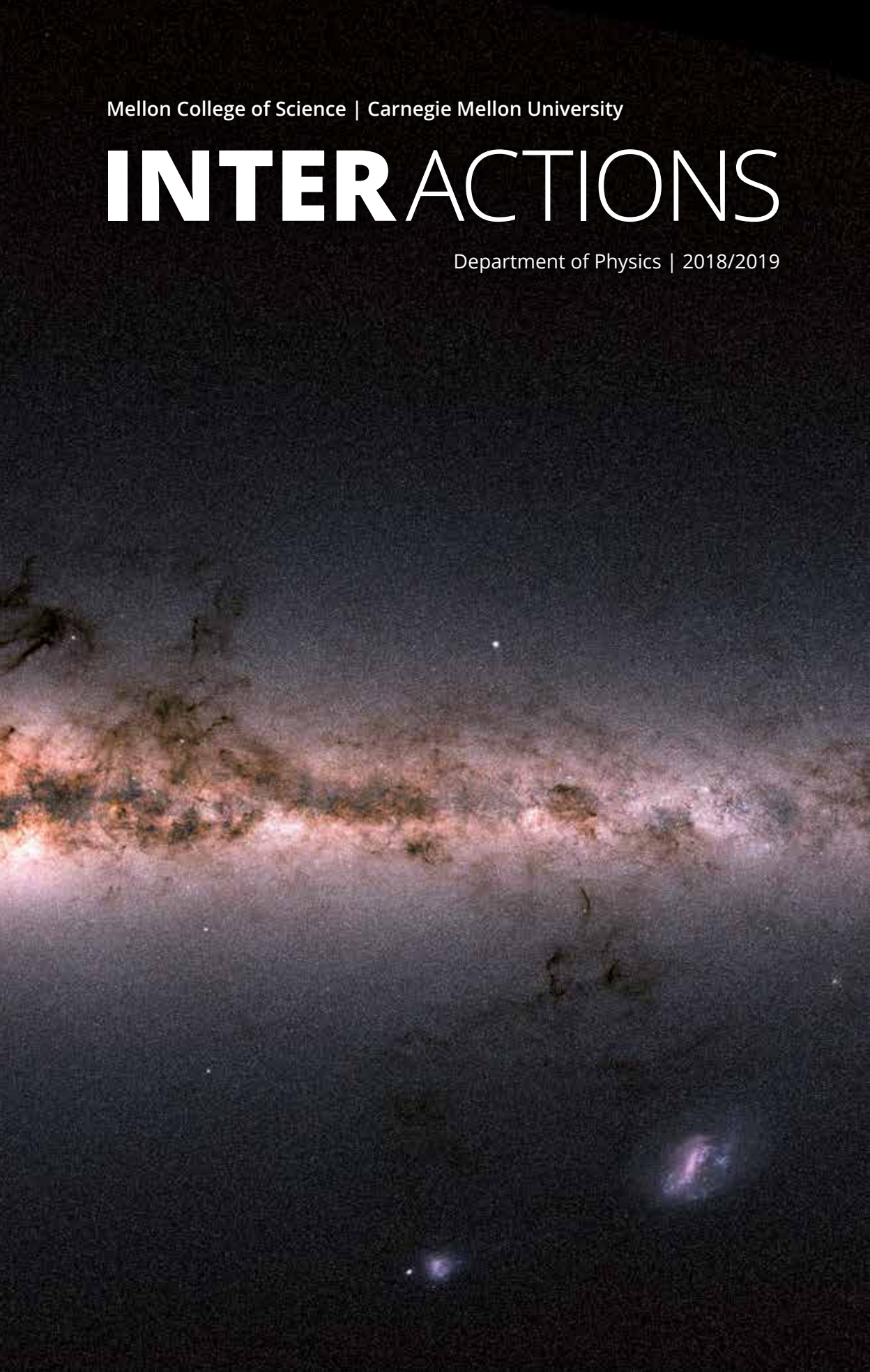
Mellon College of Science | Carnegie Mellon University

INTERACTIONS

Department of Physics | 2018/2019



INTERACTIONS

Department of Physics

Interactions is published yearly by the Department of Physics at Carnegie Mellon University for its students, alumni and friends to inform them about the department and serve as a channel of communication for our community. Readers with comments or questions are urged to send them to Interactions. Fax to 412-681-0648 or phone 412-268-2740. The department is headed by Scott Dodelson.

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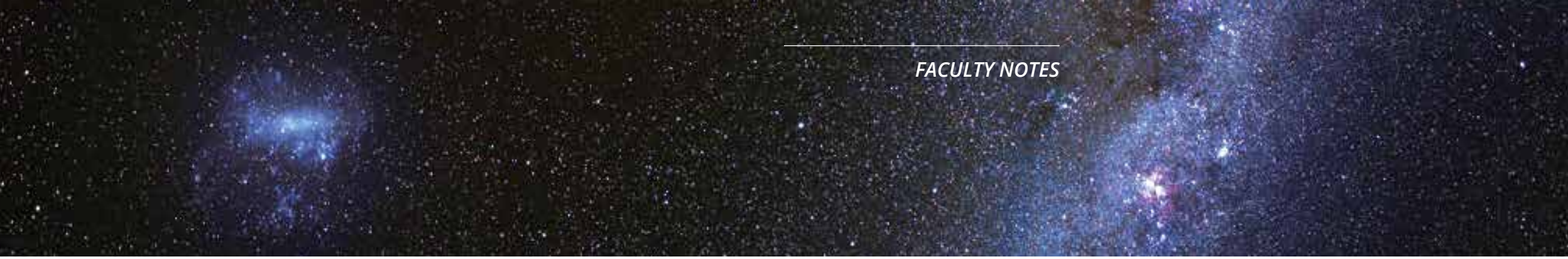


LETTER FROM THE DEPARTMENT OF PHYSICS HEAD, SCOTT DODELSON

2018 was a year of transition, growth and success in the physics department. In the pages that follow, you will read about awards received by our alumni, current faculty, graduate students and undergraduates. You will be introduced to our four new faculty members, with interests ranging from discovering the properties of the Higgs boson to the two-dimensional materials that underpin the second quantum revolution to the theory that encompasses all of this and more.

Please take a look at the section describing the illustrious careers of our three new emeritus faculty members, but keep in mind that all three are still mainstays of the department and as active as ever. The department has been at the forefront of many of the more important discoveries in physics in 2018, as you can see on pages 14-20, and is starting a Theory Center that cuts across the Mellon College of Science.

In the midst of it all was the horrific attack at the Tree of Life synagogue. Many of us had connections to the institution and some of the victims. All of us were overwhelmed by the outpouring of support from the community, far and wide. While we continue to mourn for the lives lost, we have come to appreciate more than ever the need to build an inclusive community.

What better institution to form the basis of a community than a university, one whose mission is to extend the boundaries of knowledge and educate young people to thrive in a rapidly changing world? We are trying hard in the Department of Physics to gather in and build outwards. You can read about the women who attended the Conference for Undergraduate Women in Physics; we are pleased to announce that we will host the 2020 version of this very important event. We are planning to start an "Everyone Counts" outreach program: every member of the department will participate, and we will attempt to reach students from ages 5 to 95, from those who are waiting to be inspired by the beauty of physics to those who need a helping hand in a tough economy to seniors looking for a window into the world of active research.

Please join our community: feel free to visit, chat and attend lectures; talk to our students about their career options; and — if you have the means — support our efforts to train the next generation of scientists and empower them to work with state-of-the-art equipment.

We wish you all a wonderful holiday season and a happy, healthy new year.

Banner Image: Courtesy of G. Torrealba (Academia Sinica, Taiwan), V. Belokurov (Cambridge, UK and CCA, New York, US) based on the image by ESO/S. Brunier

MANFRED PAULINI ELECTED AS A FELLOW OF THE AMERICAN PHYSICAL SOCIETY

Manfred Paulini, professor of physics and associate dean for faculty and graduate affairs, has been elected as a fellow of the American Physical Society (APS).

Fellows are elected based on their contributions to physics, through research, application of physics, leadership and service, or their contributions to physics education. The APS limits the number of fellows to no more than one-half of one percent of its members.

Paulini, who was nominated by the APS Division of Particles and Fields, was recognized for his leadership in large scale physics experiments and his work connecting particle physics with cosmology.

As a member of the Collider Detector at Fermilab experiment, Paulini searched for charge conjugation parity symmetry violations in decays of neutral B mesons. Finding these violations could yield clues that will help physicists to better understand why matter seems to predominate over antimatter in the universe.

Paulini is also a member of the Compact Muon Solenoid Detector experiment at the Large Hadron Collider. There, he is searching for supersymmetric particles — possible candidates to explain dark matter in the universe.

DI XIAO NAMED AMONG WORLD'S MOST HIGHLY CITED RESEARCHERS

Di Xiao, associate professor of physics, was listed among the most highly cited researchers in the field of physics by Clarivate Analytics. Xiao's publications were in the top one percent of the most cited papers in the field and indexed in the Web of Science, which is operated by Clarivate Analytics.

Xiao's research looks at the properties of materials in relation to quantum mechanics and how these properties can be harnessed for applications in electronic and magnetic devices.

This year's list includes roughly 4,000 highly cited researchers in 21 fields of the sciences and social sciences and 2,000 cross-field researchers.

Hael Collins and Stephen Garoff Win Mellon College of Science Awards for Education

Julius Ashkin Teaching Award: Hael Collins

Department of Physics Special Faculty Lecturer Hael Collins won the Mellon College of Science 2018 Julius Ashkin Teaching Award for his devotion and effectiveness in teaching. Collins manages to strike a perfect balance between challenging his students — pushing them to perform beyond what they believe themselves capable of — and having them appreciate him for it.

Collins has managed this feat with an extraordinary range of students, from non-science majors with a limited background in the physical sciences to graduate students working in the most advanced and narrow topics in the field; at every level, he receives rave reviews.

