Autumn 2017

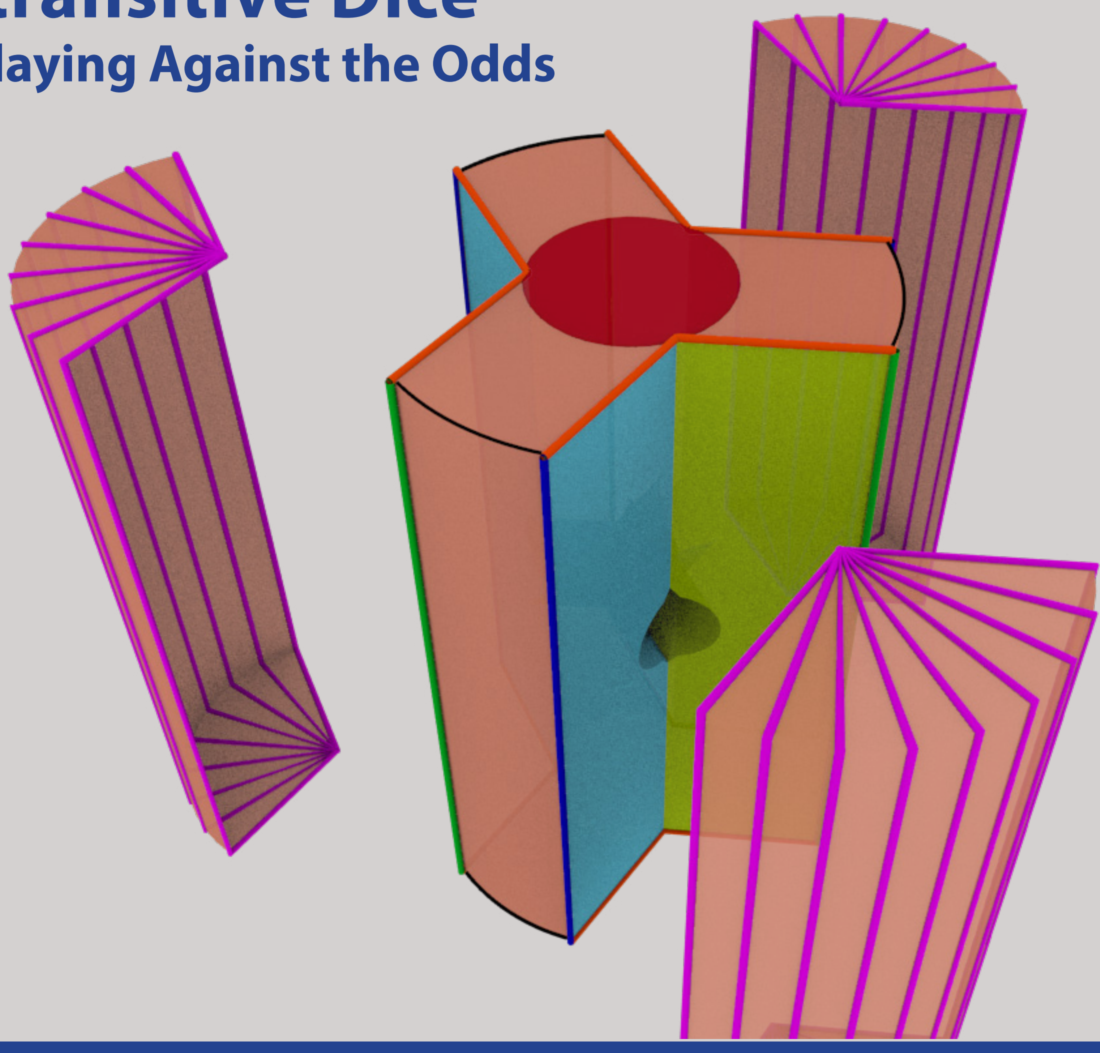
AIMatters

Newsletter of the American Institute of Mathematics

Trisections
Understanding Four Dimensions

Global Math Week
Exploding Dots

Intransitive Dice
Playing Against the Odds



Letter from the Director

Greetings from San Jose

Greetings from San Jose! We have been in our new facility inside the Fry's Electronics corporate headquarters for two and a half years now. Participants continue to enjoy the windows in the breakout rooms, the gourmet on-site lunches, and the easy access to the Guadalupe River Trail and the San Jose light rail. In our new space, we have additional room for our library, and so we are once again seeking contributions, especially of reprint collections.

We have very good news from the National Science Foundation! We have been awarded an Institute grant from 2017 to 2020. This is our fourth such award. AIM is currently one of six institutes in the U.S. supported in this way, having been awarded more than $33 million in core funding through the NSF Institutes program since 2002.

