AIMath

The Newsletter of the American Institute of Mathematics

Focused Collaborative Research

AIM's model of focused collaboration underlies the success of its many programs. It is at the heart of the AIM-style workshops, as well as the Director's Circle activities that bring together a group of interested middle schoolers to work on long-term projects. It is also the essential ingredient of the SQuaREs program that provides the resources for 4-6 researchers to engage in a multi-year program through intensive week-long collaborative meetings.

"Focused collaborative research has always been AIM's mission," says Executive Director Brian Conrey. "AIM is about bringing people together with a specific goal in mind. From the very beginning, our programs revolved around making the most out of team work." And since 1994 an ever-broadening number of programs supported by the Institute have followed this vision.

The AIM-style Workshop

To get the most out of its programs, the AIM staff works closely with each group of organizers starting long before the actual event. For all planned workshops and SQuaREs, a series of conference calls precedes the first day—often as early as a year before. The three members of the AIM workshop team (Executive Director J. Brian Conrey, Deputy Director Estelle Basor, and Director of Programming David Farmer) discuss the mathematics with the workshop organizers and help them to refine the scope of their workshop. Much to the organizers' surprise, only the first two days are planned prior to the start of the workshop. "Without knowing the dynamics of the group, it important to allow a high degree of flexibility in the schedule," said Conrey, "and planning beyond the first couple of days prevents the organizers from responding to the needs of the participants."

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Participants at the "Model Theory of Metric Structures" workshop.

From the Director

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Greetings! This is our fourth Newsletter and I hope you agree with me that they just keep getting better!

This Newsletter draws on the many activities that encompass AIM's fundamental principle of 'focused collaborative research.' While the most notable examples are the ARCC workshops and SQuaREs, AIM's style of fostering collaboration, oftentimes between diverse groups, extends to the Morgan Hill Math Programs, Math Teachers' Circles, and Focused Research Groups. I hope you find this idea stimulating.

One of the mathematical highlights of this year is the joint work of Holowinsky and Soundararajan leading to the subsequent solution by Soundararajan of something called the Quantum Unique Ergodicity conjecture (QUE for short!) about the uniform spreading out of wave forms that arise in number theory.

We also held 20 scientific workshops, most of which started down the path of new results. In addition, we hosted special workshops such as *Research Experiences for Undergraduate Faculty, Finding & Keeping Graduate Students*, and *How to Run a Math Teachers' Circle* (in fact, two Circles workshops: one in Palo Alto and one at the Mathematical Association of America's Carriage House in Washington, DC). We also held the first AIM workshop outside of the US—in Zurich in partnership with the ETH (Swiss Federal Institute of Technology). The local organizers found the AIM style of workshop both novel and productive. Plans for our second such venture are underway for next August at Nankai University in China.

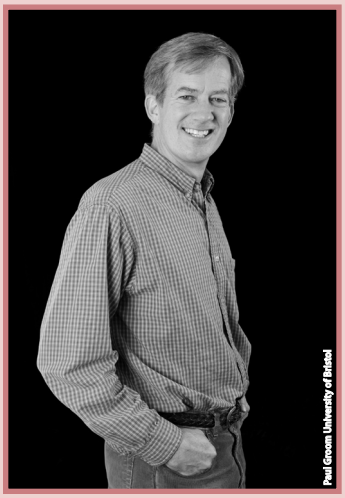
Our outreach programs, Morgan Hill Math and Math Teachers' Circle, continue to be successful. In the past year, more than 200 Morgan Hill students were involved in one or more of our local programs. In addition, there are now 30 Math Teachers' Circles in various stages of development. We are pleased and grateful to have the Mathematical Association of America as a partner in this endeavor.

We selected two AIM Five-Year Fellows this year: Melanie Matchett Wood and Kirsten Wickelgren. Wood received her PhD from Princeton and will begin her Fellowship at Stanford. At the same time, Wickelgren, who received her PhD from Stanford, will begin her Fellowship at Harvard. They are the 12th and 13th AIM Five-Year Fellows.

We were very pleased to be a part of a National Science Foundation grant that allowed the seven NSF-funded mathematics institutes to make 45 post-doctoral appointments this year. AIM appointed four mathematicians for the coming two years: Ameya Pitale, (Paul) Eddie Herman, Jeremy van Horn Morris, and Anthony Bak. Each will be based at AIM, have a research mentor at Stanford, and will teach courses either at De Anza Community College or at San Francisco State University. We are absolutely delighted to host these outstanding researchers. In addition to mentoring our new postdocs, AIM will host a workshop for all the institute postdocs. It will focus on the various elements that make a successful academic career in mathematics.

I know that many of you are wondering about the progress towards the Morgan Hill site, especially after all of the wonderful photos and stories about the Groundbreaking Ceremony in May 2007. At that time, the environmental issues surrounding the golf course had been addressed and we had just been awarded a grading permit for the project. Since then, excavation has begun, so there is a very large hole in the ground! At present, we are awaiting the foundation permit to be issued by the City of Morgan Hill; as soon as we have that, we will begin the next phase of the construction.

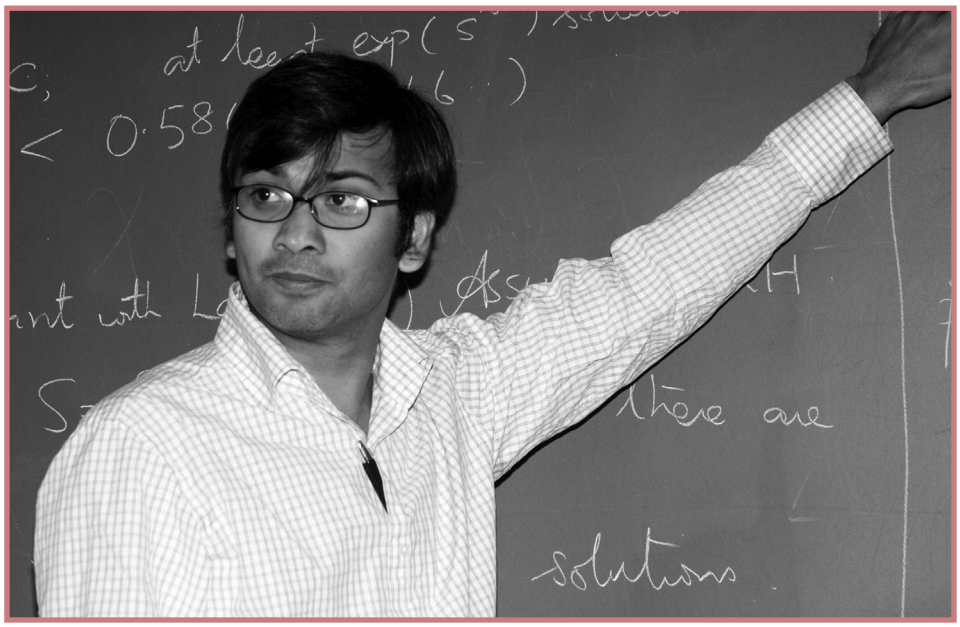
I hope you enjoy reading this issue of the Newsletter! As always, we enjoy receiving comments and input from you, so please let us know what is on your mind. Next year's Newsletter will have a section devoted to letters from our readers.



Executive Director
J. Brian Conrey

Soundararajan and Holowinsky prove QUE Conjecture

In a September 2008 seminar co-organized by Stanford University and AIM, Soundararajan announced that he and Roman Holowinsky have proven a significant version of the quantum unique ergodicity (QUE) conjecture. "This is one of the best theorems of the year," said Peter Sarnak, a mathematician from Princeton who, along with Zeev Rudnick from the University of Tel Aviv, formulated the conjecture fifteen years ago in an effort to understand the connections between classical and quantum physics. "I was aware that Soundararajan and Holowinsky were both attacking QUE using different techniques and was astounded to find that their methods miraculously combined to completely solve the problem," said Sarnak. Both approaches come from number theory, an area of pure mathematics that recently has been found to have surprising connections to physics.



Soundararajan
(courtesy C. J. Mozzochi, Princeton NJ)

The motivation behind the problem is to understand how waves are influenced by the geometry of their enclosure. Imagine sound waves in a concert hall: in a well-designed concert hall you can hear every note from every seat. The sound waves spread out uniformly and evenly. At the opposite extreme are "whispering galleries" where sound concentrates in a small area.

The mathematical world is populated by all kinds of shapes, some of which are easy to picture, like spheres and donuts, and others that are constructed from abstract mathematics. All of these shapes have waves associated with them. Soundararajan and Holowinsky showed that, for certain shapes that come from number theory, the waves always spread out evenly. For these shapes there are no "whispering galleries." According to Lev Kaplan, a physicist at Tulane University, "This is a good example of mathematical work inspired by an interesting physical problem."

> *"This is one of the best theorems of the year."*
> *— Peter Sarnak*

Soundararajan was the first recipient of an AIM Five-Year Fellowship in 1998. He has since produced many important results in number theory and related fields. In 2006, he became Professor of Mathematics at Stanford University, after being on the faculty at the University of Michigan. For the first two years, his position at Stanford was jointly funded by Stanford and AIM. Holowinsky was at the University of Toronto and is currently at The Ohio State University. ■

For more details about this result, please go to http://www.aimath.org/news/que/

Roman Holowinsky

Introducing AIM's Two New Fellows:

Kirsten Wickelgren

For Kirsten Wickelgren, one of this year's AIM Five-Year fellows, mathematics was always an interest, starting at home. Her mother models visual perception for the Department of Psychology at Columbia University, and her father worked on neural networks at Columbia. "We would go on vacation, and he would leave these ancient, slow computers running for two weeks, to model what neurons go off when," Wickelgren said during an interview.

In high school, she considered pursuing physics, and even became a science fair student under famous physicist Brian Greene, author of *The Elegant Universe*. But even before going to college, she knew math was her real passion.

"I like the fact that it's true, and will remain true forever. I like the processes involved," she explained.

Wickelgren went on to complete her undergraduate degree at Harvard University, a year at the Ecole Normale Supérieure (ENS) in Paris, and her PhD at Stanford. "I had a lot of great teachers in college and graduate school," she said, citing Pierre Lochak, with whom she worked at the ENS, and Ravi Vakil, Greg Brumfiel and her doctoral thesis advisor, Gunnar Carlsson.

Generally, Wickelgren's thesis examines ways to understand solutions to equations. Specifically, she looked at equations topologically. "Equations are delicate," she said. "If you change one number, you change the solution. But the topology of a surface is continuous, and can be pushed around." In other words, by looking at equations topologically, she finds new ways to understand the solutions.

The tool Wickelgren studied is called *potent quotients*. In essence, these are a group of loops that can be used to solve equations. The particular, simplified case that she focused on is called the no-potent quotient. "This was an attempt to understand what we could say about solutions to particular equations using algebraic topology," she explained.

For Wickelgren, this work doesn't interest her because of any possible applications outside of mathematics. Instead, she is entranced by the concepts. "I like the idea that one could use continuous, topological structures to say something about arithmetic," she said.

AIM Fellow, Kirsten Wickelgren

Wickelgren's work has been recognized throughout her education. In high school, she was an Intel Science Talent Search finalist, and in college, she received a National Science Foundation grant for graduate school. She was also offered one for her post-doctoral work, but chose to take the AIM fellowship instead.

