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

NEWSLETTER

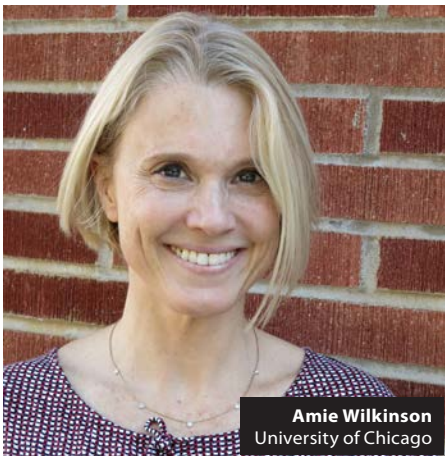
PURE MATHEMATICIAN GAINS NEW PERSPECTIVES WHILE SERVING ON IPAM'S SCIENCE ADVISORY BOARD

By any measure, Amie Wilkinson is among the leaders in her field. A professor of mathematics at the University of Chicago and an expert in ergodic theory and smooth dynamical systems, Wilkinson received the 2011 Satter Prize in Mathematics — presented biennially by the American Mathematical Society for outstanding contributions to mathematics research by a woman in the previous six years.

But Wilkinson says she is constantly enlightened by her experience on IPAM's Science Advisory Board, where she is part of a group of scientists and mathematicians from wide-ranging disciplines who meet each year to evaluate and approve IPAM-sponsored scientific programs. "These are individuals with some of the most astonishing minds of anyone I have met," Wilkinson says. "They think deeply about problems and are wildly creative in the ideas they bring to the table and in their assessment of these proposals. I always look forward to the meetings because I learn so much. This experience has broadened my perspective on my own work, and completely changed my view of how mathematicians can interact with other fields."

Wilkinson's research focuses on the interplay between smooth dynamical systems and other structures in pure mathematics — geometric, statistical, topological and algebraic. A dynamical system is a closed system that evolves according to a predetermined set of rules; examples range from the solar system to the stock market and the flow of water from a pipe. Wilkinson was named a fellow of the American Mathematical Society in 2013 for her contributions to understanding such systems.

In 2011, she accepted an invitation to bring her expertise in this area to IPAM's Science Advisory Board. "At first I was something of a spectator at the meetings," Wilkinson recalls. "I was blown away by the breadth of knowledge of the other board members, and most of the



Amie Wilkinson
University of Chicago

(continued on page 7)

SECOND LATINX IN MATH CONFERENCE HELD AT IPAM

2018 Latinx in Math Conference
Hosted by IPAM

On March 8–10, 2018, over 200 Latinx students, postdocs, professors, researchers in industry and government, and others spent three days at UCLA celebrating and showcasing the contributions of the Latinx community to mathematics. Organizers Tatiana Toro (Univ. of Washington), Mariel Vazquez (UC Davis), Federico Ardila (San Francisco State), and Ricardo Cortez (Tulane), along with other volunteers and the IPAM staff, planned a wide variety of activities for the conference attendees, including seven invited research lectures, a panel discussion on Latinx in STEM, career panels, scientific sessions, a poster session, a high school math activity, networking and mentoring activities, and a banquet. The Mathematical Sciences Institutes Diversity Initiative, with a grant from NSF, provided significant support for the conference. Other sponsors included NSA, Facebook, UCLA Graduate Division, UCLA Division of Physical Sciences, UCLA Office of Equity, Diversity and Inclusion, Elsevier, and University of Washington. Additional support was provided by UC Davis, UC Merced, and Purdue University. Videos of many of the activities are available on IPAM's website. ■

FEATURES

REGULARS

OTHER

NOTE FROM DIRECTOR DIMA SHLYAKHTENKO

Dima Shlyakhtenko
IPAM Director

In looking back over my first year as IPAM director, I can report that IPAM continues to be an amazing incubator of innovation, bringing together mathematicians and other scientists for exciting and impactful programs.

