

the view from **aim** 2025

The Sweetest SQuaRE

Modeling Swollen-Shoot Virus in Cacao Trees

AIM in Africa

Open Source Curriculum and Assessment Tools

A Joyful Math Ecosystem

Community Outreach in Southern California

Letter from the Director

A Successful First Year in Pasadena



Greetings from Pasadena! AIM has been at Caltech for about 16 months now, and the transition from San Jose has gone really well! We have hosted 34 workshops and 148 SQuaREs since we've been here, giving more than 1500 mathematicians the chance to have a

week of quality research time with their colleagues.

On June 28th we celebrated the 30th anniversary of AIM's founding with a reception and a Math Fair on the lawn in front of Caltech Hall. Approximately 700 people from the community participated in fun math activities and good snacks and company. Many thanks to Caltech facilities management and to staff and faculty for helping to make the day stimulating and enjoyable. Some of the most popular activities included solving the Soma cube, finding and marking your solution amongst the 210 possible solutions on the SOMAP, and then traversing the SOMAP with subtle rearrangements of the cube's pieces. The SET quilts were also popular, as was Hashimoto's Bucolic cube puzzle. The Zometool soap bubbles were messy but fun!

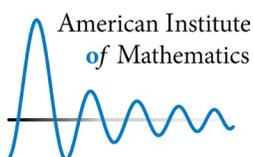
Some highlights of the year included JMM activities, including awarding the Alexanderson Award and the accompanying invited lecture; the ongoing development of a joyful math ecosystem in the LA area; the continued success of the Morgan Hill Math program; and of course the many papers that grew out of AIM workshops and SQuaREs.

We are in the process of applying for renewed funding from NSF. Our proposal went in on March 14 this year (Pi Day!), and the reverse site visit was at NSF headquarters in Alexandria, VA, on October 10 (Global Math Day!). Now we await the outcome.

The past two years have seen record numbers of proposals coming in from the community. Our deadline for proposals is November 1 each year; this year we had a total of 191 proposals for workshops, SQuaREs, and AIM Research Communities (ARCs). Our Scientific Board meeting will be December 7, where this year's successful proposals will be selected.

As always, we welcome visitors. Please stop by to see our lovely space if you are in the area. We love to show it off! ■

Brian Conrey



American Institute of Mathematics
Caltech 8-32
1200 E California Blvd
Pasadena, CA 91125
Phone: (626) 395-8522
<http://www.aimath.org>

the view from aim

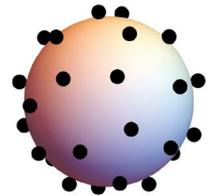
Editors-in-Chief: Michelle Manes and Brianna Donaldson

Art Director: Jessa Barniol

Contributors: Kelley Barnes, Ryan Blair, J. Brian Conrey, David Crombecque, Brianna Donaldson, Mary Flagg, Veronika Furst, Leslie Hogben, David Farmer, Sally Koutsoliotas, Michelle Manes, Pushpa Menon, and Kent Morrison

2024 Alexanderson Award

Minimizing Energy on Spheres



The recipients of the 2024 Alexanderson Award are Dmitriy Bilyk, Alexey Glazyrin, Ryan Matzke, Josiah Park, and Oleksandr Vlasiuk for their paper “Energy on spheres and discreteness of minimizing measures,” published in the *Journal of Functional Analysis* in 2021. This paper includes work arising from the 2018 AIM workshop “Discrete geometry and automorphic forms.”

The Alexanderson Award committee, made up of members of the AIM Scientific Board, selected this well-written paper from the eligible papers during the review period based on its universal appeal, the centrality of the problem, and its impact on the field in the short three years since publication.

This work concerns equidistribution on spheres. The simplest version of the problem is: how can you distribute n points on a basketball as uniformly as possible? A moment’s thought suggests that for most n , the answer is not pretty. The answer also depends on the specific definition of “uniformly.” Is the goal to have the points as far as possible from each other? Or to have every location on the sphere close to one of

the given points? An approach which generalizes to the topic of the winning paper is to give each point an identical electric charge and then minimize the total energy.

Energy minimization on the sphere arises naturally in many contexts, including mathematical physics, discrete and metric geometry, coding theory, and signal processing. The award-winning article focuses on “attractive-repulsive potentials” on the sphere. These are functions which are increasing near 1 but decreasing near -1 ; in other words, two particles experience repulsion when they are close and attraction when they are far apart.

If $f: [-1,1] \rightarrow \mathbb{R}$ is measurable and bounded below, then the *continuous energy integral* on the d -dimensional sphere \mathbb{S}^d is defined for any Borel probability measure μ as

$$I_f(\mu) = \int_{\mathbb{S}^d} \int_{\mathbb{S}^d} f(\langle x, y \rangle) d\mu(x) d\mu(y).$$

Given the function f , the goal is to find a measure μ for which $I_f(\mu)$ is minimized. Note that such a measure typically is not unique: the sphere has a lot of symmetry, so any symmetry of the sphere will move one minimizing measure to another minimizing measure.

This paper focuses on one of the simplest and most natural attractive-repulsive potentials, given by $f(t) = |t|^p$. The energy in this case is called the “ p -frame energy.” The easiest case is when p is an even integer. It turns out that in that case the constant measure is a minimizer.

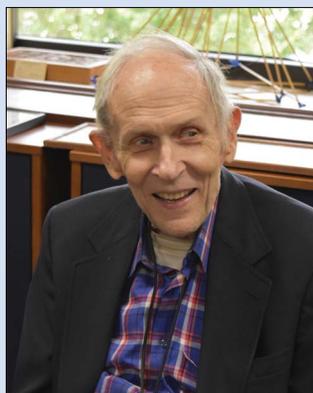
The surprising conjecture is that in every other case, any minimizing measure is discrete. The authors make significant progress on that conjecture, showing that if p is not an even integer then the support of any minimizing measure for the p -frame energy has empty interior.

For a variety of other functions f , the authors prove the full conjecture that there exists a discrete minimizing measure, and furthermore they find a bound on the number of points in the support. Examples of such f include certain functions related to the Gegenbauer polynomials. ■

— David Farmer and Michelle Manes

The Alexanderson Award recognizes an outstanding scholarly article arising from research activities sponsored by the American Institute of Mathematics and published within the past three years. The award was established

in 2018 to honor the contributions of Gerald Alexanderson, Professor of Mathematics at Santa Clara University and founding chair of AIM’s Board of Trustees. As its first chair, Jerry provided the stewardship that has distinguished AIM as an international center for mathematical research with a commitment to productive and creative collaboration.



AIM in Africa

Open Source Curriculum and Assessment Tools

In August, AIM held its first activity in Africa, in Kisumu, Kenya, in partnership with Maseno University. The workshop “Open source mathematics curriculum and assessment tools” was organized by Joe Champion (Boise State University, Idaho), Franca Hoffmann (Caltech, California), Michael Obiero (Maseno University, Kenya), and Mary Ochieng (Strathmore University, Kenya).