With the fellowship, Wickelgren plans to go to Harvard, continuing to explore the intersection of topology, arithmetic geometry, and algebraic geometry. She is looking forward to the chance to focus on her work. "The AIM fellowship means I'll really get to do research for the next five years," she said. "It's fantastic."

—Lily Beauvilliers

Melanie Matchett Wood

Throughout her life, Melanie Matchett Wood, one of this year's AIM Five-Year Fellows, found mathematics fun. In seventh grade, she participated in the MATHCOUNTS competition, and placed on the Indiana State team. "During practice, I got introduced to more math, and other kids excited about math," Wood said when interviewed.

The games continued in high school, where she joined the Math Olympiad. And as an undergraduate at Duke University, games became research. Wood participated in a Research Experience for Undergraduates (REU) program at the University of Minnesota–Duluth, working with Joe Gallian on a project that followed work by Manjul Bhargava. Bhargava later became her PhD advisor, at Princeton.

For Wood, it was the math community which interested her in furthering her education. "I've always been on track to do math," she said. "It was an 'of course.' " People like Bob Fisher, then the coach of the Indiana MATHCOUNTS team, and Bhargava, who, according to Wood, "created a new field in math and number theory," kept her engaged.

Participating in undergraduate research also helped her make the decision. "Everything was fun and I felt great doing this, so I just kept doing it," she said. For her undergraduate research, Wood was awarded the Morgan Prize in 2003. That same year, she received a National Science Foundation Graduate Research Fellowship, and a Gates Cambridge Scholarship. She attended Cambridge for one year, receiving her Master's degree, and in 2005 she was awarded a National Defense Science and Engineering Graduate Fellowship.

Last year, Wood's work at Princeton was equally well-received, garnering her a Josephine de Karman dissertation fellowship and an American Association of University Women dissertation fellowship. These prizes were given on the basis of her doctoral work with number systems. In essence, Wood looked at sets of numbers, finding ways to organize them. One set of numbers people often work with, she explained, are the integers: one, two, three, four, etc. But many other sets exist, such as sets which include square roots, fractions, and other, stranger numbers.

"What my work does is try to classify what all these bigger number systems are, every kind of number system you can get," Wood said. She identifies the systems, trying to find all the possibilities. Then, she organizes them.

AIM Fellow, Melanie Matchett Wood

Each number system becomes one point in a multi-dimensional space. Most of us are familiar with two-dimensional spaces–for example, a typical graph might have a horizontal axis for time, and a vertical axis for space. A point would show where something was located at a specific time. Wood builds similar spaces for the number sets.

"The geometry of the space keeps track of all the different traits and how they are related," Wood said.

With her fellowship, Wood will head to Stanford. "I hope to talk to a lot of people, like number theorist Akshay Venkatesh. He's done a lot of thinking about larger number systems and counting them." She will continue to build geometric spaces, and study algebraic geometry.

"I'll follow all the really interesting paths of things I'm curious about," she said.

–Lily Beauvilliers

Workshop Snapshots

Deputy Director Estelle Basor provides a summary of all AIM workshops. A selection is presented here.

Derivative-free hybrid optimization methods in hydrology
Organized by Owen Eslinger, Kathleen Fowler, and Genetha Gray *(October, 2008)*

The goal of the workshop was to solve several hydrology problems using new statistical techniques. Researchers with expertise in simulation-based optimization, sampling techniques, optimization using surrogates, and hydrology were brought together to tackle the complex issues that arise in water resources management applications. The participants considered several concrete problems such as the analysis of saltwater intrusion management in the Truro aquifer in Cape Cod. Much of the week was spent in better formulating the hydrology problems and learning how to improve accuracy, efficiency, and reliability of the solutions.

Small ball inequalities in analysis, probability, & irregularities of distribution
Organized by William Chen, Michael Lacey, Mikhail Lifshits, & Jill Pipher *(Dec., 2008)*

The main focus of the workshop was to study some problems in irregularities of point distribution and their relationships to, and related problems in, probability theory, approximation theory, and harmonic analysis. Think of an arbitrary finite set of points in a fixed square. If we take some smaller rectangles inside this fixed square and measure how many of those points are in the rectangles, we might have some idea of how close the set of points was to being uniformly distributed. Estimates of this type are difficult and are especially challenging when generalizing to higher dimensions. The workshop produced a problem list of more than 30 pages which touches on all aspects of the subject.

Combinatorial challenges in toric varieties
Organized by Joseph Gubeladze, Christian Haase, and Diane Maclagan *(April, 2009)*

Imagine a rectangular grid (like that on graph paper) on a piece of wood. Pound in nails at some of the grid line intersections. Put a rubber band around the outside of the nails so that it contracts tightly around the nails. The region enclosed is the smallest convex polygon containing the nails. An analgous construction can be described in three dimensions and higher and the resulting regions are called "polytopes." This workshop made progress on several unanswered questions about polytopes in higher dimensions that arise in a number of different fields of mathematics.

Stochastic and deterministic spatial modeling in population dynamics
Organized by Zhilan Feng and Priscilla Greenwood *(May, 2009)*

Population models arise in the study of interacting species as well as in the study of how epidemics spread. The simplest mathematical models do not account for the location of individuals in the populations but only the total numbers. When the location is taken into account the description and analysis becomes much more difficult, and when randomness is added to the models, the mathematical difficulties increase even further. This workshop brought together scientists and mathematicians from several different areas to share their expertise and to generate ideas for further progress in the understanding of questions such as: How fast and and in what patterns does an epidemic spread?

Call for Proposals

AIM, the American Institute of Mathematics, sponsors week-long activities in all areas of the mathematical sciences with an emphasis on focused collaborative research.

Workshop Program

AIM invites proposals for its focused workshop program. AIM workshops are distinguished by their specific mathematical goals. This may involve making progress on a significant unsolved problem or examining the convergence of two distinct areas of mathematics. Workshops are small in size, up to 28 people, to allow for close collaboration among the participants.

SQuaREs Program

AIM also invites proposals for a new program called SQuaREs, Structured Quartet Research Ensembles. More long-term in nature, this program brings together groups of four to six researchers for a week of focused work on a specific research problem in consecutive years.

More details are available at:

http://www.aimath.org/research/

Proposal deadline: November 1

AIM seeks to promote diversity in the research mathematics community. We encourage proposals which include significant participation of women, underrepresented minorities, junior scientists, and researchers from primarily undergraduate institutions.

Story of a SQuaRE

Peter Casazza, *Professor of Mathematics at the University of Missouri, gives an account of the SQuaRE titled, "The Kadison-Singer Problem."*

The Problem

The Kadison-Singer Problem (KS) grew out of the pioneering work of Dirac on quantum mechanics in the late 1940s. As new PhDs in the 1950s, R.V. Kadison and I.M. Singer were poring over Dirac's book when they came to a part that was 'problematic.' Dirac stated that something was essentially clear, but Kadison and Singer could not verify it. After years of returning to this statement, they showed that in fact it was false for all cases but one. Moreover, in this most important last case, it was at best an unsolved problem—which they posed in 1959. Actually, Dirac had recognized that there might be a problem with his statement but thought he had taken care of it by introducing the Dirac Delta Function.

At that time, the Kadison-Singer Problem was thought to be a specialized problem in C*-Algebras and it did not generate much attention outside the area. Over time, the problem died for lack of ideas until 1979 when Joel Anderson brought the whole area back to life by showing the Kadison-Singer Problem is equivalent to a fundamental question in operator theory—now known as the "Anderson Paving Conjecture." This breakthrough brought many significant mathematicians into the area and resulted in the 1980s being an exciting time for the Kadison-Singer Problem. However, after 10 years of work, KS was still open and, again, all ideas had been exhausted and, again, the problem slowly drifted into the background. In 2005, the whole area was brought back to life for a second time when Casazza and Tremain surprised everyone by showing that the Kadison-Singer Problem is actually equivalent to fundamental unsolved problems in a dozen areas of research in pure mathematics, applied mathematics, and engineering. This lifted the Kadison-Singer Problem to the level of one of the most important open problems in analysis today and caused a resurgence in interest in the problem. (For up-to-date information on the Kadison-Singer Problem, see the AIM website *http://www.aimath.org/pastworkshops/kadisonsinger.html*.) By the way, it is universally believed that this problem has a negative answer as did all the other earlier cases related to the problem.

Before the Meeting

The four people who attended the SQuaRE represent a group that is dedicated to resolving this problem—while at the same time not being foolish enough to ruin their careers over it. Since this group is already accustomed to working and publishing together, they knew that they could work together in the intense atmosphere of a SQuaRE. We began preparing for the SQuaRE several months in advance. Each person was given one of the most promising directions for constructing a counter-example to the Kadison-Singer Problem (and in an area of interest to them) and they were left to prepare a presentation of this area and to do some preliminary research on it. Six weeks before the SQuaRE, we all took part in a conference call with AIM's Deputy Director, Estelle Basor, when we discussed the goals of the SQuaRE.

"Ideas were coming so fast that it was difficult to keep up with the pace."

The First Day

We stayed at the wonderful Creekside Inn and met on Sunday evening to get an early start. Monday morning we arrived at AIM at 8 AM (we were expected at 9 AM) to start organizing. After some introductions from Estelle Basor, we retired to one of the seminar rooms to begin work. The rooms at AIM are small with a large table at the center with seating for up to 10 and whiteboards on three walls—perfectly suited for this style of workshop. The boards were soon filled with a recent construction that we felt had the best chance of generalization to a counter-example to KS. By the end of the morning, we had pushed the construction as far as we could. It was quite intense and fast-paced as people were running to the board to add to the construction and introducing new directions on the side boards. Ideas were coming so fast that it was difficult to keep up with the pace. But there was an overriding level of excitement as we moved forward as rapidly as possible. It immediately became clear why this format was ideal for trying to push a very difficult problem forward at a blistering pace. For

(Continued on page 8)

Story of a SQuaRE *(Continued from page 7)*

lunch we went next door to Fry's Electronics, returning with sandwiches that we took to the park just two blocks away. We worked on the new construction through the afternoon until 5 PM when we paused for a social hour and then went to dinner to continue our discussion.

Continuing the Program

On Tuesday morning, everyone arrived early again and had a number of new ideas for the construction after thinking about it overnight. There was still a high level of excitement in the room as we contemplated finally solving KS—right there and then. However, by noon, it was clear that this construction needed a significantly new idea and it was not coming to us at this time. We decided that it was best to mull over this on our own private times and for now to switch to a new approach to KS—an operator theoretic approach. One of the participants presented his new ideas concerning this direction; it included some constructions showing that a number of important open problems in frame theory would need to have positive solutions if KS is true. We immediately switched to examining these problems.

"There was still a high level of excitement in the room as we contemplated finally solving KS —right there and then."

Checking the Operator Theory Approach

First, we looked to see if there might be a counter-example available to one of them (and hence a counter-example to KS). Eventually, we would try to decide if they were equivalent to KS or simply had positive solutions independent of KS. We quit in time to make it to the "banquet" at AIM's favorite Chinese restaurant. Having been at AIM before, we knew to eat very little that day since dinner would be a 7-course feast that no reasonable person could consume. The food is absolutely wonderful—everything from Peking duck to delicate sauces we tried hard to identify. But after 6 courses we begged them to stop bringing it because it was irresistible and we were all about to explode.

