the view from AIM 2026

Any Way You Turn It

Quasicrystals and Aperiodic Tilings

Letting the Discovery (Un)fold

From Math Fair to Molecular Helix

From the Eyes to the Heart

Spotlight on an AIM Workshop

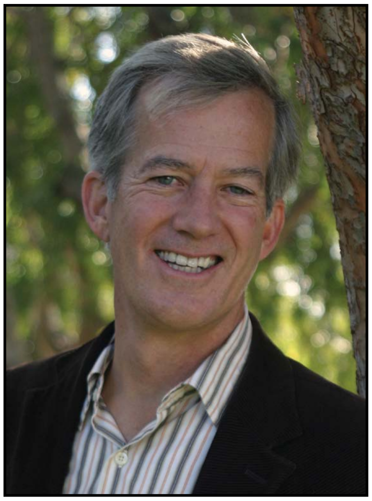
Kip Thorne Shines at AIM Lecture

A Message From a Billion Light Years Away

American Institute of Mathematics

With Change Comes Opportunity

Letter from Outgoing Director J. Brian Conrey



This letter marks a farewell of sorts: After 28 years as AIM's Executive Director, I'll be stepping down from this role effective January 1, 2026. Our incoming Executive Director, Sergei Gukov, is taking over at a time of great change, but also great opportunity. I believe he is the perfect person to lead AIM at this juncture.

2025 started with high expectations. We were in the midst of the recompetition for NSF Math Institutes that takes place every five years and were fairly confident about our chances for success because our proposal had received higher ratings – all "Excellents" – than any of our previous five institute proposals, dating back to 2002, all of which were funded. Eventually we were awarded a 5-year grant, but because of the funding situation at NSF our proposed budget was cut back dramatically (see p. 18 for further details).

Despite these funding challenges, we were still able to host many visitors at AIM for workshops and SQuaREs, including a fascinating workshop on "Multiscale modeling of ocular and cardiovascular systems" and the conclusion of a SQuaRE on "Spectral theory of quasicrystals," both of which are featured in this issue. At the JMM, we will present the 2025 Alexanderson Award to Raphaël Beuzart-Plessis, Yifeng Liu, Yichao Tian, Liang Xiao, Wei Zhang, and Xinwen Zhu, members of the AIM SQuaRE "Geometry of Shimura varieties and arithmetic application to *L*-functions" (see p. 5).

We also continued to build our public outreach presence on the Caltech campus. On June 28, we hosted our second annual public Math Fair for more than 700 kids and community members (see p. 14). Without the balloon animals and Zome soap bubbles, the Math Fair was less chaotic but still as fun as last year! Also, in October we hosted our first public lecture since moving to Pasadena. Nobel laureate Kip Thorne gave an amazing talk telling the fascinating story leading up to how gravitational waves were first detected (learn more on p. 23).

I want to end by saying what a great time I've had as Executive Director of AIM. Thank you to all of the terrific AIM staff who have worked so hard over the years to make AIM what it is. It is so rewarding to be at the AIM booth at JMM or MathFest and see all the people come by who love AIM and our programs: workshops, SQuaREs, REUF, ARCs, Math Circles, PreTeXt, …. I won't be leaving AIM, just playing a different, part-time role. I hope to still see many of you in the near future at AIM or at one of the national meetings. ■

Brian Conrey

Signed books and "swag bags" at the reception for the AIM Public Lecture by Kip Thorne.

Building Bridges

Letter from Incoming Director Sergei Gukov

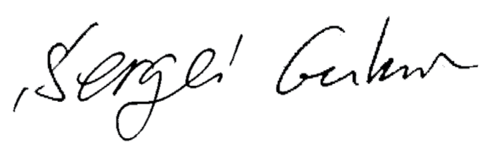
I am thrilled to start my new role as the next Executive Director of the American Institute of Mathematics. It is a great privilege and an equally great responsibility to lead AIM. Thanks to the visionary work of its founders, AIM is a vibrant hub for mathematics, renowned for its collaborative culture and the exceptional reach of its programs.

My journey with AIM began as a young scientist, when the Institute was still based in Palo Alto. I quickly fell in love with its unique style and have since followed AIM through its many transitions. Over the years, I have participated in multiple workshops and SQuaREs. I also had the pleasure of serving on AIM's Scientific Board from 2011 to 2022. Soon after, I became involved in AIM's relocation to the Caltech campus, a place close to my heart, where I have spent more than 20 years, including two years as a graduate student.

As a student, I was deeply moved by Sir Michael Atiyah's words: "The main thing that interests me in mathematics always is the interconnection between different parts of mathematics, the fact that one problem may have half a dozen different ways of being looked at in different subjects, a bit of algebra, a bit of geometry, a bit of topology. It's this interaction and bridges that interest me." Those words resonated with me and have served as a compass for my entire career. I love building scientific bridges, for example between different areas of mathematics or between mathematics and other disciplines, such as AI, which has been a focus of my recent work.

Throughout my experience with AIM, what I have found most exciting is the breadth and diversity of ideas represented in the Institute's programming. These ideas often transcend boundaries of particular mathematical areas and sometimes, the boundaries of mathematics altogether. Today the world of mathematics is more interconnected than ever, both geographically and scientifically. As the new Executive Director, my goal is to strengthen AIM's role by building new bridges across cultures and research traditions, between researchers, teachers, and institutes, and, of course, between AIM and Caltech.

We have a solid foundation on which to build, and I am excited to pursue these goals with the support of a team that embodies AIM's mission. I am grateful to AIM's Board of Trustees for their trust and partnership as we begin this work. And I want to close this letter by expressing deep gratitude to Brian Conrey, whose kind and generous mentorship has meant so much to me over the years. I am eager to begin this new chapter and am dedicated to ensuring the continued success of AIM. ■



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the view from aim
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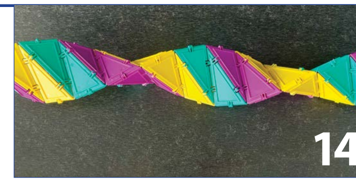
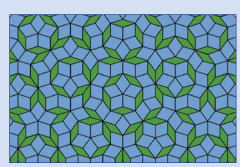
Table of Contents



about the cover images



The front cover shows a Penrose tiling with two rhombi exhibiting 5-fold rotational symmetry. (Image is in the public domain.) The spectral properties of the graph Laplacian associated to this tiling (and other aperiodic tilings) were investigated by an AIM SQuaRE group. See article on p. 10.

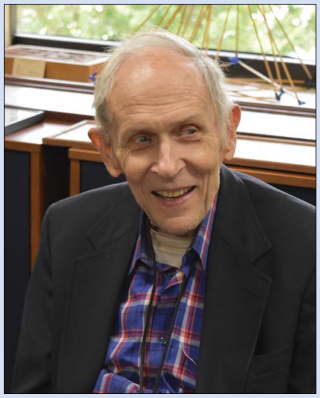
The back cover shows several images from AIM's first Public Lecture at Caltech, delivered by Nobel laureate Kip Thorne. The bottom right photo shows SkyRiver Hart Flores, age 9, talking with Kip Thorne after asking him a question about gravitational waves during the Q&A portion of the lecture (photo credit: Susie Hart). Other photos by AIM staff.

2025 Alexanderson Award

Progress on Two Major Conjectures

The recipients of the 2025 Alexanderson Award are Raphaël Beuzart-Plessis, Yifeng Liu, Yichao Tian, Liang Xiao, Wei Zhang, and Xinwen Zhu. These members of the AIM SQuaRE "Geometry of Shimura varieties and arithmetic application to *L*-functions" are recognized for two papers: "Isolation of the cuspidal spectrum, with applications to the Gan-Gross-Prasad conjecture" by Beuzart-Plessis, Liu, Zhang, and Zhu, published in the *Annals* in 2021; and "On the Beilinson-Bloch-Kato conjecture for Rankin-Selberg motives" by Liu, Tian, Xiao, Zhang, and Zhu, published in *Inventiones* in 2022.

Mathematics is about relationships. Applied mathematics seeks relationships between the real world and mathematical objects, and from those mathematical objects, to provide useful information about the real world. Much of pure mathematics is about relationships between different mathematical objects. When the relationship is surprising, such mathematics is considered "deep."



The Alexanderson Award recognizes an outstanding scholarly article arising from research activities sponsored by the American Institute of Mathematics and published within the past three years. The award was established in 2018 to honor the contributions of Gerald Alexanderson, Professor of Mathematics at Santa Clara University and founding chair of AIM's Board of Trustees. As its first chair, Jerry provided the stewardship that has distinguished AIM as an international center for mathematical research with a commitment to productive and creative collaboration.

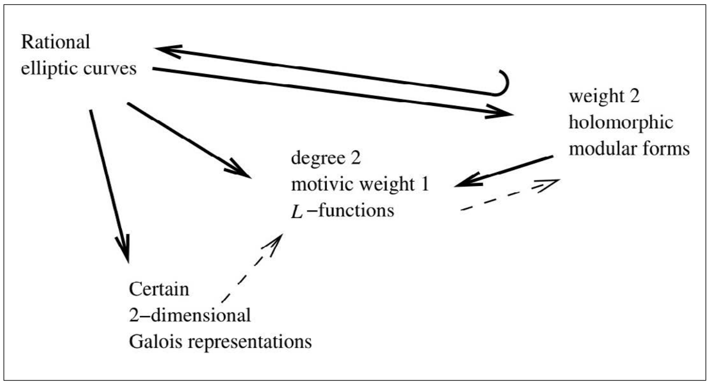


Figure 1: Some special cases of the Langlands program. Solid arrow: There exists a construction which directly produces the target object. Hook arrow: The construction only works for some of those objects. Dotted arrow: The target object may not be known to have all the necessary properties.

