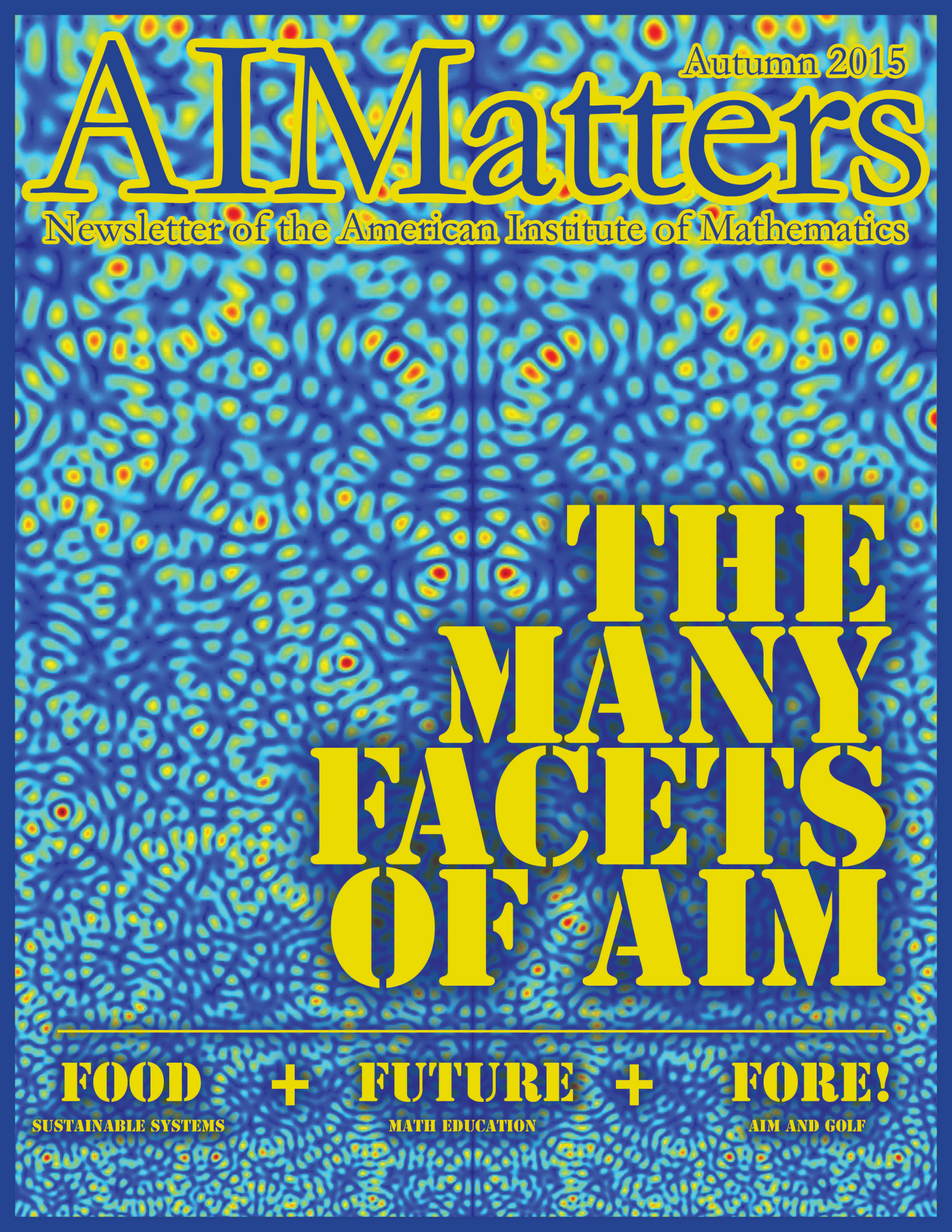
AIMatters

Autumn 2015

Newsletter of the American Institute of Mathematics



THE MANY FACETS OF AIM

FOOD + FUTURE + FORE!