"I feel he went above and beyond in his effort putting this course together, and the class as a whole reaped the benefits of this, enjoying the experience of a very challenging and perhaps equally rewarding course," said one former student of Collins' Introduction to Nuclear and Particle Physics course.

Collins has taught an impressive 13 different courses in the past seven years. Students profess their appreciation for both his teaching style and the rigorous content of his classes. He balances difficult and unrelenting coursework with subtle humor, genuine care and a significant amount of extra time to prepare additional study materials.

Students are extremely grateful for his efforts outside of class, as he makes himself available for questions regardless of office hours, sometimes even attending evening student study sessions. Through dedication and meticulous work, Collins has crafted the ideal environment to encourage and inspire his students to learn, to push themselves and to succeed.

The Richard Moore Award: Stephen Garoff

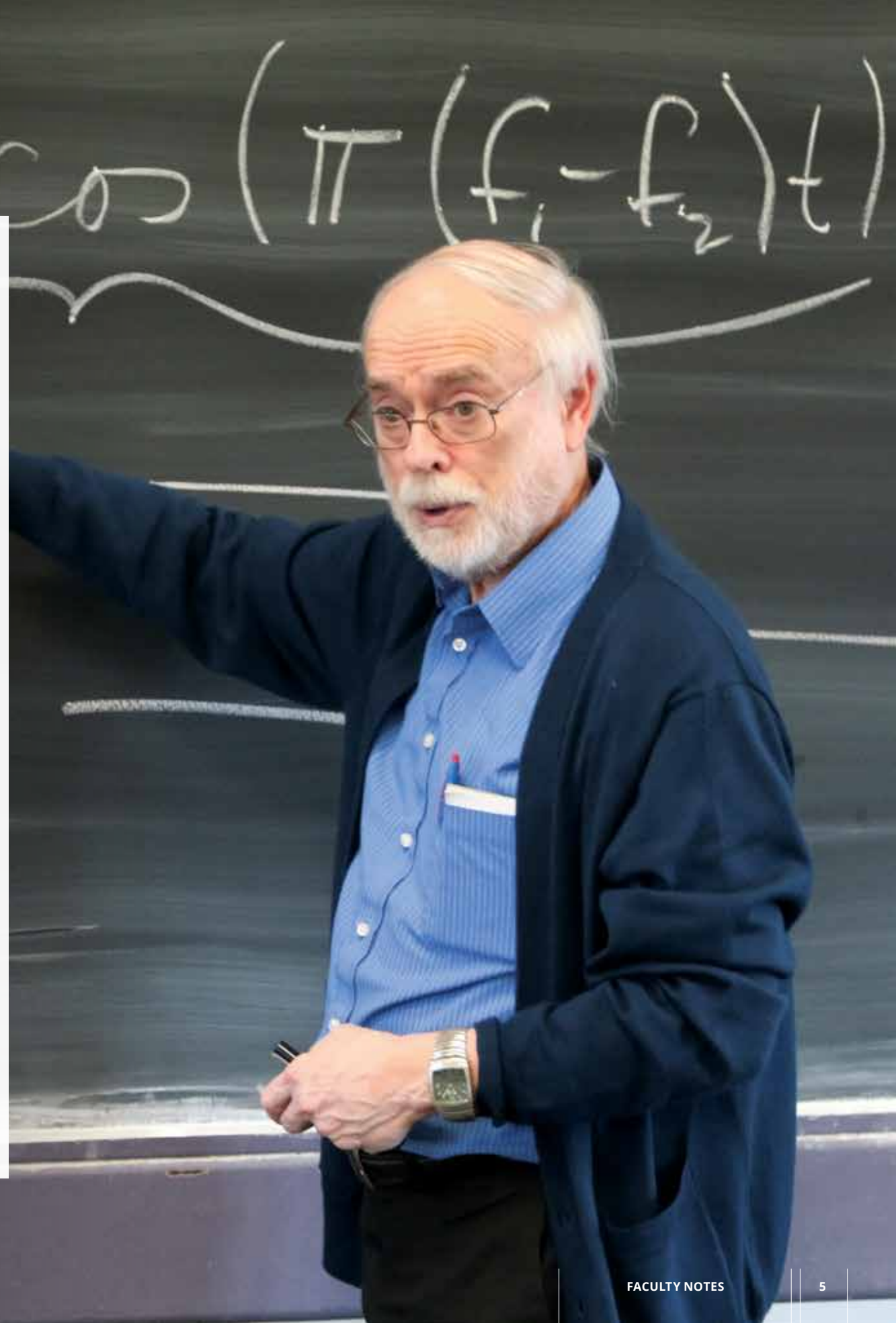
Professor of Physics Stephen Garoff has been honored with the Mellon College of Science 2018 Richard Moore Award. This award is presented every year to a faculty member in the college who is making substantial and sustained contributions to the educational mission of the college, particularly when those contributions have extended over a significant portion of their academic career.

Garoff has been a member of the Department of Physics for over three decades, and in that time, he has been instrumental in shaping both the department and MCS as a whole. He advocated for interdisciplinary cooperation and research between departments, helping to implement courses such as Physics I for Engineering Students and Physics II for Biological Sciences and Chemistry Majors.

Along with his colleagues, Richard Edelstein and Reinhard Schumacher, Garoff developed the Modern Physics Laboratory, which has become a highlight of the undergraduate curriculum. He has striven to design curricula that emphasize real-world applications of classroom material and prepare students to succeed after graduation.

Garoff has been unrelentingly dedicated to the education of MCS students. He served as advisor to dozens of graduate students in various fields across the university and supervised over 100 undergraduate research projects. He developed and instituted the Department of Physics' graduate student orientation program and graduate student visitation weekend. The annual visitation weekend was one of the first of its kind among physics departments across the country and is now one of the department's most important recruiting tools.

■ *Emily Payne*



Pictured: Stephen Garoff, Professor of Physics

NEW FACULTY

This fall, the Department of Physics welcomed four new faculty. They bring with them a depth of experience and wide-ranging research interests in fields such as particle physics, condensed matter systems, cosmology and quantum materials.

John Alison

A native of Pittsburgh, Assistant Professor John Alison came to Carnegie Mellon from the University of Chicago, where he was a Fermi/McCormick Fellow for five years. Before that, he obtained his Ph.D. in physics from the University of Pennsylvania and two bachelor's degrees in physics and philosophy from the University of Pittsburgh.

For the past decade, Alison has participated in experiments with the Large Hadron Collider at the European Organization for Nuclear Research (CERN) in Switzerland to understand the properties of the Higgs boson. While the Higgs boson was famously detected in 2012 after a decades-long search, a process about which Alison wrote his Ph.D. thesis, there's still very little understanding about the physics behind it, he notes. "The Higgs boson is really unlike anything we have ever seen before," Alison said, "so it's critical to learn all we can about it."

Alison's research at Carnegie Mellon will focus on learning more about the Higgs boson through building upgraded detectors for the Large Hadron Collider. Alison will oversee building the devices, which he likens to high-tech digital cameras for particles, on campus in Wean Hall. Building these detectors at Carnegie Mellon will provide students with an opportunity to get hands-on experience in particle physics. Once built, the detectors will be shipped to Geneva to be used by CERN. Alison's lab will also focus on being able to better understand and classify the images collected by using machine learning processes. "It's a really incredible time to study this field," Alison said.

Outside of his research, Alison enjoys reading and playing basketball and guitar.

Jyoti Katoch

A native of India, Assistant Professor Jyoti Katoch came to Carnegie Mellon from the Ohio State University, where she was a research scientist and postdoctoral researcher. She received her Ph.D. from the University of Central Florida and her bachelor's degree from Panjab University in India.

Katoch's research is centered on studying the various physical properties of quantum materials, especially two-dimensional materials. Along with Assistant Professor Simranjeet Singh, Katoch leads Carnegie Mellon's Lab for Investigating Quantum Materials, Interfaces and Devices.

"The field of 2D materials has grown massively in the last decade," Katoch said. "These materials are very exciting as their properties can be tuned by various knobs like supporting substrate, defects, adsorbates and more for on-demand applications."

Just like how we can create different structures using legos, similarly 2D materials can be stacked on top of each other to make novel materials. "You have so many degrees of freedom by which you can change their properties," Katoch said. And all of these new electronic and physical properties can help make better computers and other devices, she notes. "It has vast applications in different fields such as electronics, aviation, medical, sensing, etc."

In addition to her research at Carnegie Mellon, Katoch will be spending time working with collaborators at the Lawrence Berkeley National Laboratory in Berkeley, California.

Outside of her research, Katoch enjoys spending time with her son. She also enjoys reading books, hiking, visiting museums and experimenting with cooking.

Simranjeet Singh

A native of India, Assistant Research Professor Simranjeet Singh came to Carnegie Mellon from the Ohio State University, where he was a postdoctoral researcher. He received his Ph.D. from the University of Central Florida, and his bachelor's degree from Panjab University in India.

Singh's research focuses on the physics of quantum materials, and along with Assistant Professor Jyoti Katoch, he leads Carnegie Mellon's Lab for Investigating Quantum Materials, Interfaces and Devices. "We want to use quantum effects in these materials for next generation devices," Singh said. Currently, electronic devices such as computers and smartphones use electric charge to code bits of information — one level of charge can represent the "1" of binary code, while another level can represent the "0." However, Singh notes, this isn't the only way one could encode information in our devices.

By exploiting a particle property called spin in addition to charge, Singh said, one could not only create a way to store more information in devices, but also make these devices faster and more energy efficient. “People are really thinking these materials can change state-of-the-art electronics,” Singh said.

While it may be a long time before these spin-based devices, such as quantum computers, reach our homes and pockets, Singh said it’s exciting to contribute to this growing field. “Everything we have, somebody was doing basic research on 60 to 70 years ago,” Singh notes. “You’re slowly shaping human civilization in the long term.”

Outside of his research, Singh enjoys spending time outdoors, especially with his son. The plethora of parks close to Carnegie Mellon’s campus make it easy for him to take a stroll or run during the workday.

