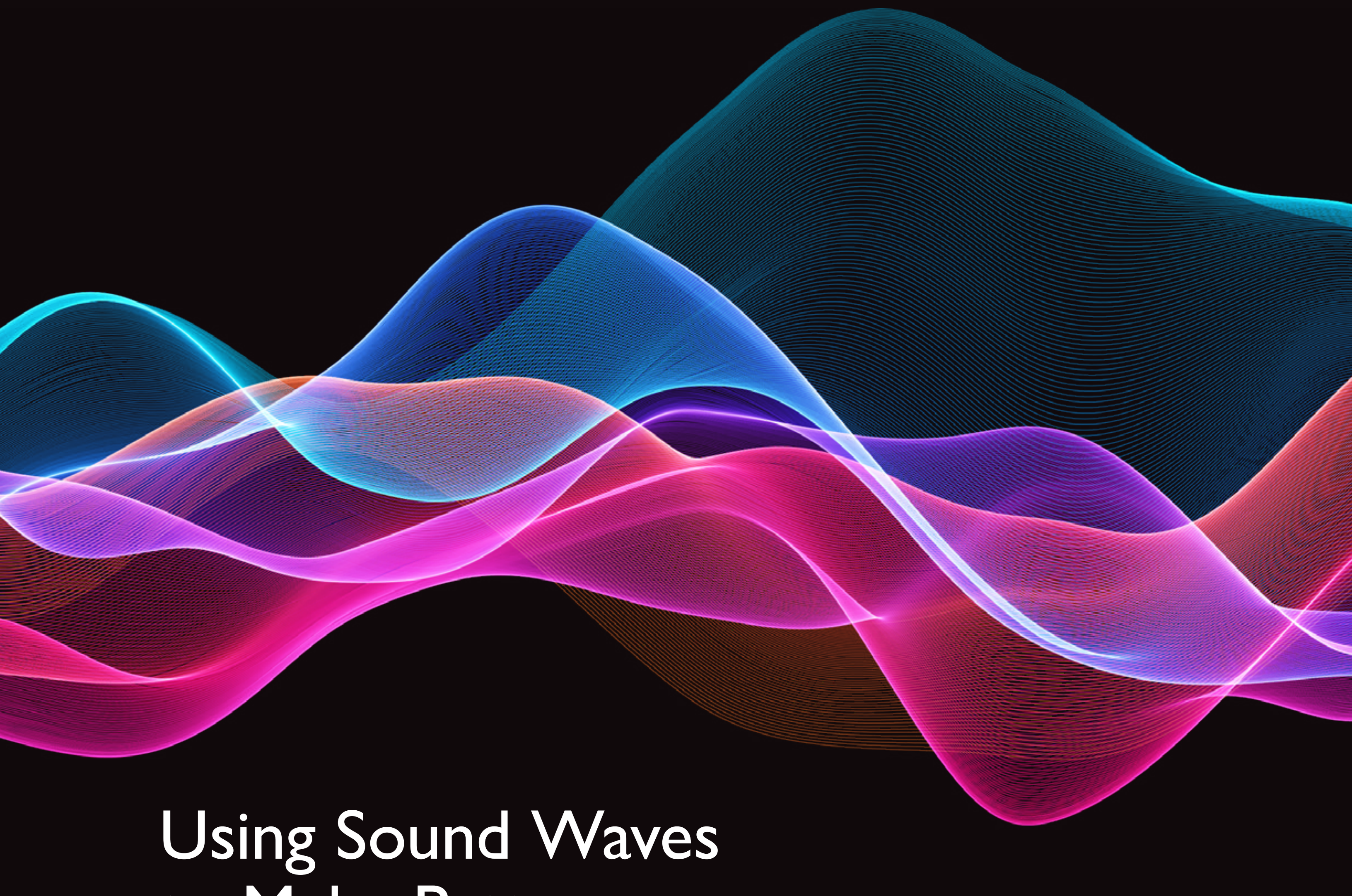
Summer 2021 | Volume 20, Issue 2

Aftermath

UNIVERSITY OF UTAH DEPARTMENT OF MATHEMATICS



Using Sound Waves to Make Patterns that Never Repeat

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**Correction: the fall 2020 print issue had an incorrect photo on page 14. We regret the error.*

Message from the Chair

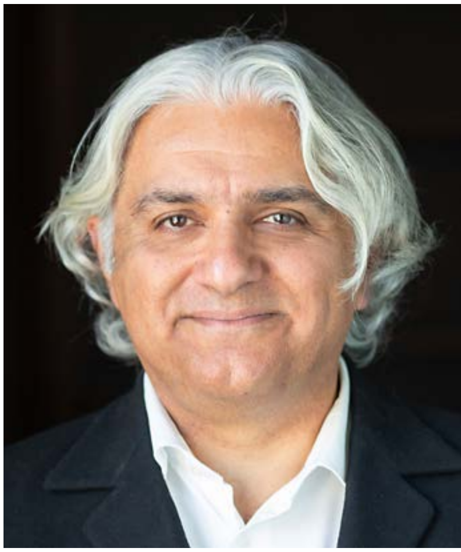
As you know, the 2020-2021 academic year has been difficult and challenging for our students, faculty, and staff due to the pandemic. We have risen to these challenges with determination, flexibility, and good humor.

With the success of the COVID vaccination program at the university and in Utah, faculty and students were able to meet in person for convocation and the hooding ceremonies for our Ph.D. candidates. It was wonderful to see our students—even with masks and social distancing—after so many months apart.

We want to recognize the achievement of our undergraduate and graduate students in completing their degree requirements. They have worked very hard to reach this milestone under truly extraordinary circumstances. It has been a great pleasure teaching and working with them, and we wish them the best as they move forward in their lives and careers.

We anticipate a full return to campus—with in-person teaching and on-campus events—in the fall. It will be wonderful to return to campus and resume our patterns of academic life.

Our faculty has been honored to receive a number of National Science Foundation awards and a Simons Fellowship (see page 5). This is a remarkable achievement for our department to be recognized in this way, and it reflects well on our entire academic community. We are fortunate to have such dedicated and talented faculty, who serve as teachers, researchers, and mentors to our students. I hope you'll take the time to read about their interesting research and accomplishments in the magazine.