A classic example is the Birch and Swinnerton-Dyer (BS-D) conjecture, which concerns elliptic curves: think equations of the form $E : y^2 = x^3 + ax + b$, where a and b are rational numbers and the cubic has no repeated roots. Natural questions are: Does that equation have a solution where x and y are also rational numbers? If so, is the number of solutions finite or infinite? And if there are infinitely many, what is the rank (a property similar to dimension) of the set of solutions?

The BS-D conjecture asserts that the answers to those questions are hidden in the analytic properties of a function $L(s, E)$ which can be derived from the elliptic curve. That function can be graphed, just like the polynomials and trigonometric functions students learn to graph in high school. By "analytic properties" of the function we mean characteristics like: Where is it positive or negative? Where is the graph curving up or curving down? Where does the graph cross the axes? The BS-D conjecture uses those properties to deduce information about the rational solutions to the equation E. By any reasonable measure, that is a surprising connection.

The story is even richer: There are other types of objects which have L-functions, two of which are called *modular forms* and *Galois representations*. We can represent these relationships with a diagram like in Figure 1.

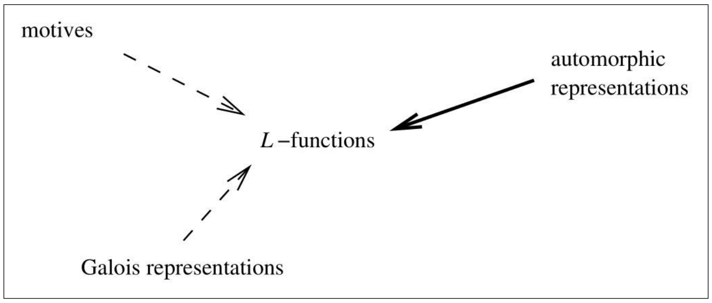


Figure 2: The general case of the Langlands program.

The collection of relationships between the types of objects in the diagram is known as the *Langlands program*, initially formulated by Robert Langlands in the late 1960s. The cases shown in Figure 1 are largely proven, but those are the simplest instances of a wide-ranging web of conjectured connections. Very few other cases have been proven.

Historically the BS-D conjecture came first, but a more useful way to view it is that the Langlands program provides a framework of connections between objects. The BS-D conjecture describes how properties of one of those objects gives information about a related object.

The winning team for this year's Alexanderson Award made significant progress on two generalizations of the BS-D conjecture, known as the Beilinson-Bloch-Kato (BBK) conjecture and the Gan-Gross-Prasad (GGP) conjecture. To see how these conjectures relate to the BS-D conjecture, we consider a more abstract version of the connections conjectured by the Langlands program in Figure 2.

In this perspective, L-functions are the "glue" that provides an intermediate step in connecting the other objects: those objects are related if they have the same L-function. Unlike the special case shown in Figure 1, no constructions have been found which provide direct connections between the objects; the relationships are indirect, via having an association to the same L-function.

For the BBK conjecture, one begins not with one equation, but with a system of equations — more precisely an algebraic variety. That is a type of "motive," as in the diagram. That algebraic variety has an L-function, and the BBK conjecture relates analytic properties of that L-function to information about solutions to that system of equations, in a manner very similar to the BS-D conjecture.

For the GGP conjecture, the starting point is an automorphic representation, which is a generalization of a modular form. That object has an L-function, as indicated in the diagram. The GGP conjecture uses information about the L-function to deduce information about the automorphic representation. The connection to the BS-D conjecture is more subtle.

Both the BBK and the GGP conjectures are quite general and apply to a wide range of varieties and representations, respectively. The results of the Alexanderson Award winners do not resolve the general cases, but do cover several situations, the details of which are too intricate to present here. However, their results have special cases which are easier to describe. Consider the case of two elliptic curves, E_1 and E_2, and instead of insisting on having rational coefficients in their equations, allow those coefficients to be algebraic numbers. Together those elliptic curves have an L-function denoted $L(s, E_1 \times E_2)$. The analytic condition in their theorem is quite simple: Is $L(½, E_1 \times E_2) = 0$? If the answer is no, then one of their results states that yet another object, known as the Bloch-Kato Selmer group, is 0. That proves a case of the BBK conjecture.

The web of conjectures in the Langlands Program provides surprising connections between mathematical objects. The BS-D conjecture and its generalizations go further by positing relationships between the properties of those objects. Special cases of these conjectures will be the focus of research for many years to come. ■

— David Farmer

AIM Welcomes New Trustees

New Board of Trustees Members (term beginning in 2025)

Tom Davis • Fiona Harrison • Richard N. Merkin

From the Eyes to the Heart

An Interview With AIM Workshop Organizers

Editors' Note: Since 2014, AIM has hosted a series of SQuaREs and workshops on the eye as a window onto the body. AIM's Deputy Director Michelle Manes sat down with the organizers of the most recent such workshop, "Multiscale modeling of ocular and cardiovascular systems." The following is an edited and condensed transcript of the interview.

Michelle Manes (MM): Can you talk about your history with AIM and the goals for this workshop?

Sergey Lapin (SL, Washington State University): We all connected through Giovanna [Guidoboni, University of Maine]. She is kind of like the founding father for many of the projects we're doing. We got that first SQuaRE [in 2014]. And it was purely on the eye. And then eventually, Giovanna came to Missouri where they do ballistocardiography [a technique for measuring the forces generated by the heart in moving blood through the body]. So we started to add the cardiovascular system to the eye, so to speak.

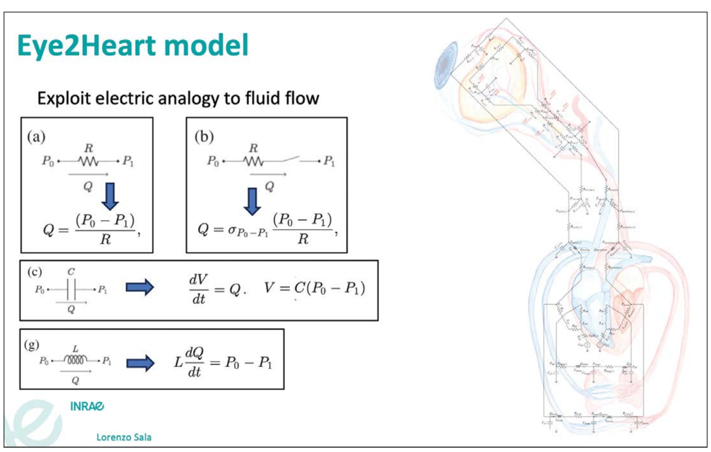
Lorenzo Sala (LS, INRAE, France): The first time I was at AIM was a workshop that Sergey and Lucia [Carichino, Rochester Institute of Technology] organized in 2018. And then I was in a SQuaRE with these guys [the other organizers of the current workshop]. There are several mathematical challenges, to couple the two things [ocular and cardiovascular models]. Numerical and modeling issues. And this is where the [second] SQuaRE really was like, okay, can we do it?

Mohamed Zaid (MZ, Foresite Healthcare): One of the main points, for which I felt like this workshop was extremely useful, is that I found myself at a certain point working with cardiologists. Working with ophthalmologists. Working with mathematicians. And no one was talking with each other except with me meeting them.

SL: So the workshop is a chance to break free, out of the silos, and let these people talk.

MM: So let me ask about the mix of participants at this workshop. You've got applied mathematicians, data scientists, biomedical engineers, med school faculty and students, a trauma surgeon, veterinary students. Have there been challenges in getting those folks to collaborate?

MZ: I think a lot of them are extremely humble. Like everyone understands that the other has skills. So like, for example, the trauma surgeon [Sal Ahmad], he is like, oh, I'm interested in seeing if your model can actually model a pregnant woman. So we pass from the



A slide from Lorenzo Sala's talk "Eye2Heart model."

Photo by AIM staff

Workshop organizer Marcela Szopos introduces speaker Luca Alasio.

male, to male versus female, to now make our model pregnant.

Marcela Szopos (MS, Université Paris Cité and CNRS): And I think, honestly, it's a particular way of organizing this kind of workshop. Because from the beginning, you don't need to come and just give this presentation on what you did, where you have all the answers. On the contrary, it's what you did but also what kind of questions you have right now.

Virginia Huxley (VH, University of Missouri): And people have been feeling free to ask questions during the presentations spontaneously, like wait a minute, what is this? Or have you considered that?

MM: Virginia, you had a beautiful slide in your talk about what you called the holy grail [a non-invasive method for monitoring health and disease]. Can you talk a little bit about that?

VH: So the reason that the eye has been looked at so much is that when you look inside the eye, you get to see this beautiful vascular system. And it's been noted over time that there are changes in that vascular structure depending on various disease states. So, this is trying to tell me something about the whole cardiovascular system. And I can see it just by looking in your eye. Because we strive from the medical end to be able to monitor maintenance of health and progression of disease and, hopefully, ultimately regression. It's like, okay, there's a lot of information here, and I'm not sure how to quantify it. You know, some of my engineering colleagues want one number. What happens when you do that is frankly you lose a lot of information. So it's trying to be precise on the one hand, and informative on the other hand. And for me as an experimentalist, modeling has allowed me to test my thoughts about how things come together. AI is a wonderful tool, but it copies. It copies patterns, but it doesn't tell you the mechanism. And as a physiologist or a pathophysiologist or a clinician, I need to understand why. How is it that I get to this endpoint? What has gone on in this path?