Riccardo Penco

Assistant Professor Riccardo Penco came to Carnegie Mellon from the University of Pennsylvania, where he was a postdoctoral fellow for two years. Before that, he spent four years as a postdoctoral research scientist at Columbia University. Penco received his Ph.D. in physics from Syracuse University and his bachelor’s and master’s degrees from the University of Trieste, located in his hometown in Italy.

“My research interests are very broad,” Penco said. While he focused on cosmology in the work for his Ph.D., Penco has since done theoretical research on condensed matter systems such as fluids and superfluids, and more recently has been working on black holes. “What ties all these topics together is the tool I use to study them — effective field theories,” Penco said.

Effective field theories are a modern theoretical tool that can be used to simplify the description of systems that feature more than one energy scale. Widely used in the context of particle physics, Penco applies these techniques to other areas of physics. “I like to draw connections between phenomena that appear completely different.” Penco said he was drawn to work on this particular area of physics because it allowed him to work on so many different and varied problems. “It keeps it interesting and lively for me,” he said.

Outside of his research, Penco enjoys reading and listening to music. However, since the birth of his son last January, his main hobby is spending time with him. “It’s the best part of my day,” Penco said.

■ *Ben Panko*

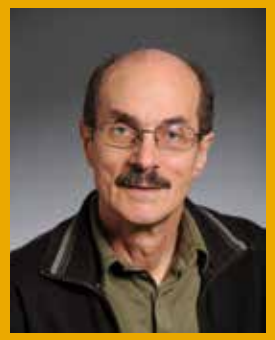
RETIRED FACULTY

James Russ

The professor of physics joined the Carnegie Mellon faculty in 1967 shortly after graduating with his doctorate from Princeton University. Russ’ career has focused on accelerator-based, high energy physics experiments, including the Collider Detector at Fermilab and the Compact Muon Solenoid at the Large Hadron Collider. He served as the spokesperson for the Segmented Large X Baryon Spectrometer (SELEX) project that studied charmed baryon production and decay at Fermilab.

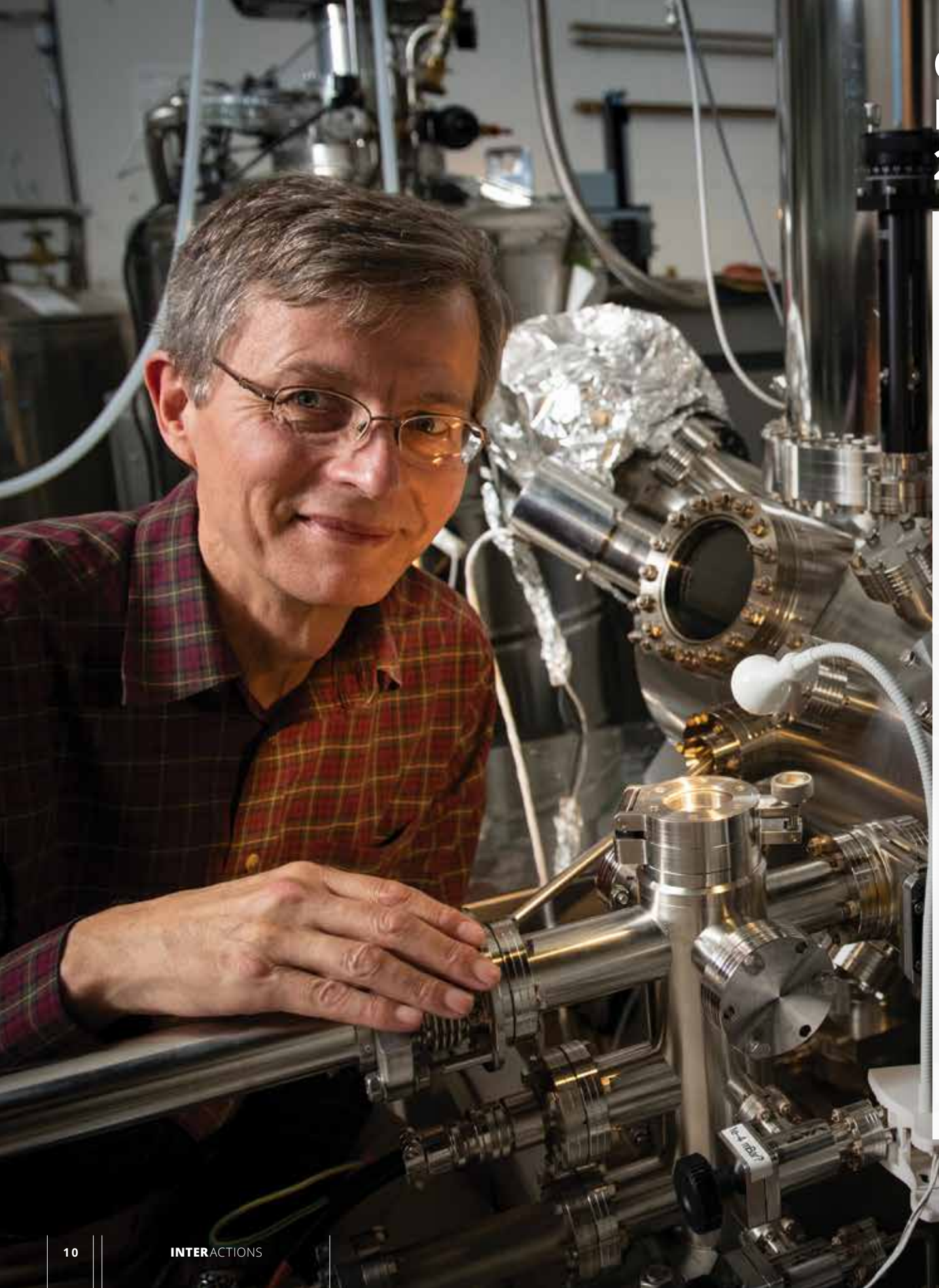
Robert Suter

The professor of physics has been a member of the physics faculty since 1981. His early research focused on taking X-ray and other measurements of thin films, and his most recent work uses High Energy X-ray Diffraction Microscopy (HEDM) to study the microstructures in bulk crystalline and polycrystalline materials. He invented a technique that uses high energy X-rays and high-performance computing to create 3D maps of the microstructure of hard materials that can be used to develop stronger materials.



Helmut Vogel

The professor of physics joined the Carnegie Mellon faculty in 1983. Vogel conducted high energy physics research at particle accelerator laboratories, including CERN, the Cornell Laboratory for Elementary-Particle Physics, the Stanford Linear Accelerator and DESY, searching for new quarks and leptons beyond those already found. Vogel is also well respected as an educator, having received MCS’s Julius Ashkin Award, Richard Moore Award and the university’s William H. and Frances S. Ryan Award for Meritorious Teaching.



Carnegie Mellon Physicist Randall Feenstra Wins 2019 Davisson-Germer Prize

Physics Professor Randall Feenstra has been awarded the 2019 Davisson-Germer Prize in Atomic or Surface Physics from the American Physical Society. The award recognizes his distinguished career in surface science, particularly his "pioneering developments of the techniques and concepts of spectroscopic scanning tunneling microscopy."

A scanning tunneling microscope (STM) images surfaces at the atomic level. Unlike an optical microscope that provides a direct image of an object, the STM uses a stylus and electric current to scan the surface and record each atom. The STM was invented at IBM Zürich by Gerd Binnig and Heinrich Rohrer in 1981; they received the Nobel Prize in Physics for their work in 1986.

After receiving his doctorate from the California Institute of Technology in 1982, Feenstra began his career at IBM labs in Yorktown Heights, New York. He traveled to Zürich to study Binnig and Rohrer's STM and returned to the United States where he reconstructed the STM and improved it to yield spectroscopic measurements.

Over the years, Feenstra and his colleagues worked to continue to develop STM, with a particular emphasis on refining the specifications for the microscope and improving the computational tools that would convert STM data into images. He developed new STM systems that were used to study semiconductor surfaces in an ultra-high vacuum. Along with his postdoc Joseph Stroscio, he created new techniques that allowed them to make novel observations about specific materials, including gallium arsenide, a semiconductor used in integrated circuits, light emitting diodes (LEDs) and solar cells.

Feenstra joined the faculty of the Department of Physics in 1995. In his early work at CMU, Feenstra, with Electrical and Computer Engineering Professor David Greve, developed a molecular beam epitaxy system to grow gallium nitride films, which are essential components of blue LEDs and microwave transistors. The system included a STM, which they used to image the surface atomic arrangement and thereby understand and optimize the growth procedures.

Feenstra's current research focuses on the development of two-dimensional materials. Two-dimensional materials are made by stacking one-atom-thick layers of different materials, creating a heterostructure. By carefully selecting the materials in each layer, scientists can create specific electronic properties that can enhance a material's performance and create new functionalities. Feenstra uses low-temperature STM to study these semiconductor heterostructures and determine their unique electronic properties.

The Davisson-Germer Prize was established in 1965 to recognize and encourage outstanding work in atomic or surface physics. The prize is named after Nobel laureates Clinton Davisson and Lester Germer who first measured electron diffraction. Davisson was a physics faculty member at the Carnegie Institute of Technology, which merged with the Mellon Institute of Industrial Research in 1967 to form Carnegie Mellon University.

■ *Jocelyn Duffy*

IN MEMORIAM

Top to bottom: Richard M. Edelstein, Robert Thorton Schumacher and Ned Stuart VanderVen

Richard M. Edelstein

Richard Edelstein was born in Los Angeles, attended the Los Angeles public schools and graduated from Pomona College, in Claremont, California. He received his Ph.D. from Columbia University and accepted a position as a research physicist at Carnegie Mellon University (then the Carnegie Institute of Technology) in 1960. He moved into the tenure track as assistant professor of physics in 1962 and was promoted to professor of physics in 1969.