SUSTAINABLE SYSTEMS | MATH EDUCATION | AIM AND GOLF

Letter from the Director

A New View

Greetings from San Jose! AIM has moved and the Palo Alto location is now closed. We reopened in January in the Fry's Electronics Corporate Headquarters. We now have four nice break-out rooms, eight staff offices and two visitors' offices. Our library fits nicely and our presentation area is more secluded. And we have windows! Western tanagers congregate in the trees just outside.

Downstairs, chefs Matt deLosso (formerly of Aqua in San Francisco) and Richard Tamura operate the Fry's Cafe. Most workshop participants—and the AIM staff—order lunch there every day. Try the blackened salmon Caesar salad!

We have already hosted more than a dozen workshops and two dozen SQuaREs in our new space. Our participants stay in the DoubleTree Hotel, which features a pool and spa in an inner courtyard, an exercise area, several restaurants, and a wine bar. The hotel is about a mile from AIM, so our newest staff member – Renaissance man Brian "Jamie" Jameson—shuttles people back and forth.

Last November, we hosted a workshop on bounded gaps between primes, building on the spectacular recent work of Goldston-Pintz-Yıldırım, Zhang, Maynard and Tao. Another excellent workshop focused on the proof of the Kadison-Singer conjecture, whose solution came as a completely unexpected and beautiful surprise! Our first workshop at the new AIM (three weeks after we moved in) was on Graph-Ramsey theory.

Our partnership with Fry's has deepened. The marketing division plans to incorporate AIM into their advertising. The director of outreach connected us with the Valley Transportation Authority, which will likely lead to interesting mathematics projects. We regularly discuss plans for the upcoming Frys.com PGA golf tournament, of which AIM is the main beneficiary.

We started a Math Teachers' Circle in San Jose at the new AIM. Not wanting to leave our Palo Alto teacher friends behind, we also started a Math Teachers' Circle at Stanford University in space graciously provided to us by Rick Sommer and the Pre-Collegiate program.

In May, we had the third-year site visit of our third five-year institute grant from the NSF. Happily, AIM has been invited to submit a renewal proposal to NSF in March. We will be applying for a three-year rather than a five-year renewal, after which all NSF-funded math institutes will be on the same funding cycle. From now on, we will be part of an open competition for institutes every five years.

In this issue of AIMatters you will read about our expansion plans for the Math Teachers' Circle program and about one of our interesting SQuaRE projects. With our new facility, we hope to expand our SQuaREs program to 80 SQuaREs per year.

Remember that November 1 is the deadline for workshop and SQuaRE proposals. We hope to have a large number of exceptional proposals again this year.

Enjoy this issue! ■

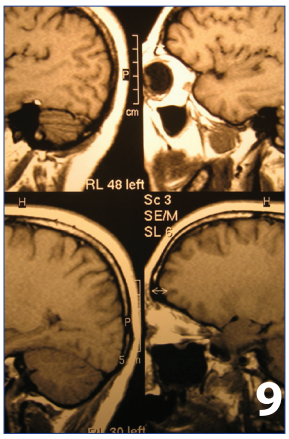
Brian Conrey

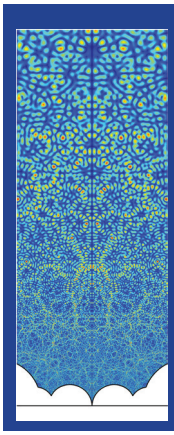
American Institute of Mathematics

American Institute of Mathematics
600 East Brokaw Road
San Jose, CA 95112
Phone: (408) 350-2088
http://www.aimath.org

AIMatters
Editor-in-Chief: J. Brian Conrey
Art Director: Jessa Barniol
Contributors/Editors: Estelle Basor, Brianna Donaldson, Mary Eisenhart, Ellen Heffelfinger, Leslie Hogben, Lori Mains, Kent Morrison, Hana Silverstein

Table of Contents





ABOUT THE COVER IMAGE

The cover image, courtesy of Fredrik Strömberg, depicts a contour plot of a Maass form. Much like the sine and cosine functions that can be used to describe periodic functions on the real line, Maass forms are the basic building blocks for 'periodic' functions defined on the hyperbolic plane. Amazingly, Maass forms are connected to deep questions in number theory, such as the Riemann hypothesis, through their L-functions.