Participants from the US, Africa, and Europe came together to tackle the problem of how to best use technology for teaching and learning, specifically, how to use open source software to provide just-in-time feedback to students. Several efforts have been launched to address this need, but none had built a community of practice and research basis to advance this work. Workshop organizer Hoffmann participated in a previous AIM workshop and felt that the AIM style would work well in this new area. She assembled a team to submit a proposal which was approved by the AIM Scientific Board. With the enthusiastic support of local organizer Michael Obiero, the leadership role of local educators, and Maseno University’s hotel and conference center providing suitable facilities, it was natural to hold the workshop in Kenya.

A new direction

The workshop brought together research mathematicians, teaching faculty, and researchers in math education. As with all of our workshops, AIM staff worked closely with the organizers to understand their perspective on the workshop area, to invite an appropriate group of participants, and to design activities to support their goals. One concern of AIM staff: Would the workshop structure developed to support research in the mathematical sciences also work for research in mathematics education?

A reason for skepticism is that education research involving students requires identifying test sites, securing Institutional Review Board or similar approval, and then collecting and analyzing data. Unlike research in mathematics, which generally can be undertaken by a small group sitting together in a room, some components of math education research

must take place over a longer span of time, outside of a workshop setting.

Organizers focused on the components of education research that could be undertaken in a weeklong collaborative workshop: surveying what has been done previously, bringing new people into the research community (many of who are keenly aware of issues that need to be addressed, and would willingly use their classroom as a laboratory), designing experiments and data collection methods, identifying potential test sites, and planning for how the data would be later analyzed.

Challenges as opportunities

Many countries in Africa are dealing with the challenges of providing educational resources in an environment with limited resources, and there is a growing sense that working together to develop innovative approaches will be of significant benefit throughout the continent and beyond. Workshop participant David Stern highlighted some key issues, including:

- Class sizes are large: It is not uncommon to have courses with more than 700 students, one instructor, and no TAs.
- Instructors may be teaching 5 or 6 courses each term.
- Essentially no research funding is available, nor is there any supplementary support for curriculum development.



Professor Julius Nyabundi, Vice Chancellor of Maseno University, speaking at the opening ceremony.

Stern encouraged the participants to recast each of these challenges as opportunities. Some of the responses included:

- With large classes, educational research studies can be done very quickly since you can conduct A/B testing and achieve statistically significant results in a single class.
- Busy instructors are in an ideal position to evaluate which technological innovations are both likely to benefit learning and also worth the effort to implement.
- If a successful innovation requires no outside funding, then it is likely to be sustainable and implementable in both resource-low and resource-rich environments.

Stern's "challenges-as-opportunities" helped to frame the discussion and led to a sense among the participants that they were in a good position to make realistic progress toward the goals of the workshop. Furthermore, the solutions that are viable in African universities are likely to be useful everywhere, providing effective education to large groups of students.

The role of technology

A focus of the workshop was the use of open source technology in teaching, specifically, systems which allow students to do practice problems and receive immediate feedback. Such systems are in wide use and include commercial products as well as open source alternatives.

The workshop focused on two open source projects: STACK and WeBWorK.

STACK, created by Chris Sangwin, grew out of

research on the automatic assessment of mathematics using a computer algebra system. The software uses the Macsyma computer algebra system to do symbolic manipulation to evaluate student answers.

WeBWorK was created by Michael Gage and Arnold Pizer, with the first classroom-ready version available in 1996. The software is written in the Perl programming language and uses pattern matching and numerical evaluation to evaluate student answers.

Both systems offer immediate constructive feedback for incorrect answers; both support a variety of questions, ranging from simple multiple choice to free-form responses of algebraic expressions which require interpretation by the system; and both are open source and available for free. But free can come with a cost: It takes resources and skill to set up either system, and many users choose to pay for a hosting service.

Some issues which motivated discussion at the workshop were:

1. Both systems have a learning curve for authoring new problems.
2. Both systems have repositories of problems, but the quality is variable and it can be difficult to find questions which target a particular learning goal.
3. Lack of interoperability between WeBWorK and STACK prevents users from easily using both systems and prevents developers from working together.

Progress was made on items 2 and 3, looking initially at the simplest types of problems and focusing on an authoring format which does not require knowledge of the inner workings of the system. The first item was judged to be an issue which, for now, each project should address separately.



A group photo from the workshop.



David Stern describes some challenges and opportunities.

What next?

This workshop set in motion a wealth of activity which will continue for many years, including several math education research projects and the ongoing work on STACK and WeBWorK. The presence of high-level administrators and department leaders from several Kenyan universities allowed planning for activities which are beyond the scope of any one institution. A specific challenge is the new “Competency Based Curriculum (CBC)” recently introduced in Kenyan secondary schools. The effects of the CBC will require university instructors to make changes to their curriculum and instructional methods. To help meet that challenge, a new “Master of Science in Mathematical Innovation” degree with corresponding curriculum was designed during the

workshop. The program at the Open University of Kenya will begin enrolling students as soon as January 2025.

Overall there was a sense of excitement at the workshop. The collaborative emphasis of the AIM style, with its focus on forming groups and beginning work which will continue long after the workshop week, was much appreciated by the participants. Several expressed an intention to adopt the AIM style for future activities.

More information about the workshop, including a detailed report from the organizers, is available on the workshop follow-up page: <https://aimath.org/pastworkshops/oerassessment.html>. ■

— Sally Koutsoliotas and David Farmer

The American Institute of Mathematics thanks our partners and sponsors for their generous support!

The National Science Foundation

The Richard N. Merkin Center for Pure and Applied Mathematics

The California Institute of Technology

The Fry Family Foundation



Caltech

Lean-ing In

Teaching Algebraic Geometry to a Computer

In the 1960s, Grothendieck revolutionized algebraic geometry and wrote the foundations of the subject (with various co-authors) in the celebrated EGA volumes. Fifty years later, Johan de Jong began the Stacks Project, an open-source, collaboratively authored textbook explaining many of the same ideas but this time in LaTeX and HTML (and in English). One of the many advantages of this new version is that the work can be hyperlinked, and dependencies can be tracked and checked.

Not long after the beginning of the Stacks Project, Microsoft released an experimental programming language called Lean, designed to enable computer scientists to rigorously prove the correctness of computer programs. This is a computer language, readable by trained humans but also by machines. The language is sufficiently rich that it can express precise mathematical content, even at research level. Within a few years of its appearance in 2013, mathematicians realized that Lean could also verify proofs of theorems, but it needed to “understand” the vast body of definitions, axioms, and theorems of mathematics before it could be truly useful for research-level work.