In 2016, for the third consecutive year, we had more than 100 proposals for our workshop and SQuaREs programs. This level of interest has certainly challenged our Scientific Board, as it gets more and more difficult at our annual meeting to select 20 Workshops and 15 new SQuaREs. We intend to seek funds to support more SQuaREs in the future.

Last year we also had a record number of AIM publications: 134 papers in Volume 2016 of our preprint server (https://aimath.org/preprints/). The scientific productivity of our workshop and SQuaREs participants has inspired AIM to create an annual prize that will be awarded to the authors of one of these papers. The details are still being finalized, but we do know that the annual prize will be called the Alexanderson Award, named after the Chair of our Board of Trustees, Gerald L. Alexanderson, who has been and continues to be very influential in the establishment and continued evolution of AIM.

This issue of AIMatters features highlights from selected workshops and SQuaREs, along with updates on our ongoing education and outreach initiatives, including the Research Experiences for Undergraduate Faculty program, the Math Teachers' Circle Network, and the Julia Robinson Mathematics Festivals. AIM is also a proud partner in a new initiative called the Global Math Project, which intends to engage students in math in much the same way as the "Hour of Code" does in computer science.

We hope you enjoy reading this newsletter, and we look forward to staying in touch with you in the year ahead! ■

American Institute of Mathematics

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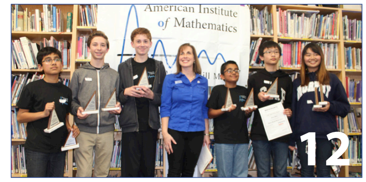

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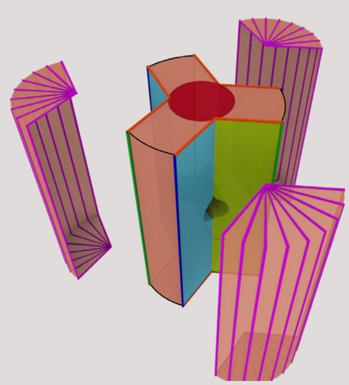


ABOUT THE COVER IMAGE

Understanding four-dimensional objects or structures is a mysterious and difficult task. Some recent progress shows that every four-dimensional object can be put together (in rather complicated ways) from three simple pieces. This approach bridges some of the gap between the three- and four-dimensional worlds. This is described in more detail by David Gay and Robion Kirby in their "Trisections" article in this issue. The cover is a three-dimensional analog of the process of building a trisected four-manifold with boundary.

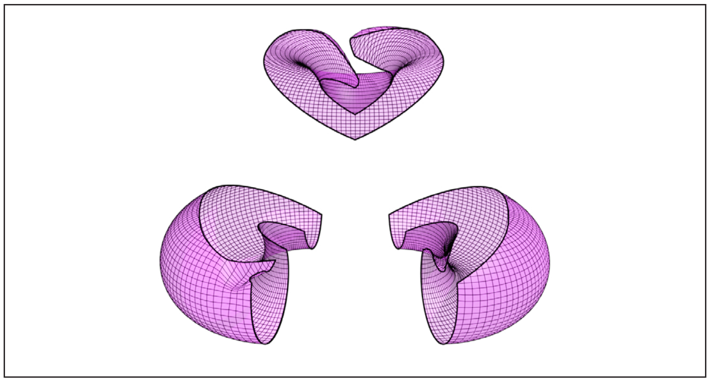
Trisections

Understanding Four Dimensions

Understanding four-dimensional structures or manifolds is both a mysterious and complex task. The goal of the AIM workshop, "Trisections and low-dimensional topology" held in March of 2017, was to study these four-dimensional objects with a new perspective introduced by the authors in 2012. In three dimensions it has been known for a fairly long time that closed manifolds can be decomposed into two simple pieces called handle-bodies (think here of a solid donut for an example). The manifolds are constructed by gluing the handle-bodies together along their boundary. The theory of trisections says that every smooth four-dimensional manifold can be decomposed into three simple pieces via a trisection, a generalization of the splitting of a three-dimensional manifold. There is now tantalizing evidence that reveals that trisections may bridge the gap between three- and four-dimensional topology.