Our fall 2017 Complex High Dimensional Energy Landscapes long program focused on mathematical techniques for sampling and analyzing complicated multivariable functions. Such functions include energy and electronic property landscapes of inorganic, organic, biomolecular, and hybrid materials and functional nanostructures. It was motivated by previous IPAM programs, including Chemical Compound Space in 2011 and Many Particle Systems and Machine Learning in 2016. Our spring 2018 long program, Quantitative Linear Algebra, focused on connections between quantitative finite-dimensional linear algebra questions and a "continuum limit" of these questions described by infinite-dimensional functional analysis.

In addition to a short workshop on privacy in biomedical data, IPAM hosted stand-alone workshops on Zimmer's conjecture and on mathematics of deep learning. Demand was so high that we had to close registration to these workshops weeks in advance. This past summer, we offered a Graduate Summer School on mean field games, following a workshop on that topic last August. In addition to our undergraduate Research in Industrial Projects for Students (RIPS) program in Los Angeles, we offered RIPS in Hong Kong (in partnership with HKUST), and graduate programs in Berlin (MODAL) and, our newest, Japan (Tohoku University). One of the highlights of the year was a conference showcasing and celebrating mathematical achievements of the Latinx community.

Thanks to a generous gift from Mark Green and his family, we were able to expand the Green Family Lecture series to twice a year. This past year, we featured Facebook's Yann LeCun and Fields Medalist Vaughan Jones. Other public events included the Calculus of Comedy, featuring a panel of math-y Hollywood scriptwriters, and a lecture by French mathematician Yann Brenier on optimal transportation theory.

IPAM is grateful to its many donors, whose combined generosity raised over $200,000 for the Director's Endowment fund (which will be matched 1:1 by the Dean of Physical Sciences at UCLA). Through a special arrangement, the Dean has extended his matching program for one more year.

I hope that you enjoy this Newsletter and that you will engage with IPAM by participating in a program or workshop, attending a public lecture, or taking part in our fundraising campaign. ■

IPAM'S ENVIRONMENT AND NETWORK A MAJOR DRAW FOR UCLA MATH PROFESSOR

Whether it's a workshop lasting a few days or a long program spanning several months — and he has participated in both — UCLA mathematics professor Wilfrid Gangbo always knows the time he spends at an IPAM event will be highly productive.

"IPAM provides an environment where you can focus on your research free of any distractions," Gangbo says. "During the time of the program you are not teaching or performing any administrative responsibilities that you would typically have in your daily academic work. And, whereas in your home institution you might have a few people whose research is in a similar area, at an IPAM program there are dozens of people you can interact with who have overlapping interests, which makes for a much different dynamic."

Gangbo's work focuses on the calculus of variations — specifically, optimization problems in fields such as fluid mechanics, economics and materials science. Such problems are of particular interest when they come with a constraint. For example, if a bridge is being designed with a certain material, an optimization problem might ask what would be the minimal mass of a bridge to ensure stability under a certain load.

In recent years, Gangbo has concentrated on a specific class of problems known as optimal mass transportation — in its simplest formulation, how, for example, to transport a pile of dirt from an excavation site while expending the least amount of energy. This seemingly rudimentary question has generated an enormous amount of attention in the field of mathematics. "In optimal transportation you are given a rule — the cost per unit mass of going

Wilfrid Gangbo
UCLA

from one location to another — and are asked to determine the least expensive form of transport," Gangbo explains. "We have spent a lot of time developing a theory for characterizing best strategies."

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IPAM PROGRAM SHAPES NEW GENERATION OF TRAFFIC ENGINEERS

Raphael Stern is a PhD student at the University of Illinois and a Visiting Scholar at the Institute for Software Integrated Systems, Vanderbilt University.