Mathematicians began creating a mathematical library for Lean. That library, called mathlib, can be

found at <https://leanprovercommunity.github.io>. Recent successes — including Thomas Bloom’s formal proof of an old conjecture of Erdős and Graham, and a team led by Commelin and Topaz formalizing Clausen and Scholze’s “fundamental theorem of liquid vector spaces” — have led to a surge in interest in formalizing new areas of mathematics.

About six years ago, a group of algebraic geometers began translating the foundations of algebraic geometry into Lean. By now, basic notions — e.g., schemes, sheaves, and homological algebra — are in place, but there is still much work to do before Lean can be used to verify current research.

In June 2024, more than 30 people from the US, Canada, Europe, and Taiwan participated in a virtual AIM workshop devoted to formalizing basic and advanced concepts in algebraic geometry. The workshop, co-organized by Kevin Buzzard (Imperial College), Johan Commelin (Univ. of Utrecht),

For more background on Lean and mathematics, we recommend these excellent articles from Quanta Magazine:

“Can Computers be Mathematicians,” Steve Strogatz interviewing Kevin Buzzard, June 29, 2022, <https://www.quantamagazine.org/can-computers-be-mathematicians-20220629/>

“Building the Mathematical Library of the Future,” Kevin Hartnett, October 1, 2020, <https://www.quantamagazine.org/building-the-mathematical-library-of-the-future-20201001/>

And for an introduction to Lean for undergraduate math, there is an online text by Heather Macbeth, “The Mechanics of Proof,” <https://hrmacbeth.github.io/math2001/>



Screenshot from Sococo, the office overlay software AIM uses for virtual workshops.

Joël Riou (Univ. Paris-Saclay), and Adam Topaz (Univ. of Alberta), brought together two groups: experts in Lean and experts in algebraic geometry, with a few who qualified on both counts. The plan was to bring the mathematicians up to speed with Lean and then to spend significant time with small groups working on well-defined projects. The organizers hoped that an AIM-style workshop would allow the most important projects to emerge and significant progress to be made on many of them.

Time zones were a major issue for the workshop. With participants scattered all over the world, when would we schedule the “morning” talks, the “lunch” break, and the “afternoon” working groups? The organizers and AIM staff eventually agreed to run the workshop from 9am until 5pm Eastern time each day, which meant very early mornings in California, very late nights in England, and participants in Taiwan shifting their lives to work through the night for that week. There was, quite literally, round-the-clock work on projects during the week of the workshop, and each morning, groups reported out on their progress.

Participants worked on over a dozen different problems, including developing Lean code for the Krull dimension of topological spaces, rings, and schemes; constructing affine and projective schemes attached to Weierstrass curves; and formalizing the fact that there are enough injectives in the category of sheaves of modules over a ringed space. This last problem was a bottleneck that needed to be resolved so that other projects could proceed.

So, how did it go? Organizers reported that it was a workshop unlike any other they had ever attended, with undergraduates, graduate students, postdocs, junior faculty, and senior faculty all contributing to the success of the endeavor. One of the senior mathematicians said that he felt they were educating a whole new generation of algebraic geometers. Kevin Buzzard remarked, “People took things seriously. The workshop has so far generated 56 pull requests to Lean’s math library, which is a huge number, and no doubt there will be more to come as well. ... To say this approach worked would be an understatement.” ■

— Kent Morrison and Michelle Manes

Welcome New Board Members

Board of Trustees

Estelle Basor

Scientific Research Board (terms beginning in 2024)

Maria Chudnovsky, Princeton University / graph theory and combinatorics

Tristan Collins, University of Toronto / geometry and analysis

Amanda Folsom, Amherst College / number theory

Jonathan Keating, Oxford University / mathematical physics and number theory

Kathryn Leonard, Occidental College / computer science, machine learning, data science

Julia Plavnik, Indiana University / category theory and noncommutative algebra

The Sweetest SQuaRE

Modeling Swollen-Shoot Virus in Cacao Trees

The members of the AIM SQuaRE “Sustainable plant harvest in fragmented landscapes” — Folashade Augusto, Benito Chen-Charpentier, Owusu Domfeh, Natali Hritonenko, Maria Leite, and Frank Owusu — set out to create mathematical models of the complex interactions between plant pathogens, harvest, and forest fragmentation. One of their goals was to investigate the optimal control strategies necessary to curtail plant diseases and maximize plant viability and survival at the same time. The second paper from their SQuaRE, “Cacao sustainability: The case of cacao swollen-shoot virus co-infection,” was published in *PLoS ONE* in March 2024 (<https://doi.org/10.1371/journal.pone.0294579>) and has been receiving a lot of attention in the press.

It’s no wonder, since these researchers are addressing a major threat to the world’s supply of chocolate.

Ghana is the second-largest exporter of chocolate in the world. However, cacao trees are not native to Ghana. Native to America from Mexico to Brazil, cacao was introduced to Africa by the Portuguese. Legend has it the beans were brought to Ghana from Equatorial Guinea in the pocket of a blacksmith in 1895. Swollen shoot virus, on the other hand, is endemic to Ghana. First identified in 1936, the virus is transmitted primarily by mealybugs. It decreases cacao yield dramatically and kills the tree within a few years. Despite ambitious and costly eradication efforts, it has not been effectively contained.

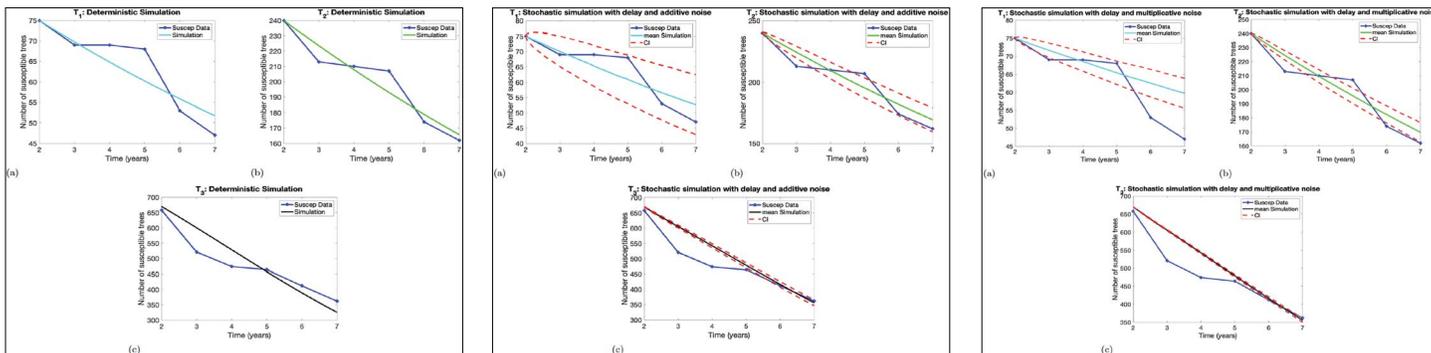
Between 1936 and the 1960s, the disease nearly ended the cacao industry in Ghana. Mitigation efforts — including removing infected trees or leaving space between newly planted trees and previous crops of infected trees — have helped to revitalize the industry. However, these methods are costly, and many farmers who are managing on slim profit margins feel that cutting down trees that are producing any cacao at all or leaving swaths of land unplanted are simply wastes of money. The farmers’ resistance, while understandable, makes the containment efforts less effective overall and contributes to the continued spread of the disease.