Davar Khoshnevisan

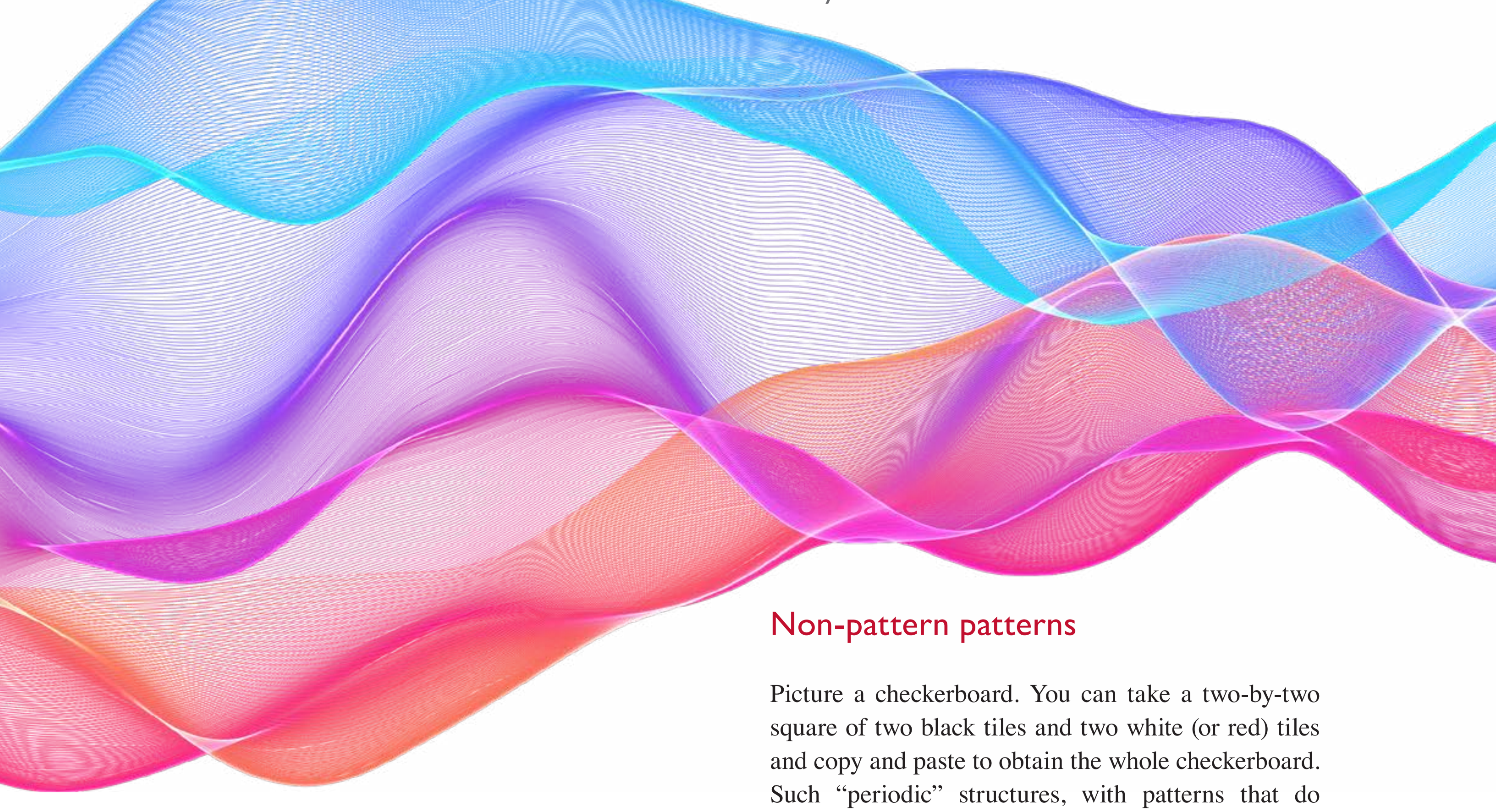
Thank you for your support and generosity. Your interest makes such an important difference in advancing our mission of excellence, teaching, mentoring, and research.

Best regards,

Davar Khoshnevisan
Professor and Chair
Department of Mathematics

Using sound waves
to make patterns that never repeat

By Paul Gabrielsen, science writer,
University of Utah Communications



Mathematicians and engineers at the University of Utah have teamed up to show how ultrasound waves can organize carbon particles in water into a sort of pattern that never repeats. The results, they say, could result in materials called "quasicrystals" with custom magnetic or electrical properties.

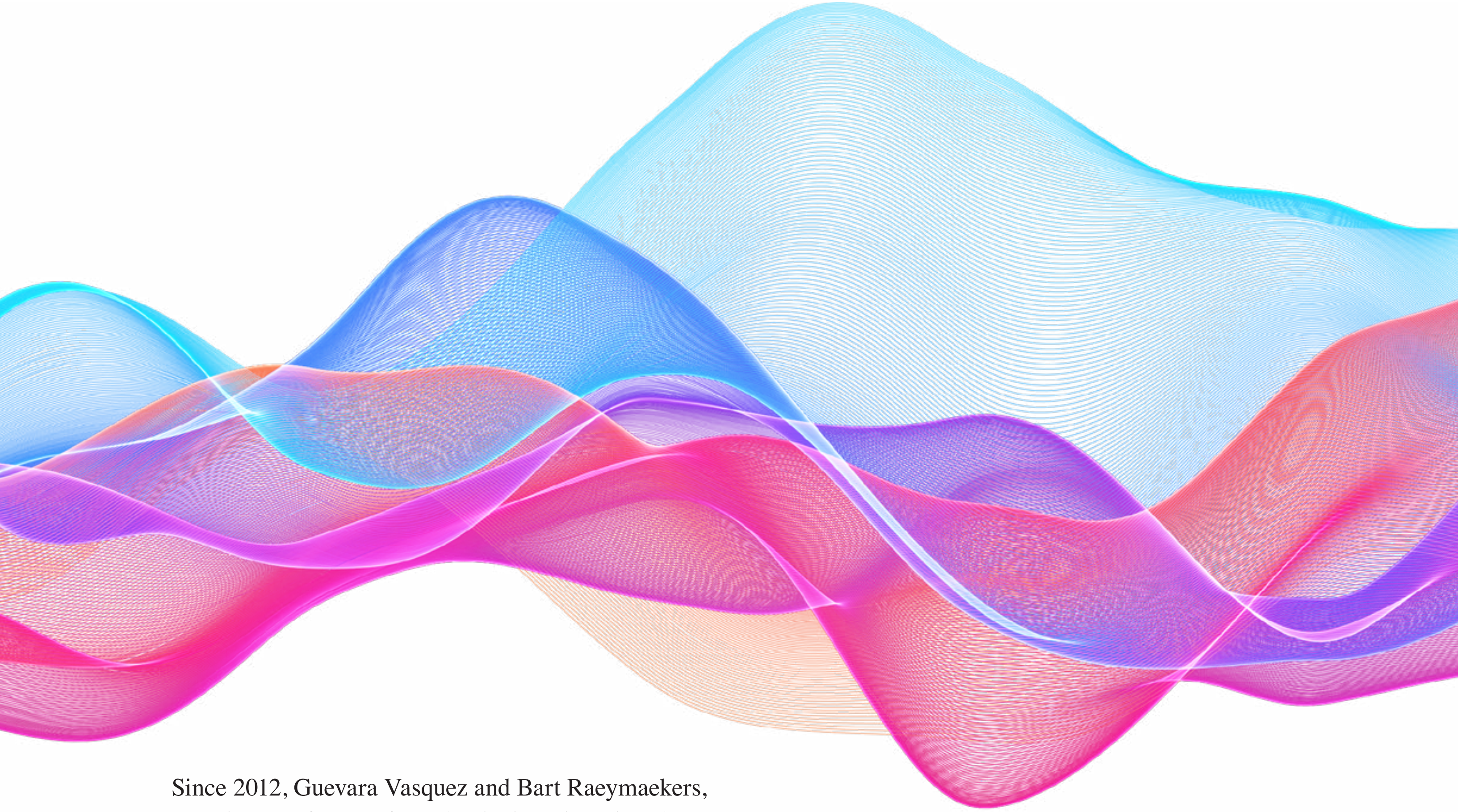
The research is published in *Physical Review Letters*. "Quasicrystals are interesting to study because they have properties that crystals do not have," says Fernando Guevara Vasquez, associate professor of mathematics at the U. "They have been shown to be stiffer than similar periodic or disordered materials. They can also conduct electricity or scatter waves in ways that are different from crystals."

Non-pattern patterns

Picture a checkerboard. You can take a two-by-two square of two black tiles and two white (or red) tiles and copy and paste to obtain the whole checkerboard. Such "periodic" structures, with patterns that do repeat, naturally occur in crystals. Take, for example, a grain of salt. At the atomic level, it is a grid-like lattice of sodium and chloride atoms. You could copy and paste the lattice from one part of the crystal and find a match in any other part.

