and function in vascular tumors" by Helen Byrne from the University of Oxford. Most of the talks in this series are recorded and available online. In 2023, PIMS ran eight other Distinguished Lecture Series at PIMS sites.

- The PIMS Emergent Research seminar series showcases the research of PIMS Postdoctoral Fellows. The seminar is a network-wide event offered virtually using Zoom. During the reporting period, 12 PIMS PDFs presented research in this seminar series.
- PIMS sponsors a large number of seminar series across our sites which play a key role in ensuring a regular flow of high-level visitors to member universities. In 2023, PIMS sponsored 24 seminar series at nine different universities.
- During the reporting period, PIMS sponsored 41 research conferences and workshops, including four which were primarily graduate student oriented.
- The CRM-Fields-PIMS Prize is intended to be the premier award for mathematical research in Canada, with the recipient chosen jointly by the three Canadian mathematical sciences institutes. The winner is invited to present a lecture at each institute or may choose to deliver a lecture in hybrid format at one of the institutes. In 2023, the winner was Christian Genest from McGill University. He presented a lecture titled "Drawing inference without directly relevant data".
- PIMS created MathTube (mathtube.org) as a resource for sharing videos and other content. People can browse or search MathTube directly, or they can find links to individual recordings on the event pages of the PIMS website. MathTube makes posting, finding and viewing mathematical content as simple and easy as possible. We post all new PIMS media to MathTube.
- Social media is used to publicize the excellent research being done across our network. PIMS uses Twitter, Instagram and LinkedIn to share its activities and programs, and to celebrate the accomplishments of its researchers.

Community service that leverages expertise, such as membership on scientific or advisory committees, or journal editorships

- PIMS Director Ozgur Yilmaz is on the Board of Directors of BIRS, the Executive Committee of the UBC Data Science Institute, and the Steering Committee of the UBC-AIM-SI (AI Methods for Scientific Impact) Cluster. Hi is also on the editorial Boards of "Applied and Computational Harmonic Analysis", "Sampling Theory Signal Processing, and Data Analysis", and "Mathematics, Computation and Geometry of Data". He also served on the MFO (Mathematisches Forschungsinstitut Oberwolfach) Review Board.
- PIMS Co-Director, Industry, Kristine Bauer is on the Board of Brain CREATE. Engin Ozberk (PIMS Board Chair) is also on this Board. The Brain CREATE training program focuses on the development of neurotechnologies. The trainees will play critical roles in revamping and modernizing traditional industries with brain-centric innovations. Kristine Bauer is a founder of the Women in Topology network and serves on its steering committee.
- PIMS Co-Director, International, Jayadev Athreya chairs the AMS Nominating Committee in 2024 and will continue to serve on the committee in 2025. He serves on the Park City Mathematics Institute Steering Committee and is an editor at the Illinois Journal of Mathematics and Geometriae Dedicata. He was Chair Jean-Morlet at CIRM Luminy in Autumn 2023.
- BC Education Coordinator, Melania Alvarez, is a key organizer for Science Rendezvous at UBC. This is a national festival that takes science out of the lab and onto the street. Festival-goers get a chance to meet world-class researchers and innovators, participate in hands-on experiments, and see amazing scientific demonstrations.

Creation, direction, facilitation and/or strengthening of partnerships or collaborations in the Canadian or international research community, or with other communities, including through research networks, large collaborative projects or community-engaged research/citizen science