Recent recommendations of the Cocoa Research Institute of Ghana (CRIG) include using mild-strain cross protection strategies: systematically planting trees that have been inoculated with a mild strain of the virus in order to protect the whole plot. In their work, the members of the SQuaRE create ordinary differential equation (ODE)-based models to describe the dynamics of the disease and spread of the virus with various interventions. Two of the SQuaRE members are scientists at CRIG, joining the SQuaRE meetings remotely and co-authoring the article. This close collaboration with CRIG gives the researchers crucial access to detailed empirical data. It also means that their findings can be used to implement recommendations to help farmers in the region make the best decisions for their land.



From top: Cacao pods ready for harvest.
Drying cocoa beans in Ghana.

images by iita-media-library on Flickr



The SQuaRE’s research uses two deterministic models (with and without delay) and two stochastic models to capture the infection transmission dynamics of the virus in cacao trees using data from three types of treatment over a period of seven years. The differences between the treatment types (T_1 , T_2 , and T_3) lie in the number and placement of inoculated trees.

For example, their deterministic model is given by an ODE relating susceptible trees X , the average number of mealybugs per severely infected tree J , a parameter p representing the transmission probability, and the number of severely infected trees in a given plot Z :

$$\frac{dX}{dt} = -pJZ(t)X(t).$$

Their stochastic model with delay τ and additive environmental white noise dW is given by:

$$dX(t) = -pJZ(t-\tau)X(t-\tau)dt + \sigma dW.$$

(Here σ indicates the intensity of the noise.) The figures above show the fit of some of their models with the CRIG-provided data.

Ultimately, the collaborators find that simple deterministic models can capture the dynamics of the disease nearly as well as more elaborate SIR-type models (Susceptible-Infectious-Recovered), and that the models combining delay and stochasticity, which take into account variability and errors in the treatments, are even more realistic. They also outline several areas for future work. Every time we eat a brownie, we’ll be thanking these researchers for their efforts, which allow us to continue enjoying these treats. ■

— Michelle Manes

2025 JMM Activities

AIM is proud to be a JMM partner. Each year, AIM sponsors Special Sessions, an Invited Address associated with the Alexanderson Award, and a reception. Check the JMM Program for details!

- **The AIM Booth:** Stop by, chat with AIM staff, and learn about our various activities. Our PRIMES Scholars-in-Residence (see story on pages 16–17) will also spend some time at the AIM booth.
- **Invited Address:** Dmitriy Bilyk will give the Alexanderson Award Lecture, “Energy minimization problems in analysis and discrete geometry.” The Alexanderson Award winners will receive their medals at the Awards Celebration. (See story on page 4.)
- **AIM-sponsored Special Sessions:** Math Circles for Makers, Creators, and Artists • Applications and Generalizations of Zero Forcing • Energy Minimization: From Analysis to Discrete Geometry (associated with the Alexanderson Award Lecture by Dmitriy Bilyk) • Pedagogical Practices in Math Circles and Other Non-Traditional, Informal, and Recreational Math Spaces.
- **Professional Enhancement Program (PEP):** Leveraging GitHub and AI for Mathematics Research and Teaching, presented by Steven Clontz and Oscar Levin. (Note that participation in PEPs requires pre-registration and an additional fee.)
- **Social Events:** AIM sponsors the Math Circles Dessert and Games Night Reception. You can also find us at the Mathematical Institutes Open House.

AIM Research Communities (ARCs)

Fostering Virtual Networks

AIM learned a lot about facilitating online collaborative workshops from 2020–2022, when we were largely unable to gather for in-person events. Rather than viewing virtual workshops as a stopgap until we could return to business-as-usual, we saw an opportunity to use what we had learned to reach more researchers and to foster new kinds of collaborations.

Even before COVID, some mathematicians were unable to or chose not to travel for a variety of reasons, such as health concerns, caregiving responsibilities, heavy teaching and service responsibilities, etc. Also, graduate students and postdocs in smaller programs or remote locations often have limited access to colloquia, seminars, and connection to their broader research community, including a wide range of mentors and potential collaborators. Many of these mathematicians found that virtual activities developed during the pandemic actually increased their access to research networks.

To continue meeting the needs of these members of our community, we designed AIM Research Communities (ARCs) as an effective virtual research experience. Because they are virtual, ARCs can be much bigger than workshops; each ARC can involve 50 or more participants.

Three Types of ARCs

Each ARC begins with some kind of launch event. The primary goal(s) of the ARC determine how that launch event is run and which activities predominate after the launch. Over time, we have observed that there are three main types of ARCs: Research Group ARCs, Capacity-Building ARCs, and Creating and Sustaining a Network ARCs.

Research Group ARCs can be thought of as AIM workshops or research collaboration workshops in slow motion. The primary outcomes of these ARCs are production of research (and dissemination via publications) and building collaborations. These collaborations are achieved by forming small working groups,

each of which focuses on a different problem. These groups can be formed in two different ways.

In the AIM workshop model, part of the launch event includes a moderated problem session in which participants pose and refine the statements of interesting open problems. A version of the AIM workshop voting algorithm can be run during the event or asynchronously to form small working groups based on participants' interests.

The research collaboration workshop model functions more like Research Experiences for Undergraduate Faculty workshops (REUF), the Mathematics Research Communities program run by AMS (MRC), and the many Research Collaboration Conferences run in collaboration with the AWM (RCCWs). In this model, research mentors propose problems, which they describe in talks during the launch event. Participants indicate their project preferences, and the organizers use that information to create the small working groups.

In both cases, the research groups self-organize to work on their research questions. The whole community may meet at regular intervals for seminar talks, panels, or even social events, but the small research groups are the heart of this type of ARC.

Capacity-Building ARCs focus on supporting junior researchers, helping them develop technical background and research skills while integrating them into an existing network of researchers. The ARC launches with a virtual learning conference, where senior mathematicians give short talks about a paper or idea necessary to understand some of their work. Throughout the semester, graduate students meet virtually in small groups to read through one of the presented papers. A mentor, usually a postdoc or senior graduate student who is familiar with the paper, holds regular office hours to support the reading groups. A virtual closing conference includes short talks by the reading groups, talks by the mentors on their research, and a moderated problem session to encourage continued collaboration.

Creating and Sustaining a Network ARCs emphasize developing a research network. Activities include talks and Q&A sessions designed to introduce the expertise and interests of community members to one another; reading seminars designed to explore connections between research areas in a supportive, collaborative space; virtual office hours, career panels, social events; and even occasional in-person meet-ups for those who can travel to local conferences or large national meetings like the Joint Math Meetings.