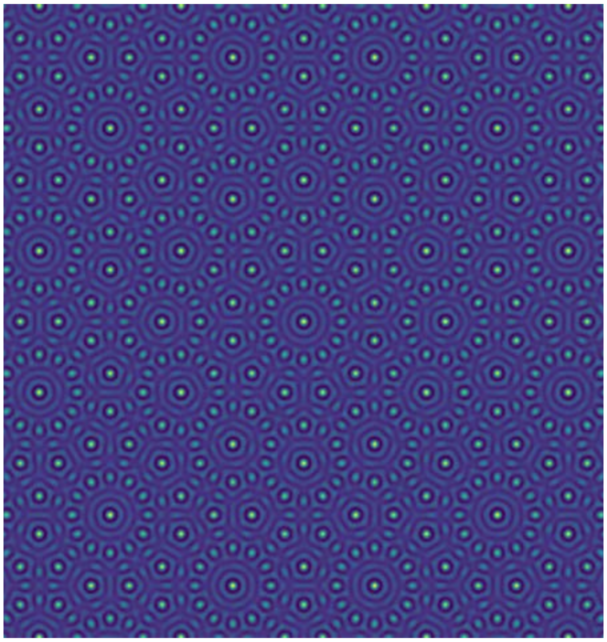
But a quasiperiodic structure is deceiving. One example is the pattern called Penrose tiling. At first glance, the geometric diamond-shaped tiles appear to be in a regular pattern. But you can't copy and paste this pattern. It won't repeat.

The discovery of quasiperiodic structures in some metal alloys by materials scientist Dan Shechtman earned a 2011 Nobel Prize in Chemistry and opened up the study of quasicrystals.



Since 2012, Guevara Vasquez and Bart Raeymaekers, associate professor of mechanical engineering, have been collaborating on designing materials with custom-designed structures at the microscale. They weren't initially looking to create quasiperiodic materials—in fact, their first theoretical experiments, led by mathematics doctoral student China Mauck, were focused on periodic materials and what patterns of particles might be possible to achieve by using ultrasound waves. In each dimensional plane, they found that two pairs of parallel ultrasound transducers suffice to arrange particles in a periodic structure.

But what would happen if they had one more pair of transducers? To find out, Raeymaekers and graduate student Milo Prisbrey (now at Los Alamos National Laboratory) provided the experimental instruments, and mathematics professor Elena Cherkaev provided experience with the mathematical theory of quasicrystals. Guevara Vasquez and Mauck conducted theoretical calculations to predict the patterns that the ultrasound transducers would create.



A quasiperiodic two-dimensional pattern.

PHOTO CREDIT: Courtesy of Fernando Guevara Vasquez

Creating the quasiperiodic patterns

Cherkaev says that quasiperiodic patterns can be thought of as using, instead of a cut-and-paste approach, a "cut-and-project" technique.

If you use cut-and-project to design quasiperiodic patterns on a line, you start with a square grid on a plane. Then you draw or cut a line so that it passes through only one grid node. This can be done by drawing the line at an irrational angle, using an irrational number like pi, an infinite series of digits that never repeats. Then you can project the nearest grid nodes on the line and can be sure that the patterns of the distances between the points on the line never repeats. They are quasiperiodic.

The approach is similar in a two-dimensional plane. "We start with a grid or a periodic function in higher-dimensional space," Cherkaev says. "We cut a plane through this space and follow a similar procedure of restricting the periodic function to an irrational 2-D slice." When using ultrasound transducers, as in this study, the transducers generate periodic signals in that higher-dimensional space.

The researchers set up four pairs of ultrasound transducers in an octagonal stop sign arrangement. "We knew that this would be the simplest setup where we could demonstrate quasiperiodic particle arrangements," Guevara Vasquez says. "We also had limited control on what signals to use to drive the ultrasound transducers; we could essentially use only the signal or its negative."

Into this octagonal setup, the team placed small carbon nanoparticles, suspended in water. Once the transducers turned on, the ultrasound waves guided the carbon particles into place, creating a quasiperiodic pattern similar to a Penrose tiling.

"Once the experiments were performed, we compared the results to the theoretical predictions and we got a very good agreement," Guevara Vasquez says.

The experimental setup with four pairs of ultrasound transducers surrounding a reservoir with carbon nanoparticles suspended in water.

PHOTO CREDIT: Courtesy of Fernando Guevara Vasquez

Custom materials

The next step would be to actually fabricate a material with a quasiperiodic pattern arrangement. This wouldn't be difficult, Guevara Vasquez says, if the particles were suspended in a polymer instead of water that could be cured or hardened once the particles were in position.

"Crucially, with this method, we can create quasiperiodic materials that are either 2-D or 3-D and that can have essentially any of the common quasiperiodic symmetries by choosing how we arrange the ultrasound transducers and how we drive them," Guevara Vasquez says.

It's yet to be seen what those materials might be able to do, but one eventual application might be to create materials that can manipulate electromagnetic waves like those that 5G cellular technology uses today. Other already-known applications of quasiperiodic materials include nonstick coatings, due to their low friction coefficient, and coatings insulating against heat transfer, Cherkaev says.

Yet another example is the hardening of stainless steel by embedding small quasicrystalline particles. The press release for the 2011 Nobel Prize in Chemistry mentions that quasicrystals can "reinforce the material like armor."

So, the researchers say, we can hope for many new exciting applications of these novel quasiperiodic structures created by ultrasound particle assembly.

Firas Rassoul-Agha

FACULTY DISTINCTIONS

Firas Rassoul-Agha awarded a Simons Fellowship

Firas Rassoul-Agha, professor of mathematics, has been awarded a Simons Fellowship in Mathematics for 2021. The Simons Foundation supports the work of distinguished scientists by providing academic leaves from one term to a full year, enabling recipients to focus solely on their research for the long periods often necessary for significant advances.

“Joining the list of Simons Fellows for the second time is a great honor,” said Rassoul-Agha. “It’s an opportunity to have a whole year of intense research, which will accelerate progress on several big projects and get them to completion much sooner.”

Rassoul-Agha’s research is on the interface of probability theory and rigorous aspects of statistical mechanics. “I work on understanding the evolution of systems with complex interactions, such as particles moving in a disordered environment, heat diffusing in an inhomogeneous alloy, cars navigating their way through traffic, the rough surface of a growing crystal, and the boundary of an infected tissue,” he said. “Complexity is captured by the randomness in the model, both in the environment with which the particles interact or in which the crystal grows, and in the interaction or growth process itself. I focus on developing the mathematical laws that govern such systems such as quantifying the particle density evolution, the roughness of the growing interface, and the properties of the optimal particle trajectories.”

He obtained a Ph.D. from New York University’s Courant Institute of Mathematical Sciences in 2003 and was a visiting assistant professor and postdoctoral researcher at Ohio State University. He joined the U as an assistant professor in 2005; an associate professor in 2009; and a professor in 2014.

Rassoul-Agha has received numerous awards throughout his career, including a previous Simons Foundation Fellowship and a National Science Foundation CAREER Award. In 2019, he was named a member of the Class of Fellows of the Institute of Mathematical Statistics.

Priyam Patel

FACULTY DISTINCTIONS

Priyam Patel receives NSF CAREER Award

Priyam Patel, assistant professor of mathematics at the U, has received a National Science Foundation CAREER Award. The award is the most prestigious NSF award for faculty members early in their careers as researchers and educators. It recognizes junior faculty members who successfully integrate education and research within their organizations. The award comes with a federal grant for research and education activities for five consecutive years.