- PIMS Collaborative Research Groups (CRGs) develop research and training networks establishing lasting interdisciplinary links between researchers at member universities. CRGs are organized by researchers, typically faculty at PIMS universities, with common interests and a desire to collaboratively develop aspects of their research programs. CRGs are thematic programs including seminars, workshops, PDF appointments and graduate training programs. The fruits of these activities persist for many years, increasing visibility and communication with colleagues around the world. CRGs create a critical mass that enhances training programs, leveraging PIMS to support a large number of PDFs and graduate students and creating new research opportunities for young scientists. PIMS started a new CRG in 2023 – Forecasting and Mathematical Modeling for Renewable Energy. The organizers are from the University of Victoria, University of Calgary and Acadia University. Wind and solar energy are expected to be the primary sources of electricity in the future. Both wind and solar power are stochastic and intermittent as they are weather driven. The main purpose of this CRG is to develop meso, submeso and micro scale forecast methods for wind and solar power and create quantitative tools to support a wide range of decision-making problems related to wind and solar power systems and their integration to the power grid and electricity markets. In their opening year they ran a summer school and workshop on Forecasting and Mathematical Modeling for Renewables. They also were a partner in the FACTS public panel on climate change. Other active PIMS CRGs during 2023 were: Quantum Topology and its Applications; Novel Techniques in Low Dimension; Movement and Symmetry in Graphs; and L-Functions in Analytic Number Theory. The PIMS SRP also recommended funding of a new CRG on Structure-Preserving Discretizations and their Applications" which will launch on April 1, 2024.
- Building on the success of the CRG program, PIMS has developed large-scale initiatives called PIMS Research Networks (PRNs). These networks are designed to build bridges between research groups in academia, industry and the public sector. They are designed to go above and beyond the CRG mission by combining research, training, and crucially, strong external partnerships, leading sustainable long-term collaborations. Our first PRN, the Kantorovich Initiative, was created to address challenges in optimization and optimal transport. It is named after the mathematician and Nobel Laureate in Economics, Leonid Kantorovich. Optimal transport is a unifying theme which brings together diverse areas of mathematics with transformational applications in artificial intelligence, economics, genomics, and logistics problems common to many industry sectors. In their first year they ran a Summer School on Optimal Transport and several workshops. They also ran a network wide course and a seminar series. PIMS SRP recommended funding of our second PRN, the Maud Menten Institute which will launch April 1, 2024. The primary purpose of this institute is to provide a collaborative research platform for mathematical biologists at PIMS sites to promote interactions with life science experts and decision makers in government, industry, and non-governmental organizations.
- PIMS designated the 2023 summer as the Action on Climate Thematic Summer (PIMS-ACTS). The program helmed several events that took place during this time, with a particular focus on the ongoing climate emergency. The role of mathematics in understanding the challenges faced and finding solutions was highlighted. These events spanned several areas of the PIMS mandate and included events such as: FACTS Public Panel on Climate Change; Math to Power Industry 2023 (M2PI 2023); PIMS CRG Summer School on Forecasting and Mathematical Modeling for Renewable Energy; and Workshop on Forecasting and Mathematical Modeling for Renewable Energy.
- PIMS partners with similar institutions around the world, for details on these partnerships, see the "Partnerships" section.

Support for traditional knowledge or Indigenous ways of knowing, including cultural practices

- First Nations University (FNUniv) has joined PIMS as an Affiliated Member. FNUniv is dedicated to enhancing the quality of life and preserving, protecting, and interpreting the history, culture and artistic heritage of First Nations
- The North Coast Skeena First Nations Stewardship Society participated in the 2023 Math to Power Industry program as an industry partner. Their project was to determine a program to expand Genetic Stock Identification (GSI) data. This program would then be applied to produce meaningful stock proportion estimates in the mixed stock recreational Chinook harvest for Pacific Fishery Management Areas managed by the Society.
- Indigenous-owned Innovatree Carbon Group participated in the 2023 Math to Power Industry program as an industry partner. Their project was to measure the carbon emissions and efficiency of converting slash-piles to biofuel for the purpose of reducing carbon emissions in forest regions in Alberta and British Columbia.
- Judith Sayers is the President of the Nuu-cha-nulth Tribal Council, a renewable energy leader and Chancellor of Vancouver Island University. As part of PIMS ACTS, Judith gave a talk and participated in our public panel on climate change. The title of her talk was "First Nations leadership in clean energy and climate action".
- The PIMS Indigenous Engagement Committee (IEC), consisting of distinguished mathematical scientists and industrialists from Indigenous backgrounds, has done exemplary work in identifying Indigenous-led efforts in the mathematical sciences that PIMS can collaborate with and support including the Indigenous Mathematicians Network.

