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Institute for Pure and Applied Mathematics
a National Science Foundation Math Institute
at the University of California, Los Angeles

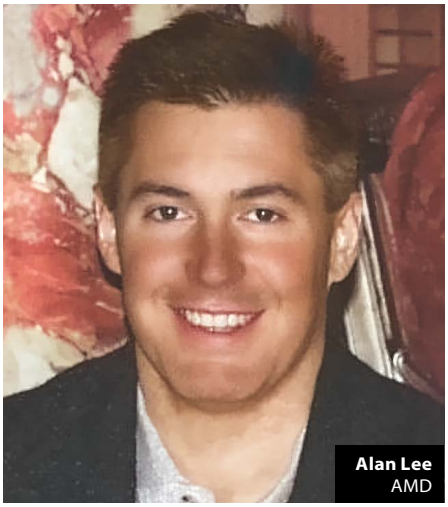
NEWSLETTER

THE NEED FOR GREATER INDUSTRY INVOLVEMENT AT IPAM

Advanced Micro Devices (AMD), the Santa Clara, CA-based developer of high-performance computing and visualization products that has become one of the hottest companies in Silicon Valley over the last several years, has a simple mantra that helps to explain both its business strategy and its partnership with the Institute for Pure and Applied Mathematics (IPAM): "Technology changes the world, but not on its own. When processing power meets brain power, the future comes alive."

As corporate vice president of research and advanced development, Alan Lee leads the teams that operate as AMD's headlights, rapidly bringing new ideas to fruition through research in artificial intelligence, machine learning, and high-performance computing. The teams drive the creation of new software, hardware, and platform technologies for applications ranging from computational finance to COVID research and scientific discovery. Lee, who has served on IPAM's Board of Trustees and is now heading up the effort to establish an industry advisory board for IPAM, sees tremendous value for industry to invest in the brainpower harnessed by IPAM as a National Science Foundation institute.

"There has never been a more important time in modern history to invest in mathematics and to support the work that IPAM does," Lee says. He pointed out that the rise in data science, artificial intelligence, and machine learning, along with the computing power developed by companies like AMD, has enabled applications of mathematics that would have been challenging to comprehend even 10 years ago. These developments are having substantial bearing on the large-scale problems facing industry and



Alan Lee
AMD

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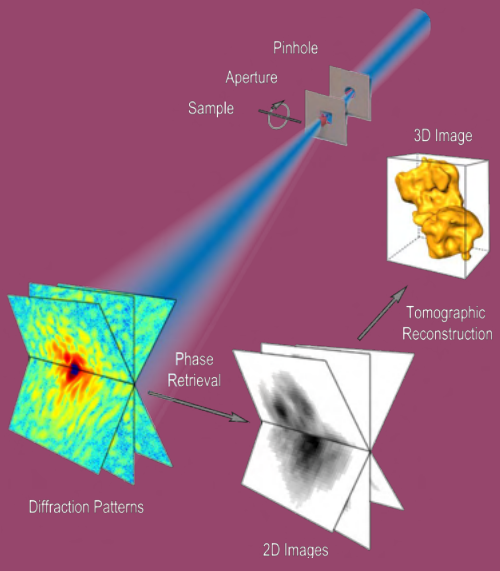
COMPUTATIONAL MICROSCOPY (SEPTEMBER 12 - DECEMBER 16, 2022)



This long program will bring together senior and junior applied mathematicians, physicists, chemists, materials scientists, engineers, and biologists to examine the current status and future perspectives of modern microscopy using computation, mathematics, and modeling. Cryo-EM has revolutionized life science (including solving the 3D atomic structure of COVID-19, facilitating the development of vaccines) and aberration-corrected electron optics and high brightness X-ray sources have transformed physical science imaging. The next steps in these fields will advance the temporal resolution and energy resolution by orders of magnitude, while maintaining atomic spatial resolution, in a variety of sample environments from near zero Kelvin in vacuum to temperatures of a thousand degrees in a highly corrosive atmosphere. However, these result in multidimensional, multimodal, big and extremely noisy data. Thus, sophisticated mathematical and computational methods to derive the maximum possible useful scientific information from the minimum possible quanta of radiation are crucial. The four workshops will assemble leading applied mathematicians, physicists, data scientists, and computational scientists to discuss strategies to tackle these major scientific challenges through advanced algorithms, mathematical modeling, computational tools, big data processing, and deep learning. ■