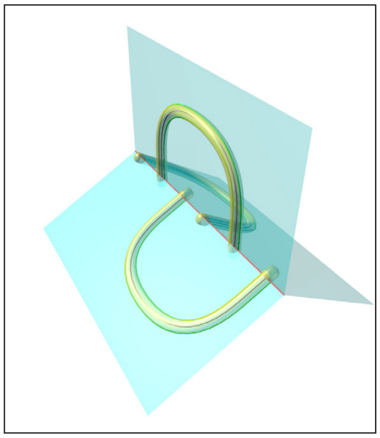
Along with Jeffery Meier and Alexander Zupan, we organized the AIM workshop. Many facets of the theory were explored by the subgroups formed at the workshop, and the hope is that this work will continue to influence the subject long after the workshop.

Invariants in mathematics are objects used to tell which objects are the same in some sense and which are different. So it was natural that one of the many interesting questions and ideas considered at the workshop included investigating the connection between invariants of the manifolds and trisections; another was the topic of trisections and symplectic topology; and yet another was focused on trisections of complex curves in the complex projective plane.



Three disks that fit together to make a torus; this is a trisection of a 2-manifold.

One group of participants looked at the extent to which computer programs could understand and depict trisections, asking questions about how best to encode four-dimensional manifolds as data. They were extremely successful; at the end of the week, they had developed the framework for such a program.



A 3-dimensional illustration of a 4-dimensional stabilization operation, at the heart of the uniqueness statement for trisections.

Finally, a group made up of three graduate students studied bridge trisections and invariants. A bridge trisection is a relative notion of a trisection for knotted surfaces in the four-dimensional sphere, and group members successfully defined a new knotted surface invariant using the diagrams coming from bridge trisections. This is related to the idea of knot colorability in dimensions three and four. The students developed a computer program to compute the invariant.

Shortly after the workshop, nine of the participants learned that their application for a Focused Research Group grant was approved by NSF. One of the referees mentioned that it would be good to have a book or set of lecture notes on trisections. So in response there will be a "Feature" (a collection of papers on a "hot topic") in the Proceedings of the National Academy of Sciences (PNAS). The trisections feature will have an introduction to the subject with accompanying research papers, and the front cover of that forthcoming issue of PNAS will be devoted to mathematical art involving trisections. A majority of the papers in this feature either began in collaborations at AIM or made significant progress at AIM. ■

– *David Gay and Robion Kirby*

Julia Robinson Math Festivals

Sea to Sea and Overseas

The Julia Robinson Mathematics Festival, a partner program for AIM, continued to expand in 2016-17, reaching more than 6000 students in 58 venues. Among the new areas served by the program are East Harlem in New York City, the Navajo Reservation in Arizona, Hong Kong, Taiwan, and Ghana. The festivals are capturing the imagination of teachers and students throughout the country and around the world.

A Julia Robinson Mathematics Festival reaches many types of students, including those who do not enjoy competition or working under time pressure. At a Festival, students have fun with mathematics. Typically, there are a dozen or more tables, each with a facilitator and a problem set, game, puzzle, or activity. Students are encouraged to look for patterns, pursue more than one approach, and share their exploration and discoveries. A facilitator at each table listens, supports, and guides participants.

Here's what Vi Hart, Recreational Mathematician (**https://www.youtube.com/user/ViHart**), writes:

> *"The Julia Robinson Mathematics Festival really gets it right. Usually the best parts of mathematics are kept away from the public, as if you needed to be a mathematician to get to the fun stuff! It's refreshing to see a festival that brings this stuff to light, and in such a relaxed atmosphere. If you're lucky enough to have a JRMF near you, don't miss it! It's the best math party around."*

If you would like to start a Julia Robinson Mathematics Festival in your school or community, send an email query to **info@jrmf.org**. We can support and guide your efforts. ■

– *Mark Saul*

Overseas festival in Bucharest

Julia Robinson Math Festival at Pixar

Intransitive Dice

Playing Against the Odds

Brian Conrey and Kent Morrison, both on the AIM staff, received the Carl B. Allendoerfer Award at the recent MAA MathFest for their paper "Intransitive Dice" co-authored with three high school students from Morgan Hill. The students, James Gabbard, Katy Grant, and Andrew Liu, are all in college now, at USC, UCSD, and UCLA, respectively. This award is made to authors of articles of expository excellence published in *Mathematics Magazine*.

"The authors of this article hit on all the important modes of mathematical research."

The "dice" they studied are not physical objects but rather mathematical abstractions of physical dice in which the number of sides can be something other than six and the numbers on the faces can be chosen differently. Given two dice, A and B, they say that A is stronger than B if it is more likely to show a higher number when the two dice are rolled. Now suppose that A is stronger than B and B is stronger than C. Wouldn't you expect that A is stronger than C? Well, intuition is wrong—spectacularly so! Explicit examples of such dice were first found by Bradley Efron and popularized by Martin Gardner in 1970 in one of his *Scientific American* columns.

