INTERACTIONS

2023 / 2024

Carnegie Mellon University
Mellon College of Science
Physics

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 sdodelson@andrew.cmu.edu. The department is headed by Scott Dodelson.

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Letter from the Department Head, Scott Dodelson

Six eminent physicists came to visit our department this year to review us. They opened their review by writing "The department is a major asset of CMU, explicitly supporting CMU's mission through its outstanding research, outstanding teaching and mentoring, and overall reputation." Let me give you a flavor of what they heard and were excited about: we are starting a Quantum Track for our majors so they can be prepared for the opportunities opening up due to discoveries in quantum mechanics. The McWilliams Center is thriving with young talent, expanding its reach into astrophysical phenomena that change over time, and — for the first time — is looking to secure telescope time for its members. Our "string of theorists" with interests ranging from how life emerges from inanimate molecules to black holes is now strong and interactive enough to develop an interdisciplinary Theoretical Physics Center. Similarly, our success applying AI and Physics is emboldening us to propose an AI and Science Center that would live within and unite the Mellon College of Science.

You can read more about the department in this newsletter, but please spend some time reading about Fred Gilman and his contributions to the university. Many of you probably know Fred. You may not know that he is a giant in the world of particle physics, and he broadened his expertise to include cosmology, launching the initiative that begat the McWilliams Center. Then, he worked tirelessly for everyone in the Mellon College of Science as dean. He and his wife, Barbara, are wonderful people, generous, upbeat and welcoming. It has been such an honor to get to know them a bit.

To give you a sense of what it is like to be around Fred, let me share a story he told me after I mentioned that I had read Michael Lewis's book "The Undoing Project." The book is (partly) about the polymath Amos Tversky, who is considered one of the founders of behavioral economics. The Gilman and Tversky families were close friends at Stanford. Amos once went to a conference at the Salk Institute in San Diego, where he met Jonas Salk and his wife. He was struck by the feeling he had met her before, but he could not remember either when or where. Back at Stanford, Tversky brooded about this mystery until just before the Gilmans arrived at his house for dinner. Amos was told that Salk's wife was Francoise Gilot, Pablo Picasso's partner for many years and the subject of multiple Picasso abstract paintings. That was how he had "met" her before. Yes, Amos Tversky was that smart: he had seen the essence of a person as captured by an abstract painter. And, yes, Fred is that interesting and well-rounded. He has led the fullest of lives in academia. Please join me in wishing him and Barbara continued happiness and health in retirement.

Faculty Notes

Physics Faculty Provide High School Teacher Training

John Alison wants to get more people involved in physics. To do that, the assistant professor in Carnegie Mellon University's Department of Physics organizes the Physics Teacher Program. The program provides high school educators opportunities, resources and a community aimed at motivating more students to consider physics as a career.

"Students have already made up their minds about what they want to study by the time they get to college," Alison said. "Many people in the Department of Physics got excited about the field because they had really good and interesting physics teachers in high school."

Penn Hills High School physics teacher Katharine Gorman has participated in the program since its inception.

"People don't go into physics because of Isaac Newton, but his work is foundational to what is taught in high school physics," Gorman said. "What makes physics more engaging is showing the students where the field has gone in the past 400 years."

This year's program focused on programming skills. Faculty, graduate students and undergraduates worked with teachers to design and implement Python programs that can be used to visualize physics problems and solutions in classes. Teachers also toured lab spaces and met faculty, staff and students.

The program took place June 26–29. On the last day, teachers were encouraged to bring an administrator or another teacher to learn about the experience and hear about physics careers. One of the misperceptions about physics is that the only job path is to be a teacher.

"Most people who get a physics degree aren't physics professors. They're also not working in pure physics," Alison said.

A physics background teaches students how to develop essential problem-solving skills, he said. A degree in physics can be beneficial in fields such as nuclear power, astronomy and space, medical physics, optoelectronics, quantum technologies and software engineering.

Through exposing high school teachers to advances in the field, Alison said that information goes through a multiplier effect.

"Each teacher has the potential to reach 20, 50 or more students in a year," he said.