Richard was active in both medium and high energy physics research and a key participant at Carnegie Mellon's Nuclear Physics Laboratory, located in Saxonburg, Pennsylvania, until it was decommissioned in the late 1970s. He designed and performed experiments at national research laboratories, including Argonne, Brookhaven, SLAC and Fermilab, as well as the KEK facility in Japan and CERN in Switzerland. Richard was a senior research fellow at the Weizmann Institute in Rehovot, Israel, in the early 1970s and associate dean of the Mellon College of Science from 1978 to 1981.

In the 1990s, Richard was the driving force behind the physics department's initiative to enhance the undergraduate experience in the department. He created a number of metacurricular activities, including the popular senior banquet and a working dinner for juniors, which Richard dubbed "Life after CMU." While the senior banquet was purely for fun and celebration, the junior dinner provided an opportunity for physics majors to begin serious discussion and planning for job-hunting and graduate school applications. Richard also oversaw the improvement of undergraduate advising and served as head of advising from 1993 until his retirement in 2000. During this time, he also served as vice president (1996-97) and as president (1997-98) of Upsilon Chapter of Phi Beta Kappa at CMU.

Richard is survived by his wife, Ruth, and his three children, Daniel, Amy and Elizabeth.

■ *Barry Luokkala and Stephen Garoff*

Robert (Bob) Thornton Schumacher

Bob Schumacher was born in Berkeley, California, and was raised in Tahoma (Lake Tahoe), California. He attended high school and college in Reno, Nevada.

He earned a bachelor's in science from the University of Nevada at Reno in 1950, graduating first in his class. As an accomplished violinist, he considered pursuing a career in music before deciding to study physics. He continued to practice and play the violin well into his 80s.

Schumacher attended graduate school at the University of Illinois, Urbana–Champaign, and received his Ph.D. in physics under the late Professor Charles Slichter in 1955 on the topic of Nuclear Magnetic Resonance (NMR). He continued to research the topic of NMR over the next 15 years and published Introduction to Magnetic Resonance: Principles and Applications in 1970.

Schumacher joined the physics faculty at Carnegie Mellon University (then Carnegie Institute of Technology) in 1957. He continued to teach at Carnegie Mellon for 40 years, most notably as the thesis advisor for John L. (Jan) Hall in 1961. Hall shared the 2005 Nobel Prize in physics with Theodor W. Hänsch for their pioneering work on laser-based precision spectroscopy and the optical frequency comb technique.

Later, Schumacher shifted his field of research to the physics of music, focusing on the physics of the bowed string, combining his two lifelong interests of violin playing and physics. He published numerous papers on the physics of music in the Journal of the Acoustical Society of America and collaborated with Michael McIntyre and Jim Woodhouse of Cambridge University and Steve Garoff of Carnegie Mellon, among others.

In the early 1970s, Schumacher developed and taught an undergraduate course titled the Physics of Musical Sound. This course proved very popular, and it is still offered by the physics department.

Schumacher retired in 1996 as a full professor.

He is survived by his wife of 64 years, Carolyn Sutcher Schumacher, and their two children, Linda and Lee Schumacher, and grandchild Dean Brown.

■ *Lee Schumacher*

Ned Stuart VanderVen

Ned VanderVen was born in Ann Arbor, Michigan, attended Michigan public schools and graduated from Harvard University. He received his Ph.D. in physics from Princeton University and accepted a position as instructor in the Department of Physics at Carnegie Mellon University (then the Carnegie Institute of Technology) in 1961. VanderVen moved into the tenure track as an assistant professor of physics in 1963 and was promoted to professor of physics in 1979.

As an experimental physicist, his work focused on low temperature solid state physics and the physics of musical sound. VanderVen was an active participant in outreach to local schools and gave talks on physics as a career at the Pennsylvania Junior Academy of Science. He also served on an educational advisory panel for the National Science Foundation (NSF) and as an educational consultant in India, under the auspices of the NSF and the U.S. Agency for International Development. He was actively involved with the Intercultural Communications Center and the improvement of English-speaking ability for international graduate students at Carnegie Mellon. VanderVen played an instrumental role in creating the Modern Physics Laboratory course, which was offered for the first time in the spring semester of 1968.

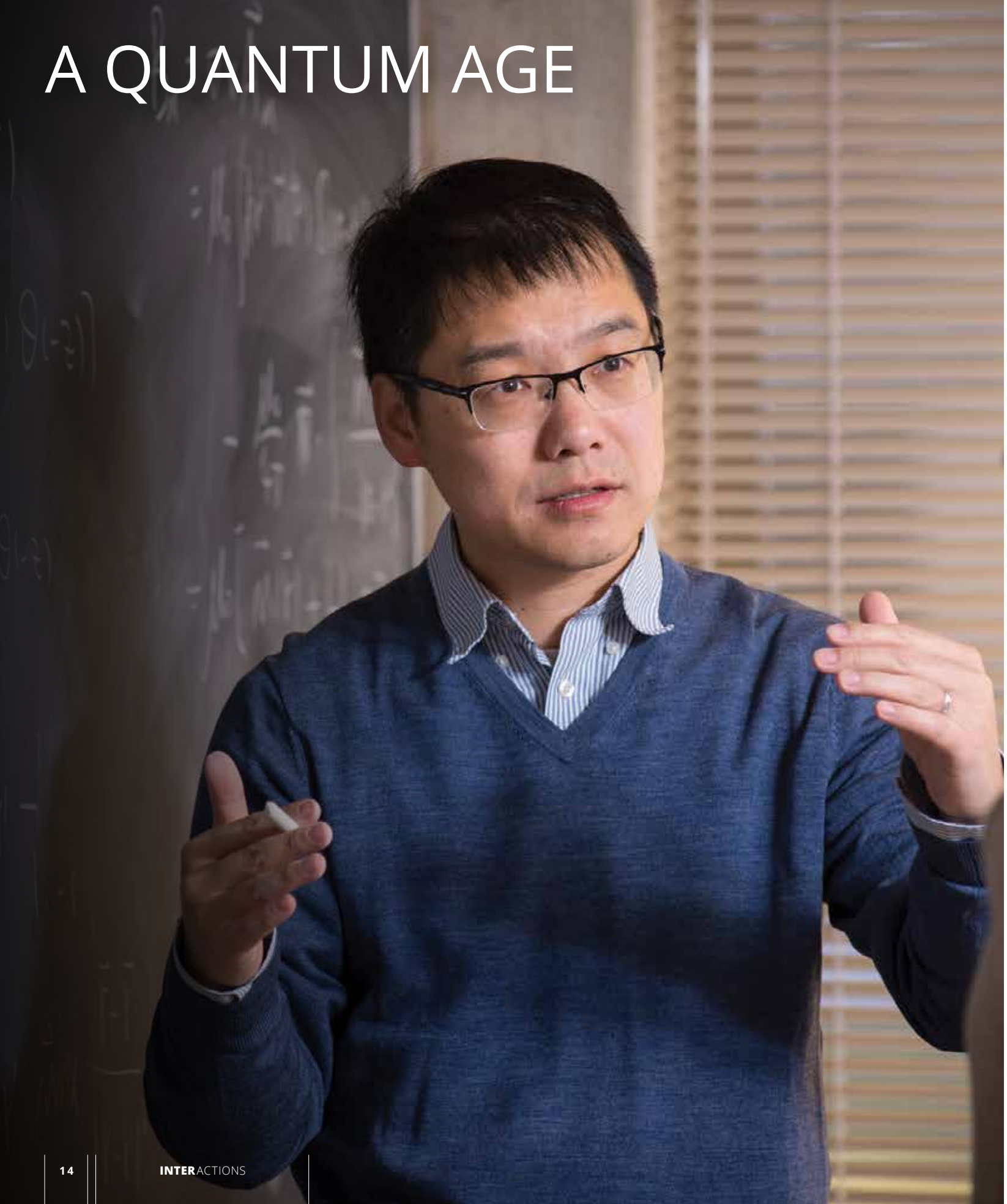
In the early 1990s, VanderVen brought the physics department into the Information Age by introducing the department to the novel concept of the World Wide Web. He constructed the physics department's first webpage and continued to maintain it until his retirement in 2000.

VanderVen had many interests, including athletics and music. A cyclist, he served as president of the Allegheny Cycling Association. He enjoyed classical music, played the piano and was on the board of the Renaissance and Baroque Society.

VanderVen is survived by his wife of 57 years, Karen, and his twin children, Elizabeth and Mark Edwin.

■ *Barry Luokkala*

A QUANTUM AGE



Nearly 300 years ago, Isaac Newton pioneered the study of the movements of the visible universe (including famously falling apples). However, it wasn't until the early decades of the 20th century that physicists began to understand that things worked a lot differently at the atomic and subatomic levels, a field of research that came to be known as quantum mechanics.

"After almost a century, I think physicists understand a lot of quantum mechanics, but we haven't really explored the usefulness of quantum mechanics," Professor of Physics Di Xiao said. His research in the past five years has aimed to change that.

> **"Now I think we're at a new age — a quantum age."**

Broadly, Xiao seeks to understand what determines the properties of materials. This is a simple question with a lot of complexity behind it. For example, mercury and gold are neighbors on the periodic table and looking at their individual atoms closely shows very similar-looking particles.

"But when you put many of them together, one becomes a liquid, one becomes a solid, one is expensive, but the other one is very, very, very expensive," Xiao said. Understanding why differences such as these exist when atoms are pushed together is the foundation of condensed matter physics.

'A New Paradigm'

"I think it's safe to say that modern technology is entirely based on our understanding of how electrons travel in a piece of semiconductor," Xiao said, referring to the silicon-based computer chips living in computers, smartphones and so many other devices. Since their invention in the mid-20th century, these circuits have been improved and made smaller but still more powerful each year, allowing companies to make the ultra-thin smartphones we all crave. However, even as these semiconductors continued to shrink, designers were until recently still able to count on the electrons moving through them in the predictable manner found in classical mechanics.

"Now we're talking about things moving around at a nanometer scale," Xiao said. "At that scale, you cannot ignore quantum mechanics."