AIM's Support for ARCs

ARC proposals (along with workshop and SQuaRE proposals) are accepted each year, with a deadline of November 1. AIM's Scientific Board determines which proposals to support. In a series of planning meetings, AIM staff work with organizers to articulate the goals for their ARC, review applicants, invite participants, and plan the launch event.

AIM provides a virtual meeting space called Sococo for the launch event and throughout the first year of the ARC. Sococo has many advantages over simply using Zoom at the start of a community: there are multiple virtual meeting spaces, and participants can move themselves between them, just like walking between the breakout rooms at AIM's facility. Participants have virtual offices where they can meet with collaborators or hold virtual office hours without having to remember who is hosting the Zoom meeting. Groups can leave links to their personal web pages, meeting schedules, papers to read, in-progress work, computations, and more on their virtual office desks. Sococo makes it easy to find the documents, people, and meetings for the community; it's a one-stop shop.

AIM also helps organizers set up and manage a QUBES site for their ARC. Developed by biologists with support from the NSF, this open-source system allows ARCs to manage both internal communication (mailing lists, community messages, shared documents, and more) and external communication (public-facing web pages).

In addition, AIM provides each ARC with financial support that can be used flexibly depending on the needs of the community. Some ARCs distribute equal stipends to every participant. Others pay mentors or project leaders to compensate them for the time they devote to making the community successful.

And some ARC leaders distribute funds based on a survey of their ARC participants' needs. Stipends may cover a tablet that allows graduate students to access a shared virtual whiteboard, a headset for postdocs in a shared office that makes attending virtual events less disruptive, or childcare so that parents can attend the launch event without having to worry about other responsibilities.

Some ARCs have a one-semester or one-year cycle and then draw to a close. Others continue past the first year of AIM support, revitalizing their activities with new launch events, new research collaborations, new reading groups, and even new leadership.

ARC profile: IEPG-ZF

The Inverse Eigenvalue Problem on Graphs and Zero Forcing (IEPG-ZF) ARC is a Research Group ARC that began in February 2021 and is still continuing. At the beginning of each year-long cycle, research groups are formed through moderated problem sessions and voting polls. This ARC has resulted in at least 13 papers published or posted on arXiv (with several more in preparation), and members have organized eight special sessions at the Joint Mathematics Meetings and other conferences. Half the participants of the IEPG-ZF are at colleges and universities that do not offer a doctoral degree in mathematics.

Mary Flagg, one of the organizers, sums up why ARCs will continue to be a useful model for building collaborations and sustaining research communities: "As an organizer of the IEPG-ZF ARC, my goals were to maintain my own research program and help my friends and colleagues at primarily undergraduate institutions have the opportunity to be active in research. A member of my current group who has a teaching position at a research university told me that our group was her lifeline to research. The same group has members with young children and members who have changed positions during our year together. Even with funding, travel for these mathematicians is not feasible at this point. I have had the privilege of working with friends that I would never have met without the ARC. Had I met them at an in-person conference, it is unlikely that I would have developed a productive relationship with them." ■

— Leslie Hogben

Celebrating 30 Years of AIM

A “Perfect” Day for a Math Fair

A “perfect number” is one that equals the sum of its proper divisors. For example, $6=1+2+3$ and $28=1+2+4+7+14$. With such a simple definition, it’s perhaps surprising what we don’t know about perfect numbers. An even number is perfect if and only if it is expressible as $2^{n-1}(2^n-1)$ where 2^n-1 is a prime. Notice that $6=2\cdot(4-1)$ and $28=4\cdot(8-1)$. Are there infinitely many such numbers? We don’t know! What about odd perfect numbers? We don’t know if there are any of those at all!

The date June 28, or 6/28, comprising two perfect numbers, is sometimes called “perfect number day,” and is often a day for mathematical celebrations. For AIM, the day is even more auspicious because AIM was incorporated as a non-profit organization on June 28, 1994. In honor of our 30th birthday, we hosted a weekend of celebrations at our new Caltech home on Friday, June 28 and Saturday, June 29, 2024.

The weekend kicked off with a Friday happy hour reception for local friends of AIM — including participants in that week’s SQuaREs program and local members of AIM’s Scientific, Advisory, and Human Resources Boards — followed by a formal dinner at Caltech’s Faculty Club, The Athenaeum.

On Saturday, an estimated 700 students, friends,

parents, and kids of all ages joined us for a day of mathematical fun, games, puzzles, prizes, and treats on the Caltech Hall lawn. The event was free and open to the public. Volunteers for our Math Fair included AIM staff; postdoctoral scholars organized by the Caltech Postdoctoral Association; Caltech professors and students; and math professors, undergraduate students, and teachers from the greater Los Angeles area. Longtime friends of AIM’s joyful math work also volunteered: James Taylor (MathAmigos, Santa Fe) and Donna Fernandez (Alliance of Indigenous Math Circles) ran a popular “SET Quilt” station; and Yana Mohanty, founder and CEO of Geometiles, traveled from San Diego to host a colorful table where children and adults alike built interesting polyhedral structures throughout the day. Several members of AIM’s Board of Trustees — Estelle Basor, John Fry, Harry Saal, and Stephen Sorenson — also participated in the festivities.

Along with the 20 or so math games and activities, there was a face painting booth, snow cones, popcorn, lemonade, and ice cream bars. There was also a taco truck that did a brisk lunch business. The support of the Caltech community was terrific and helped make the day a great success. ■

— Michelle Manes and Brianna Donaldson



Photo by Yana Mohanty/Geometiles

From left: Local families enjoying the SOMA cube activities. Donna Fernandez (in cap) explains the SET quilt activity.



Photo by Yana Mohanty/Geometiles



Clockwise from top left: In addition to fun math activities, kids and adults enjoyed face painting and treats. The Geometiles table was a big draw. It was a beautiful day for outdoor math. Building a SET quilt is fun for all ages. Zometools and soap bubbles create minimal surfaces.

Big Impacts of a New NSF Program

AIM PRIMES Scholars in Residence

The National Science Foundation (NSF) Division of Mathematical Sciences (DMS) recently created a new program designed to support partnerships between non-R1 minority-serving institutions and the DMS-supported research institutes, including AIM. The program, Partnerships for Research Innovation in the Mathematical Sciences (PRIMES), supports MSI faculty to participate in programs at one or more of the Mathematical Sciences Institutes, building their own research capacity in ways that ultimately benefit their students. PRIMES awardees receive a full year of release time from their institutional responsibilities of teaching and service, plus summer salary and travel funds for an additional year.

At AIM, PRIMES Scholars in Residence have the opportunity to organize a SQuARE and attend workshops relevant to their research. Below, our three current PRIMES Scholars provide updates on their activities. As we prepared this article, all three expressed their gratitude to the NSF, their institutions, and AIM for the opportunity to participate in this program.