FEATURES

HIGHLIGHTS

INFORMATION

NOTE FROM DIRECTOR DIMA SHLYAKHTENKO

The COVID-19 epidemic continues to impact every aspect of our living, and mathematics is no exception. This past year has been one of unprecedented change in the way we communicate, with "Zoom" becoming a household word. All of IPAM's programs in Fall 2021 and Spring 2021 were held virtually. Although such offerings are not an adequate substitute for in-person events, time and again we have received testimonials to their positive impact. IPAM's great staff deserves the lion's share of credit for the success of our online programs.

Our two virtual long programs were the Fall 2020 program on autonomous vehicles, highlighting both the engineering and societal challenges associated with autonomous driving, and the Spring 2021 program on tensor methods. The latter program investigated the use of tensors and tensor networks in mathematics, statistics, and statistical and quantum physics. In addition, we hosted 4 winter workshops, whose topics included turbulent flows, actions of tensor categories on C*-algebras, entropy in quantum information and quantum physics, and applications of deep learning to combinatorial optimization.

Thanks to a successful US vaccination campaign and the decline in COVID-19 cases, IPAM was able to hold a reunion for one of its programs in person at the Lake Arrowhead Conference center last June. The event was a great success and a testament to the effectiveness of in-person communication. We were also able to offer our Los Angeles undergraduate Research in Industrial Projects for Students (RIPS) in person this year, welcoming 37 excited students from across the US.

Going forward, we anticipate being able to hold our long programs and workshops in person during this academic year. Our workshops (including those which are part of long programs) will be held in a hybrid format, allowing both local and remote participation and presentations. In this way, those still unable to travel due to the pandemic will still be able to actively participate in our activities. We are also hoping to finally celebrate IPAM's 20th (now already 21st!) birthday; please stay tuned for more information about this event, tentatively scheduled for Spring 2022.

Dima Shlyakhtenko
IPAM Director

Lastly, I would like to give a word of thanks to Maria D'Orsogna, who served as IPAM Associate Director in 2018-21, and welcome our new Associate Director Selenne Bañuelos. ■

IPAM CREATES IDEAL VENUE FOR UPENN MATHEMATICIAN

Given his interest in partial differential equations (PDEs) — and problems that describe changes over space and time in a variety of mathematically oriented fields, but are highly challenging to solve — Ryan Hynd, an associate professor of mathematics at the University of Pennsylvania, has worked on PDEs arising as mathematical models in fields as disparate as fluid mechanics, control theory, and finance, to name a few. "Differential equations play a crucial role in countless models, and in most cases they aren't derived by people like me who work in PDE," he says. "So by being in a program with experts from a variety of fields, pure and applied, I can see the different applications and approaches to questions that involve these equations. And seeing that there are people who really care about these equations for their applications is highly motivating."

Ryan Hynd
University of Pennsylvania

Hynd's first visit to IPAM came as a graduate student in 2004, when he attended the five-day workshop Geometric Flows: Theory and Computation, which brought experts in geometry together with those in numerical analysis to explain open problems in their area that might benefit from tools and insights from the other area. "I applied and got some funding to attend, and it was so fascinating for me to see all of these heavy-hitter mathematicians working intensely on big problems that people had been trying to solve for years," Hynd recalls. "It had a significant influence on me. I continue to see IPAM meetings as a great way for graduate students to learn about hot topics in ways that can really make an impact."

In the last three years, Hynd has been particularly active in IPAM. He was on the organizing committee for a summer school in 2018, which introduced students and postdocs to mean field games, a theory that seeks to advance the understanding of problems in game theory with very large number of agents, and which has found applications to economics, crowd dynamics, and network engineering.