MS: One year ago at a conference, the most important meeting for ophthalmologists, Mohamed presented our joint results showing that in male and female populations, that we can get to the same endpoint but by two different mechanisms. At least from my perspective, what Virginia explained is that if something is impaired, you might not want to act in a similar manner to fix it because the mechanism was not the same. And now you have this deeper understanding of the mechanism, which could not be directly inferred just from data, because data will just show you similar values.

MM: Are there things you think are coming out of this workshop that are leading you towards that holy grail?

Photo by Terry Busk

Group photo from the 2025 workshop "Multiscale modeling of ocular and cardiovascular systems."

SL: I would say that we discussed the pregnancy model, I think there is a good chance that we can keep working on it. There's the multiscale model group. They created this kind of abstract methodology, which can be applied to all kinds of things, to cancer, or to whatever.

MS: As an applied mathematician, you have the end point of either a clinician or an experimentalist or something. You think, okay, I have this question. Am I able to give an answer to it? So I have my methods and skills as an applied mathematician. Is it something that I can take, you know, from the shelf and use it straightforwardly most of the time? No. Then I have to develop some new skills or some new methods or maybe first just adapt something. But at some point, even that's not enough. It's really being creative on the math side in terms of methods or approaches or maybe just combining different skills coming from two different branches. And it's something that pushes forward our understanding, not only of the applied question that we had at the beginning, but also the kind of math we are trying to develop.

SL: I just want to say that successful projects, I've seen a few where people realize that existing methodology, if they adjust it, they can apply it to something else. I mean, we're modeling blood flow using electrical circuits.

LS: So my thing is that a vessel is just a tube. You can write the equations. There are complex partial differential equations that describe the fluid motion inside this vessel, given parameters that are lengths of the vessels, diameters of the vessels, thicknesses of the wall, capacity of the vessels, viscosities of the fluid that is inside. But that would require a lot of computation. And those models exist, but they are very complex.

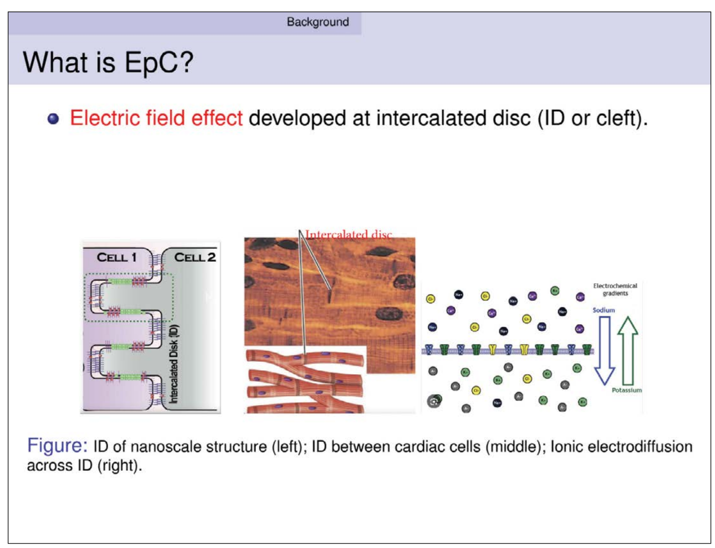
And then you've got this electrical analogy [for modeling blood flow], and it's like electrical circuits, but then instead of having resistances, or instead of having electric current, you have fluid flow. I'm missing something of course. But I can give the first idea, oh, look, your hypothesis that maybe this thing is working like this. Then, okay, now I'll try to do more mathematics on that, and then I can give you a more precise answer.

MM: Anything else that you want to share?

SL: I guess I just want to say that we realized one more time how well you guys designed this. Once we came here, there is an algorithm for everything which works. It's not just the lectures, the groups, it's the hallway discussions, especially for the students. The open-mindedness, that's something that they learned. Hey, it's better to be open-minded. Because there's like the vet student talking to the math student and actually finding things to talk about. ■

Photo by AIM staff

Workshop participants vote on which problems to tackle as part of the "AIM algorithm" for splitting into groups.



A slide from Ning Wei's talk "The impact of ephaptic coupling and ionic electrodiffusion on arrhythmogenesis in the heart."

Any Way You Turn It

Quasicrystals and Aperiodic Tilings

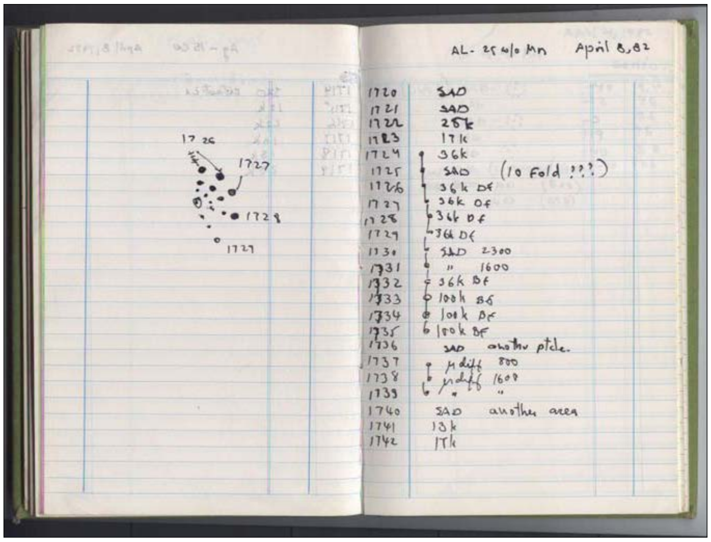
The AIM SQuaRE "Spectral theory of quasicrystals" met three times between January 2022 and October 2024. The researchers — David Damanik (Rice University), Mark Embree (Virginia Tech), Jake Fillman (Texas A&M), Anton Gorodetski (UC Irvine), and May Mei (Denison University) — sought to develop new tools, techniques, and ideas to advance understanding of mathematical models of quasicrystals. The SQuaRE was enormously successful, producing twelve preprints and papers over three meetings with at least three more in progress.

Quasicrystals are a new type of matter exhibiting exotic material and mathematical properties. The crystals we are familiar with (like diamonds and salt) are arranged in a 3-dimensional grid: There are three independent directions in which the atoms are regularly spaced. Furthermore, those crystals exhibit two-, three-, four-, or six-fold rotational symmetry at the atomic level. Quasicrystals have some properties in common with these structures, namely a symmetric pattern that can fill space. The differences are that for quasicrystals the atoms are only approximately, not exactly, regularly spaced, and the rotational symmetry can be five-, 10-, or 12-fold.

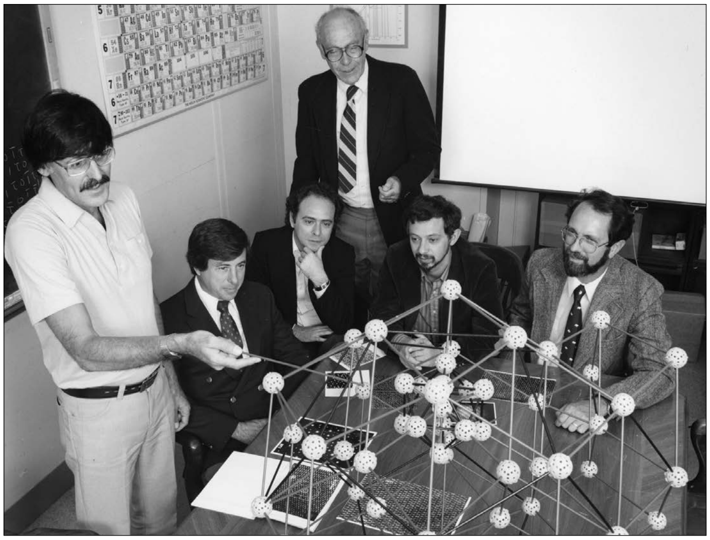
In 1982, NIST scientist Dan Shechtman was studying aluminum and manganese and found surprising diffraction patterns, writing in his notebook "10 fold???" next to one of his observations. The diffraction pattern suggested 10-fold rotational symmetry, but it was known that this is impossible for a crystal. (Shechtman later won the Nobel Prize in Chemistry for his discovery.) Around the same time, physicist Paul Steinhardt hypothesized the existence of quasicrystals with five-fold symmetry, eventually finding two natural quasicrystals (icosahedrite and decagonite). In 2023, researchers at University of Toronto and MIT created superconductive graphene quasicrystals.

Given the physical origins and potential applications of quasicrystals, there is interest in the quantum mechanical systems associated with them. Mathematically, this corresponds to studying *spectral problems*, which are analogous to the diffraction patterns used by chemists. There are many possible spectral problems, each corresponding to a choice of a *self-adjoint operator*.

Physical quasicrystals like the ones described above are three-dimensional objects, but progress in understanding the mathematics of the one- and two-dimensional setting is an important intermediate step. The SQuaRE group worked on one-dimensional quasicrystals by studying ergodic families of operators



Dan Shechtman's lab notebook at NIST recorded the first observation of crystals with 10-fold symmetry. Credit: Dan Shechtman.



Meeting at NIST in 1985 where Shechtman (left) explains the atomic structure of quasicrystals. Credit: Wikimedia Commons.

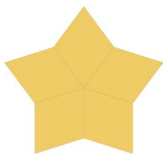
and their spectral gaps, a fruitful line of research that has been active for many years. A major new contribution was their investigation of higher dimensional quasicrystals modeled by *aperiodic tilings of the plane*, that is, tilings that do not exhibit translation symmetry.

