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

NEWSLETTER

SEIBOLD BRINGS EXPERTISE IN TRAFFIC FLOW, VEHICLE AUTOMATION TO IPAM PROGRAMS

Few problems are as universal in affecting everyday lives as the traffic jam. Often, highway slowdowns seem to materialize without explanation — no accident, stoplight, reduced speed limit, or narrowing of the road. But so-called phantom traffic jams can be mathematically modeled and understood, says Benjamin Seibold, an applied and computational mathematician who is an associate professor at Temple University. What's more, Seibold says, the emergence of automated vehicles could have a major disruptive impact, with the potential to greatly reduce or prevent this kind of traffic — or, conversely, to make it worse.

Seibold's path to becoming a leading expert on the mathematical underpinnings of traffic flow grew out of his focus on computational fluid dynamics. "Looking at traffic flow with similar types of mathematical equations allows one to understand the systematic way in which, based on collective behavior, we get these stop-and-go traffic waves and instabilities, and potentially how we might leverage vehicle automation and connectivity to counteract them," he explains.

In a widely viewed animated TED-Ed video, Seibold explains that when the number of cars on the road reaches a critical density, it takes only a minor disturbance — such as a single driver braking slightly — to set off the chain of events culminating in a traffic jam. This phenomenon, caused by a positive

Benjamin Seibold
Temple University

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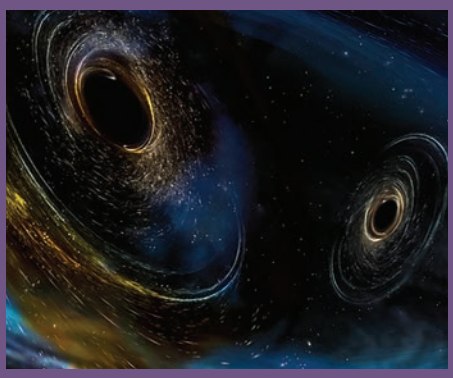
MATHEMATICAL AND COMPUTATIONAL CHALLENGES IN THE ERA OF GRAVITATIONAL WAVE ASTRONOMY



The field of Relativistic Astrophysics has witnessed a major revolution with the historical Nobel-Prize-winning observation of Gravitational Waves (GWs) from a binary black hole merger and the first GW observation of the merger of two neutron stars. The latter was followed by electromagnetic detections from the ground and space triggering an unprecedented multi-instrument observational campaign. These detections have led to the beginning of GW astronomy and the era of multi-messenger astrophysics.

Processing and interpreting the anticipated huge number of forthcoming GW detections will pose a significant challenge and will require close interaction between mathematical modelers, waveform developers, numerical relativists, data analysts and theoretical and observational astrophysicists.

The aim of this program is to connect efforts of the mathematical and physical sciences communities to address the latest advances and new challenges on the understanding of multi-messenger astronomy. The IPAM program will comprise four workshops, each addressing a different topic: the generation of catalogs of waveform templates; the discussion of the mathematical modeling of the equations governing strong relativistic systems; parameter estimation of astrophysical sources of gravitational waves; and the state of the art of big data and deep learning techniques for GW data analysis. ■

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NOTE FROM DIRECTOR DIMA SHLYAKHTENKO

This past year will clearly be remembered as one of the most challenging in recent history. The COVID-19 pandemic has affected the lives of everyone on our planet and has transformed how we live, learn, and do science. IPAM rose to the challenge, transforming its Spring 2020 long program on Hamilton-Jacobi equations as well as our summer undergraduate research programs (RIPS) to an online format. Although not an adequate substitute for our regular in-person programs, the success of these programs has been a testament to the resilience of the human spirit. One important component of this success was IPAM's incredible staff, who were able to rapidly implement multiple changes to our programs as this crisis evolved.