“I’m thrilled to receive the award, and I’m very excited to have the ability to pursue the research and educational projects the grant will afford,” said Patel. “The award also recognizes the significant support the Math Department and the University of Utah provide to faculty.”

Patel works in geometry and topology. The two areas differ in that geometry focuses on rigid objects where there is a notion of distance, while topological objects are much more fluid. In her research, Patel’s goals are to study and understand curves on surfaces, symmetries of surfaces, and objects called hyperbolic manifolds and their finite covering spaces. Topology and geometry are used in a variety of fields, including data analysis, neuroscience, and facial recognition technology. Patel’s research doesn’t focus on these applications directly since she works in pure mathematics.

She is currently working on problems concerning groups of symmetries of certain surfaces. Specifically, she has been studying the mapping class groups of infinite-type surfaces, which is a new and quickly growing field of topology. “It’s quite exciting to be at the forefront of it. I would like to tackle some of the biggest open problems in this area in the next few years, such as producing a Nielsen-Thurston type classification for infinite-type surfaces,” she said. She is also interested in the work of Ian Agol, professor of mathematics at Berkeley, who won a Breakthrough Prize in 2012 for solving an open problem in low-dimensional topology. Patel would like to build on Agol’s work in proving a quantitative version of his results. Other areas she’d like to explore are the combinatorics of 3-manifolds and the theory of translation surfaces.

Patel joined the U’s Math Department in 2019.

Professors awarded NSF Fellowships

Two professors in the Department of Mathematics each have been awarded a Mathematical Sciences Postdoctoral Research Fellowship from the National Science Foundation. The fellowship is for three years and is given to support future leaders in mathematics and statistics by helping them participate in postdoctoral research that will enhance their development.

Elizabeth Field

Elizabeth Field serves as assistant professor (lecturer). "I'm delighted to have received this award, and I'm very excited to be able to continue as a postdoc at the University of Utah and to pursue research projects which will be supported by this fellowship," said Field. "The Math Department has a fabulous group of undergraduate, graduate, postdoctoral, and faculty researchers in my area, and I'm thrilled to be able to continue to work with them."

Elizabeth Field

Field's research intersects three related fields of mathematics: geometry, topology, and algebra. Geometry and topology both study the "shape" of an object, with geometry focusing on rigid features such as distance, and topology concerned with more fluid notions, such as dimension. The algebraic side of what Field studies provides a formal way of describing how geometric and topological objects interact with various other spaces.

Her research takes inspiration from what is known about finite-type surfaces and 3-manifolds, with the goal of extending results to the setting of infinite-type surfaces, as well as to more general algebraic settings. In general, geometry, topology, and algebra have many applications to areas such as neural mapping, data analysis, and cryptography; however, Field's research is theoretical in nature and doesn't focus on these applications.

Field is grateful for the support and encouragement of the faculty in her research area, especially to Distinguished Professor Mladen Bestvina, who will serve as her official NSF sponsoring scientist, and assistant professor Priyam Patel, who has inspired many of the goals of Field's research.

She received a Ph.D. from the University of Illinois at Urbana-Champaign in 2020 and began teaching at the U in July 2020.

Alicia Lamarche

Alicia Lamarche

Alicia Lamarche is an assistant professor (lecturer) in the department. "I am incredibly grateful and excited for this opportunity that will allow me to focus on my research goals," said Lamarche. "I want to thank all of the wonderful mentors, collaborators, and peers that I've had the privilege of working with (and learning from) thus far in my mathematical career."

Her research interests lie at the intersection of algebraic geometry and number theory, she says. In particular, Lamarche is interested in using techniques from algebraic geometry to answer questions that are traditionally number-theoretic in nature, such as determining if/when a collection of equations has a solution given certain constraints—and examining the geometry of these solutions.

She received a Ph.D. in mathematics under the supervision of Dr. Matthew Ballard from the University of South Carolina in May 2020 and began her postdoc position at the U in July 2020.

Amanda Cangelosi

Amanda Cangelosi receives U's Early Career Teaching Award

Amanda Cangelosi, instructor (lecturer) in the Mathematics Department, has received the 2021 Early Career Teaching Award from the University of Utah. The award is given to outstanding young faculty members who have made significant contributions to teaching at the university. Specifically, the University Teaching Committee looks for a faculty member who has distinguished her or himself through the development of new and innovative teaching methods, effectiveness in the curriculum and classroom, as well as commitment to enhancing student learning.

"I'm honored to receive this award and recognition from the university," said Cangelosi. "Since my work focuses on the preparation of future Utah K-12 teachers, which intersects with social justice goals in a foundational way, this award means that the U cares about dismantling systemic oppression. There is nothing more systemic than K-12 education, and thus no more impactful space to invest one's energy."

Cangelosi received her Bachelor of Science degree in Mathematics Education, as well as a Master's of Statistics degree from Utah State University. She also has a post-baccalaureate degree in mathematics from Smith College. Cangelosi is leaving the U and joining Utah State University. We wish her continued success in her career.

Isaac Martin awarded NSF Fellowship

Eleven University of Utah graduate students were awarded the National Science Foundation's Graduate Research Fellowship Program (NSF GRFP) for 2021. The prestigious and highly competitive fellowship supports outstanding doctoral and research-based master's students doing research in science, technology, engineering, and mathematics (STEM) disciplines.

One recipient is Isaac Martin, who recently graduated from the U with an Honors Bachelor of Science Degree in Mathematics and a Bachelor of Science Degree in Physics. Martin received a number of scholarships during his undergraduate years at the U, including an Eccles Scholarship and a 2020 Barry Goldwater Scholarship. He recently was awarded a Churchill Scholarship and will begin studies this fall at the University of Cambridge in England. After he completes his year in Cambridge, he will begin a Ph.D. program in mathematics at the University of Texas at Austin.

Isaac Martin

What was your research that served as the basis for receiving the fellowship?

"For the NSF GRFP statement I wrote about conjectures surrounding the 'weak implies strong' conjecture and the following stronger conjecture: 'if R is a strongly F-regular ring of prime characteristic $p > 0$, the symbolic Rees algebra is Noetherian at divisorial ideals.' The latter would imply the former, and they are some of the most important open conjectures in the field of F-singularities. My most recent research involved F-singularities. I proved a small result, which said that the number of torsion divisors is bounded by the reciprocal of F-signature."

What does receiving the award from the NSF mean to you?

"Being recognized provides validation to my potential as a researcher and confirms that the work I put in as an undergraduate was worth it. Renowned mathematicians who had previously never heard of me judged both my past work and my future plans and deemed that I have potential. That alone means a lot to me.

"The funding I'll receive is also very important. Combined with a fellowship provided by UT Austin, during my Ph.D. program, I will have up to five years of funding, with no teaching requirements. This will leave me free to teach at my own volition and will allow me to dedicate most of my time to research. With this increased freedom, I hope to start an outreach program for high school students, specifically for those who have been homeschooled. Often, these students don't have access to extra-curricular opportunities in math. Such a program would have been tremendously beneficial to me back when I was in high school."

Continued on page 11

Andy Liu

GRADUATE DISTINCTIONS

Andy Liu receives Honorable Mention from NSF GRFP

As noted in the previous article, 11 University of Utah graduate students were awarded the National Science Foundation's Graduate Research Fellowship Program (NSF GRFP) for 2021. Fourteen other U graduate students received an Honorable Mention from the NSF.

Andy Liu is one of those who received an Honorable Mention. He is a graduate student in the Department of Mathematics, working on a Ph.D. in mathematical biology.

Tell us about your research.