Besides providing a stimulating educational program for the students, Hynd was inspired by his own learning to pursue mean field games in greater depth, leading him to develop a method of approximating Nash equilibria in certain noncooperative games. Also in 2018, Hynd presented at LatMath, a three-day meeting held triannually at IPAM to encourage young Latinx to pursue careers in the mathematical sciences, promote the

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IPAM Creates Ideal Venue for UPenn Mathematician

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advancement of Latinx currently in the discipline, showcase the research of Latinx at the forefront of their fields, and build community around shared academic interests.

Hynd was an enthusiastic participant in the 2020 IPAM long program High Dimensional Hamilton-Jacobi PDEs. The program focused on a particular form of PDEs that was originally introduced during the 19th century as an alternative way of formulating mechanics, and has since received a considerable amount of attention because it arises in many scientific areas and real-life applications beyond physics. For Hynd, who did his thesis on Hamilton-Jacobi PDEs, the program resulted in his writing a survey article about the field for the Notices of the American Mathematical Society. He also gave a talk on the topic at the Joint Mathematics Meetings last January, and recently wrote a paper that used Hamilton-Jacobi equations to study optimal vaccination rates in an epidemiological model for COVID-19.

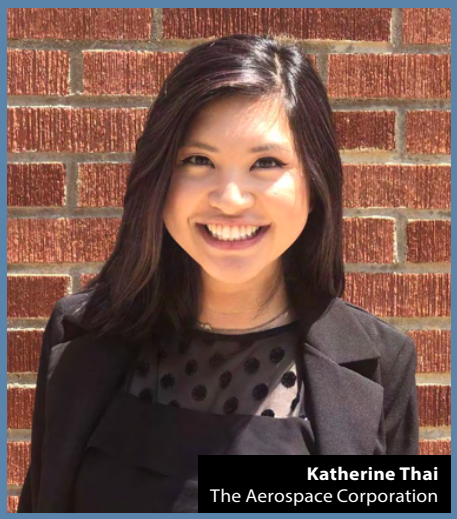
"IPAM has so much going for it," Hynd says. "Whenever you get invited to spend time in Los Angeles, that's a good thing. The math department at UCLA is just outstanding, and so from a professional point of view, it's great to have a chance to meet and interact with these experts, as well as with the leading experts from other institutions. And both the staff and leadership at IPAM are incredibly thoughtful people who go out of their way to help you get the most out of your time there."

Best of all, Hynd says, is the way IPAM meetings take participants out of their silos and allow them to hear fresh perspectives and exchange ideas. "You tend to come to these meetings with your narrow interests, and then you hear about things from other people that can expand your approach," he explains. "You might have a question for someone that normally you would be hesitant to ask, but it's so easy to approach them at lunch or at the coffee station, and before long you might think this is a person you could work with. And for those of us who do mathematical models, it's always exciting to find out what others are thinking about and what's behind the applications. I'm much more motivated to attend a meeting where I'm learning new things and encountering different perspectives." ■

EXPERIENCE IN RIPS PROGRAM PROVES PIVOTAL

Like many undergraduates, Katherine Thai was uncertain about her post-college plans. But in the summer after her junior year, Thai spent nine weeks in Hong Kong as a member of the Research in Industrial Projects for Students (RIPS) program, sponsored by IPAM. The next summer, Thai again participated in RIPS, this time in Los Angeles. The experiences proved pivotal: Entering her second year as a PhD student in computer science at the University of Massachusetts Amherst, Thai now knows what she wants for her career, and is on a path to getting there.

RIPS provides an opportunity for talented undergraduates studying math, computer science, and related disciplines to work in teams on real-world research projects proposed by industry sponsors, with support from academic and industry mentors. For Thai, getting to know and work with students with varied interests from all over the world left a lasting impression. "You meet a bunch of people the same age who are looking to have careers in science, and everyone is passionate about what they're studying, supportive, and looking to get to know the other participants," she says. "I am still in constant contact with many of them."