The COVID-19 pandemic has attracted the attention of many scientists, and the role of mathematics has been highlighted in the August 2020 hot topics workshop "Mathematical Models in Understanding COVID-19" at IPAM. IPAM's slogan, "Math Changes Everything" has truly acquired a new meaning, as mathematical techniques of increasing precision are brought in to model, understand, and mitigate the spread of this disease.

The ability to bring together mathematicians and scientist to work on societal problems has been one of the key strengths of IPAM since its inception. Over the last year, IPAM hosted two long programs: one, highlighting applications of Machine Learning to physics, and building on physics insights for Machine Learning; and another, focusing on Hamilton-Jacobi equations in high dimensions and their applications. In addition, we ran five winter workshops, on topics ranging from 2D materials to applications of Deep Learning in Medicine, to Asymptotic Algebraic Combinatorics, Computational Psychiatry, and Intersections between Control, Learning and Optimization. We also ran two exploratory workshops: on Deep Fakery (whose participants collectively wrote a white paper on the subject) and on Mathematics in the Microbiome.

Last, but not least, IPAM received some exciting news: the National Science Foundation has awarded us a $25M renewal grant to fund IPAM's operations through 2025. This investment will enable us to continue fulfilling our mission of building inclusive scientific communities that bring the full range of mathematical techniques to bear on the great scientific challenges of our time. Although no longer a teenager (IPAM turned 20 this Fall), IPAM continues to reinvent itself, focusing on new challenges and ever-expanding scientific horizons. ■

Dima Shlyakhtenko
IPAM Director

LEGAL SCHOLAR CO-ORGANIZES DEEP FAKERY WORKSHOP

Alicia Solow-Niederman
Harvard Law School

When she was preparing to graduate from Harvard Law School in 2017, Alicia Solow-Niederman wouldn't have predicted that she would be attending a two-day mathematics institute workshop barely more than two years later. But such is the multidisciplinary nature of the Institute of Pure and Applied Mathematics (IPAM) that for the workshop Deep Fakery: Mathematical, Cryptographic, Social, and Legal Perspectives, held at IPAM on November 15-16, 2019, Solow-Niederman was not only an attendee, but one of three co-organizers alongside Mark Green and Jacob Foster.

Currently a Climenko Fellow and Lecturer on Law at Harvard, Solow-Niederman specializes in algorithmic accountability and algorithmic governance. "I am interested in how to ensure that, for the regulation of emerging technologies like artificial intelligence in general and for administrative law decisions in particular, we retain democratic and public accountability and adequate safeguards as the law evolves — or doesn't evolve — in the face of technological challenges," she explains.

Solow-Niederman traces her interest in the topic to when she was an undergraduate political science and communications major at Stanford taking a course in the law, politics and technology. She pursued her interest in technology and the law after graduation, working as a research assistant at Harvard's Berkman Klein Center for Internet and Society, and concluded she had found her niche. "Technology is a force multiplier of a lot of social and political inequities, and it seems to me that much of the law is too doctrinal in thinking about these things," Solow-Niederman says. "I'm trying to marry the two sides."

Beginning in 2017, Solow-Niederman was a fellow in UCLA Law's Program on Understanding Law, Science, and Evidence (PULSE). Through PULSE, she helped to organize an ongoing series of informal coffee talks and lunchtime conversations among an interdisciplinary group of scholars from wide-ranging fields — law, political science, sociology, physics, math, computer science, and data science — who shared a common interest in emerging issues and concerns surrounding artificial intelligence. From that group and a conference PULSE organized in the spring of 2018, Solow-Niederman got to know

(continued on next page)

Legal Scholar Co-Organizes Deep Fakery Workshop

(continued from page 2)

Jacob Foster, a UCLA sociologist, and Mark Green, a UCLA mathematician who co-founded IPAM, and she became more interested in deep fakes — automated methods for fabricating information, which have proliferated with advances in technology.

"It's a thorny issue, because it's associated with speech and fundamental rights, but also with the strong potential for harm around degradation of truth — both in courtrooms and in society writ large," Solow-Niederman says. "There is this looming threat, in that so much of society and the health of our democracy rests on a sense of what truth is. At the same time, I'm keenly aware that sitting within law, I don't have all the answers."