WE'VE MOVED

WELCOME TO OUR NEW HOME IN SAN JOSE

photos by Sonya Kohli, Shelby Mitchell, and Hana Silverstein

625 boxes packed full of books and ready to be moved.

AIM staff moves empty boxes out of the truck for the next round of packing.

One last group photo in front of the old door in Palo Alto.

From October 1 to December 17, 2014, AIM moved from its old facility in Palo Alto to its new headquarters in San Jose. We moved over 2,000 boxes of binders and books, all our furniture, and an entire kitchen, all while maintaining a packed schedule of workshops and SQuaREs. With the dedicated efforts of our entire staff, by January 1, 2015, we were ready for a workshop in the new facility. Here is the story of our move in pictures.

Ellen Heffelfinger sets up the library.

Welcome to our new space! Look at all those windows.

Offices and a cozy couch area. Grab a coffee and a book and stay a while.

Lecture area: bright and lively. Home sweet home.

The Future of Food

AIM Workshops Explore Sustainable Food Systems

With over seven billion people living on our planet, how do we ensure a secure food system? How do we manage to produce, harvest, process, transport, sell, and eventually prepare the food we consume and do this better so that over one billion people are not hungry? Food system activities such as these comprise a highly complex system, with complicated feedback loops.

To address some of these questions in a mathematically sophisticated way, a unique set of participants met at an AIM workshop in April 2015, with the goal of forming a research agenda for developing a mathematically robust conceptual model of the U.S. food system. The participants, led by organizers Mary Lou Zeeman and John Ingram, included experts and stakeholders from different levels of the food system, social scientists, economists, and mathematical modelers.

The focus of the workshop was to begin to understand the overall structure of the food system network and the relative strengths of inherent feedbacks. As the week progressed, themes emerged to help define a research agenda for the food systems modeling community. One promising technique is hybrid modeling that brings together conceptual dynamical systems models, agent-based models, and Bayesian uncertainty models. Other aspects of the agenda include making connections and collaborations with food system scientists, urban social scientists and demographers, data and behavioral scientists, and agricultural economists to capture the data required.

The food workshop was followed by a water workshop entitled "Integrated analysis for agricultural management strategies," which was devoted to the development of mathematical models to aid agricultural entities and water policy boards in the management of water resources. The water workshop, led by Katie Fowler, Lea Jenkins, and Shawn Matott, was an extension of the work featured in the NSF video "Math in the Quest for Sustainable Agriculture" highlighting the modeling done for berry growers in the Pajaro Valley of California. In the previous work, Fowler and Jenkins and collaborators evaluated how various water and land management techniques could be utilized by landowners and growers to work towards balancing aquifer levels. The most recent workshop focused on making the past work more universal and applicable to other parts of the country.

While AIM has generally concentrated on workshops that involve fundamental research questions, these workshops and SQuaREs that address more directly the important and crucial problems of food and water in our society are also an important part of the AIM mission. ■

– Estelle Basor

A simplified food system, showing the interconnectivity of various stages. Image courtesy of John Ingram.

Dispatches from Morgan Hill

Multi-Generational Mentoring

"How much water does a typical shower use? How about a bath? What is the cost differential?"

These are timely questions, given the current drought in California. Sixth grade students worked to solve these and other real-life problems this spring in one of AIM's Morgan Hill Math programs, designed to challenge young mathematicians.