Here's an example with four-sided dice. Notice that the sum of the values is 10 for each of the dice, which is to say that they all have the same average value when rolled.

A: 1, 1, 4, 4
B: 1, 3, 3, 3
C: 2, 2, 2, 4

When A is compared with B there are 16 possible outcomes: A wins 8 times, B wins 6 times, and there are two ties. Comparing B with C shows B winning 9 times, C winning 7 times, and no ties. But comparing A with C results in C winning 8 times, A only 6 times, and 2 ties. Therefore, A is stronger than B, B is stronger than C, and C is stronger than A, and so the three dice form an intransitive triple.

The dice investigated in the paper are n-sided dice whose face values lie between 1 and n and sum to $n(n + 1)/2$. The reason for the restriction on the sum is that all the dice have the same average value and that average is equal to the average for the n-sided die with face values 1, 2, …, n. The surprising result of the article is the evidence from computer experiments that intransitive triples are very common. This evidence leads the authors to conjecture that as the number of sides grows large the probability approaches ¼ that a random choice of three dice forms an intransitive triple.

The paper has a long, interesting, and still evolving history. The original motivation for the project came from a Math Teachers" Circle on intransitive dice developed by Paul Zeitz. Then James, Katie, and Andrew began their research on intransitive dice while they were high school students participating in a math circle sponsored by AIM. Their work developed into a

successful project that received an Honorable Mention for First Place in the 2013 California State Science Fair.

After that it appeared as the Grade 11 problem in Gord Hamilton's Unsolved K12 initiative; see **http://mathpickle.com/unsolved-k-12/**.

And then, in the spring of 2017, it made its debut in the arena of high-level research in pure mathematics, when Fields Medalist Tim Gowers, founder of the PolyMath project, took it up as the 13th PolyMath project. On July 25, 2017, he announced a solution of a version of the problem closely related to the original conjecture (**https://gowers.wordpress.com/category/polymath13/**). The very clever solution is 21 dense pages and uses Fourier analysis in its proof.

So the story goes from middle school teachers to high school students to the upper echelons of research. The award citation states,

> *"The authors of this article hit on all of the important modes of mathematical research. They collect data, generalize patterns, look for conjectures, and even prove theorems. All of this is tied together in a fun article that touches on many areas of mathematics and keeps the reader engaged to the end."*

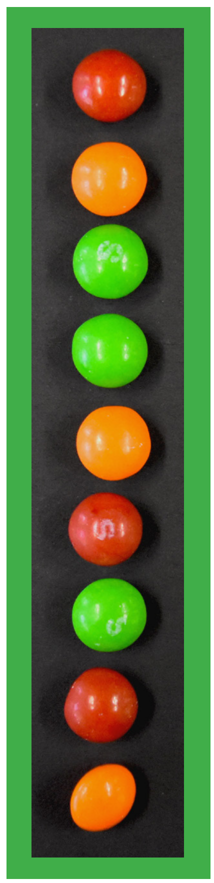
The full article from *Mathematics Magazine* can be found here: **http://www.calpoly.edu/~kmorriso/Research/IntransitiveDice.pdf**. ■

– *Estelle Basor*

Skittles

Making Intransitive Dice

Here is a game that a person can play with just a handful of Skittles. Each group of colored Skittles constitutes a "team," giving us Team Orange, Team Red, and Team Green. The goal of the game is to place the colored Skittles in a vertical line in such a way that one team "beats" another team by having more candy pieces above the other color(s).



In the arrangement of the Skittles in the picture, we can first compare Team Green to Team Red. Although there is one red Skittle above all the green Skittles, Team Green wins this round: the two uppermost green Skittles earn 2 points for being above the middle red, 2 points for being above the bottom red, and the bottom-most green Skittle earns 1 additional point for being above the bottom-most red Skittle. This gives Team Green 5 points.

Team Red, on the other hand, earns a total of 4 points by having the uppermost red Skittle above three green Skittles (3 points), plus 1 point for the middle red being above the bottom green Skittle. Thus, Team Green beats Team Red, 5-4.

Simultaneously, Team Red defeats Team Orange by a score of 5-4, and so it is no surprise that Green also beats Orange. That's what we call a *transitive* relation among the three teams, and Green is the best of all three.

However, your challenge is slightly different: Rearrange the nine Skittles so that Green beats Orange; Orange beats Red; and Red beats Green. Now which team is the best?