PARTNERSHIPS AND COLLABORATIONS

Fields Institute for Research in Mathematical Sciences (FIELDS)

- PIMS and Fields supported Computational and Mathematical Population Dynamics 6 as well as Dynamics of Differential Equations. We co-sponsored the national meetings of CMS and CAIMS. PIMS together with CRM and Fields award the CRM-Fields-PIMS Prize. Increasing Diversity in Mathematical and Related Sciences, an annual summer school, has been established in collaboration with BIRS, AARMS, CRM, Fields, CANSSI and CITA.

Atlantic Association for Research in the Mathematical Sciences (AARMS)

- PIMS and AARMS co-sponsor national meetings of the Canadian Mathematical Society (CMS) and the Canadian Applied and Industrial Mathematics Society (CAIMS) together with CRM and Fields. PIMS and AARMS supported the International Conference and Adjoint School on Applied Category Theory. PIMS, AARMS and CRM have partnered with the American Mathematical Society (AMS) and become new partners at the Joint Mathematics Meeting (JMM). Increasing Diversity in Mathematical and Related Sciences, an annual summer school has been established in collaboration with BIRS, AARMS, CRM, Fields, CANSSI and CITA.

Banff International Research Station (BIRS)

- Together PIMS and BIRS launched the PIMS/BIRS Team Up! program. We also collaborated on two events: Alberta Number Theory Days and Inclusive Paths in Explicit Number Theory. Increasing Diversity in Mathematical and Related Sciences, an annual summer school, has been established in collaboration with BIRS, AARMS, CRM, Fields, CANSSI and CITA.

Canadian Statistical Sciences Institute (CANSSI)

- PIMS and CANSSI collaborated on Statistical Data Science Conference, Data Science Bootcamp and Canadian Statistics Student Conference. PIMS, AARMS, BIRS, CITA, CANSSI, CRM and Fields have formed a partnership to run an annual summer school, Increasing Diversity in Mathematical and Related Sciences.

Canadian Institute for the Theoretical Astrophysics (CITA)

- PIMS, AARMS, BIRS, CITA, CANSSI, CRM and Fields have formed a partnership to run an annual summer school, Increasing Diversity in Mathematical and Related Sciences.

Centre de recherches mathematiques (CRM)

- PIMS and CRM collaborated on Seminaire de Mathematiques Superieures (SMS). The topic for 2023 was Periodic and Ergodic Special Problems. PIMS and CRM also collaborated on Conference on Orderable Groups and Workshop in Honor of Prof. Gordon Semenoff. We co-sponsor the national meetings of CAIMS and CMS. PIMS and CRM collaborate together with Fields, to award the CRM-Fields-PIMS Prize. PIMS, AARMS and CRM have partnered with the American Mathematical Society (AMS) and become new partners at the Joint Mathematics Meeting (JMM). Increasing Diversity in Mathematical and Related Sciences, an annual summer school, has been established in collaboration with BIRS, AARMS, CRM, Fields, CANSSI and CITA.

New Canadian Non-government organization

- North Coast Skeena First Nations Stewardship Society is primarily focused on the conservation and sustainable management of local and regional pacific salmon stocks. Their M2PI project related to a program used for producing meaningful stock proportion estimates in the mixed stock recreational Chinook harvest.

New Canadian Industry Partners

- Innovatree Carbon Group works with First Nations, government and industry to rehabilitate forests. Their M2PI team modeled the carbon footprint of slash-pile burning vs grinding for bioenergy in the forestry industry and created a web interface which could report those costs in real time.
- Multiverse Computing are leaders in accelerating computing through quantum. Their M2PI project used machine learning techniques to analyze data regarding deforestation in the Amazon basin.
- Cenovus Energy Climate and Sustainability Division was a new M2PI partner in 2023. This is an oil and gas company working with peers, governments, academics and scientists to achieve ambitious environmental, social and governance targets and be sustainability leaders in the industry. Their M2PI project was to produce a model of feedstock sources that can be used in the production of biofuel.