"I'm interested in using a branch of machine learning called 'reinforcement learning' to better understand the function of biological brains. My goal is to explain why intelligent agents perform tasks that are indirectly related to their goals (called auxiliary tasks) and how we can replicate those tasks to improve artificial intelligence performance.

"To understand this, look at babies and young children. They play with intense curiosity, challenging themselves and developing an understanding of how the world works. Without any definite goals, they can become adept at physics, language, and even abstract thinking. What drives them? How do they decide what they are interested in or when to give up?

"Research in robotics has shown that allowing an artificial intelligence (AI) to play just like a baby—without any goals or desired outcome—helps us develop a much more masterful AI—one that is more robust than one trained on only one task. I believe that programming more general AI with this kind of intrinsic motivation and curiosity will allow it to learn more effectively. Studying how the AI responds to different ways of learning will teach us about ways we can improve or enhance our own teaching and learning capabilities."

What does receiving recognition from the NSF mean to you?

"I've wanted to study intelligence for a long time but was always told that the big picture ideas I'm interested in are impossible to study. Receiving an honorable mention from the NSF means a lot to me because it's confirmation that my ideas are worth pursuing. It's like hearing a respected source say, 'Go, and show us what you've got!'"

What do you like about math?

"There are a ton of things I like about it! I like how we can start with a few definitions and assumptions and play with them to create new knowledge. I like how the same math problems can be approached from different angles to allow us to learn new things in the process. Most of all, I like how the same mathematical concept will appear in nature over and over in different contexts, as if math gives us the language to listen to the world."

Where did you study as an undergraduate?

"I received my undergraduate degree in mathematics from the University of California, Los Angeles. One of my professors obtained her Ph.D. from the University of Utah and spoke highly of it. With my interest in biologically inspired intelligence, I was attracted to the math biology program here at the U. After I visited, saw the friendly atmosphere, and met with Dr. Alla Borisyuk (who has since become my advisor), I knew this was the place for me!"

Long-term career plans?

"I'm still early in my Ph.D. life, so I think what happens moving forward depends on how my research goes. I want to pursue a doctorate because I have ideas about studying intelligence that I want to try. I plan to continue my research until I'm satisfied that I've given it and my ideas the time and space they deserve."

Isaac Martin Awarded NSF Fellowship *continued from page 9*

What do you plan to study at UT Austin?

"When I begin my Ph.D. program at UT Austin, I intend to pivot into a different area of algebraic geometry. Specifically, I hope to study mirror symmetry and tropical geometry. Mirror symmetry is a branch of algebraic geometry that is motivated heavily by string theory and quantum field theory. In recent years this has been studied in conjunction with tropical geometry, particularly through the Gross-Seibert program.

"At this point in my studies, I know far less about mirror symmetry than I do about F-singularities, in no small part because the barrier to entry is quite high. Nevertheless, I'm quite excited by the prospect of working in this area because it features connections to many different subfields of math, including algebraic geometry, differential geometry, and complex geometry. Even more exciting to me is that this area of study stems from string theory and may one day provide answers to some of the biggest questions in theoretical physics, potentially changing our perception of the universe. This topic fits perfectly with my desire to work as a mathematician, while still aiding research in theoretical physics. In many ways, I couldn't ask for a better area of research!

"Interestingly, two of the biggest active researchers in the area—Mark Gross and Bernd Seibert—are professors at Cambridge and UT Austin, respectively. I will begin reading with both Gross and Seibert over this summer. After that, I hope to write a Part III essay with Gross during my year at Cambridge. By the fall of 2022, I hope to have developed the requisite background to begin actively conducting research in mirror symmetry and tropical geometry. I'm looking forward to it all."

Isaac Martin brings home the U's sixth straight Churchill Scholarship

By Paul Gabrielsen, senior science writer, University of Utah Communications

For the sixth consecutive year, a College of Science student has received the prestigious Churchill Scholarship to study at the University of Cambridge in the United Kingdom. Isaac Martin, a senior honors student, who majored in mathematics and physics, is one of only 17 students nationally to receive the award this year.

Martin's designation ties with Harvard's six-year run of consecutive Churchill Scholars (1987-1992) and is second only to Princeton's seven-year streak (1994-2000).

"Isaac's recognition as a Churchill Scholar is the result of years of remarkable discipline and dedication to a field of study that he loves," said Dan Reed, senior vice president for Academic Affairs.

Martin decided to apply for a Churchill Scholarship as a freshman after meeting for lunch with Michael Zhao, a 2017 Churchill Scholar, who unexpectedly passed away in 2018.

"I am positively delighted and quite flabbergasted to receive the scholarship," Martin said, "but I wish I could phone Michael to thank him for making the opportunity known to me. His legacy lives on in the undergraduate program of the Math Department here at the U, where many others like me have greatly benefited from the example he set."

Martin, a recipient of an Eccles Scholarship and a 2020 Barry Goldwater Scholarship, remembers as a kindergartener trying to write down the biggest number in existence and, as an eighth grader, suddenly understanding trigonometry after hours of reading on Wikipedia.

"That sensation of understanding, the feeling that some tiny secret of the universe was suddenly laid bare before me—that's something I've only felt while studying math and physics, and it's a high I will continue to chase for the rest of my life," he said.

Books by Carl Sagan and Jim Baggott also kindled his love of math and physics, and after several years of self-directed study in middle and high school and a year at Salt Lake Community College, Martin enrolled at the U as a mathematics and physics double major.

After early undergraduate experiences in the research labs of physics professors Vikram Deshpande and Yue Zhao, Martin found himself gravitating more toward mathematics. He completed a Research Experience for Undergraduates (REU) at UC Santa Barbara studying almost Abelian Lie groups, which have applications in cosmology and crystallography, under Zhirayr Avetisyan. This experience resulted in Martin's first research paper. He later completed another REU at the University of Chicago.

"This research was incredibly rewarding because while it applied to physics, the work itself was firmly rooted in the realm of pure math," said Martin.

Returning to Utah, Martin worked with professors Karl Schwede and Thomas Polstra to study F-singularities and developed this work into a single-author paper and his honors thesis with Professor Anurag Singh.

"I would not be where I am today without the incredible faculty at the U and their willingness to devote time to undergraduates," he said.

At Cambridge, Martin hopes to study algebraic geometry, number theory, and representation theory ("in that order," he says) in pursuit of a master's degree in pure mathematics.

"I'm particularly interested in learning as much as I can about mirror symmetry, which I intend to make my essay topic," he adds. "I also plan to drink a lot of tea and to buy one of those Sherlock Holmes coats. I will also begrudgingly begin using the term 'maths,' but I promise to stop the instant I board a plane back to the U.S. in 2022."

After he returns from Cambridge, Martin plans to earn a doctoral degree in pure mathematics and enter academia, using his experiences in many different educational systems including U.S. and British public schools, homeschooling, and online learning, to broaden opportunities for students from a diversity of backgrounds.

"My past has molded me into who I am today," he said, "and I hope I can use my experiences to create programs in STEM for opportunity-starved students, whether they are held back due to non-traditional schooling or to socio-economic factors."

ALUMNA PROFILE

Jan McCleery


Mike and Jan McCleery

Jan McClure was one of four women in a physics class of 200. It was Professor Emeritus Irvin Swigart's sophomore physics lecture class. The students were seated alphabetically, and the guy next to McClure was Michael McCleery—they met for the first time that day. "I got really lucky," said Mike. Later, after they had both completed their undergraduate degrees, they married. In June 2021, they will have celebrated 50 years of marriage.

"Math was always my favorite subject," said McCleery. "As a child, my cousin would gather the neighborhood kids to marvel while I solved long-division problems on the sidewalk in chalk. Yes, I was quite the geek."