Physics Head Scott Dodelson said Carnegie Mellon should be a resource for teachers and local students.

"It's our responsibility to reach out as far as we can to help expose people to what an intellectual life is so that it can be part of their aspirations," Dodelson said. "Through outreach efforts by the Department of Physics, we're trying to attack this problem in a variety of ways."

■ *Heidi Opdyke*

Ferguson Gifts Support Future of Physics at Carnegie Mellon

Physicists spend years planning projects on a grand scale such as with the Compact Muon Solenoid (CMS) experiment at CERN'S Large Hadron Collider in Geneva, Switzerland.

Emeritus Physics Professor Thomas Ferguson took that idea one step further when he heard that Carnegie Mellon's Department of Physics had fewer endowed professorships than its peers. Looking toward the future, he set up a life insurance policy that will one day endow a chair for a faculty member in experimental high-energy physics.

"As far as I know, I'm the only one to endow a chair like that," he said. "That was my way to help the department."

Since setting up the life insurance policy, Ferguson regularly gives to the university's general fund. A recent conversation with Carole Panno, an associate director of development, offered another opportunity: an ACS Legacy Scholarship.

The ACS Legacy Scholarship Program provides donors an opportunity to assist a student enrolled in a designated school or college, and the gift immediately benefits the student. Students and donors will often correspond through emails and letters as well as have the opportunity to meet one-on-one.

Ferguson chose to support a four-year scholarship for a physics student, which first-year Marissa Parris received.

"It's a great way of having your donations targeted," he said. "This is a way you can really see donations going to someone and really helping."

Ferguson joined Carnegie Mellon in 1985 after working as a postdoctoral researcher at Cornell University. He earned his undergraduate and graduate degrees in physics from the University of California, Los Angeles. His research lies in experimental high-energy particle physics and in particular colliding beam accelerators. A member of the CMS collaboration, Ferguson is still involved with CERN and continues to work with graduate students on data analysis and papers.

During his first semester in Pittsburgh, he taught Physics for Humanities Majors. At the time he accepted the position, the chair told him to anticipate 20 to 25 students. Almost 150 students enrolled.

"I always appreciated and loved teaching students, and it was always an important part of what I did at CMU," he said.

Ferguson taught a variety of courses including everything from Physics for Science Students to the Physics of Music. For his efforts he was awarded the Mellon College of Science's Julius Ashkin Teaching Award in 1990 and the university's William H. and Frances S. Ryan Award for Meritorious Teaching in 1998.

■ *Heidi Opdyke*

Ben Hunt Named Pittsburgh Quantum Institute Co-Director

Ben Hunt, associate professor of physics, has been named co-director of the Pittsburgh Quantum Institute (PQI). A collaboration of CMU, the University of Pittsburgh and Duquesne University, PQI aims to advance research, education and training in quantum information science and engineering. The new co-director role will harness CMU's expertise to help solidify Pittsburgh's leadership in the field.

Hunt joins his longtime collaborator Michael Hatridge, associate professor of physics at Pitt, as co-director. Hatridge leads the Hatlab and is the director of Western Pennsylvania Quantum Information Core, one of the shared facilities for PQI members.

As co-directors, Hatridge and Hunt will provide strategic direction and oversee PQI's research programs, foster collaborations with industry and government partners and further the education and training of the next generation of quantum scientists. Immediate plans include workshops, a seminar series located at both CMU and Pitt, research support and a one-day event.

Hunt said he is excited to foster more connections at CMU.

"I'm really excited to bring our researchers together — to get computer science folks talking to physicists, people from our Software Engineering Institute, the Pittsburgh Supercomputing Center and more," said Hunt, an experimental condensed matter physicist whose research focuses on two-dimensional materials. "There have been huge advances in quantum science in the last decade. And we at PQI are trying to energize and promote quantum science and engineering by making connections among researchers at Pitt, CMU, Duquesne and beyond."

Hatridge said he was excited to welcome Hunt to the PQI team.

"As co-director, I look forward to working alongside Ben to strengthen this enhanced partnership between our schools in furthering quantum research and education throughout our region and attracting government and industry leaders to partner with PQI," he said.