Bad News & Good News

Wednesday morning did not generate the requisite new idea for our construction of a counter-example to KS, so we decided to continue with the frame theory problems we identified on Tuesday. Throughout the course of the day we gave positive solutions to all but one of them. So they were not equivalent to KS, but positive solutions meant we now had a new collection of theorems in frame theory which had been holding up the progress of parts of that field.

On Thursday morning, we all arrived early again since it was always exciting to see what each person had developed overnight based on the ideas of the previous day. We pushed some new ideas on the two major directions we had been developing for KS until they ran out. We then decided to switch to a third form of KS—from the harmonic analysis direction—and pushed this throughout the day. We eventually identified some slightly weaker versions of KS in this setting and began working to explore whether they may have positive solutions also. This brought us to a totally new area—monoids—a new topic for us, but luckily one of our members had spent his pre-meeting time learning the subject. We quickly absorbed this new idea and tried to bring it to bear on the problems. By the end of Thursday we had a large pile of notes and began to think we had better organize them before we left AIM. So, we decided who was in charge of writing up what and where we would be going in the future.

Friday morning began with someone arriving with what he thought was the correct construction of the counter-example to KS. We went over it in minute detail. Of course, after two hours of working out the details, it failed right on the last calculation. But this gave us hope that we were finally close to the end. Feeling a little pressure by Friday afternoon, we started putting this altogether and looked deeper into our new tool and finally managed to use monoids to solve the last frame theory problem that was a consequence of KS—just at 4 PM. Our goal was to solve KS. What we accomplished was to write an important paper on frame theory, introducing a new tool to the field and developing several new directions for KS which need to be fully explored. Under any other circumstances, we would have been very happy to have produced so much serious mathematics in a week. But since we had only one goal—to solve KS—we made the mistake of not celebrating our victory enough.

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The Morgan Hill Community Welcomes Game Night

Game Nights are the newest addition to AIM-sponsored events in the Morgan Hill area. On the last Wednesday of every month, families come to the Morgan Hill Community Center for an evening of games and fun. The program was developed in conjunction with the City of Morgan Hill's Department of Recreation and Community Services and the Morgan Hill Library Foundation's Silicon Valley Puzzle Day. Open and free to the public, the program invites local residents (especially families) to learn a new game in a light-hearted and fun environment. Door prizes are offered, so just showing up can make anyone a winner.

The 'game of the night' changes each month. Each time, the featured game focuses on particular skills and has its own set of strategies. Of course, a little luck doesn't hurt, too. In this way, returning participants can try different games and explore their mastery of various skills, learning what suits them best. The program attracts families and individuals in the Morgan Hill area who are interested in getting together, socializing, and having fun playing games of skill and logic. The players work in skill- and age-appropriate groups, with most games aimed at ages 8 to adult.

SET was the game of the night at the first Game Nights meeting in May 2009. Forty-six people gathered to learn the rules of collecting sets of various forms and enjoyed an evening of friendly competition. The night culminated in a very exciting winner's circle game hosted by AIM's Executive Director Brian Conrey (who reportedly won the SET match by just one point). Prizes supplied by Morgan Hill's Booksmart bookstore and the Morgan Hill Aquatics Center were awarded to players of all ages, with the grand prize being a new SET game.

Game Nights promotes learning new games and friendly competition, and hopefully encourages its younger participants to go on to compete at the Math Mardi Gras and at the Morgan Hill Library Foundation's Puzzle Day, both great annual educational events offered in the Morgan Hill community.

—David Holmstrom

Scenes from Morgan Hill's first Game Night.

Focused Collaborative Research *(Continued from page 1)*

"The AIM staff is extremely helpful at creating an atmosphere that encourages the open exchange of ideas and makes possible opportunities for joint work," said Motohico Mulase (UC Davis), co-organizer of the *Recursion Structures in Topological String Theory* workshop. "AIM assists to create a mathematical atmosphere in which speakers can talk about what they really wanted to do, and at the same time, the audience can hear what they really wanted to learn. AIM workshops are unique and it's the participation of the staff that makes the difference."

"It's important that the staff members are also professional mathematicians," says Estelle Basor, AIM Deputy Director. "We build a relationship with the organizers and ask them to trust our experiences when it comes to planning the workshop activities. Sometimes our suggestions are contrary to traditional practices, and without our common background as researchers, we could not attain this trust." But at the end of most workshops, the once-skeptical organizers are pleased that the week was a success.

Successful Collaborative Proposals

Key to AIM's success is the staff's ability to work with mathematicians to articulate and organize long-term research programs. In fact, several groups of mathematicians have approached AIM to assist them in mapping out long-term research plans. Often, these teams are preparing proposals for highly competitive NSF-sponsored Focused Research Group (FRG) grants. "We help groups formulate their vision: first for the goals they wish to accomplish and second, for the process that will allow all the participants to contribute in reaching them," explains David Farmer, Director of Programming. "Being mathematicians, but not immediately connected to the research topic, allows AIM to help groups articulate their goals, draw out concerns, develop a unified vision for what they want to accomplish, and guide the balance between manageable small goals and planning and providing for long-term results."

Each year, AIM helps three or four groups prepare large, collaborative proposals such as FRG grants and CDI grants (Cyber-Enabled Discovery & Innovation), many of which have been successfully funded.

Focused Collaboration—a universal approach

AIM has extended the theme of focused collaboration to its outreach and diversity programs. Farmer has run summer undergraduate research programs at AIM where he has gathered a team of collaborators and 6-7 students to work on a variety of related topics.

Similarly, collaboration between middle school math teachers and research mathematicians has been central to the Math Teachers' Circle activities (see article below) and to both the 'Finding & Keeping Graduate Students' program and the 'Research Experiences for Undergraduate Faculty' program, described later in the newsletter. In this issue, we highlight these programs with accounts by their organizers and participants.

Math Teachers' Circles -an expanding national network

Interest in the Math Teachers' Circle Program has continued to grow over the past year. This activity brings middle school math teachers together with professional mathematicians to work on mathematically rich problems and enhance the teachers' content knowledge and problem-solving skills. Since the first Math Teachers' Circle began meeting at AIM in 2006, AIM has helped launch an additional 14 Math Teachers' Circles that are now meeting around the country. Each Math Teachers' Circle of 15 to 20 teachers affects approximately 1,500 to 2,000 middle school students per year.

Summer 2009 saw the expansion of the Math Teachers' Circle Network through two "How to Run a Math Teachers' Circle" workshops, one held at AIM and one held in Washington, DC, and sponsored by the Mathematical Association of America and the National Security Agency. Thirteen new teams from 10 different states spent a week learning about how to start and sustain their own local Math Teachers' Circle, including everything from conducting a math session through recruitment and fundraising. The teams will continue to plan this year and will start their Math Teachers' Circles by next summer.

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Organizer's Perspective

***Timothy Riley**, Assistant Professor of Mathematics at Cornell University, gives an account of the "Isoperimetric Inequality for SL(n,Z)" workshop at AIM, Sept. 8-12, 2008.*

For a week in September 2008, a workshop was held at AIM with the objective of cracking a problem concerning the geometry and combinatorics inherent in SL(n, **Z**), namely to establish what isoperimetric inequalities it enjoys.

To the organisers, Nathan Broaddus, Kevin Wortman, and me, this topic seemed ideal for AIM. There are multiple perspectives on isoperimetric inequalities: in finitely presented groups like SL(n, **Z**) they can be understood in terms of manipulations of generators and relations, or in terms of the areas of discs spanning loops in associated spaces. AIM offered the opportunity to bring together experts with diverse backgrounds—geometric group theory, arithmetic groups, and differential geometry—to see if together they could crack the problem.

We were also attracted by the tantalizing history of the problem. Two celebrated geometers had provided pointers, but no proofs. The key case is n=4, for which Bill Thurston claimed in the 1990s the answer to be quadratic; that is, SL(4, **Z**) behaves like Euclidean space in that loops can be filled with discs of area no more than quadratic in their length. Misha Gromov echoed this and suggested that the Euclidean behavior for filling spheres in SL(n, **Z**) persists up to a critical dimension. However, no proof has since been forthcoming from Thurston, Gromov, or anyone else.

We were aware that AIM workshops are unusual in that they are rather free-form—they do not consist of a succession of talks in which researchers showcase their latest results. But we discovered that even for AIM, focusing so intensely on a single problem is not the norm. Our narrow focus led to the concern that morale might fall if, by the third or fourth day, there was no sign of progress. We also wondered if all the participants would feel engaged for the whole week. So we strategised that we should begin the workshop as mathematical hedgehogs and over the week morph into foxes. Hedgehogs focus on one task—for us, cracking our problem; foxes dart around the landscape—for us, exploring the broader context of our problem.

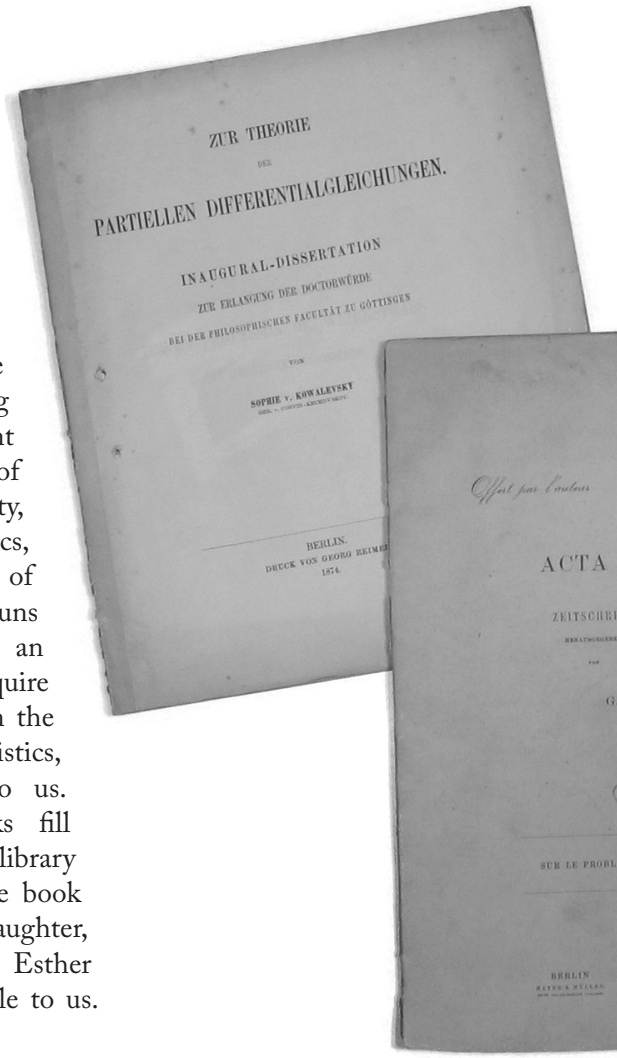
(Continued on page 24)

... our secret workshop plan was: 'Introduce the problem and then attack it head on!'

The AIM Library Continues to Grow

The AIM Library grew by nearly 50% in the last year, with the addition of stores of reprints from many donors, a massive shipment of journals from a Midwestern university, and the arrival in June of 5000+ volumes from the collection of Barnard H. Bissinger.