As a senior at South High School, she was encouraged to apply to the U, Stanford University, and Carleton College in Minnesota. She was accepted to all three, but her parents couldn't afford to send her out of state. "My father never owned a credit card and paid cash for his cars and our home. I was only 17, so the idea of financial assistance was never a consideration," she said. "I received a scholarship to the U and could live at home. I'm glad it worked out that way since I met Mike at the U."

Memories of the U

In addition to their classes, she and Mike enjoyed Greek life—Mike was a member of Sigma Phi Epsilon, and she joined the Golden Hearts little sister group. They both enjoyed the special friendships they made and still get together for reunions when they visit Utah.

She loved skiing, and she and Mike would arrange their Tuesday/Thursday schedule so they could finish classes by 10 or 11 a.m. "We'd wear our ski clothes to class, so we could go directly to the ski slopes for a half-day pass," she said. "In the warmer months, we enjoyed hiking and backpacking in the mountains."

After receiving a bachelor's degree in math (with a minor in physics), she taught math at Lincoln Junior High in Salt Lake City, the same middle school she had attended and where Mike's mother also taught. "The kids called us the upstairs Mrs. McCleery and the downstairs Mrs. McCleery," she said. "They were going to call us the old and the new, but Mike's mom squelched that idea quickly."

Graduate school

She also began taking graduate night classes. The next year, she and Mike moved into his parents' basement so they could afford to both attend school full time.

Her favorite math teacher was Professor Don Tucker. "He was caring and wise, and I still remember his exciting outlook on mathematics, as well as his humor," she said. The late Professor Emeritus William J. Coles was her thesis advisor and encouraged her to use Professor Emeritus Klaus Schmitt's new, unique approaches to boundary value differential equations for her thesis. Dr. Schmitt's findings enabled her to prove a set of non-linear stability equations each in less than a page—theorems that had previously taken many pages to prove. Those three professors mentored her and gave her confidence during her orals.

During the summer, she was working for the Math Department, typing up new math books written by department professors. The day before the semester began, Professor Tucker realized he hadn't received an acceptance from one of the teaching fellows from Stanford. He knew McCleery had applied as a teaching fellow and ran into the office where she was typing to ask if she wanted a half-fellowship starting the next day, teaching one undergraduate math class. "Sure!" she exclaimed. A few hours later, Dr. Tucker ran in again and yelled, "Make that a full fellowship!"

Life in Silicon Valley

After she and Mike received their master's degrees in 1973, they began working at Ford Aerospace in Silicon Valley—she spent nearly 20 years there while they raised their two daughters. She began as a scientific programmer with assignments such as satellite design and tracking, circuit simulations, raster-scan analysis, and microprocessors. She enjoyed the variety and wide range of programming languages she learned and new technologies. She found that her studies at the U equipped her with strong analytical skills and a passion for problem solving. During her tenure, she was promoted to software manager, responsible for the company's software design tools, artificial intelligence, software security, and computer and configuration management.

She left Ford Aerospace after accepting a job in a commercial software company, eventually moving on to become director of quality assurance at ASK Computers Ingres Database division in Alameda, Calif. Later, she was a product line manager for ASK MANMAN, responsible for marketing, development, and customer support.

The dot-com boom was going strong, and she was invited to join a startup that focused on building sales tools for semiconductor companies. Starting a company had been her dream for years. She and two other co-founders formed Intelic, which was later renamed Azerity. She created the product prototype, formed an engineering team, and served as vice president and chief technology officer. "Those years were the highlight of my career," she said. "We had a great deal of success because of the industry knowledge of my two partners and the quality of the talent we were able to attract." McCleery solicited a manager she knew from Ford Aerospace to join them. Together they developed a new, practical software methodology that resulted in bug-free, on-time, scalable, reliable, and maintainable enterprise software.

Azerity's product was called "ProChannel" and was used by 30,000 semiconductor company sales reps and distributors worldwide. After the U.S. economy began to slow in the 2000s, she and her partners sold the company, but their product is still being used worldwide today. Jan stayed on to consult for the new company and retired in 2014.

Advice for students

Her advice to students is to study hard but also enjoy college life. "Some of the friendships you make at the U will last a lifetime," she said. She encourages students to study math, physics, astronomy, and computers to broaden their analytical skills and to open up a wide spectrum of possible vocations. In terms of a career, her recommendation is to find a company to work for that has a product or service you want to put your time and effort into—a product that excites you and with a working atmosphere that inspires you to be your best.

Retired life

The McCleerys live in Discovery Bay on the California Delta, which marks the confluence of the Sacramento River and the San Joaquin River. The Delta has 1,000 miles of waterways, and they enjoy exploring them by boat. A decade ago, McCleery and others formed Save the California Delta Alliance, when the state of California planned a big tunnel construction project that would have ruined the Delta. She served as president for several years, and the nonprofit has been raising money for scientists to testify on behalf of the alliance. To date, they have successfully pushed back on proposed projects that threaten the Delta.

McCleery has written several books, including two children's books. One is called *The Fable of the Farmer and the Fish* that educates kids about the water issues in the Delta and how to be good stewards of the environment. *Sassy the Salmon* is about the circle of life. She has also written two non-fiction books: *It Starts with an Idea* about her software start-up adventure, including advice on software development and management. The other, *Class of '67*, is for her granddaughter and contains stories about growing up in Utah. She had so much fun writing them that she went on to write two spy novels: *Alias Juno Wolfe* and *Who Is Juno Wolfe?* All titles are available on Amazon under her name—Jan McCleery.

ALUMNUS PROFILE

Cameron Soelberg

Honors science graduate Cameron Soelberg, HBS'00, forged an adventurous—and rigorous—path as a student at the U. He continues to travel on a pioneering trail to this day.

Soelberg recently climbed to the summit of the highest point in Utah—Kings Peak at 13,528 feet—and has also lived and worked in Colorado, Illinois, New Hampshire, and New York.

"I think my personal history is a good example that your education and career don't need to necessarily move in a straight line from point A to point B, because your goals might change as you gain experience, and that could launch you on a completely new path from what you had in mind originally," said Soelberg.

When Soelberg first enrolled at the U in 1994, his intention was to pursue a Ph.D. and become a college professor.

After he completed his honors degrees in mathematics and physics, he stayed on campus to complete a master's degree in Mathematics. While in graduate school, he was supported with a teaching assistantship in the Math Department and taught one or two courses each semester.

"After finishing the master's degree, I felt like I needed some time away from school and decided to pursue an opportunity with a startup company in Colorado Springs. There I was involved in prototyping projects for the U.S. Special Forces, which was fascinating work," said Soelberg.

In 2006, Soelberg took a job as a systems engineer with Lockheed Martin in Salt Lake City, developing biometric tagging and identification algorithms. "I enjoyed engineering and appreciated the quick learning curve and exposure to cutting-edge technology, but I wanted to broaden my horizons in the direction of business management, so after a year at Lockheed, I chose to leave Utah again to pursue an MBA at Dartmouth College," he said.

Cameron Soelberg

While at Dartmouth, Soelberg became interested in investment banking. He completed an internship with Deutsche Bank in New York in the summer of 2008, between his first and second years of business school.

"The timing couldn't have been worse as that was the start of the global financial crisis. But witnessing it firsthand was an invaluable experience, and I was fortunate to receive a full-time offer to join the firm in Chicago after graduation," said Soelberg. (He earned an MBA at the Tuck School of Business at Dartmouth College in 2009.)