“PRIMES PAIR: Partnering with AIM for Inclusive Research,” by Mary Flagg (Associate Professor, University of St. Thomas in Houston)



During Mary’s PRIMES research leave in 2023–2024, she attended AIM workshops, met twice with her SQuARE, and worked intensively with another group of collaborators. Her SQuARE, “Matrix Strong Properties as tools for the Inverse Eigenvalue Problem for a Graph” (with Aida

Abiad, Bryan Curtis, H. Tracy Hall, Jephian C.-H. Lin, and Bryan Shader), has published one paper so far, “The inverse nullity pair problem and the strong nullity interlacing property,” with a second paper in progress. With Bryan Curtis and grant co-PI Leslie

Hogben, Mary has also submitted a paper on reconfiguration for graph parameters determined by subsets of the vertex set of the graph. In addition, she attended two AIM workshops: “Theory and applications of total positivity” and “Graph Theory: structural properties, labelings, and connections to applications.”

The PRIMES grant has also given Mary the opportunity to grow in her professional leadership, especially in assisting AIM with some of the programs that made a lasting impact on her career. For example, she served as a project leader at the 2024 Research Experiences for Undergraduate Faculty (REUF) workshop, coming full circle from her introduction to research in linear algebra and graph theory during REUF 2015. Mary also worked to improve the web-based infrastructure supporting the Inverse Eigenvalue Problem for a Graph and Zero Forcing (IEPG-ZF) AIM Research Community (ARC), which she co-founded in 2021 along with Jane Breen, Bryan Shader and Jephian Lin.

This academic year, Mary is looking forward to sharing her enthusiasm for research with her students, starting with a graph theory course in Spring 2025.

“PRIMES: The Inverse Eigenvalue Problem for Graphs and Collaboration to Promote Inclusivity in Undergraduate Mathematics Education,” by Veronika Furst (Professor, Fort Lewis College)



Since Veronika’s grant was awarded, in September 2023, she has had several short stays at AIM (from 2 to 5 weeks long). These visits have included two meetings with her SQuARE, “Graphs that Admit Two Distinct Eigenvalues” (with Wayne Barrett, Shaun Fallat, Shahla Nasser, and Brendan

Rooney, and Michael Tait, pictured here). One paper was revised in Summer 2023 and published by the end of the year, another was started at the group’s first meeting and is almost ready for submission, and a

third paper was begun at their most recent meeting. Veronika also continued working with other collaborators from the IEPG-ZF ARC, resulting in one paper published late last year (co-authored with Louis Deaett, Shaun Fallat, John Hutchens, Lon Mitchell, and Yaqi Zhang) and one submitted this summer. Additional collaborations resulted from her participation in the workshop “Graph theory: structural properties, labelings, and connections to applications,” as well as the REUF workshop.

Veronika’s grant also supports her efforts to improve undergraduate mathematics education at her institution and beyond. She is supervising an undergraduate research project for two Fort Lewis College students. She is also supporting the use of Open Educational Resources (OERs) to promote inclusivity, by helping reduce education’s financial burden on students. Toward this end, she co-organized a two-day workshop last May in Colorado and will also co-organize an upcoming AIM workshop “Open educational resources: adoption, curation, and customization,” with Oscar Levin, Mitchell, Nasserar, and Violeta Vasilevska.

“PRIMES: The Topology of Knots and Replication as a Vehicle for Student Research,” by Ryan Blair (Professor, California State University - Long Beach)

Ryan’s grant was funded in August 2024, and he’s been off to a productive start, visiting AIM weekly to benefit from the inspiring research culture present at the AIM workshops and SQuaREs. He participated in REUF this past summer, which generated several results regarding product throttling for power domination of graphs. He and his collaborators from that workshop (Leslie Hogben, Veronika Furst, Nandita Sahajpal,



Gabriel Elvin, and Wing Hong Tony Wong) are preparing these results for publication. Additionally, he has been making progress on research projects related to the bridge number of knots and rep-tiles in high dimensions. Ryan’s SQuaRE “Bridge number and me-

ridional rank of links” (with Alexandra Kjuchukova, Maggie Miller, Ella Pfaff, and Michel Boileau) will have their first meeting in 2025.

Ryan’s goal is to leverage the programs and expertise at AIM to create innovative student research activities and expand a research culture for students at his institution, an urban comprehensive university and Hispanic Serving Institution. He is a first-generation college student whose educational and professional journey was transformed by an undergraduate research experience in knot theory, and he is devoted to creating and implementing similarly transformative research experiences for his students. Already the partnership with AIM is paying dividends: Based on insights from the REUF workshop, Ryan is currently engaged in research projects with CSULB students on applications of zero forcing of graphs to knot theory.

If you are a faculty member at an eligible institution and you would like to partner with AIM on a PRIMES proposal, please read over the information here <https://tinyurl.com/PRIMES-AIM>, and then write to research@aimath.org for more details. ■

— Michelle Manes, Mary Flagg, Veronika Furst, and Ryan Blair

Call for Proposals

Each year, AIM accepts proposals for Workshops, SQuaREs, and Research Communities. Proposals are short (generally 2-3 pages) and focus on the mathematical goals of the activity. The proposal submission window is Aug. 1 – Nov. 1 each year, during which the proposal submission form is available at <https://aimath.org/>. The AIM Scientific Board meets in early December to select programs to support for the following year. AIM staff are always willing to answer questions from potential organizers at workshops@aimath.org.

Perspectives on REUF

Research Experiences for Undergraduate Faculty

Research Experiences for Undergraduate Faculty (REUF) is a long-running program of AIM and ICERM (another NSF-supported math research institute), with a primary goal of equipping faculty who teach at undergraduate institutions to mentor their students in research. Below, three REUF alumni share their perspectives on their experiences.

From REUF to Math Circles

Benjamin Gaines, Iona College

I participated in a REUF project where we worked with Francis Su on a game described in his book, *Mathematics for Human Flourishing*. Playable on a planar graph drawn without edge crossings, the “Game of Cycles” seems simple, but we quickly found that different strategies were appropriate depending on the graph.

The students I worked with enjoyed playing the game with their friends, even those who had not taken any math courses beyond Math for Liberal Arts. In this, I saw an opportunity to share this work (and hopefully some enthusiasm for mathematics!) with area high schools. I designed an activity that would introduce students to the ideas of combinatorial games through the Game of Cycles. Students were able to discover tricks and methods for themselves, and have fun in the process. They also were fascinated to learn that this is an area of active research! I am currently in the process of writing up this activity so that others can share this game with interested students of all backgrounds and ages.

From REUF to a SQuaRE

Lauren Grimley, University of Oklahoma (formerly at Spring Hill College)

I participated in REUF after my second year at my small liberal arts college, my first job out of the PhD. I was quite isolated from research and was already beginning to struggle to remain active and find new projects. REUF provided me the opportunity to explore a new area, one which would be sustainable because I could



Lauren Grimley (second from left) and her SQuaRE at AIM.

collaborate on these projects with my undergraduate students rather than needing outside collaboration.