You can turn your nine Skittles into three "dice" each having three sides. Number the Skittles from bottom to top with the numbers 1, 2, 3, … , 9. Put the three numbers from the same color on a single die. When you roll these dice, the green die is more likely to roll a higher number than the orange, which is more likely to roll a higher number than red, while red is more likely to roll a higher number than green. You have just made a set of *intransitive* dice! ■

– *Estelle Basor*

Holy BATMath!

The Math Teachers' Circle Network is Growing

Math Teachers' Circles (MTCs) – professional learning communities of math teachers and professors – are now located in 125 sites across 37 states. As the nationwide MTC Network grows ever larger, our biggest priority is helping regions and states build networks of MTCs. We have helped organize training workshops for MTC leaders in Ohio, Montana, and North Carolina. There are a few additional states we are talking with that have expressed serious interest in developing networks of MTCs as well.

The MTC Network was recently highlighted as a "bright spot" in teacher professional development by 100Kin10, a national network with the goal of training and retaining 100,000 excellent math and science teachers (**https://100kin10.org**). Through our membership in 100Kin10, we have undertaken a collaborative effort with the National Council of Teachers of Mathematics and the Association of State Supervisors of Mathematics to help promote the advancement of mathematics education explicitly in state and district ESSA plans. The Every Student Succeeds Act (ESSA) is the education program that replaced No Child Left Behind and restructured how and where federal money for education is allocated.

Locally, we are developing the Bay Area Teachers and Mathematicians Network (BATMath) as an alliance of eight MTCs hosted in counties that touch the San Francisco Bay.

This summer, AIM held an immersion workshop for newcomers to BATMath. Thirty-five teachers spent the week immersed in doing mathematics. Meanwhile, six teacher leaders – all veteran BATMath members – spent the week writing middle school lesson plans based on topics presented at the workshop, including planar graphs and equivalent diagrams. You can find these lesson plans online at **https://batmath.org**.

Post-workshop surveys overwhelmingly showed that participants felt a sense of belonging to a community of problem solvers, and more importantly felt a burning desire to expand their horizons in mathematics and to encourage others to do the same. It really says a lot about where we are headed with education in the U.S. to see so many committed teachers.

In general, MTCs attract participants with a deep interest in both mathematics and teaching, who welcome tough problems and who are likely to take back what they learn to their students and their colleagues.

Working among mathematicians allows teachers to see that creative thinking and logical thought processes are prized just as much as great computational skill in a successful math career. In turn, professors gain a direct understanding of the complex task of creating a numerate populace in the U.S.

We encourage mathematics departments around the U.S. to consider hosting these groups. We are delighted to help encourage the development of new MTCs by providing consulting, mentors, and seed funding when available. Please contact Brianna Donaldson, AIM Special Projects Director, at **brianna@aimath.org** if you are interested in finding out more. ■

– *Hana Silverstein*

Participants at the BATMath immersion workshop.

A BATMath meeting at Proof School in San Francisco, CA.

Hosting a Math Teachers' Circle

Why should my math department host a Circle?

- Hosting a Math Teachers' Circle demonstrates that your department is involved with and committed to the local education community.
- You will maintain ongoing ties with local teachers who are department alumni or who have completed other programs through your department. Not only will you enjoy continuing to work with them mathematically, but they also may be able to help you with pre-service teacher placement or with guiding talented undergraduate students to your department.
- Faculty can share their enjoyment of mathematics with other professionals, while at the same time demonstrating a concrete commitment to the broader impacts of their mathematical work.
- Graduate students can develop their teaching and outreach credentials, positioning them well in a highly competitive job market.
- Pre-service teachers can observe a professional learning community in action and make connections with local practicing teachers, enriching their educational experience and potentially increasing local employment opportunities.

An article describing the benefits of Math Teachers' Circles for mathematicians appeared in the December 2014 issue of the Notices of the American Mathematical Society. Read it online at **https://tinyurl.com/NoticesMTC**.

What commitment is involved?

At a minimum, your department would commit to providing:

- Space for the MTC's meetings, which typically take place 6 to 8 times during each school year
- Faculty member facilitators to lead mathematical sessions for the MTC

Here are some other ways a host institution can support the work of an MTC:

- Host the MTC's website
- Donate copies and other supplies
- Provide dinner/refreshments
- Provide staff support or a student worker to handle administrative duties for the MTC ■

– Hana Silverstein

REUF

Opening the Door to Research

The Research Experiences for Undergraduate Faculty (REUF) program, a collaboration of AIM and the Institute for Computational and Experimental Research in Mathematics (ICERM), was designed to enhance the ability of faculty at undergraduate colleges and universities to engage their students in research, and this continues to be a major emphasis of the program. Over time, REUF has evolved to serve as a research renewal program for some faculty participants, engaging them in long-term research collaborations and developing expertise in new research areas with problems accessible to undergraduates. Research group continuation meetings have become an integral part of REUF, with more than half of the groups meeting for an additional week, usually in the summer a year after the workshop to complete the research project begun at the workshop.