For the past thirteen years, AIM's Morgan Hill Math has offered free academic after-school programs for students in fourth through twelfth grade who enjoy math and show a propensity for it. Fourth and fifth grade students complete an eight-week program in the fall, using a curriculum developed by AIM coaches. Middle school students also participate in extracurricular math starting in the fall, with the option of continuing their training through the winter and competing in a chapter level MATHCOUNTS competition in February. At the high school level, students at each of the two high schools belong to a chapter of Mu Alpha Theta, a national math honors society.

One of the benefits of being involved in AIM's Morgan Hill Math program is that it gives older students a chance to come back and mentor their younger peers. For the 2015 MATHCOUNTS competition season, six high school math students joined four adult coaches as they helped forty-two Morgan Hill middle school students puzzle through challenging math questions.

The hard work and training paid off for Martin Murphy eighth grader Brian Ho, who took first place in the MATHCOUNTS Monterey Bay chapter competition, held on February 7, 2015, in Salinas, California. Ho's first place win earned him the right to attend the Northern California State Competition, held in March at Stanford University.

Michael Pham, an eighth grade student from Britton Middle School, also earned entry to the Northern California State Competition by placing sixth at the chapter level. ■

– Lori Mains

From top, sixth grade students use shadows and equivalent ratios to calculate the height of the basketball hoop on their school playground. Morgan Hill Math has a strong showing of over forty students at the chapter level MATHCOUNTS competition, held in Salinas, California. AIM Morgan Hill Math coach Kelley Barnes with winning students Brian Ho and Michael Pham.

Fun and Games

AIM Teams Up with Julia Robinson Math Festival

During the 2014-2015 academic year, AIM continued to partner with the Julia Robinson Mathematics Festival to bring the fun and challenge of collaborative problem-solving to K-12 students. An alternative to the traditionally competitive culture of math contests, the Festival offers a range of intriguing, challenging problems, puzzles, and activities, with skilled mathematicians offering guidance and encouragement.

For the first time, JRMF hosted events outside the U.S., in Canada and China, and took part in the National Math Festival in Washington, D.C. As interest grows, we are offering assistance and resources to allow local communities to host their own events, and are pleased to see a steady increase in the number of JRMF events each year. If you are interested in hosting, sponsoring, or co-sponsoring a Festival in the coming year, please contact us at info@juliarobinsonmathfestival.org. ■

– Mary Eisenhart

A student puzzles over magnetic polyhedra at a JRMF table.

CALL FOR PROPOSALS

Proposals are currently being sought for week-long workshops for up to 28 people and SQuaRE collaborations for 4-6 researchers to take place in 2016-2017 at AIM in San Jose, California.

Proposals require:

- **a list of organizers**
- **a list of potential participants**
- **a description of goals**
- **an outline of how goals will be met**

For more details and online applications:

http://www.aimath.org/research

Application deadline: November 1, 2015.

What Lies Beneath

One SQuaRE's Math Could Help Save Lives One Day

It is a common occurrence in hospitals. A patient changes into a hospital gown with no snaps or buttons, and then lies on a moving surface that conveys him or her into a sterile white tunnel. The tunnel is a Magnetic Resonance Imaging machine, an "MRI," which uses magnetic fields and radio waves to take snapshots of invisible parts of the patient's body: the brain, the heart, the malignant tumor. But then a certain amount of the gathered information is discarded as unusable.

Meanwhile, Ed Walsh of Brown University and his colleagues are, metaphorically, digging through the trash.

Walsh's colleague, Anne Gelb of Arizona State University, organized an AIM SQuaRE research group consisting of Walsh, Rodrigo Platte of Arizona State University, Richard Archibald of Oak Ridge National Laboratory, Guohui Song of Clarkson University, Ben Adcock of Simon Fraser University, and Jan Hesthaven of École Polytechnique Fédérale de Lausanne, to explore the concept that MRI scans could provide answers to questions that we usually don't think to ask.