Fundamentally, what changes things at the quantum scale is that electrons cease to act like the particles we usually picture and instead take on the properties of waves. While this property introduces challenges, it also introduces new opportunities, something which Xiao has explored extensively in his research.

One focus of Xiao's work has been so-called "valleytronics," an idea he thinks could revolutionize computing by exploiting the quantum properties of electrons in crystalline materials. The "valley" comes from the valleys of waves, the form which electrons behave like in quantum mechanics. The movement of an electron from higher-energy states to lower-energy states can be plotted like a wave, essentially. These valleys are the states where an electron is at its lowest energy, and thus most stable.

The spatial arrangement of atoms within crystalline materials means that there are multiple unique valleys that electrons can rest in at their lowest energy state. This is in sharp contrast to a classical particle, which only has one unique lowest energy state, namely when the particle is at rest.

"If I can figure out a way to put the electron in 'valley 0' or 'valley 1,' this is the equivalent of saying that I'm writing my data in '0' or '1,' the language of computer binary code," Xiao said.

This would free up computers from relying on electric charge to program binary code. Xiao has figured out how to experimentally control the "valley index" of electrons in special materials with visible light, opening up a much more energy efficient way to connect computers together.

"It's a new paradigm," he said.

The idea behind valleytronics is related to some of the most beautiful concepts in mathematics, namely geometry and topology. When Xiao came to the United States in 2001 and entered a doctoral program at the University of Texas at Austin, few people in physics took seriously the complex mathematical study of physics dealing with geometric phase and topology, or the study of quantum waves and shapes and how they affect materials.

"It had always been regarded as a really cute, elegant concept that probably doesn't have many physical consequences," Xiao said of his area of research. However, the field began to quickly take off as he worked toward his Ph.D. because physicists began to realize how important these concepts could be in dictating the properties of materials.

"Maybe just purely by luck I ended up doing what I'm doing," Xiao joked.

Following his postdoctoral work, Xiao took a job at the Oak Ridge National Laboratory in Tennessee. While working there was exciting and offered many opportunities, he eventually felt like his work lacked something.

"I kind of just missed the feeling of being on a campus," Xiao said, and he missed interacting with students in particular. In 2012, he came to Carnegie Mellon, a school that he'd heard was not too small and not too large with a strong focus on interdisciplinary research. He has no regrets since settling in Pittsburgh with his wife and two children, Ella, age 7, and Max, age 2.

"I used to have hobbies," Xiao joked. "Now I just play with my kids."

Outside of his research and parenting, Xiao has worked to improve the teaching of physics, especially to undergraduate students. For several years, he has run an exchange program between Carnegie Mellon's Department of Physics and the University of Science and Technology of China. Each summer, the universities trade undergraduate students for two months to encourage international collaboration and personal growth.

Two years ago, Xiao was named a Cottrell Scholar, an honor that supports the work of the nation's top educators.

Xiao is using this award to develop a new tool that helps students understand the complex topics behind solid state physics through computer simulations. While visualizations have long been used to teach and understand physics concepts, Xiao said, this tool will allow undergraduate students to work toward answering their own questions and experiments.

"Instead of giving them a program, I want to give the student a code," Xiao said. "They can modify the code and they can have full control of it."

This idea came to him from his own experiences teaching undergraduate physics students at Carnegie Mellon, Xiao said, where he's long been impressed with not only the computer skills that these students have when arriving on campus but also the insightful questions they often ask him. He points to the fact that when he teaches first-year students, he has to manage his lecture time carefully because questions from the students could easily fill up the entire period.

"When you have those kind of great students, I mean how can you exhaust what kind of questions they can ask?" Xiao said. "I want to see what the students can come up with."

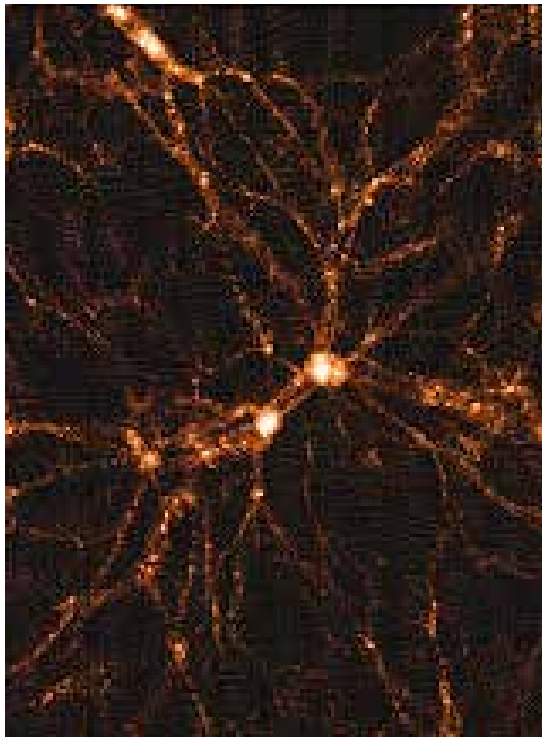
■ *Ben Panko*

RESEARCH NOTES

Gaia Data Reveals New Information About the Milky Way

Cosmologists Sergey Koposov and Matthew Walker are analyzing data collected by the European Space Agency's Gaia satellite. The satellite has been mapping the stellar content of our galaxy, recording the journeys of stars as they travel through the Milky Way. Koposov was part of a group that used the data to show that the Milky Way had a dramatic head-on collision with a "Sausage" galaxy early in its history. This collision reshaped the Milky Way's structure, fashioning its inner bulge and outer halo.

Koposov, Walker and colleagues also used the Gaia data to find an enormous, never-before-seen galaxy lurking in the outskirts of the Milky Way. Named Antlia 2, after the constellation in which it appears, the galaxy likely escaped detection due to its low density and hiding place behind the Milky Way's disk.



Hyper Suprime-Cam Survey Maps Dark Matter in the Universe

Researchers working with the Hyper Suprime-Cam (HSC) survey, including Associate Professor Rachel Mandelbaum, released the deepest wide field map of the three-dimensional distribution of matter in the universe ever made and increased the precision of constraints for dark energy.

Using data gathered by Japan's Subaru telescope located in Hawaii, the researchers measured gravitational distortion caused by lensing in images of about 10 million galaxies. The HSC survey was able to see galaxies further back in time than in other surveys, allowing them to create a sharper map of dark matter distribution.

Mandelbaum and her team created a detailed image simulation of the HSC survey data, which they used to remove distortions caused by other effects, ensuring the accuracy of the results.

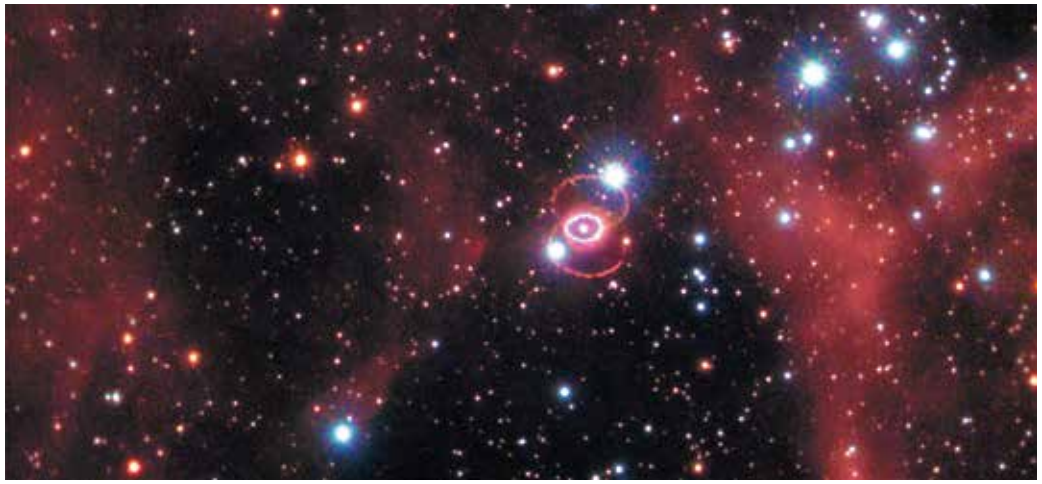
Neutrino's Physics Fingerprint

Members of the COHERENT Experiment at the Oak Ridge National Laboratory's Spallation Neutron Source (SNS), including Assistant Research Professor Diana Parno, detected and measured the coherent elastic scattering of neutrinos off of nuclei — a process that is predicted by the Standard Model of physics but had never before been seen.

Their findings, published in Science, provide scientists with a fingerprint for neutrino-nucleus reactions that will help them better understand neutrinos and the dynamics of neutron star formation and supernovae explosions. It could also provide a limiting factor for future experimental dark matter searches.

Parno, who began working on the project while she was a faculty member at the University of Washington, is on the team that developed the simulation program that calculates the number of neutrinos that pass through the SNS's detectors.

Photo Credit: Jean Lachat/ University of Chicago



Kirshner Gives 2018 Buhl Lecture

Robert Kirshner, the chief program officer for the Gordon and Betty Moore Foundation and Clowes Professor of Science Emeritus at Harvard University, presented the 2018 Buhl Lecture in April.

Kirshner's research using supernovae to trace cosmic expansion was instrumental to the discovery of cosmic acceleration. In his lecture titled "Exploding Stars, Dark Energy and the Accelerating Cosmos," Kirshner discussed what is presently known about this acceleration and the mysterious yet omnipresent dark energy that is believed to drive that acceleration. He also discussed how scientists could possibly better understand the nature of dark energy.

A member of the National Academy of Sciences and the American Philosophical Society, Kirshner's awards include the National Academy's Watson Medal, the Wolf Prize in Physics, the Dannie Heineman Prize in Astrophysics and the Gruber Prize in Cosmology.

Setting the Roadmap for the Future of Biomembrane Research

Professor Markus Deserno and an international group of colleagues published "The 2018 Biomembrane Curvature and Remodeling Roadmap" in the Journal of Physics D: Applied Physics. Biological membranes are an important area of study due to the role that membrane curvature and structure plays in processes like endo- and exocytosis and organelle functionality.