To bring together the type of multidisciplinary group needed to engage on these difficult issues, Solow-Niederman joined Foster and Green in co-organizing the deep fakery workshop, which sought to tackle the mathematical, computer science, sociological, legal, and policy issues. Noting that the deep-fake problem is fueled by developments in machine learning and exacerbated by the erosion of trusted sources, the co-organizers stated in announcing the program, "When the apparent authenticity of a piece of information can too easily be cast into doubt — and there is no accepted means to verify its provenance and reliability — we face a society-wide crisis." The workshop aimed to explore the technical, social, and legal countermeasures that should be developed and deployed in response to the quagmire.

Solow-Niederman was pleased with the outcome. "One of our primary goals was to make sure we evenly represented all of the relevant disciplines — mathematicians, computer scientists, cryptologists, lawyers, policymakers, and social scientists," she says. "We tried to be very interactive, coming at it with an attitude of humility about the gaps in our knowledge, so that no one would be afraid to ask questions of people outside their area of expertise." The workshop resulted in a white paper synthesizing the issues discussed and setting out areas for potential research.

"To have a workshop like this where an interdisciplinary group of scholars come together and exchange ideas in a way that goes well beyond the presentation of their own work is rare," Solow-Niederman says. "But these are multidimensional, cross-cutting questions that require people willing to take off their disciplinary blinders, and to its credit, IPAM provides a unique platform for doing that." ■

FOR NURBEKYAN, IPAM WORKSHOP CAREER-ALTERING

As a postdoctoral scholar at King Abdullah University of Science and Technology in Saudi Arabia, Levon Nurbekyan was quite familiar with UCLA and its reputation for having one of the world's top mathematics departments. But Nurbekyan knew little about IPAM when he arrived on the UCLA campus for Mean Field Games, a one-week workshop held August 28 to September 1, 2017.

If Nurbekyan didn't know much about IPAM before he arrived, the institute would become an important part of his professional life from that point on.

"I fell in love with IPAM that week," says Nurbekyan, whose research interest is in the use of partial differential equations (PDEs) as a tool for understanding the behavior of large systems of agents. "It was such a stimulating workshop — an opportunity to learn from the top experts in the field, all of them offering very different perspectives on the subject."

At that 2017 workshop Nurbekyan was particularly moved by a talk given by IPAM's Stanley Osher, a UCLA professor of mathematics. "He was looking at the problems from the applied mathematics and computational standpoint," Nurbekyan recalls. "During his talk, I realized that what I thought was a purely theoretical problem I was working on can actually be applied to computational methods." He returned to IPAM for workshops in 2018 and 2019, and at the second one — by which time Nurbekyan was a postdoctoral scholar at Montreal's McGill University — he had a chance to spend time with Osher and his team discussing his work. After that experience, Osher recruited Nurbekyan to come to UCLA, where he is currently an assistant adjunct professor in the Department of Mathematics.

Nurbekyan has continued to take advantage of the opportunities presented by IPAM in the three years since. Most recently, he participated in the long program, High Dimensional Hamilton-Jacobi PDEs, held March 9 to June 12, 2020. Hamilton-Jacobi PDEs have received considerable attention for their applications in a variety of areas, including mean field games and machine learning. "These equations are at the core of many important subjects of applied mathematics, and this program brought people together from different fields to exchange their perspectives," Nurbekyan says. IPAM's long programs are particularly beneficial because of the way they bring together experts from disparate disciplines and facilitate casual discussions that can spark new ideas, Nurbekyan notes. "Normally, faculty, postdocs and students have their day-to-day duties, but in these long programs everyone is focused on the research topic," he says. "As a result, you get more organic discussions that often take you in directions you hadn't planned on going in." ■