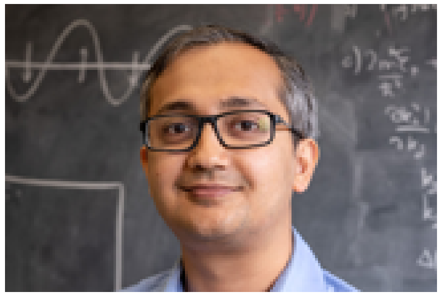
Rob Cunningham, Pitt's vice chancellor for research infrastructure and PQI's executive director, said that establishing the co-director positions is an important step toward having significant impact.

CMU's Curtis A. Meyer, interim dean of MCS and Otto Stern Professor of Physics, was integral in establishing the co-director role. He said he was thrilled to see the joint leadership.

"While there have been a substantial number of efforts scattered in both Carnegie Mellon and Pitt, having joint CMU/Pitt leadership of the Pittsburgh Quantum Institute will allow us to solidify and strengthen these efforts in a coherent manner that will benefit not only our universities, but the region as a whole," Meyer said.

■ *Caroline Sheedy*

New Faculty

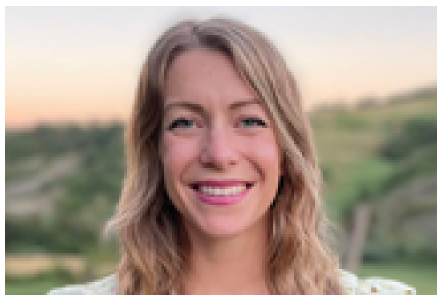


Shubhayu Chatterjee

cmu.is/ShubhayuChatterjee

Matteo Cremonesi

cmu.is/MatteoCremonesi

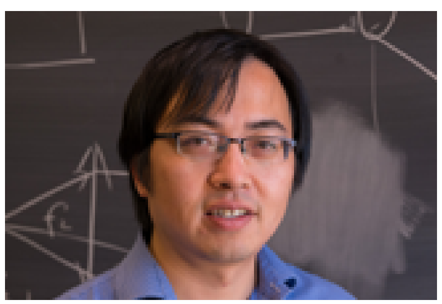


Antonella Palmese

cmu.is/AntonellaPalmese

Rachel Rosen

cmu.is/RachelRosen



Sufei Shi

cmu.is/SufeiShi

Retirement of Fred Gilman

Fifty-eight years after receiving his doctorate from Princeton University, emeritus Professor of Physics Fred Gilman can look back on the different parts of his career — much of which he did not foresee — and spot the key turning points.

Gilman experienced one of these pivotal moments as an undergraduate at Michigan State University, when he had his first experience doing research — in genetics. He took a course in the subject and worked in his professor's lab doing classical genetics experiments. It was soon after the structure of DNA had been discovered, and enormous progress in our understanding was being made. When Cold Spring Harbor Laboratory offered its first summer undergraduate research program, Gilman's professor encouraged him to apply.

"It was one of the formative experiences of my life," Gilman said. "Not only were my fellow summer students and the researchers exceptional, but I was very lucky to be assigned to the lab of someone who later won the Nobel Prize. I learned how clever but relatively simple experiments could be designed and carried out, leading to major scientific insights. I also carried away a lifelong belief in the importance of research for undergraduates."

Although he also fell in love with genetics that summer, physics remained Gilman's calling. He attended graduate school at Princeton, and a chance encounter at a physics meeting landed him at Stanford University during the summer of 1963 as the Stanford Linear Accelerator Center (SLAC) was being built. At the end of the summer, Gilman gave his first theoretical physics seminar on producing new particles at SLAC. Four years later, the accelerator was operational, and Gilman, fresh out of a postdoctoral fellowship at Caltech, returned to SLAC. He would go on to spend twenty-four years on the Stanford faculty.

"Being at Stanford was a highlight of my career," Gilman said. "Many of the great experimental discoveries that established the Standard Model of particle physics were carried out there in the 1960s and 1970s, resulting in three Nobel Prizes for my colleagues."