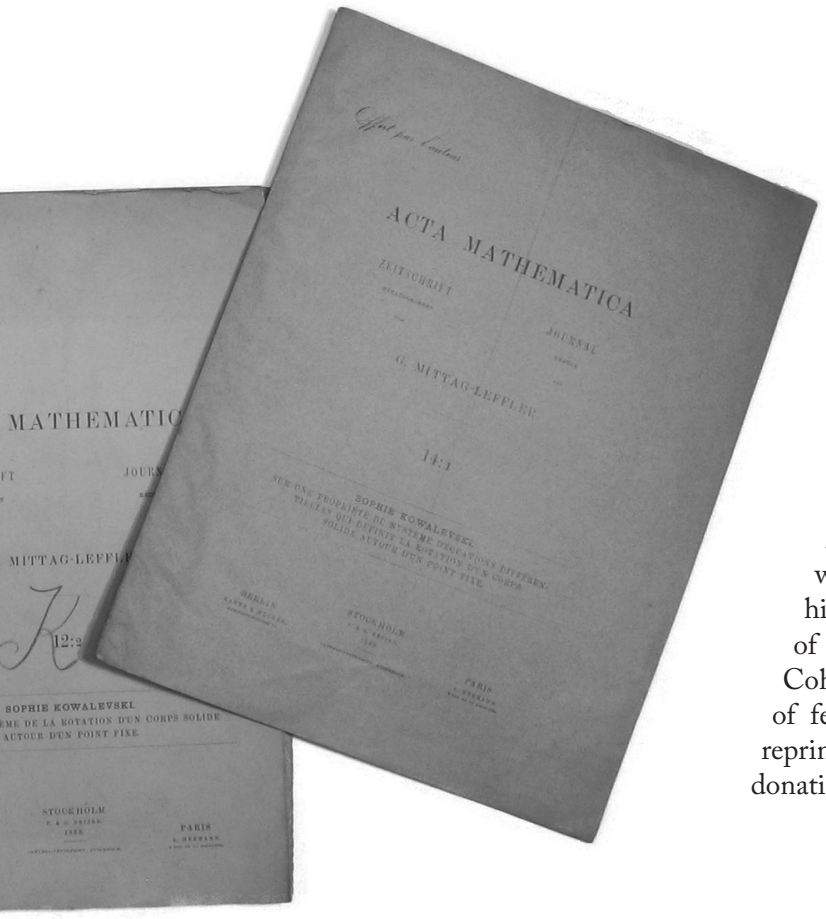
Dr. Bissinger, professor of mathematics at Pennsylvania State University, was an assiduous collector during a long, productive career that included one of the first interdisciplinary doctorates awarded by Cornell University (in mathematics and aerodynamics), stints with the National Research Council and the Air Force during World War II, and occupation of the John Evans Lehman Chair of Mathematics at Lebanon Valley College. His library was initially characterized as "the large collection of a working mathematician who liked books," and so it is, but it's more than that. Examination shows that Dr. Bissinger was in a real sense a collector's collector, accumulating not only first editions of significant and collateral texts in the fields of his expertise—statistics, probability, operations research, aerodynamics, engineering—but multiple editions of these works, and long unbroken runs of monograph series. Moreover, an antiquarian instinct led him to acquire a clutch of rare and early books in the history of probability and statistics, an area of enormous interest to us. Altogether, Dr. Bissinger's books fill many gaps in both our working library of 20th century books and the rare book collection. We are indebted to his daughter, Karen Steinrock, and to his wife, Esther Bissinger, for making them available to us.



Selection of papers by Sofia Kovalevskaya.

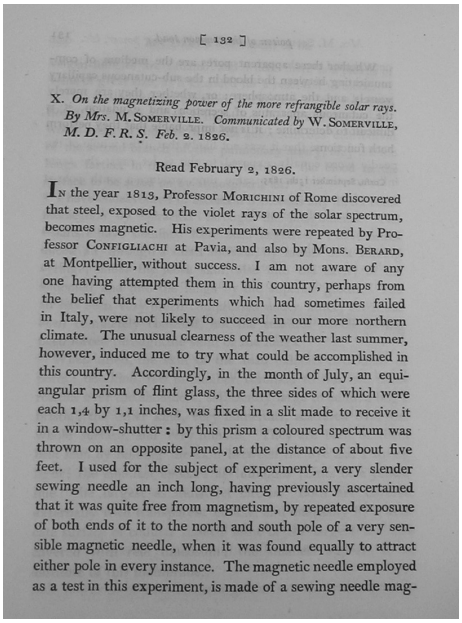
Unpacking books from the Bissinger collection.

A quiet corner of the AIM library.



Smaller but equally prized consignments came to us in 2008 from Sharon Lazarov who donated a second shipment of books belonging to her late husband, Connor Lazarov, and in 2009 from Paul Bateman and Heine Halberstam who both packed up their office libraries for AIM. In February, the family of Paul Cohen entrusted us with a first deposit of books, documents, and reprints from his personal library. This material will be housed in a corner of the new library at Morgan Hill reserved for the display of Cohen's works. Adjoining space will be dedicated to the work of fellow Fields Medalists, among them Atle Selberg, whose reprints and papers are well represented at AIM, thanks to donations from Selberg and from the Institute for Advanced Study.

(Continued on page 14)



[132]

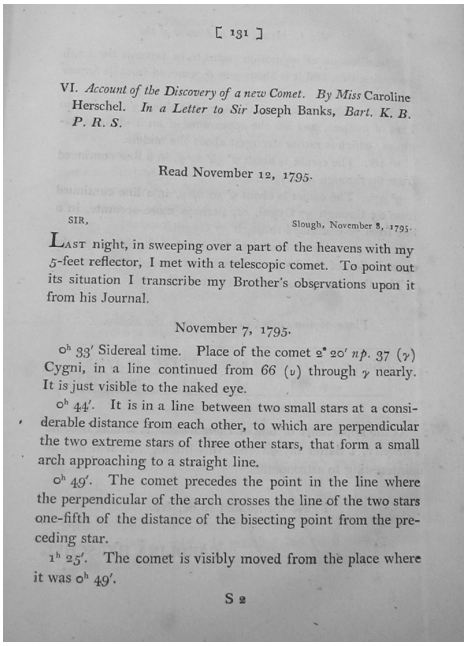
X. *On the magnetizing power of the more refrangible solar rays.* By Mrs. M. Somerville. *Communicated by* W. Somerville, M. D. F. R. S. *Feb.* 2. 1826.

Read February 2, 1826.

In the year 1813, Professor Morichini of Rome discovered that steel, exposed to the violet rays of the solar spectrum, becomes magnetic. His experiments were repeated by Professor Configliachi at Pavia, and also by Mons. Berard, at Montpellier, without success. I am not aware of any one having attempted them in this country, perhaps from the belief that experiments which had sometimes failed in Italy, were not likely to succeed in our more northern climate. The unusual clearness of the weather last summer, however, induced me to try what could be accomplished in this country. Accordingly, in the month of July, an equiangular prism of flint glass, the three sides of which were each 1,4 by 1,1 inches, was fixed in a slit made to receive it in a window-shutter: by this prism a coloured spectrum was thrown on an opposite panel, at the distance of about five feet. I used for the subject of experiment, a very slender sewing needle an inch long, having previously ascertained that it was quite free from magnetism, by repeated exposure of both ends of it to the north and south pole of a very sensible magnetic needle, when it was found equally to attract either pole in every instance. The magnetic needle employed as a test in this experiment, is made of a sewing needle mag-

Mary Somerville. "On the magnetizing power of the more refrangible solar rays." In: Philosophical Transactions of the Royal Society. London: 1826.

Somerville's first scientific paper, submitted to the Royal Society by her husband.



[131]

VI. *Account of the Discovery of a new Comet. By Miss* Caroline Herschel. *In a Letter to Sir* Joseph Banks, *Bart. K. B. P. R. S.*

Read November 12, 1795.

SIR, Slough, November 8, 1795.

Last night, in sweeping over a part of the heavens with my 5-feet reflector, I met with a telescopic comet. To point out its situation I transcribe my Brother's observations upon it from his Journal.

November 7, 1795.

0h 33′ Sidereal time. Place of the comet 2° 20′ *np.* 37 (γ) Cygni, in a line continued from 66 (υ) through γ nearly. It is just visible to the naked eye.

0h 44′. It is in a line between two small stars at a considerable distance from each other, to which are perpendicular the two extreme stars of three other stars, that form a small arch approaching to a straight line.

0h 49′. The comet precedes the point in the line where the perpendicular of the arch crosses the line of the two stars one-fifth of the distance of the bisecting point from the preceding star.

1h 25′. The comet is visibly moved from the place where it was 0h 49′.

S 2

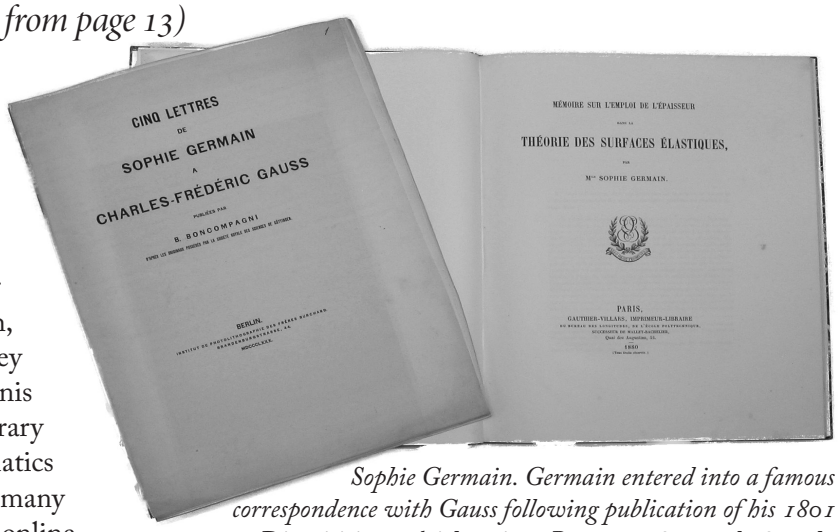
Caroline Herschel. "Account of the discovery of a new comet." In a letter to Sir Joseph Banks. In: Philosophical Transactions of the Royal Society. London: 1796.

Together with Mary Somerville, Caroline Herschel was elected to honorary membership of the Royal Astronomical Society in 1835, the first women to be so honored.

The AIM Library *(Continued from page 13)*

Reprints continue to pour in from workshop participants and from donors who are either longstanding supporters or who found us by way of newspaper articles or the AIM newsletter. AIM has been very fortunate this year to receive many boxes of reprints from the archives of Victor Klee, Sir Christopher Zeeman, Bernd Sturmfels, Victor Snaith, Thomas Banchoff, and members of the UC Berkeley mathematics department. As always, Keith Dennis of the AIM Advisory Board has alerted us to library deaccessions of comprehensive runs of key mathematics journals. Faced with budget and space constraints, many college and university libraries have turned to online journal subscriptions over print subscriptions and/or joined forces in regional consortia, making AIM the beneficiary of their largesse. With the goal of acquiring and conserving original materials, we still actively pursue complete sets of 19th and 20th century journals and are pleased to report the recent addition to the rare book library of unbroken runs of two major early periodicals: Crelle's *Journal für die reine und angewandte Mathematik* and Liouville's *Journal de Mathématiques Pures et Appliquées*, established respectively in 1826 and 1836.