Later I was part of a SQuaRE that was quite a departure from my mathematical expertise. Apart from REUF, I had never before ventured into a project where I didn't have a substantial expertise in the background material. Had I not re-energized my research with and had the experience of my REUF project, I don't think that I would have been able to participate as actively in the SQuaRE project.

From Workshops and SQuaREs to REUF

Harsh Jain, University of Minnesota Duluth

My experience with REUF was a departure from other AIM activities I've attended, where I typically work with established collaborators or people within my network. My main motivation for participating was to receive guidance on managing large, undergraduate-focused research groups, and REUF exceeded my expectations in that regard. The mentoring I received, especially from Ami Radunskaya, was invaluable. As a bonus, our REUF working group worked on a problem in a research area that is new to me. The group's commitment to the project has been inspiring, and we're excited to build on this collaboration by hopefully returning to AIM next year. ■

A Joyful Math Ecosystem

Community Outreach in Southern California

In keeping with our longstanding commitment to serve students and teachers in our local area, AIM's Special Projects Division has set a goal of enhancing and supporting a sustainable ecosystem of joyful mathematics programs in the Los Angeles area. With generous support from the Eli and Edythe Broad Foundation, we've begun planning for a sustainable citywide network of equity-focused Math Circles in Los Angeles along with other joyful math programs that are welcoming and accessible to students from historically marginalized communities.

The Broad Foundation funding also supports two pilot community Math Circle programs. One of these programs is a Family Math Circle in South Los Angeles at The Knowledge Shop LA. Founded in 2015, TKSLA is a STREAM (STEM+Arts+Reading & writing) enrichment center, offering educational programs and community initiatives to support local youth and families. Once a month, the Family Math Circle welcomes local parents and their children to discover the joy of mathematics through culturally relevant activities. The other pilot program is Math On The Border (MOTB), which provides bilingual Math enrichment programs to migrant minors through weekly online sessions and occasional in-person festivals and gatherings held in

partnership with community organizations such as Esperanza.

As part of this effort, a group of local leaders—educators, mathematicians, and community organizers with significant outreach experience—gathered at AIM in November, 2024 for the first Los Angeles Joyful Math Symposium. During this day of collaborative work, participants got to experience a joyful math activity, share their work, and brainstorm ideas on how to grow and support a sustainable ecosystem of equitable and joyful math experiences for all in the greater Los Angeles area. During the afternoon, participants tackled challenging problems such as how to train and develop facilitators and organizers of joyful mathematics experiences for children, pre-and in-service teachers, and families at scale, as well as how to evaluate the impact of such programs on the communities they serve.

This was a truly energizing event for the participants, thanks to the many ideas and connections made. We hope the symposium will serve as a stepping stone for the year ahead, where we hope to see many equitable joyful math programs being developed for the enjoyment of all children in Los Angeles. ■

— David Crombecque



From left: Math On the Border booth at Esperanza's Spring Fair, Los Angeles, May 2024. Joyful Math activity led by Daniel Kline at the LA Joyful Math Symposium, November 2024.

View from Morgan Hill Math

Shaping the Present and Future of Students

Morgan Hill Math is an outreach program sponsored by the American Institute of Mathematics (AIM) which provides free math enrichment activities and opportunities for math competitions to about 300 students each year, who live in or near Morgan Hill, CA.

Most families are introduced to Morgan Hill Math through Mathletics and MathCounts6. In Fall 2023, fourth and fifth graders enrolled in our 8-week Mathletics program, enjoyed lessons that included learning to solve Sudoku, KenKen and Chocolate Fix puzzles; discovering pi; exploring angles, areas and perimeters; and practicing problem-solving strategies such as working backwards and making charts. Students in MathCounts6 were introduced to more advanced problem-solving concepts including combinatorics, permutations, proportions, and Exploding Dots — all skills that are necessary for succeeding in math competitions.

“I would like you to know what my son said yesterday evening when I picked him up after sixth grade MathCounts. He got in the car and said: ‘Wow, Mom! That was the best math lesson I have ever had! We had Mrs. Barnes today and she totally stretched my brain! What an amazing teacher!’ I asked him what was so awesome and he said ‘she taught us

another way to look at doing problems. It works with all kinds of math equations. Mom! My mind is whirring!”

Starting in September 2023, I held weekly MATHCOUNTS training classes at 4 local middle schools and offered a weekly Zoom session for all other interested students. Over 50 students from 6 local schools sharpened their skills in exponents, divisibility rules, probability, permutations and combinations, functions, algebra, and geometry. About 40 students attended the Coyote Valley Chapter Competition in February, held at Oakwood School. Six students from Oakwood School and four students from Charter School of Morgan Hill qualified to move onto the Northern California State Competition!

“Thank you for all that you’ve done...with the different math programs over the years. (My son’s strong interest in mathematics has been fostered by your dedication and knowledge, and amazing enthusiasm!”

All interested students from Morgan Hill Math programs, 8th grade and below, were invited to participate in one or both divisions of the Math Olympiad for Elementary and Middle School (MOEMS). Over 70 kids were challenged to strengthen



Coyote Valley Chapter Competitors, February 2024



Math Olympiad Winners 2023/2024 Season



Santa Cruz Math Circle students constructing a SET quilt

their problem-solving skills in this once-per-month, five-question test. The contest is held over Zoom, which allows more kids to participate. The 2023/2024 competition series was especially difficult. In the Middle School Division, eighth-grader Anna Conca had the highest score with 21 out of 25. In the Elementary School Division, fifth-grader Aarya Dhane once again came in first place with a score of 23 out of 25. The Math Olympiad Award Ceremony was held in the community playhouse, where the kids got to come up on stage to receive their certificates and awards. It was an amazing experience and really celebrated the kids who continue to challenge themselves through such a difficult math contest.

Our middle and high school Mathletes participated in several other competitions this year. In January, 32 students involved in the weekly MATHCOUNTS training classes took the AMC8, an MAA competition for students in eighth grade and below. Mason Nishimura (8th grade) scored in the top 1% nationwide, earning him a spot on the Honor Roll of Distinction. High school students were invited to take the AMC10 or AMC12 exams. In the Purple Comet! Math Meet, a team of six students from Charter came in 3rd place in California, 24th place in the USA, and 66th place overall!

“(My son) is learning a lot and enjoys the program. Even when he doesn’t always get many questions correct each week, he’s never discouraged and continues to learn.”

The Morgan Hill Student Math Circle for Elementary and Middle School Students continued throughout the year. We met every Monday over

Zoom to explore fun math activities. Most activities were found on the Math Circles and JRMF webpages. As an online circle, families are registering from all over the USA, and I have one very enthusiastic student in Japan! This year I was invited to present at the Santa Cruz Math Circle camp program. I enjoyed sharing some of my favorite circle activities with them such as “1, 2, 3, & 4,” SET, Grid Power, billiard bounces, star drawing, and quilt squares.