"Magnetic Resonance Imaging creates a grayscale image that a skilled radiologist can interpret for medical data," Walsh explains. "Meanwhile, our group is proving how other data inherent to the scanning process, such as resonant frequencies and signal decay rates, which are currently used only to provide contrast, can be useful in diagnosing a condition or measuring a response to treatment. Much more information can be extrapolated from the same scan: temperature, blood flow, diffusion, structure, and physiology, for example. We're developing nonconventional image reconstruction techniques to get this information faster and better than has ever been possible before."

The group, which completed their second visit to AIM in April of this year, is such a diverse group of mathematicians that, Walsh says, "we have almost any tool that could likely be used to work on this problem." The group's combined expertise encompasses everything from image reconstruction and spectral analysis to approximation theory, neutron science, simulation coding, segmentation, edge detection, and the actual physics of magnetic resonance. And that large body of expertise was instrumental in allowing the group to get a large amount of work done in a short time, with a little help from AIM.

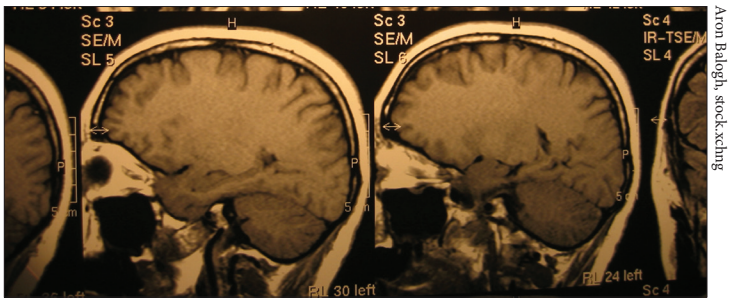
"Coming to AIM to work is almost like a short sabbatical," Walsh said. "It's a way to get away from everyday administrative responsibilities and really dive into a problem. As long as you put the phones away, it is amazing what can be accomplished in five days."

While the mathematical portion of the research is expected to be finished soon ("Really soon, based on the incredibly rapid progress we made at AIM," Walsh said), it will take a few years of industry development and regulatory research and testing before the concept will begin to be used in hospitals. However, the wider applications of the groups' work could eventually lead to life-saving precision in the fight against cancer.

One wider application of the group's work entails viewing a microwave tumor ablation treatment in real time. This treatment, by which a tumor is essentially killed by the heat of electromagnetic waves, has a high rate of tumor recurrence due to the current guess-and-check nature of the treatment. "But if you could watch the temperature changes in real time during the treatment, it would be a complete game-changer," Walsh said. "It would take some of the luck out of the equation."

But there was no shortage of luck in the creation of this SQuaRE. "It is such a great group to work with, both professionally and personally," Walsh said. "Everyone works great together, but they also have really great taste in craft brews. I'm so looking forward to our third collaboration visit next year. " ■

– Jessa Barniol



Aron Balogh, stock.xchng

A diagnostic image generated through conventional MRI techniques.

A Nationwide Circle

Growing the Math Teachers' Circle Network

Math Teachers' Circles (MTCs) are professional communities of middle school teachers and mathematicians who meet regularly to engage in rich mathematical problem solving. The goals of the program are to support teachers as mathematicians, connect mathematicians with K-12 education, and build a K-20 community of mathematics professionals.

Since their beginnings at AIM in 2006, Math Teachers' Circles have grown slowly but surely, until our network now encompasses more than 80 Circles in 37 states. From 2007 to 2014, AIM organized annual workshops on "How to Run a Math Teachers' Circle," with support from the Mathematical Association of America, the National Security Agency, and the National Science Foundation. These workshops evolved significantly over time and developed into a highly successful means of beginning MTCs, with approximately 90 percent of teams who participated in the last three years of workshops forming a Math Teachers' Circle.