Levon Nurbekyan
University of California Los Angeles

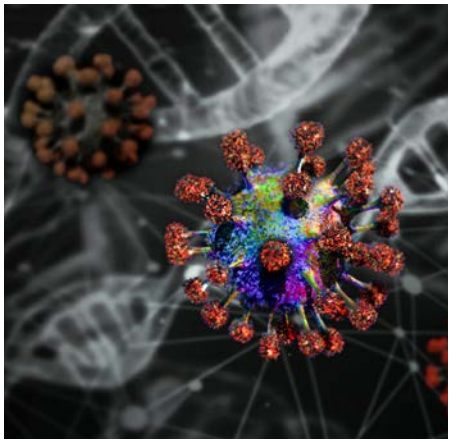
NEWS STORIES

IPAM RESPONDS TO COVID-19 PANDEMIC

In 2020, the world experienced an unprecedented crisis brought on by the COVID-19 pandemic. IPAM was not immune to the effects of the upheaval. After factoring in all developments in the US and across the globe, we made the difficult yet timely decision to transition all our programs to an online format. This included our spring long program and all associated workshops and seminars, and the large part of our student summer research RIPS/G-RIPS programs. The 2020 Graduate Summer School was postponed until 2021. Our decision was informed by our priority to ensure the safety of the students and all concerned parties, as well as the travel restrictions around much of the world.

As mathematicians and the scientific community were scrambling to find ways to virtually meet and collaborate, we shared the experiences IPAM had with organizing online seminars and events. In August 2020, we hosted a three-day workshop on **Mathematical Models in Understanding COVID-19**. The workshop was open to the general public and attracted over 900 registrants. The event brought together mathematicians, epidemiologists, and other subject matter experts to discuss and develop mathematical models that can help policymakers make informed decisions about the pandemic.

IPAM looks forward to reopening its in-person operations just as soon as it is safe to do so. Please check our web page for the most up-to-date status.



IPAM'S CONTINUED SUPPORT FOR EQUITY, DIVERSITY, AND INCLUSION

IPAM is committed to creating a professional and supportive environment for the disenfranchised and the underserved parts of our society, and welcomes participants with a diversity of experiences. Representation of women and underrepresented ethnic groups in our programs as speakers, organizers, and funded participants, as well as in our leadership and governing bodies, is a high priority for IPAM.

IPAM is a founding member of NSF's Mathematical Sciences Institutes Diversity Initiative (MSIDI). Within MSIDI, IPAM has co-sponsored and organized many conferences including the Blackwell-Tapia conference, Spring Opportunities Workshop, the Infinite Possibility Conference, and the pre-SACNAS Modern Math Workshop. Most noticeable, IPAM led the charge in organizing the first ever **Latinx in the Mathematical Sciences Conference** (LatMath) in 2015 which attracted over 150 participants. The great success of this event paved the way for the second LatMath conference in 2018 which was also very well received with participant numbers topping over 220. Speakers at these conferences ranged from high school students to a Field medalist. We are now set to host the third event in the series in 2021.

One of IPAM's signature initiatives is the Research in Industrial Projects for Students (RIPS) program which introduces undergraduate students to industry sponsors to facilitate their career progression and growth. As part of broadening the scope of this program, IPAM plans to host outreach workshops for college students at a junior level in institutions within underserved communities to promote interest and preparedness in STEM subjects. In the initial phase of this program we will leverage our strong ties with California State University at Northridge (CSUN). Apart from RIPS, each year IPAM sponsors a select number of participants from institutions that predominantly serve minority groups to attend its long programs.

While we take pride in our commitment to inclusion and equity, we know that much remains to be done. We actively listen to our participants and organizers to find ways to foster greater diversity of gender, ethnicity, and background in our programs. IPAM leadership has taken on the pledge to develop further effective measures to ensure a more inclusive future. We look forward to working towards it.