I visited IPAM in 2015 as a PhD student in civil engineering, for the program New Directions in Mathematical Approaches for Traffic Flow Management. Transportation was (and still is) at a crucial stage: the emergence of new technologies such as vehicle connectivity, automation, and shared mobility promises to rapidly change the transportation landscape. With a sense of urgency, researchers from mathematics and engineering came to IPAM to explore new developments in traffic modeling, estimation, and control.

The long program's workshops were designed to provide the basic toolset to understand mobility patterns at the level of the person, the vehicle, the system, and the planet. I received an excellent introduction to an interdisciplinary approach to transportation, which has been central to the work that I have done since then.

The program brought together world-renowned researchers with different academic backgrounds who all study similar problems in traffic theory. I had unprecedented access to these researchers, which allowed me to gain insight beyond what would have been possible anywhere else. I believe that the format of a long program, which enables this type of interaction, is one of IPAM's greatest strengths.

Through IPAM, I saw the important role that mathematics plays in traffic theory. The joint work on traffic control using a small number of autonomous vehicles that I began at IPAM with my advisor Dan Work (Civil/ECE, Vanderbilt), Jonathan Sprinkle (ECE, Arizona), Benedetto Piccoli (Math, Rutgers-Camden), and Benjamin Seibold (Math, Temple), led to a large experiment in Arizona that demonstrated the ability of a low penetration rate of autonomous vehicles (~5%) to substantially alter the traffic flow and dampen traffic waves. We will discuss the results and broader implications of this experiment at an upcoming IPAM workshop.

The IPAM program welcomed me into the academic community of traffic theory—a community that started in the 1950s when the construction of highways changed the transportation landscape. A similar transformation is occurring now as vehicle automation and pervasive data monitoring promise to revolutionize the field, requiring an interdisciplinary approach. Thanks to IPAM, I have conducted interdisciplinary work that extends theory and the application of the mathematics of traffic flow. Next year, I will join the faculty at the University of Minnesota. My desire to pursue an academic career stems from my experience at IPAM.

To watch a video on the Arizona autonomous vehicles experiment, go to http://www.ipam.ucla.edu/y4zdm ■

Raphael Stern
U. of Illinois and Vanderbilt

IPAM a Major Draw for UCLA Math Professor

(continued from page 2)

Optimal transportation theory was just beginning to emerge as a major field of focus when Gangbo, then on the faculty at Georgia Tech University, was approached by UCLA mathematics professor Andrea Bertozzi and invited to co-organize an IPAM program on the subject. The quarter-long program, held in the spring of 2008, represented Gangbo's first IPAM experience, and it led to collaborations that continue more than a decade later, including one with Alessio Figalli, who was awarded the 2018 Fields Medal for his work in this area.

That initial IPAM experience also proved beneficial eight years later, when Gangbo was recruited to join the UCLA faculty. "The fact that I had organized an IPAM program on optimal transportation theory at UCLA made me more visible to some of the faculty members, and when they learned I was interested, they didn't need to do as much investigation as if they had never met or heard of me," he says. "And from my point of view, knowing that UCLA had such an institute made a position on the mathematics faculty extremely appealing."

Gangbo has remained actively involved with IPAM since joining the UCLA faculty in 2016. He was an organizer of the Mean Field Games workshop in the summer of 2017. In a mean field game, a large number of players interact in such a way that that each individual has a negligible impact on the payoff of the rest of the players. The concept, introduced in 2006, is now widely recognized as an important approach to studying everything from financial markets to voting. "Many engineers in the U.S. had been working on this, but in the math community most of the experts have been concentrated in Europe and Canada," Gangbo says. "It was great to be able to gather experts from different geographic areas and fields in a way that exposed more people to this vibrant and promising area of study." As a follow-up, Gangbo organized and spoke at IPAM's Graduate Summer School on mean field games in June of this year. He is also co-organizer of a related long program on Hamilton-Jacobi-Bellman equations slated for spring 2020.