Katherine Thai
The Aerospace Corporation

At RIPS-Hong Kong — a program that has since moved to Singapore — Thai's group completed a proof-of-concept project for a small financial company that applied artificial intelligence to implement a reinforcement-learning approach to modeling Bitcoin investments. "I was starting to realize I wanted to combine English and STEM as I went into my graduate career," Thai explains. "So my task involved using Bitcoin-related news headlines to help inform the model, given how influential positive or negative coverage can be to the stock price."

At RIPS-LA, Thai was part of a team that worked on a project for The Aerospace Corporation, a federally funded, non-profit research and development center, to optimize the design of satellite constellations through the application of an AI technique called genetic algorithms. As part of the program, Thai's team members visited the company for a tour, during which they met two interns who were prior RIPS participants. "I kept that in the back of my mind," Thai says, "and when I got back to school, I reached out to ask about open positions. They already knew me there, because when we gave our presentation, a lot of people from the company came."

In the summer of 2020, as Thai prepared to enter graduate school, she interned at The Aerospace Corporation, finishing the project she had started at IPAM and ultimately getting it published in proceedings of a GPS satellite conference. ■

NEWS STORIES

JEFF HITTINGER RECEIVES THE 2021 JAMES CORONES AWARD

Jeff Hittinger
Center for Applied Scientific Computing

The Krell Institute, a nonprofit organization serving the scientific and educational communities, has awarded Jeff Hittinger, a Science Advisory Board member at IPAM and Director of the Center for Applied Scientific Computing at Lawrence Livermore National Laboratory, with its 2021 James Corones Award in Leadership, Community Building and Communication. The award recognizes mid-career scientists and engineers who are making an impact on their chosen fields and for mentoring and encouraging young researchers to be active in the science community and communicate their work.

IPAM WELCOMES SELENNE BAÑUELOS AS ASSOCIATE DIRECTOR

Selenne Bañuelos
IPAM Associate Director

IPAM is thrilled to announce that Dr. Selenne Bañuelos has begun a two-year term as IPAM's Associate Director on August 1, 2021. Selenne is currently Associate Professor of Mathematics at California State University Channel Islands. She received her PhD in Applied Mathematics from University of Southern California in 2013. She has been actively engaged in numerous IPAM programs since 2015, most notably as organizer and participant of the Latinx in the Mathematical Sciences Conference in 2015, 2018, and 2022, and participant in the Collaborative Workshop for Women in Mathematical Biology in 2019. Her research interests lie in the fields of differential and difference equations and dynamical systems and their applications to mathematical biology.

SIMONS POSTDOCS AT IPAM

Thanks to funding from the Simons Foundation, IPAM has established a postdoctoral program to help mitigate the effects of the COVID-19 pandemic on the academic job market in mathematics. This year, we recruited three Simons Postdoctoral Fellows: Li Li, Zhimeng Ouyang and Kevin Stubbs. They will be staying at IPAM for the entire 2021-22 academic year and will be participating in the two long programs planned for this year.

The subject matter of our two programs – Gravitational Waves and General Relativity on one side and Quantum Mechanics on the other – seems to be completely unrelated. Yet it is a testament to the unifying nature of mathematics and the breadth of the postdoctoral fellows' research that they found points of contact with both of our long programs.

Li Li
Simons Postdoc

Li Li received his undergraduate degree in mathematics from Zhejiang University and his PhD degree from the University of Washington, where he was advised by Gunther Uhlmann. His mathematical interests involve the study of fractional partial differential equations and inverse problems, with his research focusing on inverse problems related with fractional Laplacian, which are closely related with quantum mechanics. He is also interested in inverse problems arising in general relativity.

Zhimeng Ouyang
Simons Postdoc

Zhimeng Ouyang received her undergraduate degree in Mathematics at Peking University and obtained her PhD in mathematics from Brown University, where she was advised by Prof. Yan Guo and Prof. Benoit Pausader. Zhimeng is interested in the mathematical analysis of partial differential equations which arise in physical contexts. Her recent research mainly focuses on the kinetic theory and nonlinear dispersive equations.