For a number of faculty participants, these REUF research groups have catalyzed further involvement in research beyond the REUF program. Some faculty even go on to participate in other NSF math institute programs related to their REUF work. For example, Daniela Ferrero (REUF 2015), Mary Flagg (REUF 2015), and Cheryl Grood (REUF 2012) participated in the AIM workshop "Zero forcing and its applications" in January 2017. According to Flagg, "Thanks to the 2015 REUF workshop and my group's continuation meeting in 2016, I was able to go from knowing nothing about the power domination and zero forcing problems to being totally comfortable and able to contribute in such a high-level research workshop. I feel like I am now part of a new research community. This was a game-changer for me."

Catherine Buell (Fitchburg State), Vicky Klimas (Appalachian State), Jennifer Schaefer (Dickinson College), Carmen Wright (Jackson State), and Ellen Ziliak (Benedictine University), together with Aloysius Helminck (North Carolina State) who led their project at the REUF 2013 workshop, met for a REUF continuation week in 2014. Subsequently they were accepted to Collaborate@ICERM, where they held a week-long meeting in July 2016, "On the structure of orbit decompositions of the generalized symmetric spaces of $SL_n(k)$." According to Schaefer, her participation in these math institute programs has been "instrumental in expanding and sustaining my research trajectory." Outcomes of her participation include five collaborators, three publications, and two manuscripts under review, as well as two undergraduate honors theses related to the REUF group's research.

One particularly interesting example of a research collaboration arising from REUF combines two originally separate research groups. By coincidence, two of the REUF 2011 research groups worked on different aspects of the numerical range of matrices during the

Mary Flagg explains her idea to Katie Benson, Daniela Ferraro, and Vera Furst during the group's REUF continuation meeting at AIM in July 2016.

Students Jonathan Tostado-Marquez (at the board), Zara Williams-Nicholas, and Jake Mundo discuss zero forcing. They are doing research with Cheryl Grood (REUF 2012) and Thomas Hunter (REUF 2014) at Swarthmore College.

Texas State University students Taylor Baumgard, Sarah Gibbons, and Nick Montana present a poster on research supervised by Daniela Ferraro (REUF 2015).

workshop. Each group continued separately afterward, with one of the groups securing REUF continuation funding and meeting in 2012. Continued contact between the groups led Kristin Camenga (now at Juniata College), Louis Deatt (Quinnipiac College), Patrick Rault (now at University of Arizona South), math leader Ilya Spitkovsky (now at NYU Abu Dhabi), and Rebekah Yates (Houghton College) to propose a joint REUF continuation, drawing a mix of participants from the two groups, that was held this summer.

Beyond their own research, REUF alumni have also been involved in organizing REUF-related special sessions at conferences. For example, Patrick Rault and Ilya Spitkovsky organized a mini-symposium, "Numerical ranges," at the 2017 International Linear Algebra Society (ILAS) conference held at Iowa Sate University. At the same conference, Daniela Ferrero and Mary Flagg, together with Michael Young (Iowa State University), organized a mini-symposium on "Zero forcing: Its variations and applications." Cheryl Grood, Daniela Ferrero, Mary Flagg, and other REUF alumni have also organized special sessions centered on REUF work at the Joint Mathematics Meetings.

We look forward to the continued development of the REUF program and the future research collaborations it will bring. ■

– Leslie Hogben

Global Math

Begins October 10, 2017

exploding dots

A Mathematical Journey from Arithmetic to the Infinite

The **Global Math Project** aims to engage students and teachers around the world in thinking and talking about the same appealing piece of mathematics during a series of annual Global Math Weeks. Inspired by the work of **code.org**, which makes coding accessible for millions of students across the globe, the project will share the inherent joy, wonder, relevance, and meaning of mathematics with students everywhere and create a forum for the global celebration of creative mathematical thinking.

As reported in the August issue of the **Notices of the American Mathematical Society**, the very first **Global Math Week** takes place this fall. Beginning October 10, 2017, one million students will experience **Exploding Dots**, a topic developed by Global Math Project founding team member James Tanton. During Global Math Week, teachers and other math leaders are asked to commit to spending the equivalent of one class period on Exploding Dots, and to share their students' experience with the **Global Math Project community** through social media.