New Canadian Academia Partners

- First Nations University (FNUniv) has joined PIMS as an Affiliated Member. FNUniv is dedicated to enhancing the quality of life and preserving, protecting, and interpreting the history, language, culture, and artistic heritage of First Nations. This partnership will enable both organizations to collaborate in support of Indigenous-led initiatives in the mathematical sciences, aligning with the principles of reconciliation.
- PIMS, AARMS, BIRS, CITA, CANSSI, CRM and Fields have formed a partnership to run Increasing Diversity in Mathematical and Related Sciences. This is an annual summer school targeted to women and underrepresented minorities in mathematics and related sciences.

New International Academia Partners

- PIMS has formed a partnership with the International Centre for Mathematical Sciences (ICMS) at the University of Edinburgh. We will facilitate the exchange of researchers between the UK and Canada via available visitor programs, collaboration programs, and workshops.
- PIMS has partnered with the National Centre for Theoretical Sciences (NCTS) in Taiwan. We agree to seek collaborations between activities and research programs of common interest.
- PIMS has partnered with the Institute of Mathematical Sciences (ICMAT) in Spain. We will mutually support each other in the organization and establishment of scientific activities within a bilateral and reciprocal framework.
- CRM, PIMS and AARMS have signed a joint long-term partnership agreement with the American Mathematical Society to organize a plenary address and an associated special session at the Joint Mathematics Meeting. The first CRM-PIMS-AARMS invited address will be given by Henri Darmon (McGill University) at JMM 2024.

Highlights of a unique partnership that has taken place over the past year and the impact

- PIMS is an International Research Laboratory of the French Centre National de la Recherche Scientifique (CNRS). This partnership builds collaborations between mathematical scientists at PIMS member universities and researchers in France. Flagship programs include the CNRS Visitors program, where distinguished French researchers (funded by CNRS) spend the academic year at a PIMS member university and participate in research activities. PIMS had three CNRS Visitors in 2023. PIMS-CNRS Fellowships enable faculty at PIMS sites to visit France for long term collaborations. There were four of these in 2023. Via the PIMS CNRS Student Mobility Program, senior undergraduate and graduate students conduct 3-6 month research programs at a PIMS member university or at an eligible French institution. We had two students participate in this program in 2023. The PIMS-CNRS Postdoctoral Fellowships bring French-educated researchers to a PIMS site for a postdoctoral fellowship and are a key part of the PIMS PDF program. We had one PIMS-CNRS Postdoctoral Fellowship begin in 2023. Postes Rouge are research positions with three months of salary support available to non-French academics at any PIMS member university. In 2023 we had two PIMS researchers participate in this program. CNRS also supported PIMS-ACTS in the summer of 2023.

INTERACTIONS AND OUTREACH

New initiatives that support equitable and inclusive participation in outreach activities

- In 2023, PIMS supported the Math Attack Summer Camp for Girls which was an 8-day overnight camp that was held at the university of Calgary and the Banff International Research Station (BIRS). The camp brought 21 grades 5-10 students who identify as girls together to engage in fun mathematical activities and build connections. Throughout the week, students engaged in mathematical sessions that explored topics such as graph theory, topology, data science, statistics, and actuarial science. PIMS also supported the Girls Excel in Math Summer Camp which was a 3-day camp that was held at the University of Calgary. 121 grades 5-9 students who identify as girls attended the camp. The camp aimed to encourage girls to pursue their passion for mathematics and make connections with peers who shared similar interests.

Highlights of a unique outreach activity that has taken place over the past year

- Mathemalchemy Exhibition: This is a unique and collaborative art exhibit exploring the beauty of mathematics. Both art and math illuminate and describe our world and have the power to inspire our imaginations. This installation invited us to let go of preconceptions or classroom experiences about art or math, and to explore with an open mind.