-Ellen Heffelfinger



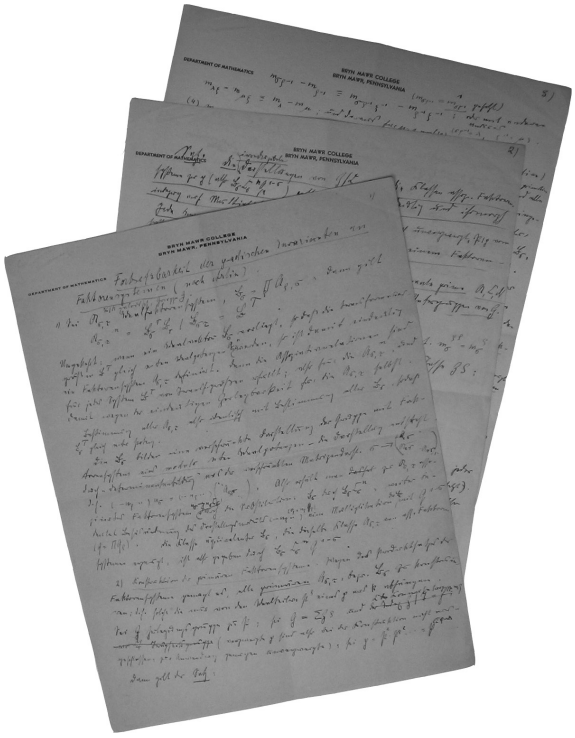
Sophie Germain. Germain entered into a famous correspondence with Gauss following publication of his 1801 Disquisitiones Arithmeticae. Between 1804 and 1809 she wrote a dozen letters to him, initially under the masculine pseudonym, 'M. LeBlanc.'

AIM Librarian, Ellen Heffelfinger

Call for Donations

The AIM Library actively seeks donations of books, reprints, journals and archives in mathematics and related fields. If you have material to donate, please contact Ellen Heffelfinger at *heffel@aimath.org*.

Emmy Noether. "Fortsetzbarkeit der p-adischen Invarianten von Faktorensystemen (nach Artin)." Three-page manuscript in ink written on Bryn Mawr College letterhead, between 1933-1935.



A Diversity of Programs at AIM

From its beginnings, AIM has maintained a commitment to inclusiveness throughout the mathematical community. Recognizing that mathematical institutes have unique opportunities to develop untapped human resources in the sciences, AIM continues to support innovative programs that encourage diversity in mathematics at all levels.

Central to the diversity efforts at AIM is the focus on full inclusion of under-represented researchers in its main activities: research workshops and SQuAREs. AIM's directors and the AIM Human Resources Board actively recruit a diverse group of researchers (including traditionally under-represented groups such as women, racial/ethnic minorities, as well as researchers at primarily undergraduate institutions), both to propose workshops and SQuAREs and to participate in these activities. Such efforts have led to the identification of participants who otherwise would not have been included and who have contributed significantly during the workshop.

AIM hosts around 20 workshops annually, most of which are funded by the AIM Research Conference Center (ARCC) grant from the National Science Foundation. While most have a research focus, in each year there is at least one that is a 'workforce' workshop which serves to enhance and diversify the mathematical workforce. Examples of ARCC workforce workshops include the *Math Teachers' Circle* and *How to Run a Math Teachers' Circle, Finding and Keeping Graduate Students*, and *Research Experiences for Undergraduate Faculty*. These workshops have seeded new programs which have since led to additional workshops and other activities with independent funding.

The workshop on *Finding and Keeping Graduate Students* brings together teams of faculty and administrators from various universities to work with leaders from math departments experienced in restructuring graduate programs. Particular emphasis is given to enhancing recruitment and retention of under-represented minorities, women, and US citizens. The participating teams develop plans to improve the climate of their departments to better support all students.

Research Experiences for Undergraduate Faculty workshops allow faculty at undergraduate colleges the opportunity to explore open problems suitable for undergraduate research projects. The workshop is led by researchers experienced in guiding research with undergraduates. Most of the participants come from colleges or universities that serve large numbers of under-represented students. This workshop includes follow-up activities such as gathering at a special session of the Joint Math Meetings to discuss successes and challenges in working with undergraduates on research projects.

In addition to its own activities, AIM is involved in the joint diversity efforts with the six other NSF-funded Mathematical Sciences Institutes. The institutes work together through the Math Institutes Diversity Committee, which is co-chaired by Leslie Hogben, AIM Associate Director for Program Diversity, and Chehrzad Shakiban, Associate Director for Diversity at the Institute for Mathematics and its Applications (IMA). Among its activities, the Committee organizes the Modern Math workshop, a regular feature of the Society for Advancement of Chicanos and Native Americans in Science annual conference. More information about the Committee can be found on the Diversity page on the NSF Mathematical Sciences Institutes website, *http://mathinstitutes.org/diversity.php.* ■

Math Teachers' Circle -an expanding national network

(Continued from page 10)

AIM's own Math Teachers' Circle continues to thrive. Nineteen area middle school teachers came to AIM for an intensive week of doing math during the Math Teachers' Circle Immersion Workshop in July. Many of these teachers commented on the depth of content in the Math Teachers' Circle Program. One remarked, "I enjoyed the opportunity to solve problems much more difficult than those I usually present in my classroom. The presentations were well done and I could see many ways to use the materials and problems in my classroom." The teachers who attended this summer's immersion workshop will join the AIM Math Teachers' Circle, which will begin its fourth year of meetings this September.

For more information about the Math Teachers' Circle Program, please visit *www.mathteacherscircle.org.*

-Brianna Donaldson

Research Experiences for Undergraduate Faculty

Roselyn Williams is Associate Professor of Mathematics at Florida A & M University.

The "Research Experiences in the Mathematical Sciences for Undergraduate Faculty" workshop was organized by Leslie Hogben and Roselyn Williams. Major funding was provided by NSF and AIM. An account is provided by Roselyn Williams.

AIM is always willing to consider opportunities that introduce more and more people to the excitement of mathematics. So, when a workshop was proposed that brings together current research mathematicians with faculty at undergraduate institutions interested in involving their students in research, AIM offered enthusiastic support.

On August 11—15, 2008, AIM hosted the first of two workshops: "Research Experience in Linear Algebra and Number Theory." Designed for faculty members from undergraduate colleges who teach and advise students who plan to apply to graduate schools in the mathematical sciences, the workshop chose to focus on two areas of current research: linear algebra and number theory. Four senior research mathematicians introduced the twenty participating faculty to current open questions in their fields and to ideas for research projects. The participants came from fifteen institutions, many serving students typically under-represented in the mathematical sciences. The workshop was organized by Yewande Olubummo (Spelman College), Joe Omojola (Southern University at New Orleans), and Roselyn Williams (Florida A & M University).

The primary goal of the workshop was to engage the participants in mathematical problems that they can work on with their students, but are not necessarily intended to lead to publishable research. A secondary goal was to forge lasting research collaborations among the project leaders and participants, re-invigorating some participants' research activities.

The workshop opened with a series of presentations giving background information on several problems in linear algebra and number theory. Many of the problems were selected because of their accessibility through numerical experimentation and computational investigations. And so, following the talks a training session on Sage (an open source computer algebra system) was provided by Michael Hansen, a mathematics graduate from Harvey Mudd College. Once the projects were introduced, participants separated into working groups either in linear algebra or number theory.

"The workshop proved to be highly successful; participants formed networks for continued collaboration and expressed an interest in more workshops..."

Problems in linear algebra were introduced by Bryan Shader (University of Wyoming), and Leslie Hogben (Iowa State University) and AIM's Associate Director for Program Diversity, while problems in number theory and random matrix theory were introduced by Estelle Basor, AIM's Deputy Director and David Farmer, Director of Programming at AIM.

A general discussion session on student mentoring occurred later in the week. Topics included: What makes a good mentor for students who will engage in undergraduate research experiences or who plan to continue on to graduate school in the mathematical sciences? How does one design a good research experience for undergraduate students? What can graduate departments do to better prepare students from small undergraduate colleges?

The workshop proved to be highly successful; participants formed networks for continued collaboration and expressed an interest in more workshops of this nature in other areas of mathematics. Roselyn Williams and Leslie Hogben submitted a proposal to the National Science Foundation for funding to run a second workshop of this style. It was supported and led to the workshop, "Research Experiences in the Mathematical Sciences for Undergraduate Faculty" also held at AIM. *(Continued on page 17)*

Research for Undergraduate Faculty

(Continued from page 16)

During July 20—24, 2009, a new set of participants gathered to investigate open questions in graph theory, algebra, number theory, and linear algebra that are suitable for undergraduate projects. Again, training sessions were provided on the use and applications of the Sage software package. Workshop presenters were Nathaniel Dean, professor of mathematics at Texas State University; Phillip Kutzko, professor of mathematics at the University of Iowa; Kent Morrison, professor of mathematics at California Polytechnic State University; and Leslie Hogben, professor of mathematics at Iowa State University.

A great breadth of topics was presented: Dean offered projects in geometric graph theory, while Kutzko introduced ideas in cyclotomy using representation theory. Projects in the area of the perfect shuffle groups and the symmetric groups were directed by Morrison, and Hogben focused on projects on minimum rank problems.

Activities planned in the future include a follow-up gathering at the Joint Mathematics Meetings in San Francisco in January. This will offer another opportunity to discuss activities undertaken by the participants since the workshops and to explore new directions of research. These workshops have been immensely successful in engaging both faculty and students in the process of mathematics. ■

Story of a SQuaRE

(Continued from page 8)

The Aftermath

The SQuaREs program is a wonderful opportunity for an intensive attack on a significant deep problem in mathematics that seems intractable. The week is intense, fast-paced, exciting, and face-to-face. So when planning such an event, one must take into consideration the personalities involved and whether they can "play well with others" and survive in such close quarters for 8-12 hours a day for five consecutive days. Overall, I am not sure that being together every minute was the best policy. With so much new information coming so fast, one needs down-time to assimilate and digest it as well as time to see where it might go. Since we were often together until 8 or 9 in the evening, I found myself getting up at 4 AM to get this personal thought time, but became exhausted over the five-day period. The AIM site has all of the necessary tools for carrying out the project. They have an adequate library (and AIM invites all SQuaREs participants to suggest new book acquisitions long before their meeting so that all needed resources will be available), computers, printers, copiers and most valuable, their reprint collection. (They collect papers from all the participants of all their meetings and carefully catalog and store them in individual binders, filed alphabetically.) The members of the AIM staff are exceptionally proficient at running these programs and are available at all times for any help that is needed. They are committed to making sure that every meeting is a complete success and will do anything necessary to assure this. You should take advantage of their expertise and help at all times. The SQuaREs program is a perfect format for trying to make significant advances on deep, intractable problems and we were very grateful for having the opportunity to take part in this program. It not only brought our work closer together, but it brought us closer together and will certainly have serious pay-off in the future. ■

Call for SQuaREs Proposals

The American Institute of Mathematics (AIM) is committed to developing productive collaborations among mathematical scientists. The SQuaREs Program supports long-term, major research initiatives for small collaborative teams.