The first aperiodic tiling of the plane was described by Hao Wang in 1961. In the early 1970s, Roger Penrose famously described aperiodic tilings using just two tiles. Though the two tiles could be used to tile the plane in a periodic manner, the addition of matching rules on how the pieces can connect forces aperiodicity. (Of course, these precise mathematical descriptions are significantly predated by what appear to be aperiodic tiling designs in Islamic decorations: **https://www.sciencenews.org/article/ancient-islamic-penrose-tiles-0**.) Penrose tilings are two-dimensional structures that share many features with quasicrystals discovered in nature, including five-fold rotational symmetry. Moving the mathematical investigation from one dimension to two represents substantial difficulty, since many of the tools in the one-dimensional case no longer apply.

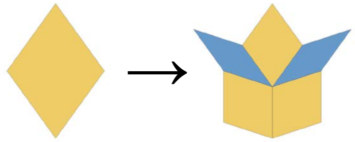
In their paper "Discontinuities of the integrated density of states for Laplacians associated with Penrose and Ammann–Beenker tilings," published in *Experimental Mathematics* in 2024, the SQuaRE group studied the *graph Laplacian* associated with the several Penrose tilings (as well as the less famous Ammann–Beenker tiling).

How to Make a Quasicrystal

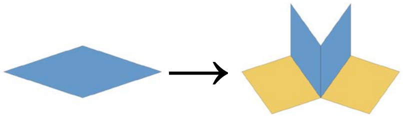
One way to build a Penrose tiling is through a substitution rule. For example, for the rhombus Penrose tiling, we start at Level 0 with five "thick rhombi" in a star shape:



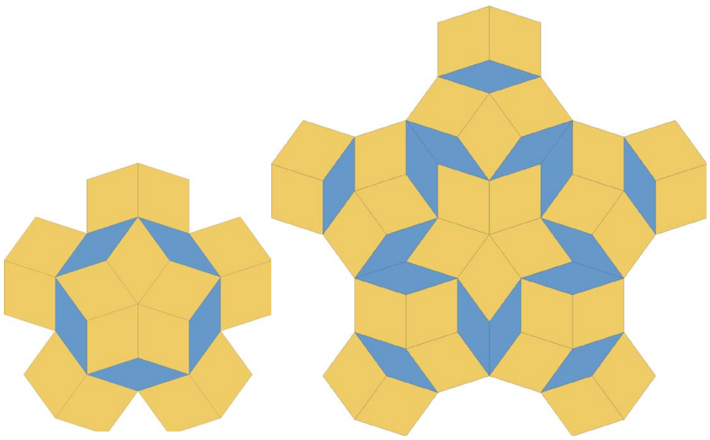
We then iterate two substitution rules. Whenever we see a "thick rhombus," we replace it with three thick rhombi and two thin rhombi in this configuration:



Whenever we see a "thin rhombus," we replace it with two thick and two thin rhombi in this configuration:



These substitution rules create a growing tiling pattern in the plane. We imagine continuing this process, which in the limit will cover the plane with an aperiodic tiling.

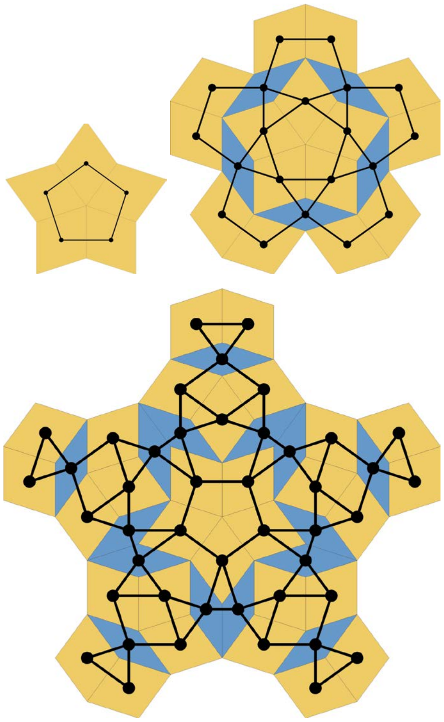


Level 1 and Level 2

The substitution rules are given in beautiful detail in the Tilings Encyclopedia (**https://tilings.math.uni-bielefeld.de/substitution/penrose-rhomb/**). The mathematical physicists who first studied these structures were T. Fujiwara, M. Arai, T. Tokihiro, and M. Kohmoto in their paper "Localized states and self-similar states of electrons on a two-dimensional Penrose lattice," published in *Physical Review B* in 1988.

Using Graphs to Study Aperiodic Tilings

The SQuaRE group associated a graph to a tiling, which allowed them to use powerful tools from graph theory. To create a graph associated to a tiling, each polygon of the tiling is a vertex of the graph, and there is an edge between two vertices exactly when the associated polygons share at least one edge. Here are the graphs associated to the Level 0, Level 1, and Level 2 tilings.



There is a well-known self-adjoint operator associated with a graph: the graph Laplacian. Applied to a function f, this operator computes the sum of the differences between f at each vertex and the average of f at the adjacent vertices. This is a discrete analogue of finding "waves" in the graph.

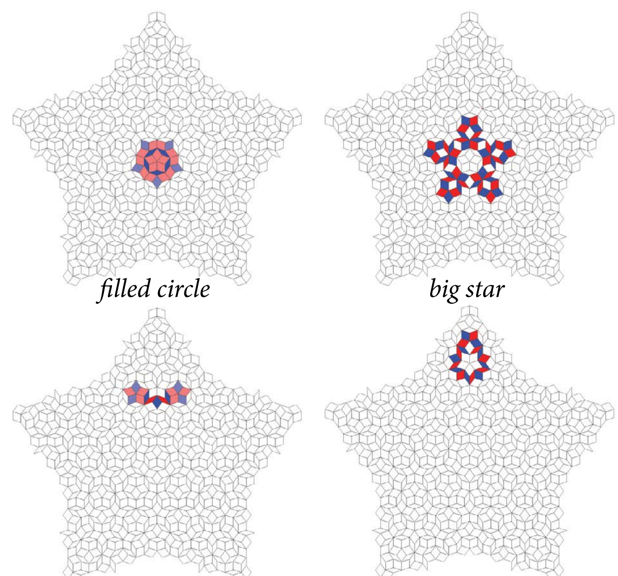
More precisely, let $\Gamma = (\mathcal{V}, \mathcal{E})$ represent a graph with vertex set $\mathcal{V}$ and edges $\mathcal{E}$, and write $u \sim v$ if vertices u and v are adjacent. Then the graph Laplacian Δ_Γ is defined by:

$$\Delta_\Gamma : \ell^2(\mathcal{V}) \to \ell^2(\mathcal{V}), \qquad [\Delta\psi](v) = \sum_{u \sim v} (\psi(v) - \psi(u)).$$

This operator is useful because we can learn things about the graph from the properties of the Laplacian, specifically from its eigenvalues and eigenvectors. The famous question about "hearing the shape of a drum," for example, mathematically translates to whether two planar domains that have the same Laplacian eigenvalues (the same *spectrum*) are in fact the same domain. (The answer, it turns out, is no.)

The SQuaRE group studied the Laplacian of an infinite graph by looking at truncations at finite levels (for example, each level of the tiling pictured above yields a finite graph). In their paper, the authors exhibit *eigenfunctions* of these truncated Laplacian operators — functions on the graph where the Laplacian operator acts as a simple scaling. It is somewhat surprising that these eigenfunctions are *locally supported*, meaning they take nonzero values on a small local area of the graph and are zero at almost all vertices. This is in contrast to a two-dimensional drum, which when struck vibrates everywhere except along certain curves known as *nodal lines*.

For example, with the rhombus tiling described above, if we form two more levels beyond the above pictures to get to Level 5, there are four locally supported eigenfunctions, as shown below. The functions take the value +1 on dark blue tiles, -1 on dark red tiles, +½ on light blue tiles, -½ on light red tiles, and zero on all of the unshaded tiles. Each of these eigenfunctions has eigenvalue (energy) $E = 6$.



Locally supported eigenfunctions for Level 5 and Energy 6.

The paper uses a mix of theory and computation, and in the words of the authors, "These results suggest a host of questions about spectral properties of the Laplacian on aperiodic tilings, which we collect at the end of the paper." The team has a lot of interesting work ahead, continuing to think about these questions along with spectra of other tilings. ■

— *Michelle Manes*

On an Upward ARC

New Virtual Communities Offer Research Support

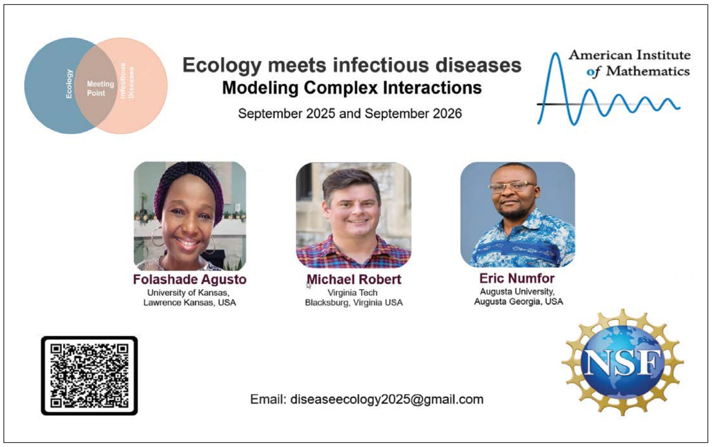
AIM's Research Community (ARC) program continues to thrive, with three new communities launching in 2025. ARCs are collaborative efforts involving at least 40 people, focused on virtual activities, organized around a particular area of mathematics research. The purpose of an ARC is to support the ongoing research activities of its participants, especially people who lack nearby collaborators or who cannot travel.