Participation by region in institute organized actvities

ACTIVITY	TOTAL NUMBER OF PARTICIPANTS	WESTERN CANADA (AB, BC)		CENTRAL CANADA (SK, MB)		ONTARIO		QUEBEC		EASTERN CANADA (NB, NL, NS, PEI)		NORTHERN CANADA (NWT, NvT, YT)		INTERNATIONAL	
Conferences/Workshops	3525	1807	51.3	467	13.2	324	9.2	136	3.9	33	0.9	0	0	758	21.5
Summer Schools (outside CRGs)	78	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Collaborative Research Group Events	968	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lecture-Seminar Series	2618	1448	55.3	251	9.6	123	4.7	18	0.7	16	0.6	0	0.0	762	29.1
Industrial Activities (M2PI)	59	42	71.2	7	11.9	9	15.2	0	0.0	0	0.0	0	0.0	1	1.7
Others	774	654	84.6	18	2.3	21	2.7	9	1.2	6	0.7	0	0.0	66	8.5

Participation by sector in institute organized actvities

ACTIVITY	TOTAL NUMBER OF PARTICIPANTS	INDUSTRY		GOVT.		NGO		ACADEMIA		EDUCATOR (K-12)		OTHER	
Conferences/Workshops	3525	78	2.2	N/A	N/A	N.A	N/A	3172	90.0	183	5.2	92	2.6
Summer Schools (outside CRGs)	78	0	0.0	N/A	N/A	N/A	N/A	78	100.00	0	0.0	0	0.0
Collaborative Research Group Events	968	18	1.9	N/A	N/A	N/A	N/A	897	92.7	14	1.4	39	4.0
Lecture-Seminar Series	2618	26	1.0	N/A	N/A	N/A	N/A	2322	88.7	13	0.5	257	9.8
Industrial Activities (M2PI)	59	10	16.9	0	0	2	3.4	47	79.7	0	0.0	0	0.0
Others	774	0	0.0	NA	N/A	N/A	N/a	138	17.8	5	0.7	631	81.5

CONTRIBUTION TO THE TRAINING AND DEVELOPMENT OF HQP

Establishment of safe, equitable and inclusive research environments, practices and norms

- We established the PIMS Code of Conduct, which provides rules that we expect all organizers and participants of PIMS events to follow. These guidelines are designed to ensure that our events are as safe, welcoming and inclusive as possible. Further, the Scientific Review Panel and Postdoctoral Fellow Panel guidelines have been updated with a strong emphasis on EDI. In particular, the PDF application now includes an EDI statement, and guidelines for evaluating candidates were made with EDI in mind to ensure that equity-deserving candidates receive fair consideration. The Math to Power Industry program includes an EDI training course to promote inclusive teams. This training is delivered immediately before participants engage in team-based projects.

Formal or informal mentoring of HQP, colleagues, collaborators, relevant partners, other professionals or community members

- PIMS Virtual Experimental Mathematics Labs (VXML) bring together faculty/postdocs with graduate/ undergraduate students from across the PIMS network to work on research mathematics questions. 2023 projects included topological data analysis and mathematical models of cognitive function.
- PIMS First Year Interest Groups (FYIG) bring together early career researchers to study active research topics in the mathematical sciences. Each FYIG is led by a PIMS PDF and centers on an accessible subject for beginning graduate students. 2023 subjects included modelling ecological population dynamics and partial differential equations.
- PIMS hosts a virtual orientation, introducing the postdocs to their cohort, providing resources for professional development and EDI training, and creating channels for interaction within the cohort.
- Changing the Culture brings together mathematicians and mathematics educators to work towards narrowing the gap between mathematicians and teachers of mathematics.

Outreach to and engagement with students, youth or members of the general public

- Math Mania presents a variety of interactive demonstrations, puzzles, games and art. These activities are designed to demonstrate to children, parents and teachers a fun way of learning both math and computer science concepts.
- Math Circle Workshops are conducted for students in grades 4-7. The goal is to convey to students the importance of mathematics in the real world.
- PIMS conducts Elmacon, a mathematics competition for students in grades 5-7.
- PIMS participates in Science Rendezvous, a national program bringing exciting STEM experiences and programming to the public.
- Through the Callysto program, PIMS funds proposals targeting Grades 5-12 students to improve their computational literacy.
- See above for Math Attack and Girls Excel in Math camps.