Research facilities and financial support are provided for groups of 4-6 researchers to meet at AIM for a week at a time over a three-year period. The goal of this program is to make major inroads into some of the most important questions currently challenging mathematics.

AIM seeks proposals for SQuaREs to begin in Summer, 2010 or later. We solicit SQuaREs in all areas of mathematics. Instructions and an application form is available on the AIM web-site

www.aimath.org/research/squares.html.

Proposal deadline is November 1.

Preference is given to groups which contain a mix of junior and senior researchers and to groups which have not previously collaborated. SQuaREs typically meet during weeks when there are no workshops at AIM.

Mathletics: a Hit with Morgan Hill Students

AIM was delighted to broaden its Morgan Hill Math activities with the introduction of two new programs this year: Mathletics and Game Night *(see Game Night article on page 9)*. Mathletics is an after school math program that is aimed at giving highly motivated fourth and fifth graders more in-depth experiences with math. Game Night takes on a lighter tone, inviting the entire Morgan Hill community to get together to challenge themselves and others with the featured game of the month.

Interest was high for the inaugural year of the Mathletics program with over eighty-five students trying out for the forty available spots in the program. Due to the overwhelming response, a third class was added and the program began with fifty-six enthusiastic 4th and 5th graders, three teachers: Lori Mains, David Holmstrom, and Margaret McCann, and three aides: Donna Dicker, Becky Garcia, and 9th grader Ernest Yip. While the main focus of the sessions was to use basic problem solving strategies (work backwards, draw a diagram, etc.) to solve multi-step word problems, students also enjoyed some hands-on activities.

In one particularly interesting project, students combined their knowledge of two basic geometric principles (symmetry and reflection) with their newfound knowledge of modular arithmetic in base-4, and created "math art" quilt squares. Students also studied and built platonic solids from Zometool and played SET and fraction games. The last lesson of the ten-week program turned out to be one of the students' favorites: they broke into teams and raced each other to be the first to solve the puzzles in the book *Get It Together: Math Problems for Groups Grades 4-12*, by Tim Erickson. Not only did it put their problem solving skills to the test, but it also encouraged one of AIM's fundamental values: collaboration with peers.

For those fourth and fifth graders who especially enjoyed challenging themselves, AIM held five additional sessions where students could take a Math Olympiad test and compete for the "High Score" award at the end of the season. On December 2, 2008, two hundred and eighty parents, students, and community members (including the Mayor of Morgan Hill, Steve Tate and AIM's Executive Director, Brian Conrey), gathered at the Morgan Hill Community Center for a ceremony to recognize students' participation in Mathletics, MATHCOUNTS, and the Math Olympiad. Marina Bireley, a fifth grade girl, won top honors for the Math Olympiad, outscoring all the other fourth, fifth, and sixth graders with a score of 22 (out of a possible 25 points). The evening was a fun ending to a successful season. Students and coaches alike look forward to the 2009-2010 Mathletics season.

–Lori Mains

Mathletics volunteers: Carol Rickard, Becky Garcia, Margaret McCann, Donna Dicker, and Ernest Yip.

Marina Bireley received her awards from David Holmstrom.

AIM's Math Mardi Gras— four years and going strong

The Math Mardi Gras, a unique Morgan Hill community event, attracted more than 300 students and their families to the Community and Cultural Center, to spend an afternoon engaged in teaching and learning math concepts, solving puzzles, and having a whole lot of fun.

Local students, ranging from grades 2 through 12, participated in a day of interactive math activities and friendly competitions. Twenty-one booths, color-coded by grade level, were set up around the building, each with a different math challenge. Participants moved to the various booths, which were staffed by trained student volunteers, and engaged in hands-on activities that taught particular math concepts. By answering a few questions that showed they understood the concept, the participants earned a string of colored Mardi Gras beads, worth one point. Those who wanted more of a challenge answered questions on an 'expert' worksheet, and if completed correctly, earned a coveted string of black beads, worth two points. At the end of the afternoon, the participants with the most points were crowned Math Mardi Gras kings and queens.

The booths were just part of the fun. The main room of the center was a bustle of activity with Math Jeopardy contests running continuously on stage, and participants of all ages competing in the preliminary rounds of SET, Sudoku, and Rubik's cube. For those visitors new to any of the games, a number of 'how to' tables were available, each staffed with enthusiastic volunteers who introduced the newcomers to the rules and strategies of each game.

At 3PM, all activity booths were shut down, beads were turned in for counting, and attention was focused on the stage for the game finals. Three final rounds of Math Jeopardy energized the room as contestants worked to be the first to hit the buzzer and correctly answer each question. For Rubik's cube, the seven students who successfully solved the puzzle in less than two minutes in the preliminaries, competed on stage in the finals. Sudoku boards were set up for each of the three finalist teams to see who would be the first to correctly fill in all the squares. The finals competition closed with a fast-paced game of SET.

This is the fourth year that AIM has hosted the Math Mardi Gras and Lori Mains, AIM Outreach Coordinator and the event's planning committee chair, credits its continuing success to the numerous volunteers. Among them were 96 students who staffed the activity booths and the 'how to' tables, graded worksheets, and entertained pre-schoolers. More than 20 adult community members participated in the planning and hosting of the event. The time, energy, and enthusiasm of these volunteers made the Morgan Hill Math Mardi Gras a tremendous success.

Thanks to Sue Brazelton and the "Morgan Hill Times" for permission to adapt her newspaper story for the AIM newsletter. The fourth annual Math Mardi Gras, which is sponsored by AIM, took place on March 29, 2009.

Members of David Holmstrom's Mathletics class proudly displays their finished math art quilt squares.

Morgan Hill Mayor, Steve Tate, presents sixth graders with their awards.

Director's Circle Explores Perfect Squares

Evidence abounds in Morgan Hill that AIM is succeeding in its goal to "nurture young mathematicians." The Director's Circle program, established in 2006, gives students who excel in AIM's after school programs a chance to work directly with AIM's Executive Director, Brian Conrey.

Director's Circle meetings take various forms depending on the needs of the students. During summer 2008, eight students from 7th-12th grade met at Conrey's house and studied various topics including randomness. In the 2008-2009 school year, Conrey met with up-and-coming 4th and 5th graders introducing them to the delightful patterns that exist in perfect squares. Conrey also continued to work with students Joshua Yip and Peter Mains, who had decided to take the randomness project one step further and develop their own pseudorandom number generator. Currently, 8th grader James Gabbard, 9th grader Mark Holmstrom, and Conrey are studying topics in advanced geometry. Some of the many successes of the Director's Circle are highlighted below.

James Gabbard

James Gabbard was recently honored by Johns Hopkins University for having the highest combined SAT score (math and critical reasoning) for a middle school student in the state of California. Additionally, his perfect score of 800 on the math section placed him in a twelve-way tie for first in the nation. AIM had the good fortune to cross paths with Gabbard two years ago, when he enrolled in the sixth grade MATHCOUNTS program. He immediately impressed AIM with his intellectual curiosity (he would often check out math books from the library for 'pleasure reading'), strong performance in the MATHCOUNTS competition, and good nature. Gabbard finished fourth overall in the MATHCOUNTS chapter competition this year, first in the Countdown round and, along with three other teammates from Britton Middle School, progressed to the MATHCOUNTS state competition. When a group of high school Director's Circle students needed an eighth person to complete their team for a math competition at Stanford University, they drafted Gabbard (then in seventh grade) knowing that his strong critical reasoning skills would carry him through.

The Director's Circle math team at Stanford University.

Mark Holmstrom

Mark Holmstrom's desire to compete in next year's United States of America Mathematical Olympiad (USAMO) competition is the impetus behind the Director's Circle's current focus on advanced geometry. As an 8th grader, Holmstrom excelled at the qualifying tests for the USAMO, achieving first place in California for writing a perfect paper on the 2008 AMC-8 examination. In addition, he achieved a score of 135 on the 2009 AMC test for students in the tenth grade and below (a score of 120 out of a possible 150 would have placed Holmstrom in the top 1% of all high school students taking the 2009 AMC-10).

When Holmstrom barely missed qualifying for the invitation-only American Invitational Mathematics Examination, he asked Conrey for help in conquering the problems that he was unable to answer. In doing so, they both became intrigued by the problems and decided to make advanced geometry the focus of the 2009 Director's Circle. Gabbard joined the group, and the threesome delved into the study of proofs in this area.

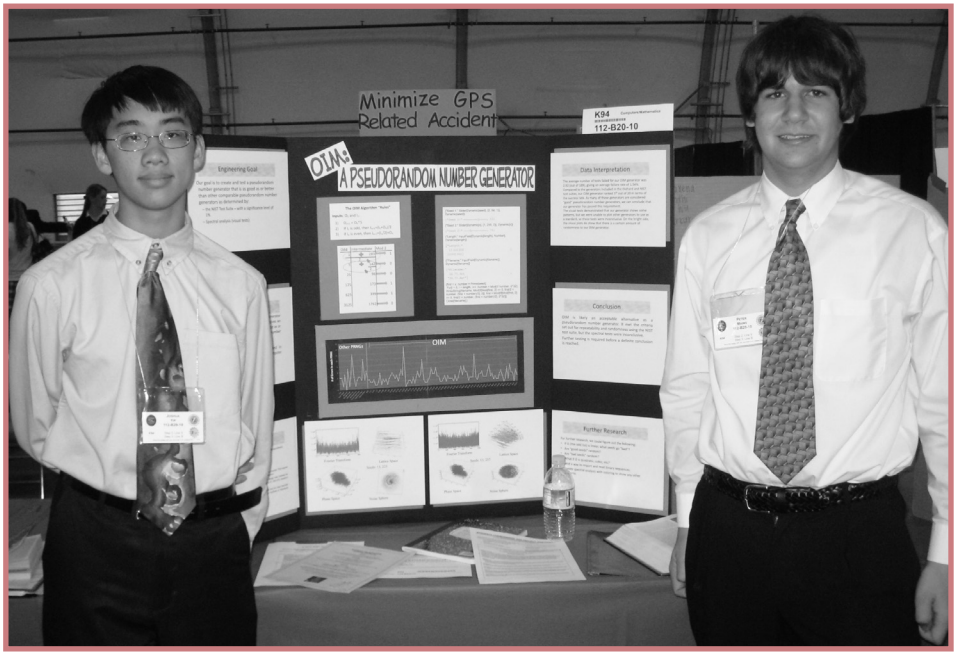
This was Holmstrom's last year to compete in the middle school competition, MATHCOUNTS, and he excelled again. In an auspicious beginning, Holmstrom came in second

in the MATHCOUNTS Monterey Chapter competition as a sixth grader in 2007. He has continued to excel in the 2008 and 2009 competitions, winning first place, both individually and as a member of the Britton Middle School team, and going on to the state level of competition. Holmstrom was honored at his middle school graduation with the *Britton Middle School Hyperbolic Scholarship* for "exceptionally outstanding performance in Mathematical Understanding and Leadership."

The Sobrato High School Math/Science club.