The new Ecology Meets Infectious Diseases (EMID) ARC and Arizona Winter School (AWS) ARC are learning community ARCs: They focus on supporting junior researchers, helping them develop technical background and research skills while integrating them into an existing network of researchers. The goals of the EMID ARC (**https://sites.google.com/view/ecologymeetsinfectiousdisease/home**) are to enhance the preparation of students, junior researchers, and faculty desiring to expand their area of expertise into mathematical epidemiology and ecology, and to broaden participation in these areas. Organized by Folashade Agusto (University of Kansas), Eric Numfor (Augusta University), and Michael Robert (Virginia Tech), the EMID ARC focuses on recent advances in mathematical modeling related to conservation, ecology, and epidemiology, emphasizing quantitative approaches such as mathematical modeling with differential equations, spatial statistics, identifiability analysis, machine learning, and network modeling. One of the EMID ARC's core activities is a series of lectures on a dozen topics presented by leading researchers from North America and Africa.

The Arizona Winter School is a well-known series of annual in-person workshops that has provided training for graduate students in number theory and arithmetic geometry for more than 25 years. The virtual companion program Preliminary Arizona Winter School (PAWS) began in 2022 and is designed to broaden the impact of the AWS by holding two mini-courses each fall for advanced undergraduate and beginning graduate students. The AWS ARC, organized by Renee Bell (Lehman College), Brandon Levin (Rice University), Padmavathi Srinivasan (Boston University), Anthony Várilly-Alvarado (Rice University), and Isabel Vogt (Brown University), provides support for this year's PAWS program (**https://swc-math.github.io/aws/2026/2026PAWS.html**), which is offering the courses *Introduction to mathematical cryptography* taught by Sabrina Kunzweiler and *Analysis and implementation of algorithms in number theory* taught by Juanita Duque-Rosero. PAWS launched with a Zoom social event in September 2025 and has more than 250 student participants.

The third new ARC, the Consortium of Digital Ecosystems for Mathematics (code4math; **https://code4math.org**), emphasizes network development, specifically bringing together developers and researchers who create and use cyberinfrastructure to support research in the mathematical sciences. Code4math, which is organized by Steven Clontz (University of South Alabama), David Lowry-Duda (ICERM), and Christelle Vincent (University of Vermont), launched with a two-day virtual symposium in September 2025. The launch event included presentations on mathematical databases, such as House of Graphs (**https://houseofgraphs.org**) and the *L*-functions and modular forms database (LMFDB; **https://www.lmfdb.org**). Other themes included accessibility, the interactive theorem prover Lean, and the newest NSF-funded Mathematics Institute, the Institute for Computer-Aided Reasoning in Mathematics (ICARM). ■

— *Leslie Hogben*



Slide advertising the new Ecology Meets Infectious Diseases (EMID) ARC.

Letting the Discovery (Un)fold

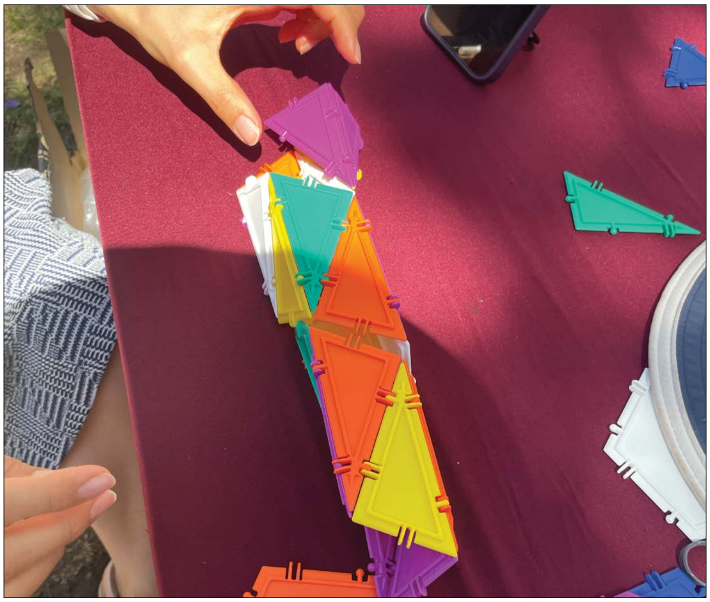
From Math Fair to Molecular Helix

The annual AIM Math Fair Birthday Bash in late June has become one of my favorite math outreach festivals. Under the shade of the jacaranda trees, surrounded by an eclectic mix of Caltech's architecture, this outdoor event has been attracting over 700 enthusiastic visitors from the greater Los Angeles area for the past two years.

The word "outreach" implies that the mathematical experience mostly travels from the hosts to the participants. However, this year I was fortunate to be at the receiving end of an inspiring idea from a fair participant. Exploring this idea eventually led me towards learning about a fascinating method that's behind some Nobel Prize-winning discoveries.

One of the people at the Geometiles table I was hosting was Mari Oka, an anesthesiologist by training who works at a neurobiology lab in Caltech. While her 5-year old son was building a giant rocket ship, Mari was playing around with a chain of right triangles (shown below) and ended up folding it into a tube. She said it reminded her of origami foldable heart stents, a thrilling and unexpected link between playful geometric folding and a real-world biomedical application.

Photos by Yana Mohanty



Mari Oka's original Geometile helix, which inspired this exploration.

Mari folded the chain in the most natural way — meaning in a way that the chain "wanted" to be folded, given the positioning of its hinges. I later learned that origami stents use a different folding mechanism, but Mari's folding idea has an important precedent with strong ties to Caltech.

After the Math Fair was over, I noodled around with Mari's idea in an effort to form a structure that holds together. I added another strip of triangles, with the same size as the original ones, but different orientation (Image 1, bottom). I then snapped together the edges in a way that was easiest from a mechanical point of view, resulting in an elegant helix I had never seen before (Image 1, top).

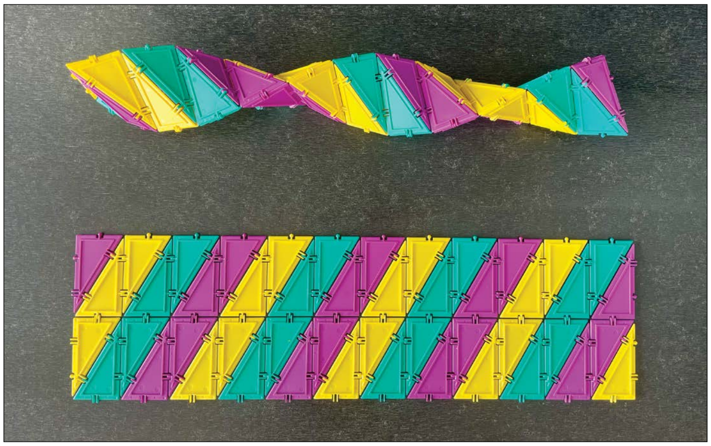


Image 1

A little more digging revealed that this helix is a modified version of what is known as the Boerdijk–Coxeter helix (BC helix): a chain of regular tetrahedra glued together, as shown in Image 2, below.

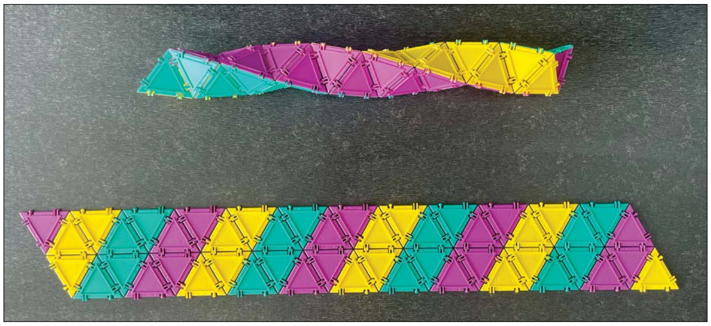


Image 2

The strip in Image 2 is a linear deformation of the strip in Image 1, and this transformation extends to the helices.

The BC helix has been the subject of much inspiration and study in the arts as well as the sciences. Famous architect and designer Buckminster Fuller called it the "tetrahelix." A large physical model of the BC helix can be found in the Art Tower of Mito in Japan. Many molecular level structures resembling the BC helix occur in both organic and inorganic matter. A really interesting property of the BC helix is that it is rotationally nonperiodic. Put in another way, no two of its vertices fit on the same line that's parallel to its axis.