Supervision of HQP in the research process

- PIMS runs a large PDF program (currently 47 PDFs) across its network of 9 Canadian universities. These fellowships are highly competitive and are awarded by our PDF Panel. The expected quality of supervision is one of the main evaluation criteria in awarding these fellowships, with the goal of assuring that the HQP receive appropriate supervision.
- During the M2PI workshop, teams of 4-6 graduate students work with industry mentors on a challenge provided by the mentor. The program requires industry partners to provide at least 2 hours per day of mentorship to students during the time they are working on the team project; many partners provide more. In addition, many teams consult with an academic mentor during their project as well.
- PIMS CRGs and PRNs create long term (3 year) thematic programs that give HQP a dynamic research environment where they get supervision through interaction with various CRG leaders as well as other students and PDFs in these groups.

Training in Traditional knowledge or Indigenous ways of knowing including cultural practices

- The PIMS Indigenous Engagement Committee (IEC) is designed to ensure that PIMS fulfills its commitment to listening to Indigenous voices and ensuring the PIMS community is respectful of and welcoming to Indigenous, First Nations, Inuit and Metis students and researchers.
- One of the lesson plans in the Callysto program is "Modeling Coast Salish fish traps". Students use a Callysto notebook to explore an example of Northern First Nations fish traps; parameters involved in the design of Northern Coast Salish fish traps; and using a simulation of a fish trap: choosing parameters to harvest fish.

Development and delivery of training workshops outside of research or course requirements

- Developed by PIMS, Math to Power Industry (M2PI) is an annual professional development program positioned to benefit the Canadian economy and industry by linking highly trained personnel to career opportunities outside academia. Following an intensive training workshop, teams of graduate students work with mentors from industry and academia to solve a challenge coming from government or industry.
- PIMS supported 3 summer schools for graduate students in 2023 on diverse emerging research topics including number theory, topology and mathematical modeling.
- PIMS supports networking and career development for graduate students and PDFs. For example, the PIMS Emergent Research Seminar is an online seminar featuring the research of PIMS PDFs to help them build their network. PIMS organizes career development sessions for both graduate students and PDFs.

Initiatives or changes to policy that support equitable and inclusive training and development of HQP

- PIMS has programs aimed at underrepresented groups including, but not limited to, women, Indigenous Peoples (First Nations, Inuit and Metis), persons with disabilities, members of visible minorities/racialized groups and members of LGBTQ+ communities.
- PIMS created an EDI recruitment fund to provide salary supplements to help make attractive and competitive offers to PDF applicants from diverse backgrounds. This program recognizes that many of these candidates face additional barriers in academia and seeks to address those inequities to ensure that their excellence can be recognized.

- PIMS has an Indigenous Engagement Committee to ensure that PIMS listens to Indigenous voices and is respectful and welcoming to Indigenous peoples.
- PIMS/BIRS Team Up! Pathways to Inclusive Research targets researchers whose program may have been disproportionately affected by various obstacles like family obligations, professional isolation, access to funding and the Covid pandemic. It provides opportunities for in-person collaboration to teams of mathematical scientists.
- For Math to Power Industry recruitment, we advertised at a CMS event for women to increase the number of female applicants.

Highlights of unique mentorship or training opportunities that have taken place over past year

- Summer School on Forecasting and Mathematical Modeling for Renewables was held at the University of Calgary. It covered 4 minicourses: Spatio-temporal processes and forecasting; Atmosphere and fluid dynamics, part 1 and 2; and Optimization for renewables. All courses were designed and delivered by a team of instructors and had lecture and exercise components. Some lectures were delivered online, however, there was always an instructor on site for each course to assist students during the exercise sessions which took place in person. Exercise components provided hands on practice on the topics covered in the lecture. We also had students formulate and work on a project in groups. One day in each week of the summer school was devoted to student presentations where students presented their progress and results on their projects. We had students from diverse academic backgrounds, including mathematics, statistics, operations research, engineering, atmospheric sciences and fluid dynamics. To make our courses accessible for everyone, our instructors assumed on a minimal background in first year calculus, elementary probability and first-year physics. To enhance the learning experience, we offered exercise sessions where students could receive one-on-one assistance from our instructors or peers on any challenging concepts. We had a reasonable representation of equity deserving groups. We were able to offer admission to all the students who applied. 22 students participated in the summer school. 7 of these were women. There were also participants who identified as persons with disability and members of minority ethnic groups. Among instructors, 2 of 8 were women.
- PIMS hosted our first PIMS Day. All members of the PIMS network (especially HQP) were invited to hear about PIMS Collaborative Research Groups and PIMS Research Networks. They also heard first-hand accounts from several established postdoctoral scholars. In the second part of the program, PIMS Directors reviewed current and future PIMS scientific and educational funding opportunities.