The first few years following the financial crisis were tough for investment banking, as regulatory changes impacted the industry, but Soelberg worked hard and was promoted to vice president and then to director and managing director. He spent a total of nine years at Deutsche Bank. In 2018, he joined the Global Industries Group at UBS Investment Bank and now splits his time between Chicago and Salt Lake City.

"My current position involves a lot of numbers and a keen understanding of the capital markets and valuation," said Soelberg. "It's not sophisticated or complex in the way that algebraic topology or particle physics may be, but it does require critical thinking and a high degree of accuracy. The most important contribution my University of Utah education has made is the rigorous way I was taught to analyze and attack problems. The scientific method (and mathematical proof, similarly) is a disciplined framework for progressing from a hypothesis or question to a well-reasoned and logical conclusion. I use this every day

Soelberg with his kids and partner

in my job, and I'm grateful for how well my learning at the U prepared me to succeed."

Soelberg recalls many people and experiences from his undergraduate years on campus. "Lab work in chemistry and physics especially stands out, mostly because I was so impatient that I could never do the experiments quite right, but I had good lab partners who kept me on track," he said.

"In the Math Department, Jerry Davey really had an impact on me as a student. I took a couple of undergraduate courses from him and helped with an accelerated calculus series one summer as a TA," said Soelberg. "He was a kind person and a great teacher. He also lived an interesting life that spanned multiple dimensions in mathematics, the military, engineering, and private industry. I've always thought of his career path as a role model for my own."

"Within the Physics Department, I'd be remiss if I didn't recognize Charlie Jui for all that he taught me in the pre-professional physics program as a freshman. I wasn't always the most present or attentive student, but his love of physics and wry sense of humor has stuck with me, and I still enjoy seeing him on campus," said Soelberg.

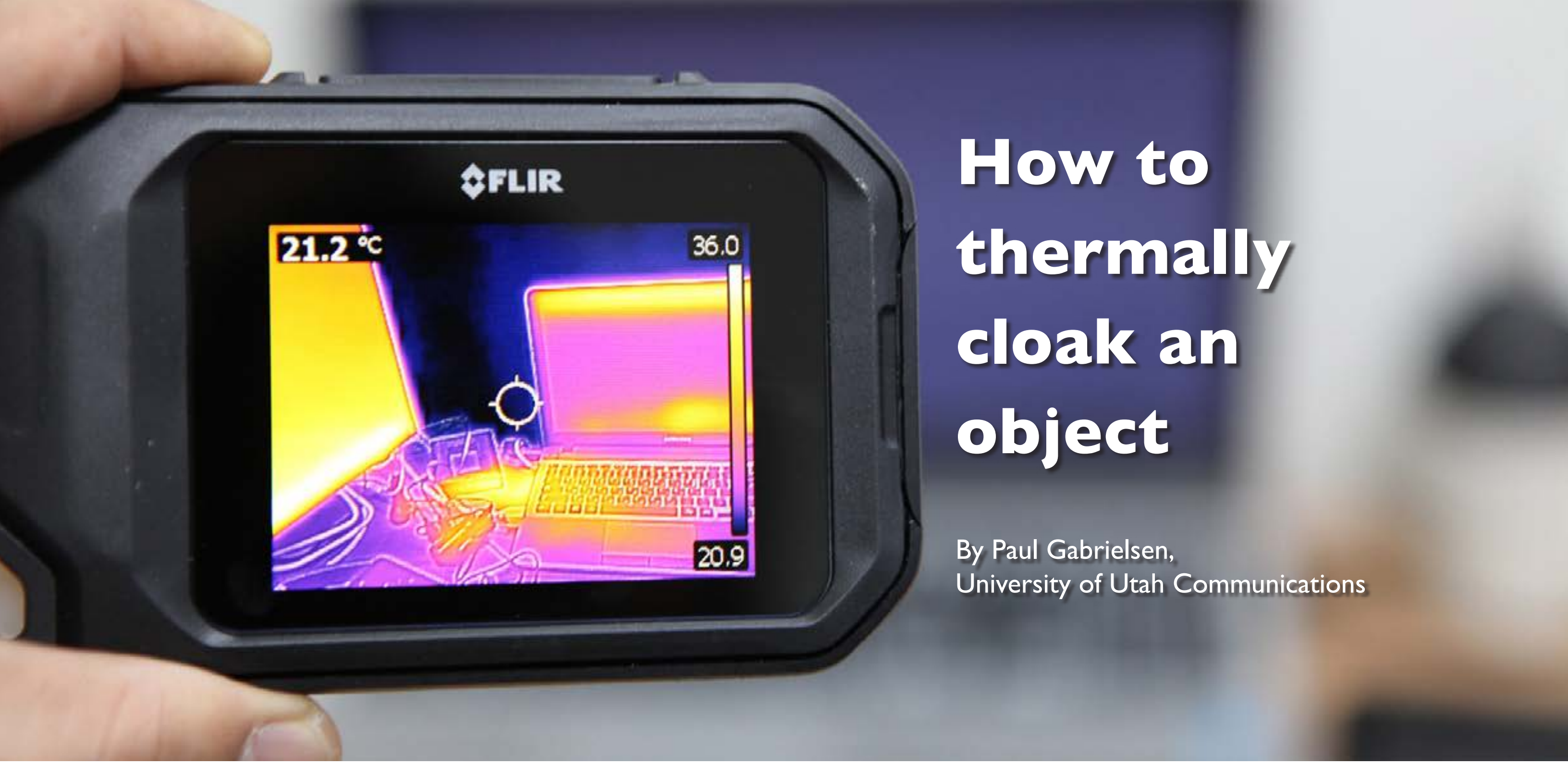
Soelberg also remembers studying in the Fletcher building (Physics) and the Cowles building (Math) after it was renovated. He was active in many organizations on campus, including a fraternity, and he held offices in student government and the Alumni Association.

"I think there are a couple of lessons I've kept in mind that could prove useful for current students. The first is that there will always be challenges, obstacles, and setbacks to overcome, no matter how or when you start out in life. Adversity creates opportunity. Being adaptable is one of the most important keys to success (and happiness)," said Soelberg.

"Second, I would say that no matter how difficult things may become, you are not alone in the struggle. There are many other people, both historically and in different parts of society today, who have faced grave difficulties and found ways to rise above their circumstances. Take comfort and inspiration in that realization and use it as a model for yourself," he said.

Soelberg is already planning his next adventure—to run the Chicago marathon. "There's always another mountain to climb," said Soelberg. "Life's challenges, and rewards, can be found anew each day."

A solid educational foundation in mathematics and physics, and the Honors College, is an exceptional "base camp" from which to operate, he said.



How to thermally cloak an object

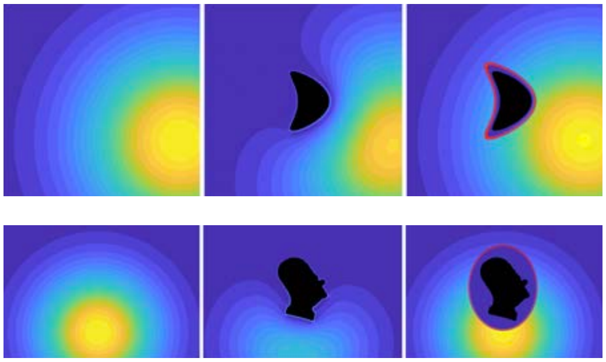
By Paul Gabrielsen,
University of Utah Communications

Can you feel the heat? To a thermal camera, which measures infrared radiation, the heat that we can feel is visible, like the heat of a traveler in an airport with a fever or the cold of a leaky window or door in the winter.