Kevin Stubbs
Simons Postdoc

Kevin Stubbs grew up in Silver Spring, MD. He received his Bachelors of Science in Mathematics and Computer Engineering from the University of Maryland, College Park in 2015 and a PhD in Mathematics from Duke University in 2021 under the supervision of Prof. Jianfeng Lu. Kevin's research interests lie in developing fast algorithms for high dimensional problems with a focus on quantum chemistry and materials science. He is particularly interested in leveraging insights from physics to design provably fast algorithms. As a graduate student, Kevin was a participant in our long program on Tensor Methods in Spring 2021.

IPAM expects three more of these one-year positions to be available next year. Prospective fellows will find an application form available on mathjobs.org later in the Fall quarter.

DONOR RECOGNITION

CORPORATE GIVING

IPAM offers opportunities for corporations to participate in our scientific programs, propose topics for programs, and support activities that promote diversity in math and science. IPAM received gifts from the following companies in the past year:

- **Aerospace Corporation**
- **Alibaba Group**
- **Air Force Research Laboratory**
- **HRL**
- **Google**
- **GumGum**
- **Microsoft**
- **AMD**

In addition to support from our main NSF grant, IPAM also received grant funding from the **Simons Foundation Institute Grant, Simons Foundation Postdoctoral Scholars, NSF's Office of International Science and Engineering, and the Air Force Office of Scientific Research.**

For more information on corporate giving, please visit our donor page at **www.ipam.ucla.edu/donate/corporate-giving**

FUNDING PRIORITIES

Your financial support allows IPAM to fund opportunities that go beyond NSF support. You can donate online or by mail at any level. Donors giving $5,000 or more will be recognized on IPAM's donor wall. See www.ipam.ucla.edu/donate for details. For multi-year gifts or estate gifts contact Sharon Chang at schang@support.ucla.edu.

Your annual membership in IPAM's Frontiers Society will help us continue to run high-quality programs attracting both internationally renowned experts as well as promising young scholars. There are three levels of membership: Innovator ($100), Visionary ($500), and Champion ($1000). Couples may join with a single membership. All gifts to this current-use fund are tax deductible.

Name a Seat! For a gift of $1,500, you may name a seat in IPAM's lecture hall. During and since our 15th Anniversary Campaign, IPAM donors named 42 of the 75 eligible seats. A plaque appears on the back of the seat with the name of the donor or someone the donor chooses to honor. We will continue to offer this opportunity until all seats are named. A gift at this level also qualifies the donor for Frontiers Society membership at the Champion level.

Industrial Support for Research in Industrial Projects for Students (RIPS). This is a unique research experience for undergraduate students sponsored by industry. We offer RIPS in Los Angeles and Singapore. A graduate-level version of RIPS is in Berlin, Germany and Sendai, Japan. RIPS allows U.S. students to work side-by-side with students from another country while gaining industrial math research experience. ■

FRONTIERS SOCIETY MEMBERS 2020-2021

IPAM thanks everyone who joined the Frontiers Society, gave to the Director's Endowment Fund, and all others who donated to IPAM in the past year. Special thanks to those who made multi-year pledges!

CHAMPIONS ($1,000+)

James C. Fraser and Diana K. Fraser

John B. Garnett and Dolores Garnett

Virginia D. Hales and Alfred W. Hales

Charles D. Levermore and Lucia Levermore

Maria P. McGee

Stanley J. Osher and Suzanne C. Lauver

Ronald J. Stern and Sharon S. Stern

Edward O. Thorp and Vivian S. Thorp

VISIONARIES ($500–$999)

Robert S. Baker

Diana R. Gillooly and Burt Totaro

Tatiana Toro and Daniel Pollack

Dimitri Shlyakhtenko

INNOVATORS ($100–$499)