Latinx in the Mathematical Sciences Conference

TATIANA TORO AWARDED 2020 BLACKWELL-TAPIA PRIZE

IPAM is proud to report that the 10th Blackwell-Tapia Conference awarded its Blackwell-Tapia prize for 2020 to IPAM's Board of Trustees member Tatiana Toro. This year, the conference was hosted at Statistical and Applied Mathematical Sciences Institute (SAMSI). The award is named after David Blackwell, the first African American elected to the National Academy of Sciences, and Richard Tapia, the winner of the 2010 National Medal of Science. The award, which recognizes "excellence in research among people who have promoted diversity within the mathematical and statistical sciences," began in 2002 and is awarded in even-numbered years. Toro, the Craig McKibben and Sarah Merner Professor of Mathematics at the University of Washington, has participated in several of IPAM's events, including having been an organizer for IPAM's 2018 Latinx in the Mathematical Sciences Conference. She has also participated as a speaker for several other IPAM conferences and workshops.

Tatiana Toro
University of Washington

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**
- **AMD**
- **Aquatic**
- **Google**
- **HLR Laboratories, LLC**
- **Lawrence Livermore National Laboratory**
- **Microsoft**

In addition to support from our main NSF grant, IPAM also received grant funding from the Simons Foundation, and NSF's Office of International Science and Engineering.

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, renovated in 2014. During and since our 15th Anniversary Campaign, IPAM donors named 40 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 allow U.S. students to work side-by-side with students from another country while gaining industrial math research experience.

FRONTIERS SOCIETY MEMBERS 2019-2020

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+)

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UPCOMING PROGRAMS

LONG PROGRAMS

Mathematical Challenges and Opportunities for Autonomous Vehicles
September 14 – December 18, 2020

Tensor Methods and Emerging Applications to the Physical and Data Sciences *March 8–June 11, 2021*

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

WORKSHOPS

Transport and Mixing in Complex and Turbulent Flows *January 11 – 15, 2021*

Actions of Tensor Categories on C*-algebras *January 25 – 29, 2021*

Entropy Inequalities, Quantum Information and Quantum Physics
February 8 – 12, 2021

Deep Learning and Combinatorial Optimization *February 22 – 26, 2021*

SUMMER RESEARCH PROGRAMS

RIPS Singapore 2021
May 31 – July 30, 2021

G-RIPS Sendai 2021
June 17 - August 10, 2021

G-RIPS Berlin 2021
June 21 - August 13, 2021

RIPS Los Angeles 2021
June 21 – August 20, 2021

Graduate Summer School on Post-quantum and Quantum Cryptography
June 22 – July 2, 2021

Graduate Summer School: Mathematics of Topological Phases of Matter
July 26 – 30, 2021

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 program idea by October 1 to 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 2022 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 2022–2023 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

January 4, 2021. Application deadline for IPAM's Latinx in the Mathematical Sciences Conference 2021.

February 12, 2021. Application deadline for IPAM's undergraduate Research in Industrial Projects for Students (RIPS) Programs Los Angeles and Singapore.

February 14, 2021. Application deadline for IPAM's Graduate-level Research in Industrial Projects for Students (G-RIPS) Programs in Berlin and Sendai.

March 22, 2021. Application deadline for IPAM's Graduate Summer School on Post-quantum and Quantum Cryptography.

March 26, 2021. Application deadline for IPAM's Graduate Summer School: Mathematics of Topological Phases of Matter.

May 21 & 22, 2021. Alessio Figalli (ETH Zurich) will give two public lectures this week as part of the Green Family Lecture Series.

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

Stay Connected

Expertise in Traffic Flow, Vehicle Automation to IPAM Programs

(continued from page 1)

feedback loop fueled by the typical behavior of drivers, is known as dynamic instability — a principle also responsible for phenomena such as raindrops and sand dunes.

In recent years, Seibold has become increasingly engaged on the issue of how vehicle automation and connectivity affect traffic flow patterns. "With vehicle automation we're no longer talking about pie-in-the-sky technology that might be here eventually, like fully self-driving cars, but rather cars with features such as lane assist and adaptive cruise control systems," Seibold explains. "These systems, which effectively modify how we drive, are in many consumer vehicles now."