Morgan Hill Math has been making an appearance at more community events. The Live Oak Robotics club hosted a STEM Night and invited me to set up a table. I had a booth at the Morgan Hill Wildflower Run. I was also invited to participate in the local Young Women Leaders’ Youth Leadership Conference. At all these events I bring fun math activities and spread the word about our enrichment programs as well as career opportunities in Math.

Making connections with students and families is what makes Morgan Hill Math so special. Listening for the gasps from that ah-ha moment, when they understand a new idea, seeing them gain confidence and perseverance in problem solving—this is why teachers teach. Heartfelt thanks from the students and their parents make it even better.

“Thank you so much for teaching me this past year and every year since I started the wonderful MATHCOUNTS program. Without you, math won’t be the same. I admire your passion for math and to teach others to enrich learning. Ever since I started the program in 4th grade, I looked forward to our weekly meetings. I will miss you so much as I move on to high school.” ■

— Kelley Barnes

AIM Library Spotlight

The Hugh L. Montgomery Collection

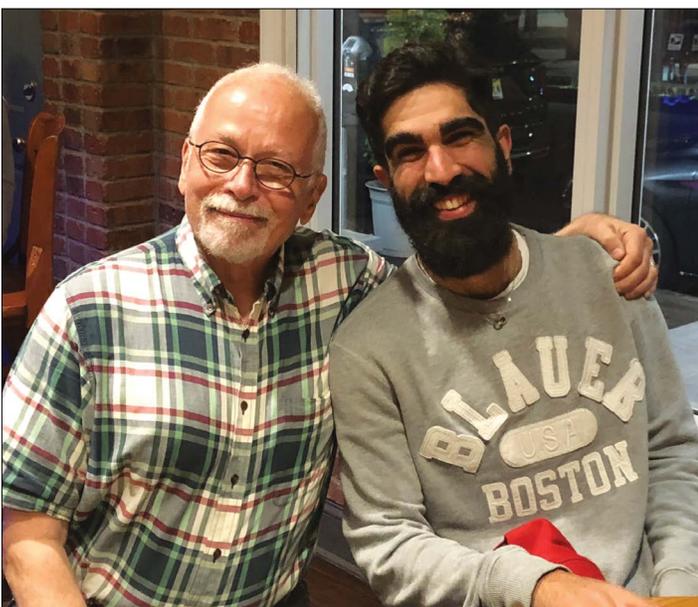
AIM's mission is "to advance mathematical knowledge through collaboration, to broaden participation in the mathematical endeavor, to increase the awareness of the contributions of the mathematical sciences to society, and to preserve the history of mathematics through the acquisition of books and documents." In service of this last goal, AIM has an enormous and fascinating collection of reprints, perhaps the largest of its kind in the world, including complete collections from Atle Selberg, Paul Cohen, John Tate, Paul Turán, and Frigyes Riesz, to name just a few.

Professor Hugh L. Montgomery recently donated his personal collection of 4600 reprints to the AIM library, for which we are very grateful. As a Marshall scholar, Professor Montgomery earned his Ph.D from the University of Cambridge in 1972 under the supervision of Harold Davenport. His primary research is in number theory and in harmonic analysis. According to the website of the University of Michigan, where he served on the faculty beginning in 1972, Professor Montgomery "is well known for the formulation of a pair correlation conjecture for Riemann zeta zeros, and for developments of the large

sieve method. His research outside number theory has touched on Turán's power sums, irregularities of distribution, extremal properties of trigonometric polynomials, and analytic inequalities." He has written five books in the areas of number theory, the Riemann zeta function, and Fourier analysis. His book Introduction to the Theory of Numbers, coauthored with Ivan Niven and Herbert S. Zuckerman and currently in its fifth edition, is one of the noted texts of introductory number theory. A cross-section of his work can be found in his compilation Ten Lectures on the Interface between Analytic Number Theory and Harmonic Analysis (available in the AIM Library). Professor Montgomery was awarded the Prix Salem in 1974, and the Henry Russel Award in 1975. He was named a Fellow of the American Mathematical Society (part of the inaugural class of Fellows) in 2013.

During his long career at the University of Michigan, Montgomery supervised 18 PhD students, including AIM Executive Director Brian Conrey. He retired in 2020. On the recent occasion of his 80th birthday, AIM wishes him many happy returns! ■

— Pushpa Menon



From left: Hugh Montgomery with Alessandro Fazzari, his academic great-grandson, at the 50 Years of Number Theory and Random Matrix Theory Conference. Part of the Montgomery Collection arranged on bookshelves.

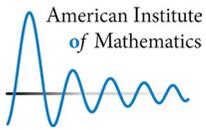
Upcoming Workshops



AIM hosts focused workshops in all areas of the mathematical sciences. AIM's workshops are distinguished by their emphasis on a specific mathematical goal, such as making progress on a significant unsolved problem, understanding the proof of an important new result, or examining the convergence of two distinct areas of mathematics. Workshops in 2025 include:

- **Motives and mapping class groups.** January 27-31, 2025
- **Geometric partial differential equations from unified string theories.** February 10-14, 2025
- **The geometry of polynomials in combinatorics and sampling.** March 3-7, 2025
- **All roads to the KPZ universality class.** March 17-21, 2025
- **New directions in G2 geometry.** March 31-April 4, 2025
- **Integro-differential equations in many-particle interacting systems.** April 14-18, 2025
- **Moments in families of L-functions over function fields.** April 28-May 2, 2025
- **Algorithmic stability: mathematical foundations for the modern era.** May 12-16, 2025
- **Open educational resources: adoption, curation, and customization.** May 12-16, 2025
- **Mathematical foundations of sampling connected balanced graph partitions.** June 2-6, 2025
- **Metric embeddings.** July 7-11, 2025
- **A social justice curriculum in mathematics: resources for future research.** July 21-25, 2025
- **Interactions between discrete and large topological groups.** August 4-8, 2025
- **Homological mirror symmetry and multigraded commutative algebra.** August 18-22, 2025
- **Flag algebras and extremal combinatorics.** October 13-17, 2025
- **Dynamics of multiple maps.** November 3-7, 2025
- **Non-Archimedean methods in complex geometry.** November 10-14, 2025
- **Modeling the mathematical sciences community.** December 8-12, 2025

Did you know? Most workshop participants are invited by the organizers, but several spaces in each workshop are held open for applicants who wish to participate. Applications are generally due about 5 months before the workshop takes place. Successful applicants are fully funded, including travel and accommodations. You can always check out upcoming workshops on the AIM website: <https://aimath.org/workshops/>.



American Institute
of Mathematics

Caltech 8-32
1200 E California Blvd
Pasadena, CA 91125

NONPROFIT
US POSTAGE
PAID
PASADENA, CA
PERMIT #648

the view from aim

2025