With space for only 12 teams each summer, however, the workshops are not able to meet the increasing demand for creating new Math Teachers' Circles. Furthermore, the centralized workshop model does not make the most of the distributed expertise of Math Teachers' Circle leaders. Our new hybrid model for starting new Math Teachers' Circles integrates centralized web and staff resources with a mentoring network of expert leaders around the country.

Our goal is to have 360 Math Teachers' Circles by 2020. We are encouraging mathematics departments around the U.S. to consider hosting these groups. Benefits to departments include maintaining ties with local teachers (who are often department alumni) and demonstrating the broader impacts of mathematical research. Through the support of our sponsors, AIM is able to offer seed grants, planning assistance, well-developed online resources, and mentoring through regional networks of Math Teachers' Circles.

We are seeking applications from teams of mathematicians and teachers who want to begin a Math Teachers' Circle in their local area. Each team's application should include a statement about the goals of their proposed Math Teachers' Circle as well as a letter of support from a host institution (for example, a mathematics department or school district office). Applications for new Math Teachers' Circles are accepted on a rolling basis throughout the year. For more details, please visit **http://www.mathteacherscircle.org/start-a-circle/** or contact Brianna Donaldson, Director of Special Projects, at **circles@aimath.org**. ■

– Brianna Donaldson

Scenes from recent meetings of the statewide Ohio Math Teachers' Circle network and the Math Teachers' Circle of Hawai'i (MaTCH).

Circles in Community

The Local Impact of Math Teachers' Circles

Earlier this summer, 25 middle school math teachers came to AIM for a weeklong problem solving workshop. Participants represented a diverse array of schools and districts from across the San Francisco Bay Area. Some had taught math for 20 years; others were newly credentialed.

Working with mathematicians from AIM, San Jose State University, Google, Silicon Graphics, and elsewhere, teachers explored the mathematics behind the game SET. They counted squares on a sheet of grid paper and learned a mathematical rope dance called Conway's Rational Tangles. Along the way, many problem-solving strategies were revealed.

Teachers described the experience as transformative, changing how they see mathematics, their students, and themselves. Participants reported becoming more flexible, creative thinkers: "I can come at problems, and help students come at them, in more than one way." Another teacher summed up her experience: "It keeps me excited about doing mathematics and keeps fresh in my mind how resilient my students have to be to do the tasks I ask of them."

Teachers will continue to build community and problem-solving skills during the school year by attending Bay Area Math Teachers' Circle meetings, held monthly in San Jose and Palo Alto.

Founded at AIM in 2006, the Palo Alto MTC is the flagship member of the national MTC network. As AIM pilots its new model for starting new MTCs, the Bay Area will continue to play an important role in the movement by providing a successful, replicable model of a regional network.

Over the next three years, we plan to expand to a total of nine MTCs in the Bay Area. The Bay Area MTC Network will link the two current MTCs in San Jose and Palo Alto with seven new ones via shared activities and resources.

Each of the seven new MTCs will launch with a five-day summer workshop to build community and problem-solving skills. During the school year, all MTCs will run monthly meetings.

AIM will also organize workshops for local teacher leaders to develop curriculum materials. We plan to provide travel funds to enable these teacher leaders and mathematician partners to travel throughout the Bay Area to lead circle meetings and demonstrate curriculum possibilities.

The Bay Area has a population of 7 million, with an estimated 2,100 middle school math teachers. Our goal is to involve 270 teachers—more than one in eight—in the nine Math Teachers' Circles. Those teachers would then influence some 27,000 students each year in their classrooms. ■

– Hana Silverstein

Scenes from past AIM MTC Immersion Workshops: cracking the game of SET and tackling a tangled problem.

Mathematicians = Movers?

Or, How to Efficiently Relocate an Entire Library

Who better to orchestrate a library move than a group of mathematicians? From assembling boxes, to packing books in call number order, to loading trucks, we accomplished the monumental task of relocating some 18,000 books and 200,000 reprints with analytical precision and efficiency. In the spirit of collaboration that defines AIM activities, the entire staff pitched in and finished the job within hours.