HQP participation in institute organized activities by career stage

ACTIVITY	TOTAL NUMBER OF PARTICIPANTS	UNDERGRADUATE		GRADUATE**		DOCTORAL		POSTDOCTORAL	
		NUMBER	%OF TOTAL	NUMBER	% OF TOTAL	NUMBER	% OF TOTAL	NUMBER	% OF TOTAL
Conferences/Workshops	3525	385	10.9	1377	39.1	N/A	N/A	313	8.9
Summer Schools (outside CRGs)	78	1	1.3	59	75.6	N/A	N/A	11	14.0
Collaborative Research Groups Events	968	23	2.3	473	48.8	N/A	N/A	150	15.5
Lecture-Seminar Series	2618	261	10.0	689	26.3	N/A	N/A	230	8.8
Industrial Activities - M2PI	59	1	1.7	8	13.6	15	25.4	6	10.2
Other	774	33	4.3	45	5.8	N/A	N/A	4	0.5

MANAGEMENT & BUDGET

Costs paid from all revenue sources

BUDGET ITEM	2022 ACTUAL	2023 BUDGETED	2023 ACTUAL	2024 BUDGETED
SALARIES & BENEFITS				
Technical/professional	715716.00	777594.00	808138.00	832382.00
HQP stipends/awards	739862.00	1111096.00	922438.00	1160000.00
Director/Co-Directors/Site Directors	137680.00	146500.00	162816.00	180500.00
INSTITUTE				
Operating costs	37726.00	34834.00	48127.00	50000.00
Maintenance	18980.00	22000.00	19927.00	22000.00
Minor Equipmetn Upgrades	42621.00	90000.00	23070.00	13000.00
TRAVEL (INCLUDING ACCOMMODATION, MEALS, ETC)				
Conference	241152.00	85500.00	306009.00	300000.00
Engagement	448386.00	651626.00	527515.00	550000.00
Board/Exec. Mtgs	35652.00	30000.00	57300.00	60000.00
DISSEMINATION COSTS				
Outreach to user communities	750.00	5000.00	1978.00	2500.00
Scientific Publications	1236.00	4000.00	1967.00	2000.00
OTHER COSTS				
Education initiatives	86012.00	185500.00	121497.00	100000.00

Costs paid from NSERC Discovery Institute Support Grant funding

BUDGET ITEM	2022 ACTUAL	2023 BUDGETED	2023 ACTUAL	2024 BUDGETED
SALARIES & BENEFITS				
Technical/professional	224116.00	226537.00	247032.00	255000.00
HQP stipends/awards	739862.00	1061096.00	905438.00	910000.00
TRAVEL (INCLUDING ACCOMMODATION, MEALS, ETC)				
Conferences	120000.00	50000.00	210000.00	100000.00
Engagement	110000.00	100000.00	207000.00	80000.00

Institute revenues

REVENUE SOURCE	2022 ACTUAL	2023 BUDGETED	2023 ACTUAL
User fees	105671.00	60000.00	113318.00
Partner Universities	788818.00	802329.00	832266.00
Donations/contributions	128802.00	55000.00	142355.00
Callysto	76385.00	190000.00	273788.00
NSERC DIS	1153748.00	1153748.00	1153748.00
Prairies Can		51500.00	6947.00
Simons Foundation		245830.00	130205.00

Overall financial statement of account

Previous balance at 31/12/2022	1844644.00
Actual institute revenues for 2023	2461105.00
Total actual institute costs for 2023	3000782.00
Total carry forward at 31/12/2023	1304967.00

The carry forward is due to having fewer in-person events post Covid. More events have converted to hybrid models which require less travel. We have increased the number of postdocs we support and have increased the length of visits encouraging people to visit more than one site per trip. We are gradually increasing the number of in-person events that we support and have created new programs which have longer collaboration periods (i.e. PIMS/BIRS Team Up!). However, we don't want to decrease the carry forward to zero. We require a balance of $200,000 - $500,000 to ensure that we can keep programs and appointments going over the fiscal year end period.