The review article gives clarity to the state of research in membrane biophysics and provides an overview of current and future challenges and the technological advances that will be needed to address those challenges.

Deserno's section focuses on Gaussian curvature, membrane topology and the energetics of membrane fusion. He shows how the Gaussian curvature modulus strongly contributes to the energetic penalty for initiating fusion. This poses a big challenge for understanding trafficking in eukaryotic cells because researchers do not know the value of this modulus for any real cellular biomembrane.

MUKUND BAPNA RECEIVES GRADUATE STUDENT RESEARCH AWARD

Physics Ph.D graduate Mukund Bapna received the 2018 Guy C. Berry Graduate Student Research Award. He was presented with the prize at the Mellon College of Science Graduate Student Town Hall in April.

"Mukund is a quiet person who does not draw attention to himself, but those who interact with him quickly recognize his abilities," Bapna's lab director, Professor of Physics Sara Majetich, wrote in nominating him for the prize.

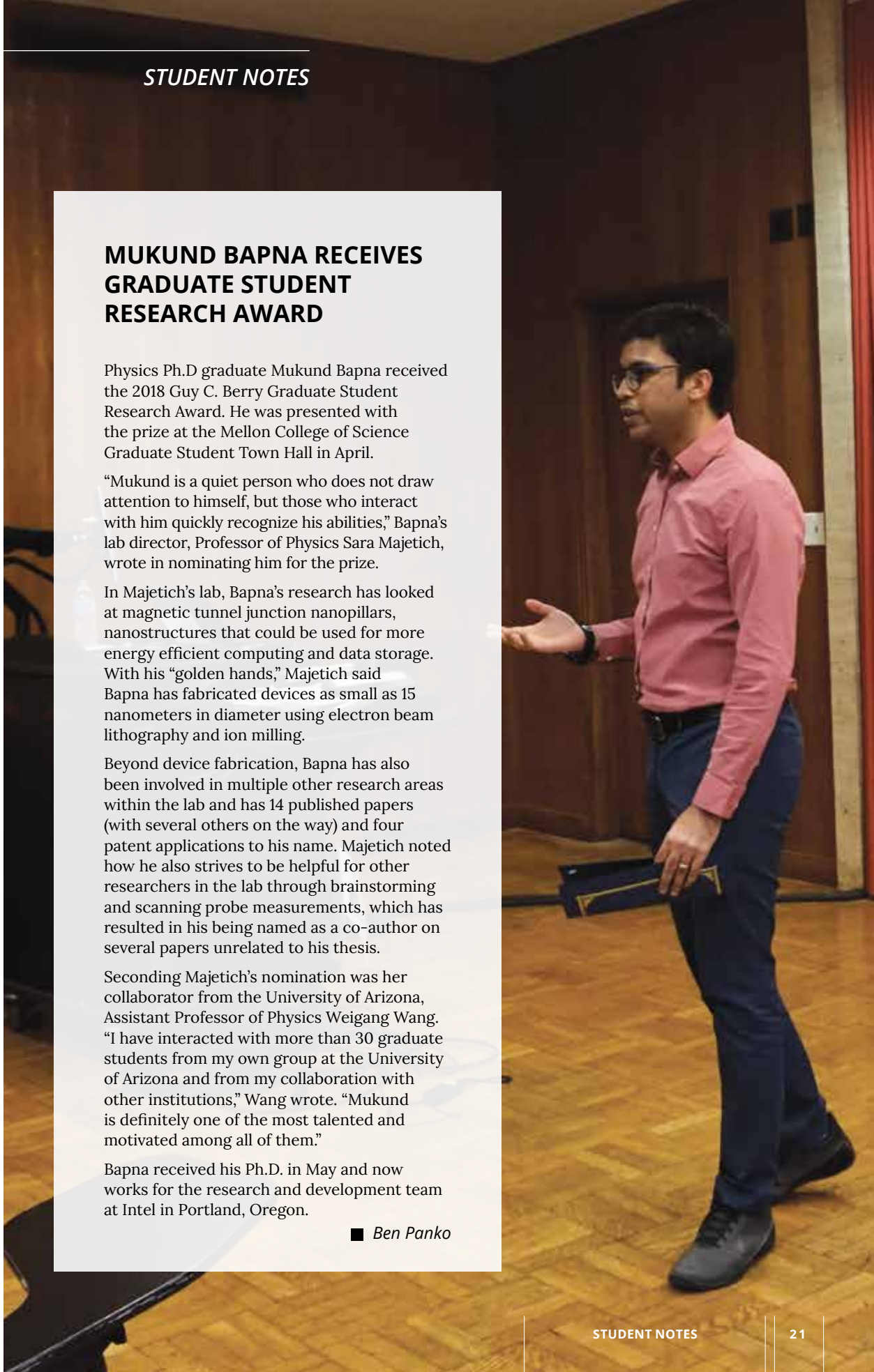
In Majetich's lab, Bapna's research has looked at magnetic tunnel junction nanopillars, nanostructures that could be used for more energy efficient computing and data storage. With his "golden hands," Majetich said Bapna has fabricated devices as small as 15 nanometers in diameter using electron beam lithography and ion milling.

Beyond device fabrication, Bapna has also been involved in multiple other research areas within the lab and has 14 published papers (with several others on the way) and four patent applications to his name. Majetich noted how he also strives to be helpful for other researchers in the lab through brainstorming and scanning probe measurements, which has resulted in his being named as a co-author on several papers unrelated to his thesis.

Seconding Majetich's nomination was her collaborator from the University of Arizona, Assistant Professor of Physics Weigang Wang. "I have interacted with more than 30 graduate students from my own group at the University of Arizona and from my collaboration with other institutions," Wang wrote. "Mukund is definitely one of the most talented and motivated among all of them."

Bapna received his Ph.D. in May and now works for the research and development team at Intel in Portland, Oregon.

■ *Ben Panko*



Physics Major Heads to Switzerland to Conduct Particle Physics Research

Physics student Ian Harris has his sights set on pursuing a career in fundamental particle research. Thanks to the ThinkSwiss scholarship, Harris got a taste for what his future might look like after spending the summer conducting research at the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland.

ThinkSwiss is a scholarship program managed by the Office of Science, Technology and Higher Education at the Embassy of Switzerland in Washington, D.C. The program promotes cross-cultural exchange by supporting American and Canadian students who wish to study or conduct research in Switzerland.

Before applying, students have to find a host professor at a Swiss university who will accept them into their research group. After some preliminary searching his sophomore year, Harris connected with Professor Aurelio Bay at EPFL, who coincidentally worked with Harris' physics professor at Carnegie Mellon University, Curtis Meyer, when the two professors were Ph.D. students at the University of California, Berkeley.

"The project about which Professor Bay told me sounded exactly like what I want to do in my eventual career, so I applied for the scholarship in order to be able to work on that project," Harris said.

His research project consisted of constructing a scintillating fiber/silicon photomultiplier detector for the Search for Hidden Particles-Charm (SHiP) experiment in order to measure charm-anticharm quark cross sections. This value is important to normalizing hidden sectors, or particles predicted outside of the Standard Model. His main tasks included writing code to extract signal threshold values for readout electronics, performing optical and electrical tests on photodetectors and assembling the detector module for installation at CERN. Harris had the opportunity to travel to CERN with his colleagues at EPFL to conduct beam tests using 400 GeV protons from the Super Proton Synchrotron, the second largest accelerator at CERN.

"The SHiP experiment is searching for various particles, including heavy neutral leptons, which can theoretically explain baryon asymmetry and neutrino masses and oscillations, as well as providing a candidate for dark matter," Harris said. "I enjoyed contributing to a cutting-edge experiment. Furthermore, I was excited to work with and test the hardware as my prior research experience consisted entirely of analysis and simulation."

As a research assistant for Carnegie Mellon's Medium Energy Group, Harris's previous research involved analyzing Compton polarimetry data from the Thomas Jefferson National Accelerator Facility in Virginia.

When Harris heard of the ThinkSwiss scholarship, he couldn't think of a more perfect place to immerse himself in the international physics community. Harris was also interested to learn the secret behind Switzerland's enviable expertise in work-life balance. To that end, Harris' colleagues and friends quickly showed him the ropes to living the Swiss life.

"While the amount of time that I worked was comparable to that of my prior research job in the U.S., my colleagues and I arrived earlier, left later and took longer lunches and impromptu ice cream breaks during the day. During lunch, we waited for everyone to sit down at the table before eating, and we played 'soccer physics' before beginning work again," Harris wrote in a ThinkSwiss Brainstorm blog. "This time together, in addition to hiking and running with my peers outside of work, made us more comfortable and relaxed working together in the lab."

As he returned to the United States, Harris was happy to see how much Swiss culture had rubbed off on him.

"Experiencing Swiss openness makes me excited for when I inevitably return to CERN throughout my future career, and I hope to bring this value back to the laboratories and my daily life in the U.S.," wrote Harris.

■ *Emily Payne*

PHYSICS STUDENTS FIND INSPIRATION AT UNDERGRADUATE CONFERENCE FOR WOMEN

Mellon College of Science students Olivia Zhiyao Li and Aileen Zhai attended the Conference for Undergraduate Women in Physics (CUWiP) at Princeton University in January 2017, supported by the Department of Physics' Undergraduate Enrichment Fund. The trip was the then first-year students' first experience at a large professional conference.

"I felt like I've never been with so many female physics majors. It was a great bonding experience," said Li.

As a program of the American Physical Society, multiple institutions across the United States host a three-day regional CUWiP each January. The goal of CUWiP is to support undergraduate women in physics by providing them with an opportunity to experience a professional conference, receive information about graduate school and professions and meet other women in physics with whom they can share experiences, advice and ideas.