We saw one way to unravel a portion of the BC helix into a parallelogram in Image 2. One can also split it into a single strip of triangles like so:

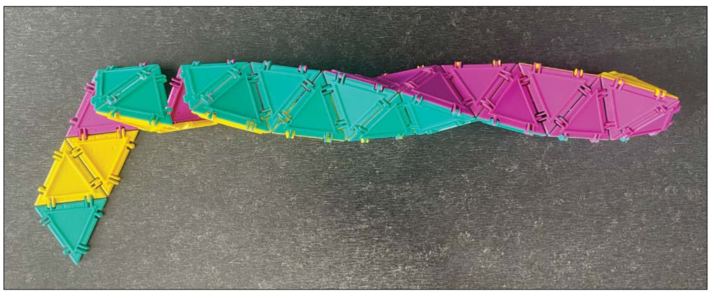


Image 3

This method of unraveling easily adapts to the helix in Image 1, as shown below:

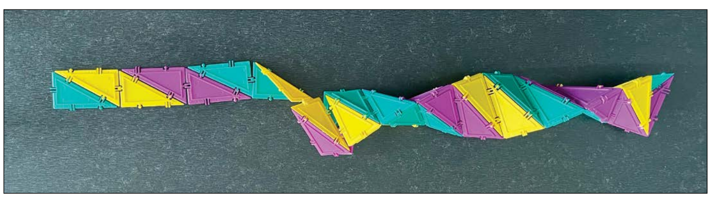
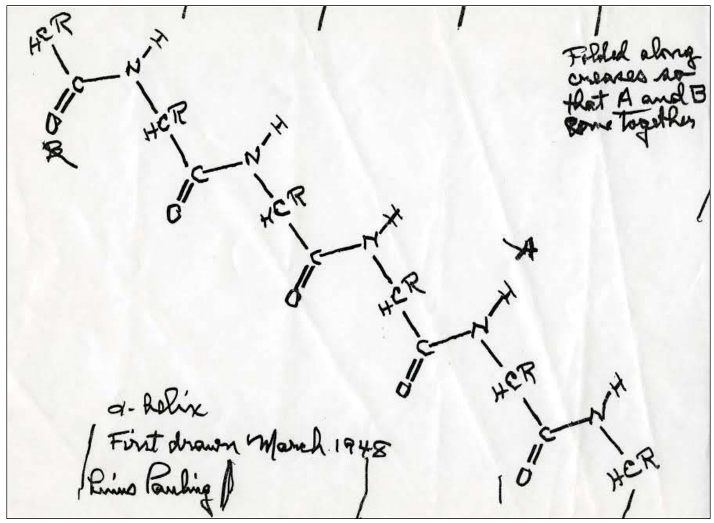


Image 4

The folding of a single rectangular strip in Image 4 into a helix is closely related to Mari Oka's original construction. The difference is that, in Image 4, the rectangles built from two triangles are connected by their *short edges*. In Mari's helix, they were connected by their *long edges*.

Remarkably, this same intuitive approach to folding was instrumental in one of the most important scientific breakthroughs of the 20th century. Renowned Caltech scientist Linus Pauling used it in the discovery of the α-helix, a common protein structure occurring in hair, fingernails and hemoglobin, among other biological substances. The α-helix is used by transcription factors (which transcribe the genetic code for life functions) by binding with DNA. In the late 1940s two main groups of scientists were competing to discover the structure of the α-helix: one led by Sir Lawrence Bragg at the University of Cambridge, and the other led by Linus Pauling at Caltech. As described by Francis Crick, of DNA fame, in his book *What Mad Pursuit*, all Bragg's models "looked ugly." Bragg's chief mistake seems to have been the false assumption of certain rotational symmetry of the helix (we have already seen that helices need not be rotationally symmetric).

Pauling, on the other hand, constructed his model by drawing the molecular chain on a piece of paper and simply folding it into a helix, as shown below:



Drawing by Linus Pauling, from the Ava Helen and Linus Pauling Papers (MSS Pauling), Oregon State University Special Collections and Archives Research Center, Corvallis, Oregon.

In Crick's description, Pauling "let the models fold naturally into any screw they were comfortable with." This resulted in a helix that did not have the periodicity assumed by Bragg. Eventually the discovery led Pauling to win the 1954 Nobel Prize in Chemistry.

I was struck by how Mari's explorations led us both to wander into the footsteps of one of the greatest scientists of the 20th century. It all started with playing under the jacaranda trees on a campus that has hosted some of the brightest minds of recent history. I cannot wait to see what discoveries the fair will bring next year! ■

— *Yana Mohanty*

*Yana Mohanty is the founder of Imathgination LLC and the inventor of Geometiles (**https://geometiles.com/**).*

AIM Welcomes PRIMES Scholars

Program Enhances Research and Opportunities

AIM is fortunate to welcome two new AIM PRIMES Scholars in Residence, supported by NSF PRIMES grants that began in summer 2025.

PRIMES: Zero Forcing in Graphs and its Applications, Mark Hunnell, Associate Professor, Winston-Salem State University

After getting tenure, Mark Hunnell wanted to focus on undergraduate research, so he attended the 2018 Research Experiences for Undergraduate Faculty (REUF) Workshop. That workshop helped him transition some of his research to zero forcing (a type of graph searching), which is more accessible to undergraduates than his original work in group theory. The REUF experience also helped Hunnell design more effective research experiences for his students. For example, as part of his PRIMES project he brought four undergraduate researchers to WSSU before classes started for a week of intense research and collaboration to jump-start the work that will continue throughout this academic year.

Hunnell has been active in the Inverse Eigenvalue Problem for a Graph and Zero Forcing (IEPG-ZF) 2021 AIM Research Community (ARC), which he will help lead during his PRIMES project. His PRIMES SQuaRE, “Reconfiguration of dynamic graph labelings” (with Mary Flagg, John Hutchens, Houston Schuerger, and Ben Small), grew out of an IEPG-ZF ARC project and will have its first meeting in 2026. This group will consider reconfiguration of the dynamic forcing process rather than reconfiguration of zero forcing sets.

Hunnell made his first visit to AIM as a PRIMES Scholar in September 2025. During that visit he and co-PI Leslie Hogben helped finish a zero forcing paper begun several years previously with several other collaborators. Hunnell also joined a research group working on the symplectic inverse eigenvalue problem of a graph, where he is sharing his expertise in matrix groups and symplectic matrices and learning more about strong properties of matrices. Both these projects arose through the IEPG-ZF ARC.

Hunnell has received generous support from WSSU to host a week-long research workshop, Graph Inference and Relational Analysis for Frameworks & Feature Extraction (GIRAFFE). The workshop is modelled on REUF, but with some differences: the inclusion of undergraduate students, a regional emphasis, and a focus on combinatorics and data science. It will be held at WSSU in 2026, with the hope of sparking ongoing regional research collaborations. Faculty and students at HBCUs and other undergraduate public colleges and universities in North Carolina will be invited, with applications open to all interested faculty at undergraduate institutions.

About WSSU Hunnell says, “I didn’t know much about HBCUs before I got here but immediately fell in love with the campus culture and how students engage in class. It is very different from an R1.” This culture and support from caring, research-active faculty like Hunnell lead to success for math majors: Last year WSSU graduated 12 mathematics majors, with 11 going on to graduate programs at schools like Arizona, Brown, and Duke.

PRIMES: Hear the Boundary via Investigating Steklov Eigenvalues, Lihan Wang, Assistant Professor, California State University, Long Beach

Lihan Wang is using her PRIMES grant to expand her research in geometric analysis, support students, and build a lasting relationship with AIM.

Her work focuses in part on Steklov eigenvalues, which provide insights into the geometry of boundaries and have applications ranging from medical imaging to designing shapes that are difficult to detect. She plans to combine her expertise in Steklov eigenvalues with that of new collaborators to develop innovative techniques and projects in related areas. Wang's PRIMES SQuaRE, "Relations between Steklov eigenvalues, minimal surfaces, and harmonic mappings," will bring her together with Daniel Stern, Jiaping Wang, and Xin Zhou at AIM for their first meeting in 2026.

Wang says, "The PRIMES grant has been truly invaluable. As a professor with a heavy teaching load, finding sustained and uninterrupted time for deep research is a real challenge. This award gives me that essential, dedicated space and a collaborative team to advance my work in a way that wouldn't be possible otherwise."

The grant also enables Wang's mentoring of students and supports her programs for mathematics majors at CSULB. She organizes and coordinates a series of talks for undergraduates, bringing in speakers who highlight the many career paths available with a math degree and provide advice and inspiration for students exploring their futures.

Wang's own path to mathematics reflects the subject's central role across disciplines. As an undergraduate initially majoring in earth science, she first learned how instruments could reveal the composition of the earth. She realized, however, that she did not fully understand the theory behind these instruments until she began studying mathematics. That experience convinced her to pursue mathematics more deeply, both for its intrinsic fascination and for its wide-ranging applications.

She greatly values AIM's strong support in developing proposals and guidance for making projects effective. ■

— *Leslie Hogben*

Upcoming Workshops

AIM hosts focused workshops in all areas of the mathematical sciences. AIM's workshops are distinguished by their emphasis on a specific mathematical goal, such as making progress on a significant unsolved problem, understanding the proof of an important new result, or examining the convergence of two distinct areas of mathematics. Workshops in 2026 include:

- **Formal scientific modeling: a case study in global health.** Jan 12-16
- **Time-dependent Bernoulli-type free boundary problems.** Feb 2-6
- **New p-adic perspectives on canonical integral models for Shimura varieties.** March 2-6
- **Addressing declining pollinator populations through new mathematics.** March 30 - April 3
- **Combinatorial coding theory.** April 13-17
- **The Bochner technique.** May 11-15
- **Algebraic and combinatorial structures in exactly solvable models.** June 15-19
- **Fairness and foundations in machine learning.** July 13-17
- **Research Experiences for Undergraduate Faculty (REUF).** July 27-31
- **Gibbsian line ensembles.** August 10-14
- **Geometric properties of Hilbert schemes.** August 24-28
- **Modularity and quantum topology.** October 12-16
- **Generalized logics and inner models.** October 26-30

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

An Update on Funding
(And How You Can Help)

National Science Foundation

Since 2002, AIM has enjoyed support from the National Science Foundation (NSF) as one of the Mathematical Sciences Research Institutes funded by the Division of Mathematical Sciences (DMS). In August 2025, the NSF announced renewed funding for AIM along with five other U.S.-based Math Institutes. AIM is grateful that the NSF DMS has provided support which enables us to continue operating during this time of funding uncertainty. Our new 5-year grant allows us to continue running our research programs, including workshops, SQuaREs, and AIM Research Communities.