RESEARCH AREA	PROPORTION OF INSTITUTE FUNDS
Pure math	46
Applied math	18
Statistics	11
Computer science	10
Math biology	5
General math (mixed)	10

Initiatives or changes to policy that support an equitable and inclusive research, management or work environment

- PIMS implemented a Code of Conduct. PIMS strives to provide a supportive and safe environment that is dedicated to excellence, equity and mutual respect. PIMS envisions a climate in which all participants are provided with the best possible conditions for learning and research. We expect all members of the PIMS community to conduct themselves in a manner so as not to cause, condone or participate in the discrimination, harassment or prejudice of another person or group of persons.
- All PIMS Central Staff are required to complete courses on Preventing and Addressing Workplace Bullying and Harassment as well as Workplace Violence Prevention.
- PIMS has an EDI recruitment fund to provide a salary supplement to recruit candidates from diverse backgrounds. We consider inequalities faced by women, Indigenous Peoples, persons with disabilities, members of visible minorities and diverse sexual orientation and gender identities in all of our EDI initiatives.
- We have updated our terms of reference for the Postdoctoral Fellow Panel and the Scientific Review Panel incorporating EDI best practices.

PROBLEMS ENCOUNTERED

- At times it has been difficult to secure suitable classroom space for hybrid seminars and events. We have attempted to equip more classrooms with the necessary equipment for hybrid events. Our larger events sometimes have difficulty finding available large lecture halls. We have had to hold events in other buildings and sometimes even move the event from day to day. We are trying to have our room booking priority level raised.
- Some potential conference participants/speakers had to cancel their trips due to very long waits for visitor visas.
- Some PDFs have had to start their appointments late due to immigration delays such as obtaining a visa/work permit.
- In some cases, Covid-19 restrictions were still in place and some participants had difficulty arranging travel. Whenever possible, we arranged hybrid events.
- The PIMS Executive Assistant position was staffed by temps for a couple of months. We now have a permanent staff member.

GENERAL INFORMATION

- The institute's website is maintained weekly.
- NSERC acknowledgement can be found at https://www.pims.math.ca
- NSERC funding is almost always acknowledged in written materials developed by the institute.
- The content of the institute's website is only available in English

LOOKING FORWARD

In 2024, PIMS will continue focusing on grand challenges facing humanity. We are excited about two collaborative events with our international partners. The first is the France-Western Canada Workshop on Ocean and Polar Sciences, focusing on the role of mathematical sciences in these fields. This workshop is co-organized by PIMS, The Centre National de la Recherche Scientifique (CNRS), and the Consulate General of France in Vancouver, and will host prominent scientists from Western Canada and France. Shortly after, we will host, together with the International Centre for Mathematical Sciences (ICMS) in Edinburgh, the PIMS-ICMS Twinned Lectures "Land and Sea: Mathematics of the Climate Crisis", a hybrid event with a special format: It will feature an in-person talk by Rashid Sumaila (UBC) at PIMS Headquarters in Vancouver, an in-person talk by Emily Shuckburgh (Cambridge) at ICMS in Edinburgh, and a trans-continental Q&A period where the speakers and audiences in both locations will have the opportunity to interact. On a different front, we are looking forward to our first PIMS PDF Summit, which will bring together PIMS Postdoctoral Fellows from all PIMS Universities. This will give the PIMS PDF cohort a chance to showcase their research and expand their networks, leading to new collaborations. We are also looking forward to our first PIMS Industry Day, which will give M2PI graduates a chance to showcase their work at an in-person event and network with industry members. In 2024, we will launch the Maud Menten Institute, a PRN on mathematical biology and Structure-Preserving Discretization and their Applications, a new CRG in applied mathematics.