Born in Porto Novo, the capital of the Republic of Benin in West Africa, Gangbo completed undergraduate and graduate studies in Switzerland before coming to the United States. He remains active in promoting math and science in Africa, especially in his country of origin. Gangbo founded the EcoAfrica project, an association of scientists involved in projects supporting African countries. He continues to organize conferences in Benin and serves on the scientific board of Benin's center for excellence in mathematics. He is also committed to promoting diversity and inclusiveness in mathematics in the U.S.

Gangbo says his IPAM experiences have broadened his perspective on his own work. "It exposes you to a much wider community," he explains. "IPAM selects top people from all over the world who can build on a topic and brings them together; out of that mixture, good things result." ■

NEWS AND RECOGNITION

IPAM WELCOMES MARIA D'ORSOGNA AS ASSOCIATE DIRECTOR

Maria D'Orsogna joined IPAM as its Associate Director on August 1, 2018. D'Orsogna is a professor of mathematics at the California State University, Northridge and holds an adjunct professor position in the Biomathematics Department in the Geffen School of Medicine at UCLA. She received her PhD in Theoretical Physics from UCLA in 2003. Since 2005, she has visited IPAM numerous times as a core participant to four long programs, a speaker at several workshops, and an academic mentor for RIPS. Her recent work focuses on mathematical models of cell biology, multi-particle swarming, and social science systems, which she studies using tools from statistical mechanics and applied mathematics.

Maria D'Orsogna
IPAM and CSUN

KRA CHOSEN TO GIVE NOETHER LECTURE

The Association for Women in Mathematics (AWM) and The American Mathematical Society (AMS) have chosen Professor Bryna Kra to give the AWM-AMS Noether Lecture at the 2019 Joint Math Meetings (JMM) in Baltimore, Maryland. Kra is the Sarah Rebecca Roland Professor of Mathematics at Northwestern University, and was a member of IPAM's Board of Trustees from 2012 to 2015. She was selected for "her profound impact on mathematics, both through her work in the fields of dynamical systems and ergodic theory and through her service to the profession."

CONGRATULATIONS TO IPAM BOARD MEMBERS AND ORGANIZERS

Several of IPAM's current and former board members and program organizers have received national and international recognition in the past year. In February, Stan Osher, IPAM's Director of Special Projects (UCLA), was elected to the National Academy of Engineering. In April, the American Academy of Arts and Sciences announced the election of Guillermo Sapiro (Duke), Arkadi Nemirovski (Georgia Tech), and Alexei Borodin (MIT). In May, Andrea Bertozzi (UCLA) and Simon Tavaré (Cancer Research UK Cambridge Institute) were elected to the National Academy of Sciences. Finally, at the ICM2018 in August, David Donoho (Stanford) was presented with the Gauss Prize.

GREEN FAMILY LECTURES FEATURED JONES AND LECUN

A gift from former IPAM director Mark L. Green and his family started the Green Family Lecture Series in 2012. In 2017, an additional gift from the Green family allowed IPAM to offer two lecture series per year. In February, Yann LeCun (Facebook and NYU) gave two public lectures on artificial intelligence during a workshop that he co-organized entitled Deep Learning Techniques. In May, Fields Medalist Vaughan Jones (Vanderbilt) gave the second set of lectures on planar algebra and von Neumann algebras, during the Quantitative Linear Algebra program. The videos of these lectures are available on IPAM's website. IPAM is thankful to the Green family for making these lectures possible.

Mark L. and Kathryn Kert Green
at IPAM

TONY CHAN APPOINTED PRESIDENT OF KAUST

IPAM cofounder Dr. Tony Chan recently became the third president of King Abdullah University of Science and Technology (KAUST). According to KAUST's Board Chairman, H.E. Khalid Al-Falih, "Chan's outstanding record as a leader in higher education and innovation will help us accomplish our ambitious goals in this important time of national transformation." Chan was the President of Hong Kong University of Science and Technology for ten years. He previously served as UCLA's Dean of Physical Sciences and NSF's Assistant Director for Math and Physical Sciences. He continues to serve on IPAM's Board of Trustees.