However, reductions in NSF funding and uncertainties about NSF's future budget have had a significant impact on recently awarded grants. In the case of the Institutes, the solicitation indicated a planned investment of up to $200 million over five years, but the final 5-year awards total to just over $74 million for all of the Institutes combined. Each Institute, including AIM, is facing a dramatic budget reduction. AIM's funding level enables running only approximately half as many workshops and one-third as many SQuaREs as planned.

While there is hope for additional NSF support in the future, the short-term picture is challenging. The need to support our previously planned activities means that we will not have a Call for Proposals for workshops or SQuaREs in 2025. We have also had to cancel or postpone a small number of in-person programs to reconcile our awarded budget with our already-scheduled activities in the first few years of the grant. We are grateful to the organizers and participants affected by these changes, who have been overwhelmingly understanding and supportive of AIM and of our need to make some difficult decisions.

NSF

American Mathematical Society

In response to federal funding cuts and grant cancellations, the American Mathematical Society (AMS) announced in May 2025 that they would award backstop grants to "provide one-time financial relief and ensure the continuity of some essential projects, conferences, and scholarly activities that align with our mission to advance research, education, and the full participation of all individuals in the mathematical sciences."

The announcement came at a crucial time for AIM: Our NSF grant was expiring (and would be completely spent out) at the end of June, and we had several workshops and dozens of SQuaREs scheduled in July and August. We had already made the difficult decision to postpone one workshop and to cancel several SQuaREs slated to have their third meeting in July. We had scraped together funds for the rest of our July programming, save for one workshop: "Impactful curriculum development in mathematics: open education resources for future research," organized by Joe Hibdon, Lily Khadjavi, Drew Lewis, and Bianca Thompson.

AMS awarded AIM a backstop grant to support this workshop, which went forward as planned, with 27 participants joining us for a week to forge collaborations aimed at the development of open educational resources for advanced mathematics courses. AIM, the organizers, and the participants are incredibly grateful to the AMS for their support.

AMS American Mathematical Society

Other Support

Recent supporters of AIM's education and outreach programs have included the Shaggy Peak Fund, The Eli and Edythe Broad Foundation, the Gates Foundation, Beyond100K, the Mary P. Dolciani

Halloran Foundation, and many individual donors. The Fry Foundation continues to support AIM with a yearly donation, and we are forever grateful for their generous support over the years. We would also like to thank all of the individual donors who have made annual or one-time donations to support our activities. We are immensely grateful for your support!

How To Help

The next few years will be challenging for AIM as we work to run programs that serve the mathematics community on a greatly reduced budget. AIM staff continue to look for new sources of funding to support our work. We are also asking the mathematics community to help when possible. Here are some things you can do.

Pay for your own travel if you can: AIM has a strong, ongoing commitment to making our programs financially accessible. Providing significant travel support helps make visiting AIM possible for graduate students, postdocs, and anyone for whom paying their own travel would be a hardship. Reducing travel costs even slightly would help us make up for our budget shortfall over the next few years. If you have a grant, institutional funds, airline miles, or your own means, please consider paying for your own airfare or ground transportation costs when you visit AIM. If everyone who is able to fully or partially fund their own travel expenses does so, AIM can dedicate more resources to supporting those whose needs are greater.

Reduce travel expenses: Even if you do not have the means to pay your own travel costs, you can still help by reducing your overall expenses when you visit AIM. For example, we encourage you to consider using public transportation or arranging shared rides to and from the airport. Some participants who are close friends as well as collaborators have asked if they might help reduce costs by sharing a hotel room. Please contact workshops@aimath.org if you have questions about how to arrange any of this.

Donate to AIM: AIM receives many smaller donations from members of the mathematics community who have had good experiences at our programs and want to give something back. You can target your donation to a particular AIM program or donate to AIM's general fund (https://aimath.org/giving-to-aim/). Every donation is appreciated! ■

— *Michelle Manes*

2026 JMM Activities

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

- **The AIM Booth:** Stop by, chat with AIM staff, and learn about our various activities.
- **Invited Address:** Yifeng Liu will give the Alexanderson Award Lecture, "From periods of modular forms to arithmetic geometry." The Alexanderson Award winners will receive their medals at the Awards Celebration. (See story on p. 5.)
- **AIM-sponsored Special Sessions:**
  - Special Session on Circles in Motion: Energizing Mathematical Thinking in Different Modalities and Localities.
  - Special Session on Supporting Undergraduate Research.
  - Special Session on Arithmetic Geometry of Shimura Varieties (associated with the Alexanderson Award Lecture by Yifeng Liu).
- **Social Events:** AIM sponsors the **Math Circles Dessert and Games Night Reception**. You can also find us at the **Mathematical Institutes Open House**.

View from Morgan Hill Math

Shaping the Present and Future of Students

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

Most families are introduced to Morgan Hill Math through Mathletics and MathCounts6. In Fall 2024, fourth and fifth graders in our eight-week Mathletics program enjoyed lessons that included learning to play SET, solving logic problems, making a Tangrams set, an introduction to modular arithmetic, discovering prime numbers, and practicing problem-solving strategies such as working backwards and drawing pictures. Students in MathCounts6 were introduced to more advanced problem-solving concepts including combinatorics, permutations, proportions, and Exploding Dots — all necessary skills for succeeding in math competitions.

Students from all local middle schools were invited to attend weekly MATHCOUNTS training classes. Seventy-five students, from five schools, developed their proficiencies in factoring, similarity, probability, permutations and combinations, functions, algebra, and geometry. In February 2025, about 60 students attended the Coyote Valley Chapter Competition. Moving on to the Northern California State Competition were 10 students from either Oakwood School or Charter School of Morgan Hill.

All interested students from Morgan Hill Math programs, 8th grade and below, were invited to participate in one or both divisions of the Math Olympiad for Elementary and Middle School (MOEMS). Over 80 kids were challenged to strengthen their problem-solving capabilities in this once-a-month, five-question test. In the Middle School Division, sixth grader Aarya Dhane had the highest score. In the Elementary School Division, sixth grader Avonlea Huang came in first place with a score of 22 out of 25, barely beating Aarya's score of 21. Families were invited to the Morgan Hill Playhouse to celebrate these awesome kids who showed their perseverance throughout this challenging competition.

Sixty students participated in MAA competitions. Students involved in the weekly MATHCOUNTS training classes took the AMC8 contest for students in eighth grade and below. High school students took the AMC10 or AMC12 exams. Eleventh graders Avi Shirgur and Yash Ambasta qualified to take the AIME, the American Invitational Mathematics Exam, which is the first in a series of examinations that culminate with the International Mathematical Olympiad (IMO).

Two middle school teams competed in the 2025 Purple Comet! Math Meet, where a team of six

Photo by Howard Barnes

Coyote Valley Chapter Competitors, February 2025.

Math Olympiad Winners 2024/2025 season.

MATHCOUNTS State Competitors, March 2025.

Photos by Howard Barnes

students from Charter came in 4th place in California, and 31st place in the USA.

For the first time, a team from Ann Sobrato High School competed in the Berkeley Math Tournament and the Stanford Math Tournament. These competitions, run by university students, really challenged the competitors in algebra, calculus, discrete mathematics (number theory and combinatorics), and geometry. The highlight was the Guts Round, where teams raced to submit answers during a live-scored event.

The Morgan Hill Student Math Circle for Elementary and Middle School students continued throughout the year. We met every Monday over Zoom to explore fun math activities. Most activities were found on the Math Circles and JRMF webpages. As an online circle, families are registering from all over the USA, and I have one very enthusiastic student in Japan! I also presented at the Santa Cruz Math Circle camp program, where I enjoyed sharing some of my favorite circle activities, such as SET, Exploding Dots, and divisibility rules.

We restarted the AIM Director's Circle, and two groups of students met with AIM's Executive Director Brian Conrey for several months. He worked with a group of middle school students on classifying planes and counting each type of plane in the game of SET. There are four different kinds of SETs: the four characteristics are all different, one is alike, two are alike, and three are alike. A plane consists of nine cards containing 12 SETs. The planes can be classified according to how many of each type of SET it contains. For example, there are planes with zero all different SETs; zero one-alike SETs, six two-alike SETs and six three-alike SETs. This project is ongoing.

The high school group developed a mental trick whereby if someone tells the cube of any number less than 1000 then they can quickly determine what number was cubed. They learned how to mentally factor any number up to 500, and they worked on congruence problems, proving that there exists a perfect power of 2 whose final 1000 digits are all 1's and 2's.

High school student Yash Ambasta continued to work during the summer and into the fall on a research project with Brian Conrey, AIM's Director of Programs David Farmer, and Paul Stahura trying to understand where the zeros of Siegel's function $f(s)$ are. This question is related to the Riemann Hypothesis.

I meet many students when they are in elementary school, and it is so rewarding to watch them continue on their math journey through high school and college. Making connections with students and families is what makes Morgan Hill Math so special. Seeing a student's eyes light up when they understand a new idea, seeing them gain confidence and perseverance in problem solving, watching them take on new challenges and succeed: This is why teachers teach. ■

— *Kelley Barnes*

AIM Director's Circle. Middle school students classifying SET planes.