In a paper published in *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, an international group of applied mathematicians and physicists, including Fernando Guevara Vasquez and Trent DeGiovanni from the University of Utah, report a theoretical way of mimicking thermal objects or making objects invisible to thermal measurements. And it doesn't require a Romulan cloaking device or Harry Potter's invisibility cloak. The research is funded by the National Science Foundation (NSF).

The method allows for fine-tuning of heat transfer even in situations where the temperature changes in time, the researchers say. One application could be to isolate a part that generates heat in a circuit (say, a power supply) to keep it from interfering with heat-sensitive parts (say, a thermal camera). Another application could be in industrial processes that require accurate temperature control in both time and space, for example, controlling the cooling of a material so that it crystallizes in a particular manner.

See a visualization below of how the method cloaks a kite-shaped object. Or see how it works for a Homer Simpson-shaped object.



Left to right:

1. *Temperature of a plate subject to a point thermal source firing at time t=0 (this could be a laser pulse, for example).*
2. *Temperature of the plate with an object present. The isotherms, or temperature contour lines, are deformed by the presence of the object. This can be used by an observer to detect and locate the object.*
3. *The object is surrounded by the active cloak. Now the isotherms look exactly like the ones in the case where the object is not present, which hides the object.*

Cloaking or invisibility devices have long been elements of fictional stories, but in recent years scientists and engineers have explored how to bring science fiction into reality. One approach, using metamaterials, bends light in such a way as to render an object invisible.

Just as our eyes see objects if they emit or reflect light, a thermal camera can see an object if it emits or reflects infrared radiation. In mathematical terms, an object could become invisible to a thermal camera if heat sources placed around it could mimic heat transfer as if the object wasn't there.

The novelty in the team's approach is that they use heat pumps rather than specially crafted materials to hide the objects. A simple household example of a heat pump is a refrigerator: to cool groceries it pumps heat from the interior to the exterior. Using heat pumps is much more flexible than using carefully crafted materials, notes Guevara Vasquez. For example, the researchers can make one object or source appear as a completely different object or source. "So at least from the perspective of thermal measurements," said Guevara Vasquez, "they can make an apple appear as an orange."

The researchers carried out the mathematical work needed to show that, with a ring of heat pumps around an object, it's possible to thermally hide an object or mimic the heat signature of a different object.

Guevara Vasquez says the work remains theoretical, and the simulations assume a "probing" point source of heat that would reflect or bend around the object—the thermal equivalent of a flashlight in a dark room.

The temperature of that probing source must be known ahead of time, a drawback of the work. However, the approach is within reach of current technology by using small heat pumps called Peltier elements that transport heat by passing an electrical current across a metal-metal junction. Peltier elements are already widely used in consumer and industrial applications.

The researchers envision their work could be used to accurately control the temperature of an object in

Fernando Guevara Vasquez

space and time, which has applications in protecting electronic circuits. The results, the researchers say, could also be applied to accurate drug delivery, since the mathematics of heat transfer and diffusion are similar to those of the transfer and diffusion of medications. And, they add, the mathematics of how light behaves in diffuse media such as fog could lead to applications in visual cloaking as well.

Results of the study were published by the NSF Division of Mathematical Sciences in information provided to Congress and others. You can review their research highlight at https://www.nsf.gov/mps/dms/documents/2021-06-Item-Cloaking.pdf.

In addition to Guevara Vasquez and DeGiovanni, other co-authors of the study include Maxence Cassier, CNRS Researcher at the Fresnel Institute in Marseille, France, and Sébastien Guenneau, CNRS researcher, UMI 2004 Abraham de Moivre-CNRS, Imperial College London, London, U.K.

Mathematics Department Awards

Students who will receive a Ph.D. in the spring or summer of 2021 are:

Yen-An Chen
Priscilla Elizondo Sanchez
Cody Fitzgerald
Matthew Goroff
Jihao Liu
China Mauck
Anna Nelson
Chee Han Tan
Conor Tillinghast
Andrew Watson
Daniel Zavitz

Department of Mathematics Distinctions

UNIVERSITY FACULTY AWARDS

Amanda Cangelosi—*Early Career Teaching Award*

OTHER FACULTY AWARDS

Firas Rassoul-Agha—*Simons Fellowship*
Priyam Patel—*NSF CAREER Award*
Elizabeth Field—*NSF Mathematical Sciences Postdoctoral Research Fellowship*
Alicia Lamarche—*NSF Mathematical Sciences Postdoctoral Research Fellowship*

Mathematics Department Awards in 2021

UNDERGRADUATE AWARDS

Churchill Scholarship
Isaac Martin

Calvin H. Wilcox Memorial Scholarship
Wolfgang Allred

Junius John Hayes Diversity Scholarship
Lia Smith

Junius John Hayes Endowed Scholarship
Sydney Kossin
Maya Wagner

The Golden Scholarship
Ben Huenemann
Jessica Soucie

D. Keith Reed Memorial Scholarship
Cassandra Schultz

Michael Zhao Memorial Scholarship
Michael Keyser

Susan C. Christiansen Memorial Scholarship
Moses Samuelson-Lynn

Thomas Andrew Hurd Mathematics Scholarship
Matthew Gordon

Tom and Cathy Saxton Scholarship
A. Nichols Crawford Taylor

C. Bryant and Clara C. Copely Scholarship
Annie Giokas

Continuing Department Scholarship
Clayton Allard
Emma Coates
Eli Counterman
Anthony Do
Katherine Oxspring
Winston Stucki

Mathematics Department Scholarship
Lela Feaster
Benvin Lozada
Lauren Mickelson

J. L. Gibson Senior Award
Kaleb Alles
Charlie Barth
Brooklyn Davis
Mackenzie McLean

Pi Mu Epsilon
Emma Coates
Aidan Copinga
A. Nichols Crawford Taylor
Carolyn LaPrete
Caroline Luman
Jameson McCarty

GRADUATE AND DEPARTMENT AWARDS

NSF Graduate Research Fellowship Program
Isaac Martin—*NSF Fellowship*
Andy Liu—*Honorable Mention*

Math Department Outstanding Thesis Award
Jihao Liu
China Mauck

T. Benny Rushing and Gail T. Rushing Fellowship
Yiming Xu

Outstanding Graduate Student Award
Jacob Madrid
Allechar Serrano López

FACULTY AND STAFF AWARDS

Don H. Tucker Postdoctoral Fellow Award
Jody Reimer

Outstanding Postdoc Award
Osama Khalil
Joshua Pollitz

Faculty Undergraduate Teaching Award
Matt Cecil
Aleksandra Jovanovic-Hacon
Rebecca Noonan Heale
Michael van Opstall
Kevin Wortman

Outstanding Staff Award
Mary Levine
Lisa Penfold

IT Award
Nelson Beebe

Update on success of Student Emergency Fund for the Math Department

At the end of 2020 and earlier this year, we asked for your help in supporting our students who have been facing life-altering challenges during these difficult times. Thanks to the kindness of individuals like you, we were able to raise $20,000 to help our students. As a result of your generous support, we provided badly needed financial assistance to 15 undergraduate and graduate students to help them continue with their education and make progress towards their graduation. Although their individual stories are unique, each of these 15 students faced extraordinary, life-changing, challenges, including unexpected medical emergencies, and/or loss of employment.

Thank you for helping them!

Here are a few quotes from our students in response to receiving financial help:

"I am beyond grateful for your kindness and generosity."

"Without your generous help, remaining in school just wouldn't be happening."

"I truly appreciate this generous aid. Thank you so much."

With my sincere gratitude,

Davar Khoshnevisan
Professor and Chair
Department of Mathematics

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