Tony Chan
KAUST

CANDÈS AWARDED MACARTHUR PRIZE

Emmanuel Candès (Stanford) received a MacArthur Fellowship, better known as a "genius grant," in the fall of 2017. Candès is known for developing a unified framework for addressing a range of problems in engineering and computer science, most notably compressed sensing. His work has laid the groundwork for improvements in many devices that make use of signal and image processing methods. Candès was an organizer of the 2004 IPAM long program, Multiscale Geometry and Analysis in High Dimensions. Around that time, Candès and UCLA's Terry Tao developed some of the key ideas of compressed sensing. Since then, the concept of sparsity has become fundamental in data science. Candès is a member of IPAM's Science Advisory Board, and will give the first Green Family Lectures of 2018-2019 in September.

CONTINUED

IPAM HOSTS "CALCULUS OF COMEDY" EVENT

Five writers and producers of The Simpsons, Futurama, and The Big Bang Theory (some of whom have advanced degrees in math, physics, and computer science) shared their love of numbers at an IPAM public outreach event on October 25, 2017. The event began with a lecture by bestselling author Simon Singh (*The Simpsons and Their Mathematical Secrets*), who examined some of the mathematical nuggets hidden in The Simpsons and Futurama. Mathematician Sarah Greenwald (Appalachian State), who teaches and writes about math in popular culture, moderated the panel.

JUAN MEZA JOINS NSF AS DIVISION DIRECTOR

The National Science Foundation appointed Juan Meza as the Division Director of the Division of Mathematical Sciences earlier this year. Meza was Dean of Natural Sciences at UC Merced since 2011. He previously served as Department Head and Senior Scientist of High Performance Computing Research at Lawrence Berkeley National Laboratory. Meza was a member of IPAM's Board of Trustees from 2009 to 2013, and has been a member of the Board of Directors of the Society for the Advancement of Chicanos and Native Americans in the Sciences, the National Academies Board on Mathematical Sciences and its Applications, and the American Association for the Advancement of Science Council.

IPAM WELCOMES NEW BOARD MEMBERS

IPAM is pleased to announce that Brenda Dietrich (Cornell) and Russ Caflisch (Courant Institute, NYU) have joined IPAM's Board of Trustees, and Klaus-Robert Müller (TU Berlin) has joined the Science Advisory Board. Caflisch was a UCLA professor and director of IPAM until 2017, when he was selected to lead the Courant Institute. Dietrich recently joined the faculty of the School of Operations Research at Cornell University. Prior to that, she had a 33 year career at IBM where she led the Mathematical Sciences function in the research division. She was elected to the National Academy of Engineering in 2014. Müller is the chair of the Machine Learning Department at TU Berlin. He has been awarded the Science Prize of Berlin and the Vodafone Innovations Award. He is a Member of the German National Academy of Sciences Leopoldina and the Berlin Brandenburg Academy of Sciences.

DEAN'S MATCHING OPPORTUNITY EXTENDED!

Good news — UCLA's Dean of Physical Sciences will match all gifts and multi-year pledges of any amount made to the IPAM Director's Fund Endowment for another year! We raised over $200,000 towards the endowment so far, including a $100,000 gift from AMD (arranged by IPAM Trustee Alan Lee) and many gifts from individuals who recognize the important role of IPAM in the scientific community and value our innovative programs. The Dean also created a matching program for estate giving. If you wish to be part of this campaign, please donate online at ipam.ucla.edu/donate or use the enclosed envelope. If you wish to make a multi-year pledge, please contact Sharon Chang at schang@support.ucla.edu. Gifts of $5,000 or more will be acknowledged on IPAM's upcoming donor wall.

You can still "name a seat" in IPAM's lecture hall with a gift of $1,500, as well! Read more about the IPAM's giving opportunities and fundraising priorities on our website.

FRONTIERS SOCIETY MEMBERS 2017-2018

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 those who made multi-year pledges!