Another AIM success is the collaboration between high school students Joshua Yip and Peter Mains. Yip and Mains met five years ago, through AIM's middle school MATHCOUNTS program; they have been teammates/friendly rivals ever since. Both boys were founding presidents of their respective high school math clubs: Yip started the Sobrato High School Math/Science club in 2006 and Mains founded a chapter of the math honor society, Mu Alpha Theta, at Live Oak High in 2007. Each summer since seventh grade, Mains and Yip have had the privilege of working with Conrey through the Director's Circle. In the early days, five students would load up in Conrey's mini-van and make the hour-long commute from Morgan Hill to AIM in Palo Alto. There, they worked on various projects including one that involved determining the probability of getting a Yahtzee on the first roll. In 2008, Yip, Mains, and six other students banded together, took on the acronym of SMART (Summer Mathematically Advanced Research Team) and tackled math problems having to do with randomness. Mains and Yip continued to explore this topic during the past school year resulting in the submission of a project to the 2009 Synopsys Championship at the Santa Clara Science and Engineering Fair. The project of Yip and Mains, "An Alternative Pseudo-Random Number Generator," received two prizes: the Mu Alpha Theta Creative Math award and the Trimble Navigation Special Award.

Members of the Mu Alpha Theta math honor society at Live Oak High School.



Both Yip and Mains have been an important part of the Math Mardi Gras standing committee since its inception, volunteering as webmasters, registrars, SET dealers, and providing technical support. The high school juniors also coach the MATHCOUNTS teams, and enjoy giving back to the program where they each got their start.

Brian Conrey sums up the Director's Circle as an "extremely positive experience for all involved." ■

Joshua Yip and Peter Mains present their work at the Synopsys Championship.

NSF Math Institutes Create New Jobs

It was the end of March 2009—after most academic searches were complete—when the seven NSF Mathematical Sciences Research Institutes advertised the creation of 45 new two-year post-doctoral positions. The year's economic downturn saw widespread hiring freezes in academia with many canceled job searches at universities across the country. For the mathematical sciences community, this has meant almost 400 lost positions for recent PhDs. The severity of the situation became apparent earlier in the year when many graduates, even of top-tier programs, were facing unemployment. The NSF, through its Mathematics Institutes, responded with the creation of these new post-doctoral fellowships.

A Valuable Investment

The training of young scientists represents a long-term investment. New math PhDs have typically spent five years in graduate education, often with some level of support from state or federal funds. "These new researchers are primed to make significant contributions to their fields," said Peter March, Director of NSF's Division of Mathematical Sciences. The newly created positions will place highly trained people as teachers at community and four-year colleges, as well as in business and industry.

Short Timeline

Exactly one month elapsed between the first meeting of the seven Mathematics Institute directors and the close of applications. More than 750 applications were received, 400 of which came from people who received their PhD just this year. And less than one week after the deadline, all the applications were reviewed and the first round of offers was made. Typically, academic job searches begin in the Fall and take several months to complete.

"The timing was perfect," said Eddie Herman, one of the newly hired mathematicians. "Most academic positions are decided by the middle of March, so the Institutes began advertising at exactly the time when many of us were losing hope of finding a research position and were ready to look for other jobs." Dr. Herman received his PhD from UCLA this year.

Pipeline Issues

The economic downturn is being felt by everyone, including the research and academic community. Universities are canceling job searches, limiting the number of positions for new PhDs and people completing postdoctoral training. Additionally, many US graduate programs have reduced the size of their incoming class. In fact, some programs will not be admitting any students in the next academic year. "This has the effect of diminishing the size of our next generation of scientists, those who would be graduating at a time when our economy is recovering and in need of a highly trained workforce," said J. Brian Conrey, Executive Director of AIM.

Huge Response

"We knew that the job market for young PhDs in mathematics was extremely tight this year, but we were astonished by the number and quality of the applicants for these new positions," said Robert Bryant, Director of the Mathematical Sciences Research Institute (MSRI) in Berkeley, California. "Being able to offer these positions allows us to keep these highly trained people in the workforce and is a great boon for mathematics and for our society," said Bryant.

"There are problems all along the pipeline," said Marty Golubitsky, Director of the Mathematical Biosciences Institute (MBI). "New PhDs are not finding jobs that make use of their extensive training, and consequently graduate programs are admitting fewer students. This stifling of scientific training in our next generation will make it more difficult for the US to remain competitive in the future."

The research areas of the new AIM postdocs are in pure mathematics. Their specialties are in number theory, representation theory, algebraic geometry, and contact topology. Their research mentors will be from Stanford's Mathematics Department. In addition to research, the AIM postdocs will teach at De Anza Community College in Cupertino and at San Francisco State University.

Much Needed Teachers

The opportunity to teach at the undergraduate level has been well-received by the local community colleges. Currently, many workers are seeking re-training in response to the needs of the changing economy—just as colleges and universities face cutbacks. "I have more than 1000 students on a waiting list for math classes, and no faculty to teach them," said Jerry Rosenberg, Dean of Physical Sciences, Mathematics, and Engineering at De Anza Community College in Cupertino, California. Thanks to this initiative, approximately 250 of those students will be able to take a math class from one of the new Institute postdocs at AIM. According to Brian Conrey, Executive Director of AIM, "We were aware of the dire need for math instructors at California colleges, and we saw the Institute postdocs as a way to help address that need. This will bring enthusiastic young instructors into the classroom, and allow the postdocs to further develop their teaching skills."

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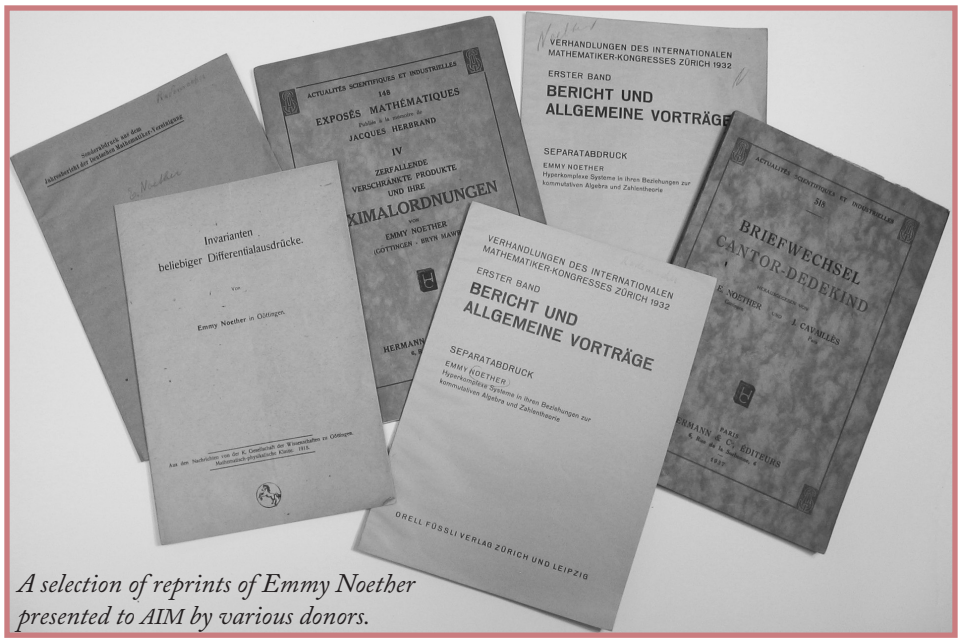
The Reprint Collection at AIM

The Reprint Library is one of AIM's most prized collections. More than 100,000 reprints can be found on AIM's bookshelves assembled into volumes of 'collected works' of more than 5000 mathematicians.

Please consider sending us your reprints or updating your collections folder as you write new papers.

Also, we warmly welcome donations of entire reprint collections as we work to build the world's most comprehensive mathematical reprint library.



A selection of reprints of Emmy Noether presented to AIM by various donors.

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Organizer's Perspective

(Continued from page 11)

In the run-up to the meeting, my co-organisers and I had a number of conference calls with the AIM staff and the plan-as-you-go approach was impressed on us. Concerned that this might end up equating to having no idea what we were doing, we surreptitiously sketched out the week, with the concession to our hosts that we would be open to adapting our plan as the week progressed. This cannot have been too mischievous as AIM's Director of Programming David Farmer said that it seemed like the workshop had come together considerably between the final call and our arrival at AIM.

The heading for Monday on our secret workshop plan was: "Introduce the problem and then attack it head on!" We arranged two lectures to give various formulations of the problem and explain what was already known, and then we divided the participants randomly into groups of four or five and sent them off with the instruction: "solve the problem... or, failing that, brainstorm strategies of attack." At the end of the day, the groups returned to compare notes. This established the various lines of thought we would follow throughout the week.

Most days began with two lectures containing descriptions of results, some classical and some recent, which we felt could be stepping stones towards solving our problem. In the afternoons we split into groups to try to push forward in what seemed to us the most promising directions. Also, we organised discussion groups on background topics, trying to keep everyone engaged and up to speed.

(Continued on page 25)

Organizer's Perspective *(Continued from page 24)*

Participants of the "Isoperimetric Inequality" workshop.

Towards the end of the week, moving to fox guises, we had talks on how our problem related to broader questions about arithmetic groups and we ran a session on open problems. But hedgehogs in our group remained focused on SL(n, $\mathbf{Z}$), particularly one group pursuing a geometric solution, and another looking at a combinatorial approach. The geometers' approach appeared the most promising. They succeeded in breaking down the problem into a sequence of sub-problems.

On our final day at the workshop, no proof having been found, we resorted to another arbiter of truth. We took a vote. For the record, 63% believed the isoperimetric inequality of SL(4, $\mathbf{Z}$) to be quadratic and 94% believed it to be polynomial.

Realistically, looking back on our week at AIM we could only hope to sow the seeds for a solution to our problem, as it appeared the sort of challenge that needs not just new ideas, but also quiet contemplation to steer a path through the technical obstacles. And so it has since proved. On March 2, 2009, workshop participant Robert Young distributed a preprint in which he established a quartic isoperimetric inequality for SL(n, $\mathbf{Z}$) when n is at least 5. His preprint can be found on the e-print service, arXiv (*www.arxiv.org*). At the same time, Mladen Bestvina, Alex Eskin, and Kevin Wortman together developed tools that might be used as a starting point to show polynomial isoperimetric inequalities in a broader class of groups, namely irreducible lattices in semisimple Lie groups of rank at least 3.

Still, SL(n, $\mathbf{Z}$) holds on to some secrets—in particular, Thurston's claim that SL(4, $\mathbf{Z}$) satisfies a quadratic isoperimetric inequality remains unproven. But these are great advances. ■

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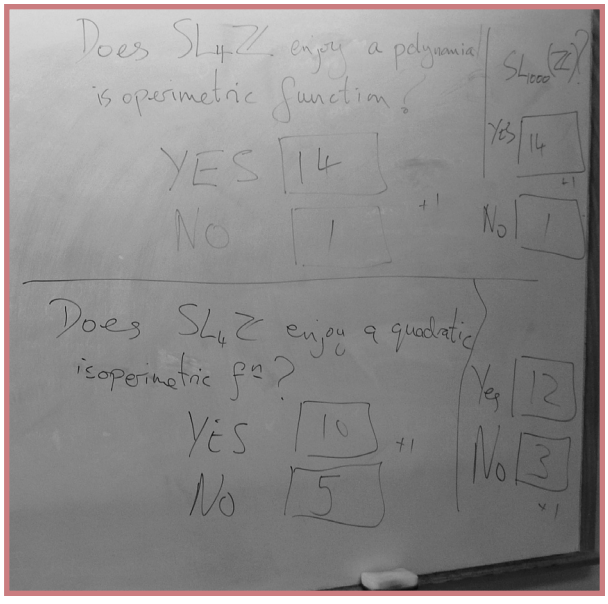

Joint Math Meeting Returns to San Francisco

The annual joint meeting of the American Mathematical Society and the Mathematical Association of America provides an opportunity to generate interest and awareness in AIM's many activities. Brian Conrey, Estelle Basor, Leslie Hogben, and David Farmer can be found at the AIM booth in the exhibit area, and are happy to talk with people about AIM and its various programs.