To find out more and register, please visit **https://www.theglobalmathproject.org**. ■

– Brianna Donaldson

GLOBAL MATH PROJECT

Uplifting Mathematics for All

Dispatches from Morgan Hill

Count On It

Competitive opportunities for the students involved in Morgan Hill Math's various programs were greater than ever during the 2016-17 school year. Morgan Hill Math is an outreach program sponsored by AIM that brings math enrichment to third through twelfth grade students who live in or around Morgan Hill and are looking for mathematical challenges outside of the normal school curriculum.

Our younger students, fourth- and fifth-graders, enrolled in the eight-week Mathletics program with activities that included learning to play the card game SET, solving logic problems, working backwards to solve problems, and making quilts using modular arithmetic. Students in MathCounts6 were introduced to more advanced problem-solving concepts including proportions, permutations, and combinations–all skills that are necessary for successfully competing in the MATHCOUNTS competition series.

Enthusiastic students from these fourth through sixth grade classes were invited to participate in the international Math Olympiad competition at the elementary school level. This year we added a new Math Olympiad team at the middle school level. Seventh- and eighth-grade students engaged in MATHCOUNTS training who competed in Math Olympiad in elementary school were very excited to be able to participate in a higher level of Math Olympiad. From November to March, 85 students were challenged to strengthen their problem-solving skills in this once-a-month, five-question test. Two students achieved nearly perfect scores, correctly answering 24 out of 25 problems.

The cornerstone of the Morgan Hill Math program has always been the training for and competition in MATHCOUNTS. This competition series has four levels: school, chapter, state, and national. In past years, our students have had to travel to the Monterey Bay Chapter Competition in Salinas or to the Santa Clara Valley Chapter in San Jose. Morgan Hill students are such fierce math competitors that, this year, I was given the opportunity to create and coordinate a new chapter. There were 42 students representing six schools competing at Oakwood School on February 4, 2017, in the brand-new Coyote Valley Chapter Competition. One student, Antarish Rautela from Charter School of Morgan Hill, achieved an almost perfect score of 44 out of 46. Five students from Charter School, four students from Martin Murphy Middle School, and one from Oakwood School qualified to compete in the Northern California State Competition at Stanford. Out of the nearly 200 students who competed, Neil Shah came in 21st place and Antarish came in 30th. These two math enthusiasts were seventh graders and are looking forward to improving their scores next year!

2016-2017 Math Olympiad winners

Competitors at the Coyote Valley MATHCOUNTS Chapter Competition

Our middle school Mathletes participated in several other competitions this year. All students involved in the weekly MATHCOUNTS training classes, as well as interested fifth and sixth graders, took the AMC8, an MAA competition for students in eighth grade and below. Many also challenged themselves with the AMC10 exam. By scoring in the top 2.5% in the United States and Canada on the AMC10, Antarish qualified to take the American Invitational Mathematics Exam (AIME), which is the first in a series that culminates with the International Mathematical Olympiad (IMO). Also, five students had the stamina to compete in the Bay Area Math Olympiad (BAMO), consisting of five proof-type math problems to be solved in four hours. Finally, six of our top students competed in the online Purple Comet! Math Meet. In the Middle School Mixed Team category, Morgan Hill Math students came in second place in California, and we landed on the Honorable Mention list for the entire international competition!

Morgan Hill Math finished the school year by hosting a Math Mardi Gras event for third graders at Barrett Elementary School. Students enjoyed rotating through ten stations and earning Mardi Gras beads by completing tasks such as solving logic problems, counting out change, identifying patterns, and sharpening problem-solving skills. It is thrilling to see eager young students discover how exciting math can be! ■

- Kelley Barnes

Coyote Valley MATHCOUNTS Chapter Competition Winners

Scientific Board
Welcomes New Members

Jacob Fox is Professor of Mathematics at Stanford University. His research interests are in combinatorics, graph theory, and the applications of combinatorics to computer science. He received his Ph.D. from Princeton University.

Chrysoula Tsogka is Professor of Mathematics at the University of Crete and Visiting Professor at Stanford University. Her research interests span a number of areas in applied mathematics, including wave propagation, inverse problems, and imaging. She received her doctorate in applied mathematics from the University of Paris IX.