Gail M Cardenas

Allen Clement and Joanie Clement

Madison B. Gray and Kristen L. Gray

Terence J. McKiernan

Tingwei Meng

Bradley S. Moskowitz and Diane Lowenthal

Vijay Pedapudi

Nancy A. Potok

Stan Schein and Mae Greenwald

Judy J. Wu

UPCOMING PROGRAMS

LONG PROGRAMS

Mathematical and Computational Challenges in the Era of Gravitational Wave Astronomy
September 13 - December 17, 2021

Advancing Quantum Mechanics with Mathematics and Statistics
March 7 - June 10, 2022

Computational Microscopy
September 12 - December 16, 2022

New Mathematics for the Exascale: Applications to Materials Science
March 13 - June 16, 2023

WORKSHOPS

Quantum Numerical Linear Algebra
January 24 - 27, 2022

Calculus of Variations in Probability and Geometry
February 7 - 11, 2022

Mathematics of Intelligences
February 14 - 18, 2022

Reconstructing Network Dynamics from Data: Applications to Neuroscience and Beyond
August 29 - September 2, 2022

SUMMER RESEARCH PROGRAMS

RIPS Singapore 2022
May 30 - July 29, 2022

G-RIPS Berlin 2022
June 20 - August 12, 2022

G-RIPS Sendai 2022
June 20 - August 9, 2022

RIPS Los Angeles 2022
June 21 - August 19, 2022

Graduate Summer School: Algorithmic Fairness & Workshop on Sex and Gender Bias in Data
July 11 - 20, 2022

Graduate Summer School: Post-quantum and Quantum Cryptography
July 25 - 29, 2022

CALL FOR PROPOSALS

IPAM seeks proposals from the mathematical, statistical, and scientific communities for its long programs, winter workshops, summer schools, and exploratory workshops. Proposals must include a plan for recruitment and involvement of members of underrepresented groups. Submitted proposals are reviewed by IPAM's Science Advisory Board (SAB) at its annual meeting in November. To receive fullest consideration, please send your proposals by October 1 to the IPAM Director at director@ipam.ucla.edu.

WINTER WORKSHOPS

Winter workshops are typically five days in length, with 20–25 presentations. The proposal should include a short description of the mathematical and scientific content, names of individuals to serve on the organizing committee, and names of individuals that you would like to invite as speakers or participants. The SAB will consider proposals for winter 2023 at its upcoming meeting. Proposals for workshops on multiscale physics will be considered for inclusion in a series of workshops made possible by an endowment from the Julian Schwinger Foundation for Physics Research.

EXPLORATORY WORKSHOPS

Exploratory workshops address urgent problems that mathematics may help solve. They are two or three days long, and can be organized in less than a year. The proposal should follow the guidelines for winter workshops, described above, and will be considered at any time.

LONG PROGRAMS

Long Programs generally have two complementary streams: one mathematical and one (or more) from other related scientific disciplines where there is the potential for a fruitful and exciting interaction. A long program opens with tutorials, followed by four one-week workshops and a culminating workshop. The proposal should include a brief description of the topic, names of individuals to serve on the organizing committee, and a preliminary list of senior researchers and representatives of industry and government you would like to invite. A long program proposal template is available online. Proposals for academic year 2023–2024 will be reviewed at the next SAB meeting.

SUMMER SCHOOLS

Summer schools are one to three weeks in length and incorporate both tutorials (a series of 3–4 talks) and research talks illustrating applications. They are directed toward graduate students and postdocs. The requirements for summer school proposals are comparable to those for winter workshops.

Mark Your Calendars

October 25, 2021. Dr. Andrea M. Ghez (UCLA) will give a public lecture as part of the Green Family Lecture Series.

November 20, 2021. Registration deadline for the 2021 Blackwell-Tapia Conference.

January 3, 2022. Application deadline for IPAM's Latinx in the Mathematical Sciences Conference 2021.

February 14, 2022. Application deadline for IPAM's Research in Industrial Projects for Students Programs in Singapore and Los Angeles.

February 20, 2022. Application deadline for IPAM's Graduate-level Research in Industrial Projects for Students (G-RIPS) Programs in Berlin and Sendai.