Photo by Kelley Barnes

A Joyful Math Ecosystem

Community Outreach in Southern California

Since its arrival in Pasadena, AIM has set a goal of increasing access to joyful and enriching experiences of mathematics for students and teachers in Los Angeles. Growing and supporting a sustainable network of local Math Circles is one of our key strategies toward achieving this goal. In 2024, with support from The Eli and Edythe Broad Foundation, AIM organized a Joyful Math symposium which led to the creation of the SoCal Joyful Math group, composed of local educators, mathematicians, and community organizers with significant outreach experience. We also formed a group of Math Circle thought leaders to develop a facilitator training model for Math Circles in L.A. Throughout the year, we invited new individuals, many of them students at local universities, to become facilitators and gain experience on the ground, for example during the annual Math Fair that AIM organized in June (see p. 14).

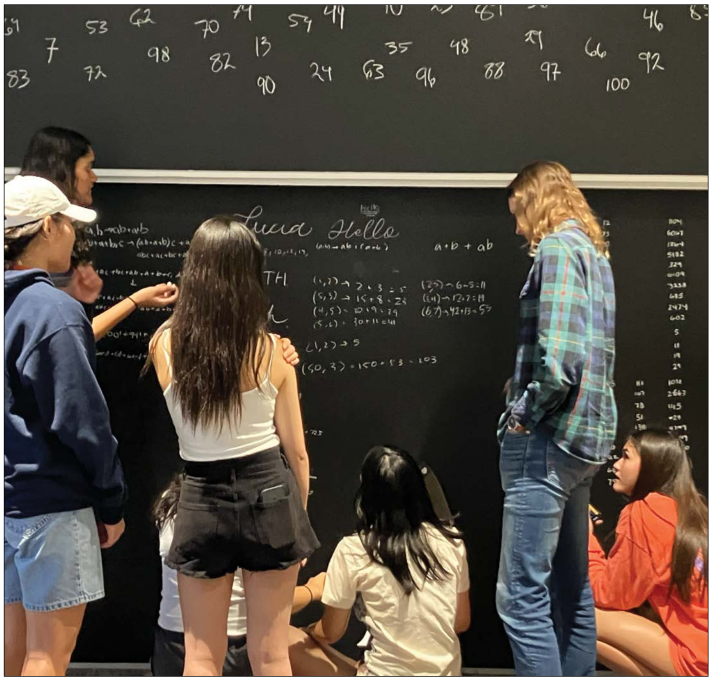
In 2025, AIM partnered with the Boys & Girls Club of the Foothills, a few miles away from Pasadena. Many families in that community were impacted by the Eaton fire. Thanks to the continuing support of the Broad Foundation, AIM organized Math Circles at the Boys & Girls Club site and also at the local schools where the club has daily after-school programs. In the future, we hope to build on this initiative by developing a network of Math Circles with other local Boys & Girls Clubs. AIM also supported monthly Family Math Circles at the Knowledge Shop LA, a South Los Angeles-based organization offering educational programs and community initiatives for local youth and families.

This year, we also strengthened our partnership with BEAM LA. BEAM (Bridge to Enter Advanced Mathematics) offers free programs and experiences in STEM, supporting students from underserved communities from middle school through college. During the school year, AIM welcomed BEAM students at its Caltech facility several times. Students engaged in Math Circles and also participated in an interactive Math Walk developed by Yana Mohanty, which engaged students in mathematical concepts inspired by art and architecture on Caltech's campus.

The summer was filled with Math Circles, including at the Boys & Girls Club, Conway Camp (a new summer math camp), and the BEAM LA summer programs in downtown Los Angeles and at Harvey Mudd College. AIM also hosted a series of Math Circles for incoming Caltech undergraduate students. More than 40 students attended each circle facilitated by AIM staff and a professor from Caltech. Each month during the academic year, AIM also hosted the Los Angeles Math Teacher Circle, where local teachers and math enthusiasts participated in engaging mathematics problems facilitated by AIM staff and faculty from USC.

Overall this year, our new Math Circles and partnerships provided an estimated 500 students with at least one Joyful Math experience. In the process, AIM has become a trusted partner of education-focused local organizations that recognize Math Circles as valuable programs tailored to the students and teachers they serve. ■

— *David Crombecque*



Incoming Caltech students work with Caltech faculty member Matthew Gherman at a Math Circle at AIM.

Kip Thorne Shines at AIM Lecture

A Message From a Billion Light Years Away

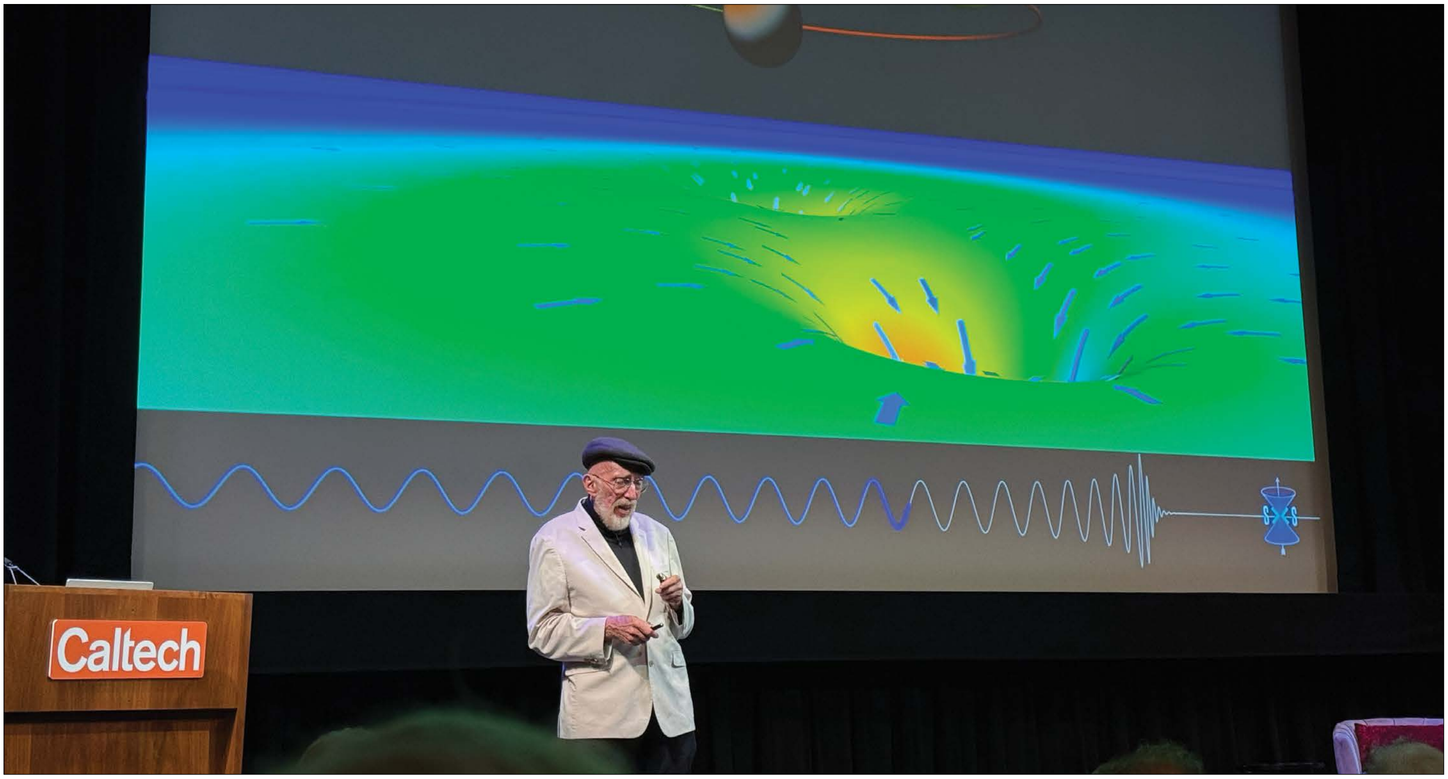
From AIM's space on the 8th floor of Caltech Hall, the views are remarkable, and the first landmark guests usually point out is Beckman Auditorium: a white ring on slender columns, impossible to miss. On October 3, 2025, that circle nearly filled as close to 800 guests gathered for the inaugural AIM Public Lecture at Caltech.

Kip Thorne, Nobel Prize-winning physicist, regaled the audience with "Vignettes from the Birth of Gravitational-Wave Astronomy," a talk built from short scenes of a long endeavor. Rather than equations, he offered the human cadence of discovery: ideas tested and retested, instruments refined beyond imagination, and collaborations that transformed a dream into reality. The evening made the cosmos feel close, not by simplifying the science, but by showing how people worked together to understand it.

Predicted by Einstein's theory of general relativity, gravitational waves eluded direct observation for a century, until the advent of the Laser Interferometer Gravitational-Wave Observatory (LIGO) — an engineering marvel combining high-quality mirrors, long vacuum arms, and the incredible precision of the quantum world. As Thorne reminded us, so much could have gone wrong across the nearly half century of effort required to build LIGO and develop the theoretical framework for interpreting its measurements. And yet, on September 14, 2015, LIGO recorded the first space-time ripples from two colliding black holes more than a billion light-years away.

Public lectures are an old AIM tradition, dating back to AIM's first location in Palo Alto with a 1999 talk by Andrew Wiles on his proof of Fermat's Last Theorem. We are delighted to continue this tradition in Pasadena, and we look forward to welcoming you at the next event! ■

— *Sergei Gukov*



Kip Thorne delivering the AIM Public Lecture. See more photos from the event on the back page of this issue.

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