BENEFACTORS: ($2500+)

Tanya Beder and Joseph H. Bretton
John B. and Dolores Garnett
Mark L. and Kathryn Kert Green
Scott and Monique Miller
George and Helen Oda Abe
Ronald J. and Sharon S. Stern

CHAMPIONS ($1000–$2499)

Tony F. and Monica K. Chan
Virginia D. and Alfred W. Hales
Stanley J. Osher
Mike R. Raugh and Vicki L. Johnson
Charlie and Sandy Schwennesen
Leland Wilkinson and Marilyn Vogel
Jeannette M. Wing

VISIONARIES ($500–$999)

Robert Baker
Russ Caflisch and Carol Meylan
James C. and Diana K. Fraser
Valerie Hajdik
Michael J. Hathaway
John W. and Jody A. Jacobs
Dima Shlyakhtenko and Olga Radko

INNOVATORS ($100–$499)

Allen and Joanie Clement
Karina L. Edmonds
Madison B. and Kristen L. Gray
Eilish and Daniel Hathaway
Tatiana Toro and Daniel Pollack

Thanks also to our corporate, foundation and other supporters. IPAM received gifts from AMD, Air Force Research Lab, Google, GumGum, HRL, Microsoft, Praedicat, and The Aerospace Corporation, as well as the Breast Cancer Research Foundation, J.B. Berland Foundation and Julian Schwinger Foundation for Physics Research. IPAM receives grants from the Simons Foundation and NSF's Office of International Science and Engineering, in addition to our main NSF grant. Special thanks to our Latinx in Math Conference sponsors, listed on the first page.

UPCOMING PROGRAMS

LONG PROGRAMS

Science at Extreme Scales: Where Big Data Meets Large-Scale Computing
September 12–December 14, 2018

Geometry and Learning from Data in 3D and Beyond
March 11–June 14, 2019

Machine Learning for Physics and the Physics of Learning
September 4–December 8, 2019

High Dimensional Hamilton-Jacobi PDEs
March 9–June 12, 2020

WORKSHOPS

Analysis and Geometry of Random Shapes
January 7–11, 2019

Women in Mathematics and Public Policy
January 22–25, 2019

Computational Challenges in Gravitational Wave Astronomy
January 28–February 1, 2019

Operator Theoretic Methods in Dynamic Data Analysis and Control
February 11–15, 2019

Braids, Resolvent Degree and Hilbert's 13th Problem
February 19–21, 2019

Autonomous Vehicles
February 25–March 1, 2019

Collaborative Workshop for Women in Mathematical Biology
June 17–21, 2019

OTHER PROGRAMS

Research in Industrial Projects for Students (RIPS)
- *Los Angeles, June 24–August 23, 2019*
- *Berlin, June 24–August 16, 2019*
- *Sendai, June 17–August 9, 2019*
- *Singapore, June 3–August 2, 2019*

CALL FOR PROPOSALS

IPAM seeks proposals from the mathematical, statistical, and scientific communities for long programs, winter workshops, summer schools, and exploratory workshops. Proposals are reviewed by IPAM's Science Advisory Board (SAB) at its annual meeting in November. To receive full consideration, please send your program idea to the IPAM Director at director@ipam.ucla.edu by October 1.

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 2020 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 (JSF).

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.

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. Alternatively, this might be an interaction between two disparate branches of mathematics. A long program opens with tutorials, followed by three or 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 faculty, postdocs, graduate students, and representatives of industry and government you would like to invite. A long program proposal template is available online. Proposals for academic year 2020–2021 will be reviewed at the next SAB meeting.

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, above, and will be considered at any time.

Mark Your Calendars

September 24, 2018. Emmanuel Candès (Stanford) will give two public lectures this week as part of the Green Family Lecture Series.

October 1–2, 2018. IPAM will offer an industrial short course on deep learning and the latest algorithms in artificial intelligence.