On arrival, the library crew took advantage of its new quarters to refresh and reorganize: we shelved newly catalogued materials, culled out-of-field books, and established dedicated spaces in seminar rooms and elsewhere for our named collections of books and reprints. Most excitingly, we inaugurated Thursday tours of the historical mathematics collection for workshop participants.

The exhibits change from workshop to workshop and draw on both the historical collection and the AIM reprint collection. Since April, we've put together displays on the history of women in mathematics, the development of calculus, Princeton mathematicians (in tribute to John Nash), and Fermat's Last Theorem. The latter incorporated not only Fermat's *Varia opera* (1679), the 1621 edition of Diophantus' *Arithmeticorum libri sex*, and Dirichlet's groundbreaking first paper (1825), but also the signed journal printing and the first separate printing of Andrew Wiles' *Modular elliptic curves and Fermat's Last Theorem*—these last donated by Wiles on the occasion of a 1999 lecture sponsored by AIM.

There is no shortage of AIM material to mine, and one display case is always devoted to extraordinary reprints received over the years, including Mandelbrot's 1967 paper on fractals, Hilbert's papers on mathematical problems for the new century, both Claude Shannon's master's thesis and his *Mathematical theory of communication*, and Alonzo Church's copy of Gödel's lectures given at Princeton in 1934, to name just a few. Supplementing the glass exhibition cases is a permanent display of red binders filled with a selection of reprints by eminent mathematicians, including many Fields Medalists. We are thrilled to open the AIM collections more widely in our new space, and we invite workshop participants to come browse! ■

– Ellen Heffelfinger

THANK YOU

AIM gratefully acknowledges the following donors for their generous contributions of books, reprints, journals and archives to the AIM Library in 2014 and 2015.

Michael Artin ◆ Thomas Banchoff ◆ Family of Raoul Bott (with thanks to Loring Tu) ◆ Jeff Cheeger ◆ Family of Ivor Grattan-Guinness (with thanks to Albert Lewis) ◆ James Heitsch ◆ J. William Helton ◆ Bruce Magurn ◆ Alfréd Rényi Institute (Frédéric Riesz collection; with thanks to Vera Sós) ◆ John Synowiec ◆ John Tate ◆ Alexander Voronov (Mark Feshbach collection) ◆ Phyllis Zemble (Marvin Knopp collection)

The permanent collection of red binders contains reprints by eminent mathematicians, including many Fields Medalists.

A Multifaceted Approach
Research Experiences for Undergraduate Faculty

The Research Experiences for Undergraduate faculty (REUF) program was originally designed to engage undergraduate faculty in research with students. Over the years, it has also created research opportunities for faculty participants themselves. REUF participants have developed long-term research collaborations and expertise in research areas that are new to undergraduates. Some have achieved tenure and promotion to full professor. Many say that REUF has helped them rediscover the joy of mathematics.

REUF models an undergraduate research experience by throwing participants into research problems they know little about. Participants often begin by rediscovering known results, acquiring background along the way, and eventually discovering new results.

REUF participants range from new assistant professors, to those approaching tenure, to tenured faculty. These different perspectives enhance the program, as participants share ideas and learn from each other.

After the mathematical leaders introduce the areas of investigation, participants sometimes propose the specific questions that the groups investigate. There are formal discussions of undergraduate research in addition to informal discussions that occur within research groups and during meals and breaks.

The 2015 REUF workshop was held at the Institute for Computational and Experimental Research in Mathematics (ICERM) in Providence, Rhode Island. Edray Goins of Purdue University led a research group working on Fuchsian differential equations with prescribed monodromy. Leslie Hogben of AIM and Iowa State University presented background in maximum nullity and zero forcing, and the group is investigating the connection between zero forcing and power domination, as suggested by participant Daniela Ferraro. Glenn Ledder of the University of Nebraska-Lincoln and Ami Radunskaya of Pomona College investigated problems in mathematical biology, including a tropical disease caused by a parasitic worm and a model for a dendritic cell cancer vaccine.