Bottom Row (L to R): Boyan Yin, Sarah Penfield, Megan Roche, Alex Jackson and Polina Petrov

Top row (L to R): Joanne Hsueh, Erica Xin, Nozomi Yasuda, Olivia Li, Aileen Zhai and Swara Srinivasan

The conferences bring together women in physics of all ages. The energy of seeing and meeting physics majors from all around the country was one of the most invigorating aspects, Li noted.

"Before the keynote speech, all the conference sites are connected via video calls. We could see over 2,000 female physics students at all the conference sites, and that gave me the feeling that I'm definitely not alone and that I'm in something much bigger than I realized," Li said.

The conference was an eye-opening experience for both Zhai and Li, though in different ways.

At the time of the conference, Zhai admits to having a hard time in some of her classes and wasn't sure if she wanted to continue studying physics. Enticed by a tour of the national Princeton Plasma Physics Laboratory, Zhai decided to go despite her worries.

She attended workshops on topics ranging from astrophysics to geophysics, toured labs and sat in on talks from university professors that recharged her desire to pursue physics.

"I realized there is so much out there in physics and that I would be lucky to be a part of it. And that's how I decided to stick to my major," she said.

For Li, the conference ignited a passion for supporting women in science, which led to her joining Carnegie Mellon University's Women in Science club after the conference.

"I learned more about the actual existence of inequality issues in math and science," she said.

> **"Women feel less supported because of a lack of female peers and mentors, and Women in Science is a way to offer that support and a place for women to go."**

Li continued to share what she learned from the conference with her peers and soon became an officer of Women in Science, where she focuses on raising awareness of underlying gender discriminations and diversity issues in science. She also hoped that more students would join her in experiencing CUWiP and worked hard to publicize the conference to her fellow physics majors.

Her efforts certainly paid off. Nine undergraduate women physics majors — Joanne Hsueh, Alex Jackson, Sarah Penfield, Polina Petrov, Megan Roche, Swara Srinivasan, Erica Xin, Nozomi Yasuda and Boyan Yin — joined Li and Zhai at the 2018 CUWiP at the University of Toledo. At the conference, senior Alex Jackson won second prize in the poster presentation.

"When I went to the first conference, I didn't know what a conference would be like, and I was worried that I had way too little physics knowledge and research experience," Li said.

> **"By the second conference, I was more confident and knew I belonged to the physics world."**

Now juniors, Li and Zhai are looking forward to Carnegie Mellon hosting a regional CUWiP in 2020.

"Sending students to the Conference on Undergraduate Women in Physics has been a wonderful experience for many women who have attended," said Scott Dodelson, head of the department of physics. "In recognition of this, Carnegie Mellon and the University of Pittsburgh are excited to host the 2020 conference at CMU."

■ *Emily Payne*

Pictured (L to R): CMWA Honorary President Tris Jahanian with scholarship winners Maitreyee Joshi, Mira Shukla, Nikita Gupta, Aubyn Heglie, Bethany Wang and Yasmene Elhady

Senior Yasmene Elhady Wins Carnegie Mellon Women's Association Scholarship

This spring, Yasmene Elhady received an early graduation gift from the Carnegie Mellon Women's Association (CMWA). She was one of the seven outstanding women from each of the university's colleges honored by the CMWA at their Spring Awards Reception. The students received a $1,000 scholarship for their commitment to the advancement of women in their academic disciplines.

"Yasmene possesses infectious positivity and the ability to bring people together across the campus to make productive change. She has had tremendous impacts on all of the students and faculty in Mellon College of Science," said Maggie Braun, associate dean for undergraduate affairs.

In the fall of 2016, Elhady worked with two other students to create a student organization for spirituality called INSPIRE (Interfaith Spirituality Embassy). The club meets weekly and holds discussions on deep questions in spirituality, belief systems, morality, ethics and "what to do" scenarios. Students and faculty participate in these discussions with a goal of understanding and a vision to work together to create a better community. Under the Student Affairs spirituality initiative, Elhady and the INSPIRE club were instrumental in organizing interfaith public meetings with large student attendance.

In addition to her work in INSPIRE, Elhady was a leader in reinventing the Mellon College of Science Women in Science organization — taking the programming from a faculty-organized initiative to a student-organized one. She and three other students created a constitution and budget proposal for the club and have coordinated bi-weekly meetings since the fall of 2016.

Elhady also serves as a role model to third-year students as a teaching assistant for the new PROPEL seminar course. Her experiences in and out of the classroom make her a natural leader in the course.

"Yasmene is very conscientious and thorough. She thinks deeply about the course and the students enrolled in it," said her advisor Kunal Ghosh, assistant head for undergraduate affairs.

> **"She raises deep issues she has discovered reading (student) homework assignments and also through their discussions (in class). This is quite rare for a teaching assistant."**

Elhady strives to bring her peers to a deeper understanding of themselves and their connections with the world. Given her success in her undergraduate journey she is planning to pursue a career in public policy and service.

The CMWA has been awarding scholarships to graduating students every year since 1964. The scholarships are funded by CMWA membership dues. CMWA membership is open to all women associated with the university.

■ *Emily Payne*

New MCS Center for Theoretical Sciences Hosts 'Science Jam'

On a cold Wednesday evening in March 2018, graduate students gathered in a large classroom in the Mellon Institute to present what they do in just five minutes. Refreshments were provided to the crowd of a few dozen at the "Science Jam," even though some of the topics covered were a little less than appetizing.

"Hi, my name is Emily and today I'm going to tell you a little about Ebola virus," said Emily Simon, a Ph.D. candidate in the Department of Biological Sciences, in beginning her presentation. She then went on to describe the mechanism of Ebola virus and her research that studies what it is about the structure of one of the virus' proteins that makes it so deadly.

In total, 13 MCS graduate and postdoctoral researchers condensed their complex work into brief presentations with PowerPoints. The presentations covered a wide range of topics such as using machine learning to measure the mass of distant galaxy clusters, using chemistry to more accurately detect synapses inside the brain and calculating the mathematics of how exactly objects such as pea pods bend to open.

The diversity of topics presented was exactly why Professor and Head of the Department of Physics Scott Dodelson organized the Science Jam. The event was sponsored by the Mellon College of Science's new Center for Theoretical Sciences (CTS).

CTS was founded to help bring theorists from across the scientific landscape together to help each other and forge new ideas and directions for research. The center's activities will include collaborations with students, faculty and postdoctoral researchers in a shared workspace, monthly seminars, support for visiting scientists and, of course, events like the Science Jam.

"There are lots of ideas that flow across science," Dodelson said, and he hopes that researchers will see how interdisciplinary their work could be. "The goal is to get people together."

CTS is projected to be a major draw to help recruit new students, postdoctoral researchers and faculty who wish to take advantage of a fertile environment for interdisciplinary research.

"It will serve as the intellectual nexus of the college and a fountainhead of innovation at the university," the center proudly proclaims on its website, which can be found at www.cmu.edu/mcs/theory/.

■ *Ben Panko*

Numerical Milling Machine, Supported by Gift from John Peoples Jr., Enhances Medium Energy Shop's Capabilities

The Medium Energy research group's shop gained a numerical milling machine thanks to a generous gift from Carnegie Mellon University alumnus John Peoples Jr. The machine will allow research groups to manufacture small-batch machined parts that can be difficult and expensive to obtain.

The shop has been a significant resource for particle physics research at Carnegie Mellon over the last 30 years. Long-term machinist Gary Wilkin oversaw the development, construction and installation of major detector elements for experiments at CERN, Brookhaven National Lab and Jefferson Lab, including most recently the Central Drift Chamber for the GlueX experiment at Jefferson Lab.

With Wilkin's retirement in 2015, Eric Day took over the shop and led the construction of the Jefferson Lab hadron calorimeter and is gearing up for a major upgrade project for the Large Hadron Collider's Compact Muon Solenoid (CMS) detector.

Day also has led a major revamp of the shop itself, where the capstone has been the installation of the new HAAS Numerical Controlled Milling Machine. This machine was funded by several research groups across the physics department and a major contribution from Peoples. This important acquisition allows the physics department to make the medium-energy shop facilities and Day's expertise more widely available to the entire department. It also gives students the opportunity to train on state-of-the-art equipment and allows trained graduate students to fabricate critical parts for their experiments.

Within days of turning on the machine, it has already saved one research group significant time and cost in the procurement of small-batch machined parts. The addition of this machine is already significantly enhancing the physics department's ability to carry out research and train students. The department hopes to be able to add more equipment to the shop under Day's direction.

Peoples received his bachelor's degree in electrical engineering from Carnegie Mellon University (then the Carnegie Institute of Technology) in 1955. He went on to receive his Ph.D. in physics from Columbia University. Among his many accomplishments, Peoples served as the third director of Fermilab for 10 years (1989–1999) and as the director of the Sloan Digital Sky Survey from 1998 to 2003. The physics department at CMU expresses sincere gratitude for his generous gift.

■ *Curtis Meyer*

Pictured (L to R): Mark Gelfand, Glen de Vries Dean of the Mellon College of Science Rebecca W. Doerge and Njema Frazier

TWO PHYSICS ALUMNI WIN **ALUMNI ACHIEVEMENT AWARDS**

Entrepreneur, Philanthropist and Activist Mark Gelfand

Physics alumnus Mark Gelfand believes in the power of STEM to change the world, one life at a time. He received Carnegie Mellon University's 2018 Alumni Achievement Award for exceptional accomplishment and leadership in his field.

For the 1973 Carnegie Mellon University graduate, STEM is more than just a field of study. Gelfand sees science, technology, engineering and math as the keys to a better life and a better world, and he leads multiple efforts to put them in hands across the world.

A native of South Euclid, Ohio, Gelfand was inspired by the space race of the 1960s and TV's "Watch Mr. Wizard" — and by his uncle Len who was a chemical and electrical engineer. A natural tinkerer, Gelfand found a passion for science and engineering that has never abated.

Gelfand earned his bachelor's degree in physics from the Mellon College of Science, a field he felt could give him the broadest view of science and engineering. In 1985, he founded Boston-based company Intex Solutions Inc., which developed the standard calculator for the international structured finance markets. Gelfand and his wife have three sons, who all became engineers.