March 11, 2022. Application deadline for IPAM's Graduate Summer School on Algorithmic Fairness Workshop on Sex and Gender Bias in Data.

May 2, 2022. Application deadline for IPAM's Graduate Summer School on Post-quantum and Quantum Cryptography.

For more information, go to w**ww.ipam.ucla.edu.**

Stay Connected

The Need for Greater Industry Involvement At IPAM

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humanity. There has been a renaissance over the decade, with mathematical thinking influencing almost all areas of science and engineering — from the narrowest problems to the largest problems affecting mankind — in ways that are changing the world. IPAM brings all these disciplines together better than anyone, and its impact can be even greater with more industry involvement."

A pure mathematician by training, Lee had known about IPAM since graduate school, but his first up-close exposure came in 2012 when he attended the workshop on Advances in Scientific Computing, Imaging Science and Optimization, honoring the 70th birthday of IPAM's Stan Osher. Lee had come to hear a talk delivered by one of his former professors, Peter Jones of Yale University, but after Jones introduced Lee to then-IPAM director Russel Caflisch, Lee saw the value in becoming more involved with the institute. When invited to join IPAM's board, he didn't hesitate to accept.

Lee's board membership led to increased AMD participation in and support of IPAM programs, including annual sponsorship of IPAM's Research in Industrial Projects for Students (RIPS), in which talented undergraduates studying math, computer science, and related disciplines work in teams on real-world research projects proposed by industry sponsors, with support from both academic and industry mentors. "RIPS has been great for our company because the benefits are so concrete," Lee says. "It brings in some of the best undergraduate mathematicians from around the world, people who don't know each other, and in 9 weeks over the summer they produce world-class work. RIPS is almost magical, with students having both published original research and generated results that are used by our engineering teams. These are amazing outcomes considering that, a few weeks earlier, none of these students knew about the problem they would set out to solve."

In all of its programs, IPAM's ability to bring experts together from across disciplinary boundaries has considerable appeal to Lee and his industry colleagues. "That cross-pollination of ideas, which is extraordinarily valuable to industry, is not something you can get through a one-hour visit to a company," Lee says. "The forums IPAM supports, whether long and short programs or summer courses, foster a much more collaborative and collegial atmosphere where you can gain a deep understanding of major problems, their solutions, and the people solving them."

After spending a number of years on the IPAM Board of Trustees, Lee is now eager to increase industry involvement with the institute. "That is something that will help elevate IPAM to the next level in terms of its impact," he says. "We want to help more companies understand that engagement with IPAM reaps substantial business, technical, and social benefits through the common language and power of mathematics. IPAM has great depth and breadth — it touches a huge number of scientific areas. Its value to industry is tangible and measurable on a variety of levels. In industry, it is important to take a broad view of one's ecosystem, and having the perspective that IPAM brings can help companies achieve their goals. Over the last nine years, AMD's involvement with IPAM has fueled insights that helped make it one of the most successful technology companies in the world today." ■

Institute for Pure and Applied Mathematics

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math changes everything.

ADVANCING QUANTUM MECHANICS WITH MATHEMATICS AND STATISTICS (MARCH 7 - JUNE 10, 2022)

Quantum mechanics is the fundamental theory of fields and matter and it is arguably the most successful and widely applicable theory in the history of physics. Quantum mechanics is widely used today to describe low and high energy phenomena. This includes studying molecules and solids throughout biology, chemistry and physics, and even the determination of constitutive relations in engineered mesoscale structures.

The aim of this program is to pave the way towards practical and error-controlled quantum-mechanical calculations with tens of thousands (or even millions) of quantum particles. This IPAM program is based on the premise that by systematically analyzing the structure and topology of Hilbert spaces of different systems and methods, as an interdisciplinary community we can overcome the bottlenecks of existing approximations, and move towards quantum multiscale methods based on Hilbert space embedding, model order reduction, and complementary mathematical and statistical techniques. This program will bring together physicists, mathematicians, chemists, engineers, and computer scientists interested in pushing the boundaries of theory and methods based on quantum mechanics. ■