When many conference attendees stop by to learn about upcoming workshops, they are often surprised to learn that they may apply to attend as fully-funded participants. On other occasions, casual conversations have formed the seed of successful workshop proposals and library donations.

AIM also joins in hosting the Mathematical Institutes' Open House reception. This event is open to all conference participants and provides another venue to learn about each institute's programs and to meet with institute members. Please join us at the Institutes' Reception on Wednesday evening, January 13, 2010.

Please join us at the Mathematical Institutes' Open House reception

Wednesday, January 13, 2010

5:30 P.M. - 8:00 P.M.

American Institute of Mathematics

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Ellen B. Heffelfinger	*Librarian* heffel@aimath.org

American Institute of Mathematics

Research Conference Center

The AIM Research Conference Center (ARCC) hosts week-long focused workshops in all areas of the mathematical sciences. ARCC focused workshops are distinguished by their emphasis on a specific mathematical goal, such as making progress on a significant unsolved problem or examining the convergence of two distinct areas of mathematics. Workshops are small in size, up to 28 people, to allow for close collaboration among the participants.

Call for Proposals

Proposals are sought for workshops which will take place in 2010 - 2011.

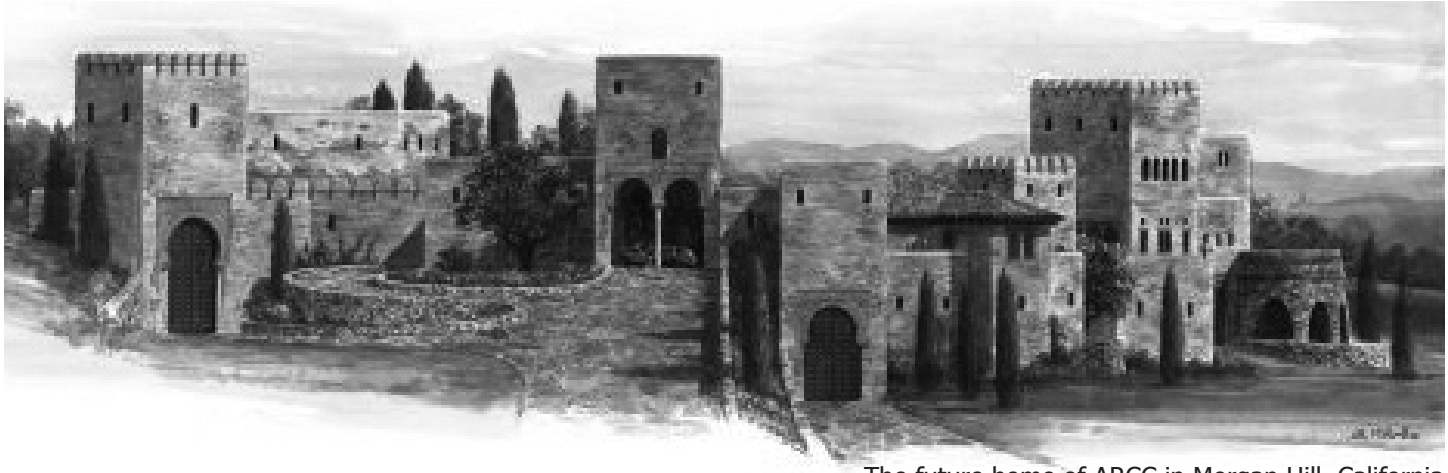
Proposals require:

- a list of organizers
- a list of potential participants
- a description of the workshop goals
- an outline of how these goals will be met

Proposals will be accepted until November 1, 2009.

Workshops will be held at AIM in Palo Alto. More details and an online application are available at:
http://www.aimath.org/research

ARCC seeks to promote diversity in the research mathematics community. We encourage proposals which include significant participation of women, underrepresented minorities, junior mathematicians, and researchers from primarily undergraduate institutions.



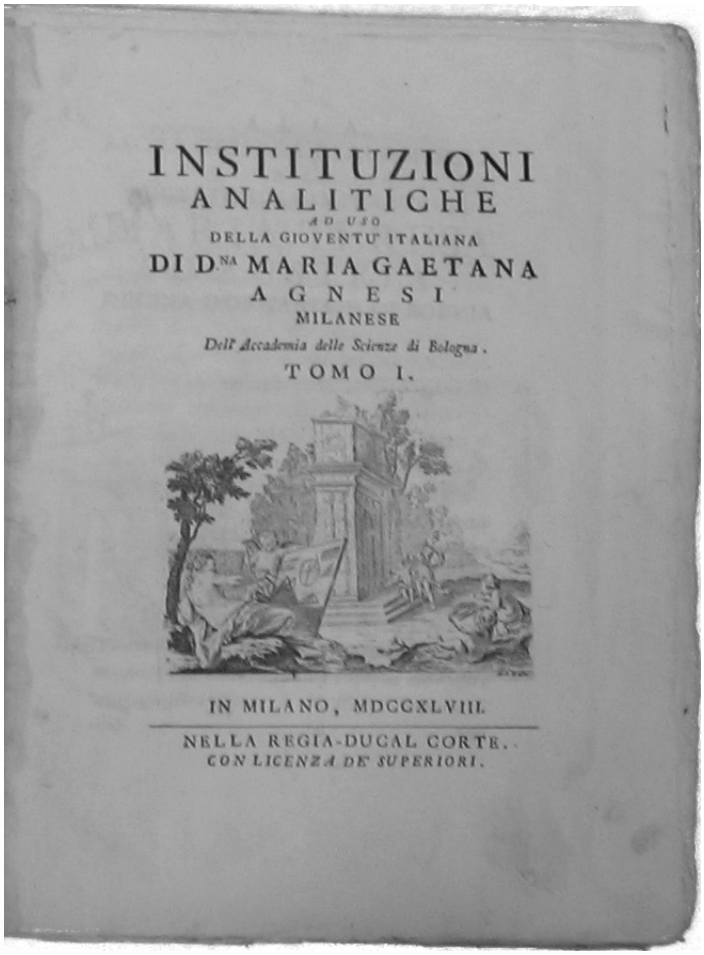
The future home of ARCC in Morgan Hill, California

Major funding for ARCC is provided by a grant from the National Science Foundation.

From the AIM Library

Maria Gaetana Agnesi
"Instituzioni analitiche" 2 vols. Milan: 1748

First edition of the principal work of "the first woman in the Western world who can accurately be called a mathematician" (Dictionary of Scientific Biography).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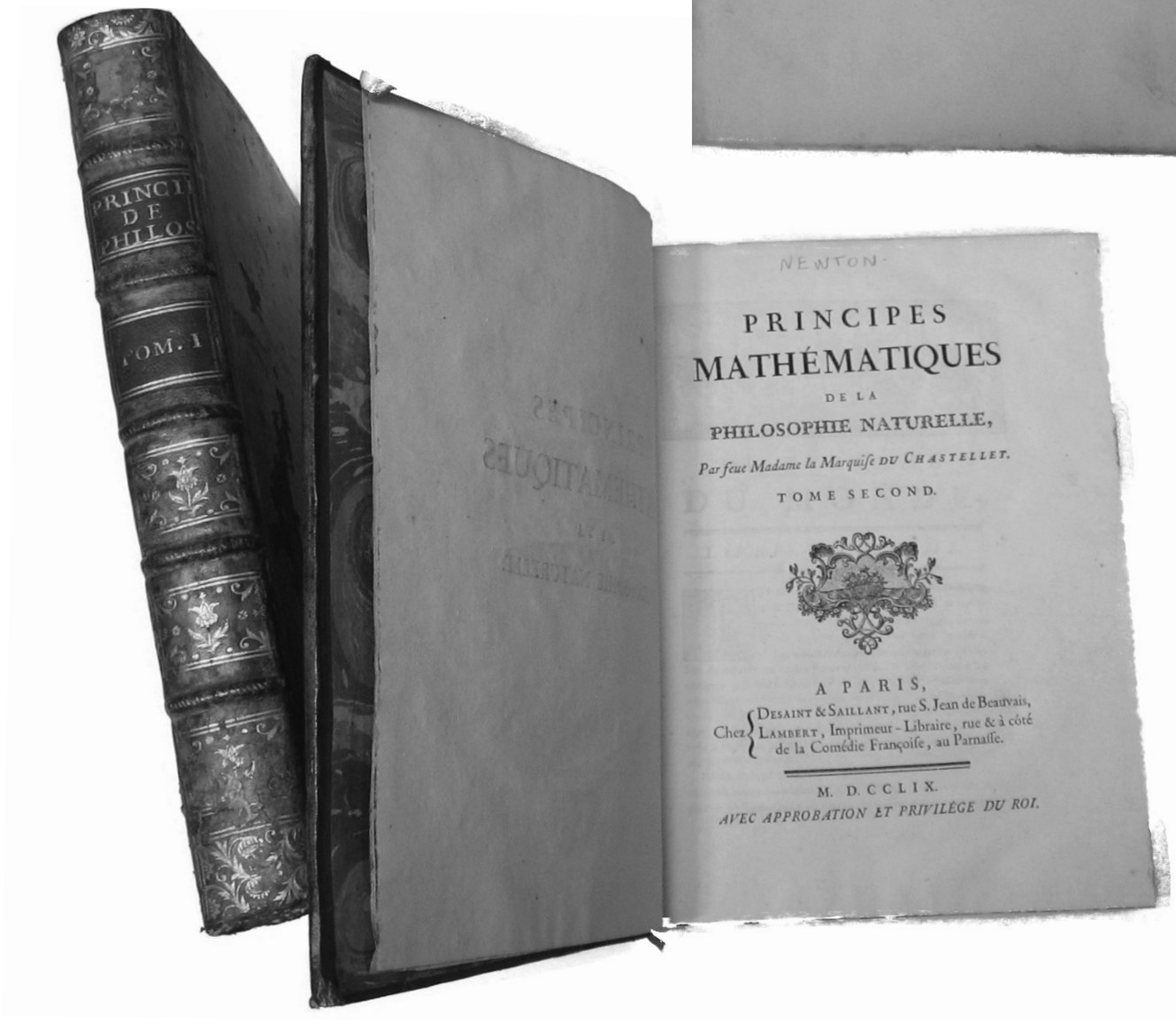
Emilie du Chatelet
"Principes Mathématiques de la Philosophie Naturelle"
2 vols. Paris: 1759

Du Chatelet's most ambitious project and crowning achievement: the first French translation of Newton's Principia, with her own learned commentary. It played a major role in disseminating Newton's thought and remains the standard version in French.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