January 28, 2019. Nobel Laureate Barry Barish (Caltech) will give two public lectures this week as part of the Green Family Lecture Series.

February 12, 2019. Application deadline for IPAM's undergraduate and graduate-level Research in Industrial Projects for Students (RIPS) Programs in Los Angeles, Berlin, Sendai, and Singapore.

For more information, go to www.ipam.ucla.edu.

Stay Connected

Pure Mathematician

(*continued from page 1*)

proposals were in applied math, which is not my specialty. Then I began talking with physicists who design particle accelerators about some of the pure mathematics problems that arise in their work. Based on those conversations, at the next scientific advisory board meeting I proposed that we do a workshop on the topic."

The result was the IPAM workshop Beam Dynamics, held in 2017 and devoted to better understanding and extending the mathematical methods available to accelerator physicists, as well as to gaining a better grasp of ways to control the physics and technology of these systems, which have many industrial and medical applications. "I was delighted to be able to come up with an idea for a workshop that was applied — the IPAM ideal," Wilkinson says. "And I know I would not have thought of it without my experience on the Science Advisory Board."

Beam Dynamics attracted a diverse group — including physicists and mathematicians, and ranging from academics to individuals working in national laboratories. "It's a wonderfully informal set up at these IPAM workshops, where I felt comfortable taking the microphone from time to time and asking questions that I thought would connect people from different fields who tend to speak very different languages," Wilkinson says. "In the end it was generally agreed among the participants that this workshop was really successful in bringing together colleagues in pure dynamics who were able to talk in depth about concrete problems that the people who design particle accelerators wanted to solve."

Wilkinson then co-organized a second IPAM workshop that was held last January, this one on a pure mathematics topic. New Methods for Zimmer's Conjecture focused on a recent breakthrough in advancing the decades-old work of the mathematician Robert J. Zimmer at the University of Chicago. One of the central questions about Zimmer's conjecture was recently answered by three researchers, including two University of Chicago postdoctoral scholars. After talking with one of the researchers, Indiana University's David Fisher, about the potential for the breakthrough to lead to new ideas that could be used to solve other problems, Wilkinson proposed that they help to co-organize an IPAM workshop that would both present the new techniques and place them within a broader context of work that had begun in parallel fields. "It was fascinating, and it opened up a dialogue that led to some interesting new collaborations," Wilkinson says.

"Some of the most interesting problems in mathematics come from a desire to answer fundamental questions, and it's easy in pure mathematics to lose touch with the original motivating questions that have borne so much fruit," Wilkinson adds. "IPAM is the place where mathematicians can reconnect to the science behind these key questions. The applied mathematics at IPAM isn't just solving a problem and then looking for a field that it might apply to; it's talking to the scientists, finding out what their issues are, and then bringing in mathematicians who are well equipped and interested in answering these questions. That makes it very rewarding for everyone involved." ■

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math changes everything.

MACHINE LEARNING FOR PHYSICS AND THE PHYSICS OF LEARNING

In fall 2019, IPAM will host a long program on the interface of machine learning (ML) and physics. ML is providing powerful tools to extract essential information from experimental or simulation data. Almost every branch of the physical sciences can make significant breakthroughs by embracing, developing and applying ML methods that interrogate high-dimensional complex data in an unprecedented way.

As yet, most applications in the physical sciences have been using rather basic ML techniques, such as fitting, clustering or classifying signals. However, ML provides exciting opportunities to learn the models themselves — i.e., to discover physical principles and structures underlying the data — and to obtain models that provide physical insight in addition to fitting the data. With more realistic constraints, ML will also be able to generate and design complex and novel physical structures.

The exchange between fields can go in both directions. Since its beginning, ML has been inspired by methods from statistical physics. Many modern machine learning tools, such as variational inference and maximum entropy, are refinements of techniques invented by physicists. It is the goal of the IPAM program to push the cross-pollination further in the specific context of discovering physical principles from data. ■