Shaping the History of Math

Reprints Over the Centuries

One of my prized reference works is Thornton and Tully's magisterial *Scientific Books, Libraries and Collectors: A Study of Bibliography and the Book Trade in Relation to the History of Science*. Originally published in 1954, it's gone through four editions; the last, published in 1999 and radically revised from the 3rd edition of 1971, opens with this sweeping statement:

> *"As the 20th century draws to a close, increasingly rapid electronic communication is challenging the viability of all print media and has accelerated change in the nature of scientific discourse. In that discourse, the printed monograph, at first central, gave way long ago to journals and paper preprints. But now scientific disciplines are moving quickly to embrace electronic modes of publication…."*

We at AIM have had a front-row seat to the evolution of information exchange, chiefly as regards reprints. Our mandate to solicit, collect, and organize mathematical reprints, including reprints from workshop participants, bumped up against the 21st century approximately ten years ago. Where once bulky, string-tied brown parcels of mailed reprints deluged our office, they gradually slowed to a trickle, and almost overnight dried up, replaced by emails filled with PDF links.

The reprint had a good long run: over 250 years. The earliest known scientific reprints date from the mid-18th century, the outgrowth of a revolution in scientific communication that had its origin in the invention of the printing press and, more particularly, in the formation in the mid-16th century of the first modern scientific societies.

Within fifty years, the earliest recorded publication of scientific research carried out by a society appeared. This was the *Gesta Lynceorum* of the Accademia dei Lincei, published in Rome in 1609. Some fifty years later, the first independent scientific periodical, the *Journal des Sçavans* was published (January, 1665), followed in March, 1665 by the Royal Society's *Philosophical Transactions*.

Learned society journals, memoirs, proceedings, transactions, and bulletins exploded in the 18th century. By the end of the 19th century and through the 20th, scientific communication largely depended on publication through journals and distribution of reprints.

Hard-copy, separately published reprints still exist—a few journals maintain the tradition of offering their authors that option—but they're vanishing. Notwithstanding, they remain key to AIM's mission. Although we didn't foresee widespread adoption of the PDF and other file formats when AIM was founded, we did have a vision of amassing the most comprehensive mathematical reprint library in the world. With current holdings of 200,000+ 19th and 20th century reprints and an active acquisition policy, we are well on our way. As the paper reprint disappears, there is not only urgency but increasing merit to collecting, preserving, and sharing what remains. ■

– 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 2016 and 2017:

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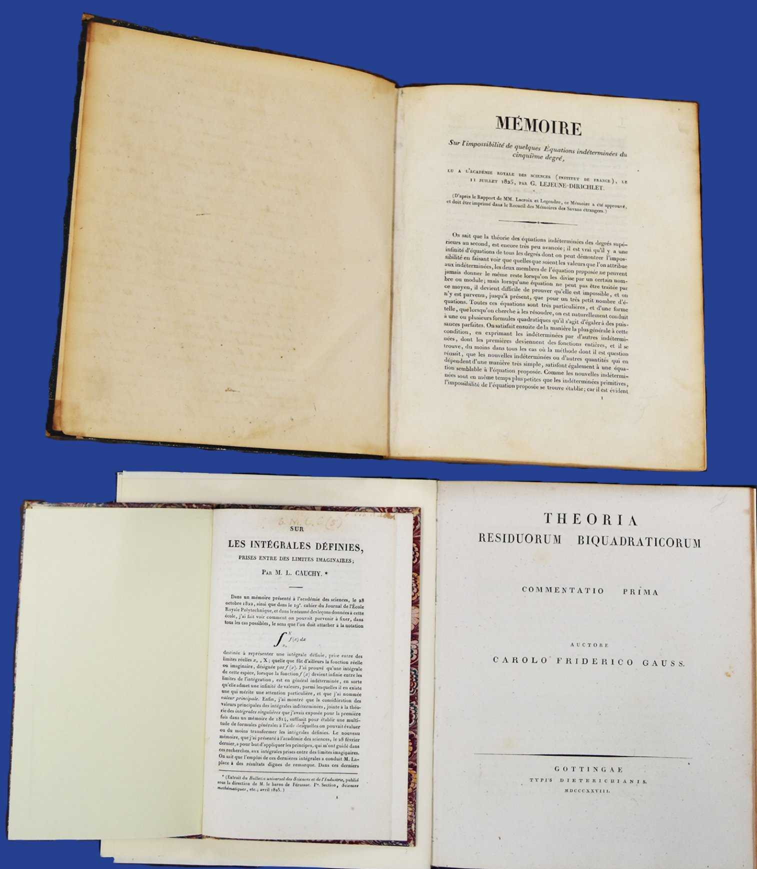

Three outstanding early reprints, including Dirichlet's exceedingly rare first paper (1825); an advance synopsis (April, 1825) of Cauchy's integral theorem which appeared in its entirety in August, 1825; and Gauss's ground-breaking two-part memoir on quadratic reciprocity, first separately published in 1828 & 1832.