In the late 1970s and 1980s, most of Gilman's research focused on understanding if the Standard Model could explain the observed differences between the behavior of matter versus those of anti-matter. More and more he was also drawn into exploring what particle physics beyond the Standard Model might look like and leading physics studies for the next generation of particle accelerators that required giant leaps in energy and intensity.

In 1990, Gilman left SLAC to lead the Physics Research Division of the Superconducting Super Collider (SSC) project, which was beginning construction near Dallas. The SSC was designed to collide two proton beams with a total energy about 20 times the highest energy machine at the time and three times the Large Hadron Collider later built in Geneva, Switzerland. Gilman managed two international collaborations, each like a laboratory with thousands of people, to design and build the major experiments. He also assembled the SSC's internal physics groups and facilities.

"It was a whole new world of activities for me," Gilman reflected. But in 1993, Congress canceled the project, and Gilman devoted the next two years to distributing equipment, transferring the knowledge gained on detector technology to other experiments and most importantly, helping people at all levels to find jobs.

After that, Gilman joined Carnegie Mellon's faculty as the Buhl Professor of Theoretical Physics, a position he held until his retirement in 2022.

"I had made up my mind to focus on research and teaching undergraduates, and to avoid administrative duties or the government," he said.

That sentiment didn't last long. He was soon drawn into CMU's strategic planning, and he joined and then chaired the Faculty Affairs Committee of the Faculty Senate. Working with then-provost Paul Christiano, he presented the proposal for a new retirement policy that included the incentive- and phased-retirement options still relevant today. Gilman jokes that he holds the record of having the shortest tenure as chair of the Faculty Senate. He was vice-chair when the chair went on leave, and Gilman promptly had to resign after one Senate meeting when he became head of the Department of Physics.

In parallel with his changing roles at Carnegie Mellon, Gilman was called upon by the Department of Energy (DOE) to lead a committee to plan the future of U.S. particle physics post-SSC. Then, for six years, he served as chair of the High Energy Physics Advisory Panel, which advises the National Science Foundation and DOE on setting the nation's priorities for particle physics.

As department head, Gilman pushed initiatives in biological physics, cosmology and quantum electronics, all of which have become major components of the department's research portfolio. He is particularly captivated by astrophysics and cosmology areas "where we will potentially get an answer to some of the deepest open questions about the particles and fields in the universe," he said.

In 2008, Carnegie Mellon joined the group of universities and labs advocating for the Large Synoptic Survey Telescope project, now under construction and called the Vera C. Rubin Observatory. Gilman served for six years as chair of the committee overseeing its construction and is on its operations management board as the project moves to its completion.

Both as department head and then as dean of the Mellon College of Science from 2007 to 2016, Gilman had the opportunity to work with exceptional students, faculty and alumni. He is especially proud of working with alumni Glen de Vries, Michael McQuade, Bruce McWilliams and John Peoples, who were deeply engaged not only in supporting one department or college, but also in the success of Carnegie Mellon as a whole.

Looking back over the more than five decades of his career, the father of four and grandfather of six couldn't have done it without his wife Barbara and their family.

"They provided love, stability and immense satisfaction," Gilman said. "Their support carries you a very long way even when the outside world gets difficult."

■ *Amy Pavlak Laird*

Retirement of Reinhard Schumacher

Reinhard Schumacher may have retired from teaching, but he will continue to be a presence in the Department of Physics.

"I'm fully retired, but I'm not stopping working," Schumacher said. "I need a bit more time to finish several projects before slowing down. I'm continuing to work on research that's fully funded, but I did stop teaching. It puts me a position to spend all day, every day, on my research."

Schumacher started teaching at Carnegie Mellon in 1987 and has taught continuously for 36 years. A native Canadian, he went to Churchill Area High School in a suburb of Pittsburgh.

"The fact that I ended up coming back to Pittsburgh was a little bit of fate," he said.

For more than two decades, Schumacher taught the Modern Physics Laboratory, a capstone course for all undergraduate physics majors with an emphasis on writing scientific papers and learning how to deliver persuasive research presentations and to think like a physicist, a skill that is valuable for many career paths.