During his son's education Gelfand found his true calling, developing a deep concern about a lack of hands-on STEM instruction for children without resources like those he provided to his family. He then founded the Gelfand Family Charitable Trust to support STEM initiatives in several U.S. cities, Israel and east Africa.

One of the first beneficiaries of the trust was Pittsburgh. In 2006, he created the Leonard Gelfand Center for Service Learning and Outreach at Carnegie Mellon, which is named for his engineer uncle and works with CMU students, faculty and staff to improve K-12 educational opportunities, specifically in STEM areas. It serves about 1,000 students annually through tutoring, mentoring and career presentations at schools.

> **"I realized that instead of putting money in a pot, I could instead propose something and then do it."**

Gelfand found himself eager to "make an impact on as many kids as possible" and traveled to Israel to see new perspectives on science and engineering education. After a chance meeting with Ethiopian students at an Israeli youth village, he saw that with the right opportunities, students in developing nations could thrive and become the scientists and engineers their communities need.

He transitioned his family trust into STEM Synergy, an Ethiopia-based NGO that funds hands-on engineering and science centers, STEM outreach programs at universities, municipal school computer labs and other enrichment programs. He also founded and is an active manager of TodayTomorrow Ventures, an impact investment fund that invests in new businesses in Ethiopia.

It's important to Gelfand that his efforts empower the community to get involved and create the change themselves.

"It has to sustain," Gelfand said of his work. "It can't be dependent on me."

Since 2015, STEM Synergy has established 15 STEM centers, each equipped with state-of-the-art laboratories and an auditorium. Gelfand has already achieved one of his major goals: 70 percent of Ethiopian university students graduate in STEM majors.

"I found a place I really wanted to be," Gelfand said. "And somehow we managed to change the country."

Nuclear Physicist, Mentor and Advocate Njema Frazier

Njema Frazier, a 1992 graduate of the Department of Physics, is a pioneering nuclear scientist and a tireless advocate for diversity in STEM fields. Frazier received Carnegie Mellon University's 2018 Alumni Achievement Award for exceptional accomplishment and leadership in her field.

Frazier works for the U.S. Department of Energy in the National Nuclear Security Administration (NNSA) Office of Defense Programs, where she serves as the acting director of the Inertial Confinement Fusion program. She is the first woman and first black scientist to head the office in its 40-year history.

Frazier leads scientific and technical efforts to ensure that the United States maintains a safe, secure and effective nuclear weapons stockpile without explosive testing. She directs nuclear weapons modeling and simulation, weapons physics experiments and international collaborations, along with budget and personnel management, including engaging with leading scientists in the field.

Prior to joining the NNSA, Frazier was a professional staff member for the U.S House of Representatives' Committee on Science.

CMU Alumni Awards

Frazier has more firsts on her record: first African-American woman to graduate with a physics degree from the Mellon College of Science and the first to receive a Ph.D. in nuclear physics from Michigan State.

"CMU was a great foundation for graduate school and my career," she says.

The firsts throughout her life prepared Frazier for another important role, that of advocate for diversity in STEM education.

"There's a lot of talent out there," Frazier explains. "If those students were able to have access and exposure to quality education, they could easily be scientists and engineers. It's important for people inside, like me, to reach out to others. In the end, diversity benefits everyone."

She is part of the Department of Energy's Minorities in Energy Initiative, co-founder of the POWER (Professional Opportunities for Women at Energy Realized) Employee Resource Group, a member of the National Advisory Board of the National Society of Black Engineers, chair of the Algebra by 7th Grade Initiative for grades 3 to 7 and founder and CEO of Diversity Science LLC, a network of scientists and engineers dedicated to broadening STEM participation.

Frazier has received many honors for her work and advocacy, including recognition by Black Girls Rock! for her work in STEM, the Department of Defense Joint Civilian Service Commendation Award, a Black Engineer of the Year award, EBONY Power 100 honors, a Distinguished Service to the NNSA award and many others.

To others following in her trailblazing footsteps, Frazier offers some advice.

> **"Don't pay so much attention to being the first. Follow your interests and passions wherever they may lead. But once a door is open, it's important to make sure it stays open."**

■ *Joyce DeFrancesco*

Alumnus Michael McQuade Named Vice President for Research

Michael McQuade, former senior vice president for science and technology at United Technologies Corporation (UTC), has been named Carnegie Mellon University's new vice president for research. The newly created position will strengthen and support research, creativity and entrepreneurship at Carnegie Mellon.

McQuade is a triple alumnus of the Department of Physics, earning bachelor's, master's and doctoral degrees. His doctoral research was conducted at the Fermi National Accelerator Lab.

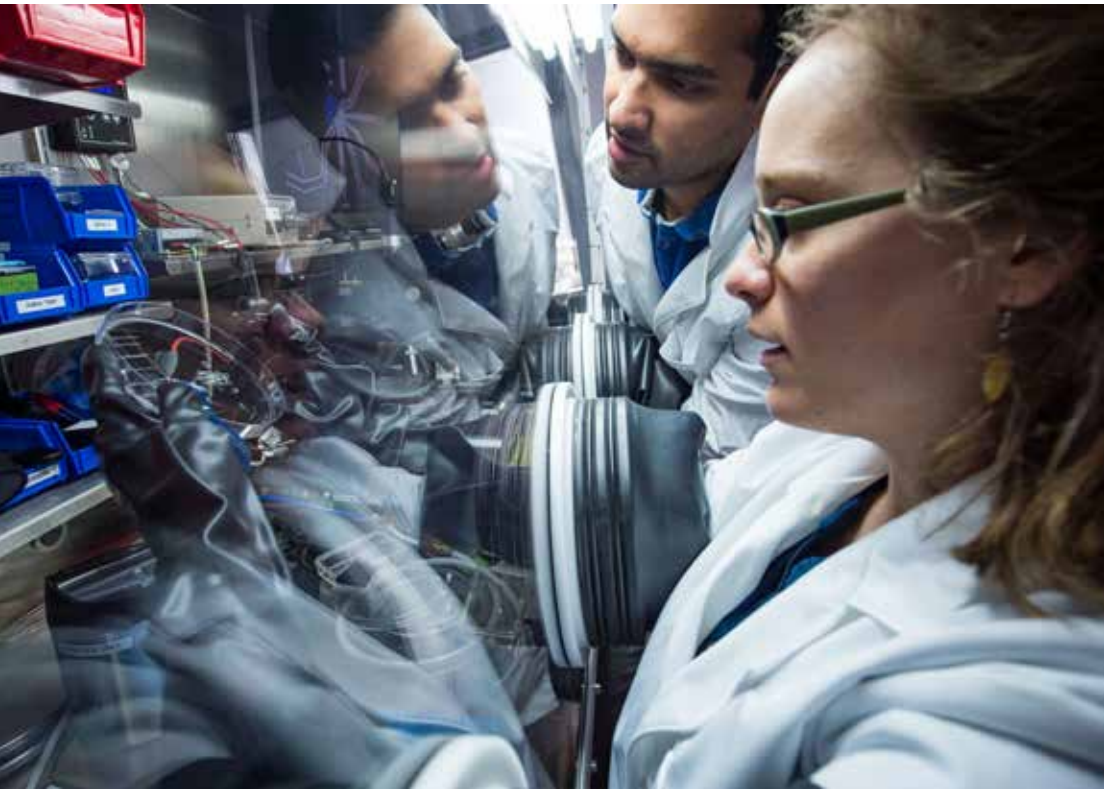
"Michael McQuade's depth of experience across industry, government and academia, as well as his familiarity with CMU as a trustee and alumnus, positions him well to take on this critical role and build upon our extraordinary momentum as a leading research institution," said Carnegie Mellon President Farnam Jahanian. "With the elevation and expansion of this critical office, we look forward to maximizing the competitiveness of our research enterprise and promoting closer collaboration with industry partners, government agencies and other stakeholders."

During his time at UTC, McQuade provided strategic oversight and guidance for research, engineering and development activities throughout the business units of the corporation and at the United Technologies Research Center. He previously held senior positions with technology development and business leadership at 3M, Imation and Eastman Kodak, with broad experience managing basic technology development and the conversion of early stage research into business growth.

"I am excited to join Carnegie Mellon to lead and support the extraordinary research enterprise of this world-class university," McQuade said. "I look forward to working closely with our faculty, researchers, staff and students to build on the university's strong foundation of success, as evidenced by the many CMU technologies, discoveries and advancements that are revolutionizing industries and making a positive impact on society."

A thought leader in Washington D.C., McQuade currently serves as a founding member of the Defense Innovation Board, an independent federal advisory committee formed in 2016 that advises the secretary of defense on how best to advance technological innovation. He also previously served on the President's Council of Advisors on Science and Technology from 2013 through 2017 and on the Secretary of Energy's Advisory Board from 2009 through 2017.

For the past six years, McQuade has served as a CMU trustee, providing strategic guidance to the university as a member of the Research, Innovation and Entrepreneurship Subcommittee.



Physics will play a critical role in the future of science. Our faculty, students and alumni are transforming how we understand the universe and enabling world-changing technologies. Our foundational physics research and our work that incorporates physics with machine learning, artificial intelligence, engineering and data science will lead to life-changing and breakthrough scientific discoveries. Invest in us as we revolutionize science and prepare the next generation of physicists.

Please consider directing your gift to one of these priority funds:

The Physics Undergraduate Enrichment Fund: Gifts to this fund support the undergraduates that are at the heart of our community by providing support for student clubs, special events, conference travel and summer research opportunities.

The Physics Graduate Student Fund: Gifts to this fund provide graduate students with support for community-building activities, research and travel to conferences and meetings.

The Equipment Fund: Cutting-edge research requires state-of-the-art equipment. Gifts to this fund will help us push the frontiers of knowledge and provide excellent training for our students.

To make a gift, visit: **www.cmu.edu/physics/giving.**

For more information or to have a confidential discussion about your philanthropy, please contact the Mellon College of Science Development staff:

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