Even when only a small proportion of cars on the road have these systems, Seibold notes, it can dramatically change traffic flow patterns, requiring new mathematical models to understand the implications and potentially leverage the new technology for safer roads and more efficient daily commutes. In one recent experiment, Seibold found that just 4-5% of vehicles being automated could result in a dampening of stop-and-go traffic waves.

Seibold's first exposure to IPAM came in the fall of 2009 when, as a postdoctoral instructor at MIT, he attended the long program Computational Kinetic Transport and Hybrid Methods. He realized immediately that this was not a typical professional meeting. "Traditional conferences are extremely tight — you have lots of content, people move around very quickly, and so there is little time for discussions and outside-of-the-box types of questions," he says. "Those are the kinds of conversations that IPAM facilitates through extra time that's built in to the program. That makes a difference in getting to know participants on a level where you start to brainstorm, and out of that you are more likely to get exciting new ideas and collaborations."

As a core participant in the fall 2015 long program New Directions in Mathematical Approaches for Traffic Flow Management, Seibold became even more enamored with IPAM's culture. The program took a holistic approach, focusing not only on traditional patterns of traffic flow, but also on issues such as shared economy solutions, sensor networks, and the impact of smartphones and social networks. "It provided a richness to a mathematician like me on these problems, with so many intriguing possibilities for new problems to work on," Seibold says. "And, unlike traditional conferences where you see a talk and then have to go home and read the papers yourself, with all the unstructured time you could just approach the speaker over coffee the day after and hear it from the world's expert directly."

As an organizer of the 2019 IPAM workshop Autonomous Vehicles, Seibold sought to build a program in the same spirit — including being purposeful in how each talk flowed from the previous one. "When you see it work out — for example, you thought these two people would appreciate hearing each other's talks, and then you see them chatting for an hour afterward — as an organizer, that is a great feeling of success that is unique to a math institute like IPAM," Seibold says.

One of the purposes of the 2019 workshop was to serve as an introduction and opportunity to get the word out to some of the key players in the field that a longer IPAM program on vehicle automation was being scheduled for the fall of 2020. That program, Mathematical Challenges and Opportunities of Autonomous Vehicles, is set to be held September 14 to December 18, and will bring together mathematicians, engineers, and other scientists to work on wide-ranging theoretical and practical issues. "With COVID-19, we will need to be creative in how this is organized," Seibold says. "But with everyone now used to videoconferencing, we believe we can still capture much of the interactive and collaborative spirit that make these IPAM experiences so great. ■

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math changes everything.

TENSOR METHODS AND EMERGING APPLICATIONS TO THE PHYSICAL AND DATA SCIENCES (MARCH 8 – JUNE 11, 2021)

Linear algebra is an essential mathematical tool in studying natural phenomena as most systems respond linearly to small increments. The most natural generalization of linear algebra is multilinear algebra where matrices are replaced by tensors. This framework is useful to describe natural phenomena where the variation is linear if we keep all but one factor constant.

Tensor representation, analysis and algorithms have recently found useful application in various fields, from many-body quantum systems to large data set analysis in high dimension. For example, in physics, tensor network formats are used to represent ground and thermal states in many-body quantum systems and tensor-based numerical methods, such as the density matrix renormalization group (DMRG) method, have become very popular to study one-dimensional systems. In data science, tensor decompositions have also been used for learning latent variable models, training neural networks, and reinforcement learning. In mathematics, tensor decompositions have been connected to algebraic geometry, and have been shown to have a direct relationship with some of the long-standing problems in computational complexity: P versus NP and matrix multiplication.

While exciting results have emerged from various research communities, there has not been much exchange and collaboration between theoreticians and developers of practical algorithms. This long program will bring together experts and junior participants from different fields and experiences, to exchange ideas, collaborate, and advance the general field of tensor methods. We foresee this program to be a milestone platform for the future development of the research area and to have a long standing impact. ■