REUF now offers opportunities to apply for funding to continue research started during the workshops. Many groups are making plans to apply.

Throughout all these wonderful developments, REUF has kept its focus on undergraduate research. Currently, more than half of REUF alumni begin mentoring undergraduates in research within one year of attending a REUF workshop. Many of these undergraduates present at conferences; several have won grants or published papers related to their research. The faculty participants are excited to share new research ideas with their students.

As REUF 2015 participant Mary Flagg said, "On the plane I was drawing graphs on my notepad and finding power dominating sets and zero forcing sets and it felt so good to just enjoy being captured by a problem! I had almost forgotten. I am glad the wonder is back! That is what I want to share with my students." ■

– Leslie Hogben

Participants and facilitators at the 2015 REUF workshop at the ICERM facility in Providence, Rhode Island.

One, Two, Three... Fore!

AIM and Golf: A Special Relationship

Among the mathematics institutes in the world, AIM has a unique relationship with the sport of golf. The 2015-16 PGA Tour begins this October 12-18 with the Frys.com Open, and AIM is a major beneficiary of the charitable proceeds raised by the tournament. This is the second year that the tournament will be played on the North Course of the Silverado Resort in Napa. From 2010 through 2013, it was held at the CordeValle Club in San Martin, Calif., in the rolling foothills of the Santa Cruz Mountains and next to the Clos la Chance Winery. In the not-too-distant future, the tournament will find its permanent home at the Institute Course (yes, as in Mathematics Institute!) in Morgan Hill, Calif.

In 2013, the PGA adopted a new schedule so that the season begins in October with the Frys.com Open as the first event of the new season. In earlier years, the Frys.com tournament was part of the PGA Fall Series, but with the new schedule, the tournament has grown in stature. Players are now awarded FedEx Cup points, and the purse has increased from $5 million to $6 million.

AIM plays an active role in the tournament each year by recruiting and managing a number of volunteers. Many AIM volunteers work on ShotLink, which is the system for tracking every shot during the tournament. Behind each green is a covered platform with a laser sighting device manned by two volunteers. On the par four fairways, there is one laser device, while on the par fives, there are two. Each has two workers who spot the balls and record the locations electronically and on a paper grid. The data from all 18 holes is constantly relayed to the ShotLink computers and staff working in a large trailer that moves from tournament to tournament. Read more about it at **http://www.shotlink.com**.

In the exhibitors' area, AIM also sets up an information booth to publicize mathematics and provides some puzzles and activities for those spectators looking for a change of pace or a piece of candy. Each year one of the four days is "AIM Day." AIM volunteers greet spectators at the gates and give them the day's schedule

The 18th hole at Silverado.

of play that includes a fun, voluntary golf+math quiz. Here is one of the questions from the 2014 quiz:

> Predict how many birdies will be recorded during this tournament.
>
> a) less than 1500
> b) between 1500 and 2500
> c) more than 2500

For the full quiz and answers, go to **http://frysopengolf.com/2014/10/aim-math-quiz-winners/**.

Last year, Brian Conrey and Estelle Basor spent an hour with kids in the junior golf program "First Tee" and told the kids about one of the mathematical mysteries of golf: although golf balls would not travel nearly so far without their dimples, no one knows exactly how many there should be or exactly where they should be for optimal performance. ■

– Kent Morrison

THE AMERICAN INSTITUTE OF MATHEMATICS

thanks

for their generous and ongoing support of our vision.

Official Event

http://frysopengolf.com

Benefiting the American Institute of Mathematics

October 12-18, 2015

American Institute
of Mathematics
600 East Brokaw Road
San Jose, CA 95112

From Our Collections

A selection of G.H. Hardy and J.E. Littlewood offprints