"It was a real pleasure to be able to do that," Schumacher said. "I spent a lot of time improving the experience for students and making it better and better as the years went by. It's really wonderful to see the lightbulb go on over their heads when they suddenly understand a concept."

Schumacher also taught Modern Essentials (Relativity and Quantum Physics) for many years.

For his excellence in undergraduate teaching, Schumacher received the Julius Ashkin Award from the Mellon College of Science in 1995.

"Lab courses are one of the only places where students really have to grapple with data in the sense that you acquire these numbers and you're trying to prove something or test an equation," he said. "It's one of the only courses where you get thorough training in that. Understanding how to crunch numbers in a way that is correct and reliable is useful for whatever career a student pursues."

Physics lent itself to Schumacher's early interests in designing and building equipment.

"When I studied physics as an undergraduate, I came to realize that the discipline gives someone with those interests a playground to explore, both in terms of physics ideas and also the opportunity to design and build experiments," he said. "I've been lucky to make a career out of something I've really enjoyed since early on."

Prior to joining Carnegie Mellon, Schumacher worked at CERN in Switzerland for several years and was a postdoctoral researcher at the Swiss Institute for Nuclear Research, now known as the Paul Scherrer Institute. He earned his bachelor's degree from Case Western Reserve University and graduated from Massachusetts Institute of Technology with his Ph.D. in 1983.

When he arrived at Carnegie Mellon, some of his MIT classmates became colleagues, such as Emeritus Professors of Physics Gregg Franklin and Brian Quinn. Along with Curtis Meyer, the Otto Stern Professor of Physics and interim dean of the Mellon College of Science, the four were the core of the experimental nuclear physics group from the late '80s through the 2010s.

They conducted experiments at CERN, Brookhaven National Lab in New York and Thomas Jefferson National Accelerator Facility in Virginia.

Schumacher studies the electromagnetic production of strange particles known as kaons and hyperons. The production of strange-quark pairs is helping to refine understanding of baryon and mesonic resonances. He served as the spokesperson for the Continuous Electron Beam Accelerator Facility (CEBAF) large acceptance spectrometer (CLAS) experiment. He also is part of the upgraded CEBAF known as the Gluonic Excitation Experiment (GlueX) and stepped down as head of its collaboration board in early 2022.

"We've been doing lots of different things at Jefferson Lab. Carnegie Mellon is ideally situated. We have good lab infrastructure, good resources from funding agencies and we've been able to make that work for a long time," he said. For his research, Schumacher was named an American Physical Society Fellow in 2014.

At Carnegie Mellon, along with collaborating with physicists, Schumacher works with researchers in the Department of Psychology. Robert Mason, senior research associate, and Marcel Just, the D.O. Hebb University Professor of Psychology, and Schumacher are investigating how human brains encode scientific concepts with the use of functional Magnetic Resonance Imaging. In one study, the researchers compared brains of Ph.D. physicists to students entering the field to compare their cognitive foundations and development during learning.

"We have funding to study similar questions across all of the STEM disciplines in the Mellon College of Science," he said. The researchers are looking at how students in physics, mathematical sciences, chemistry and biological sciences encode advanced concepts in their brain, and where there are similarities to how the brain organizes and stores different disciplines.

"This cross-disciplinary work arises from the happy coincidence that we have people like me who are interested in the science side and people like Marcel and Rob who are interested from the psychology side," he said. "And we're just about a stone's throw apart making it easy to get together and meet."

■ *Heidi Opdyke*

Student Stories

Awards & Fellowships

GILMAN AWARD

Amy Germer

cmu.is/AmyGermer

PEOPLE'S FELLOWSHIP

Wen Li

cmu.is/PeoplesFellows

MICHAEL MCQUADE FELLOWSHIP

Gina Chen

cmu.is/GinaChen

PEOPLE'S FELLOWSHIP

Phu Nguyen

cmu.is/PeoplesFellows

MCWILLIAMS FELLOWSHIP

Nianyi Chen

cmu.is/Nianyi-Chen

FULBRIGHT SCHOLARSHIP

Rachel Koenig

cmu.is/MCSFulbrights23

PAKE FELLOWSHIP

Aleesha Kallil Tharayil

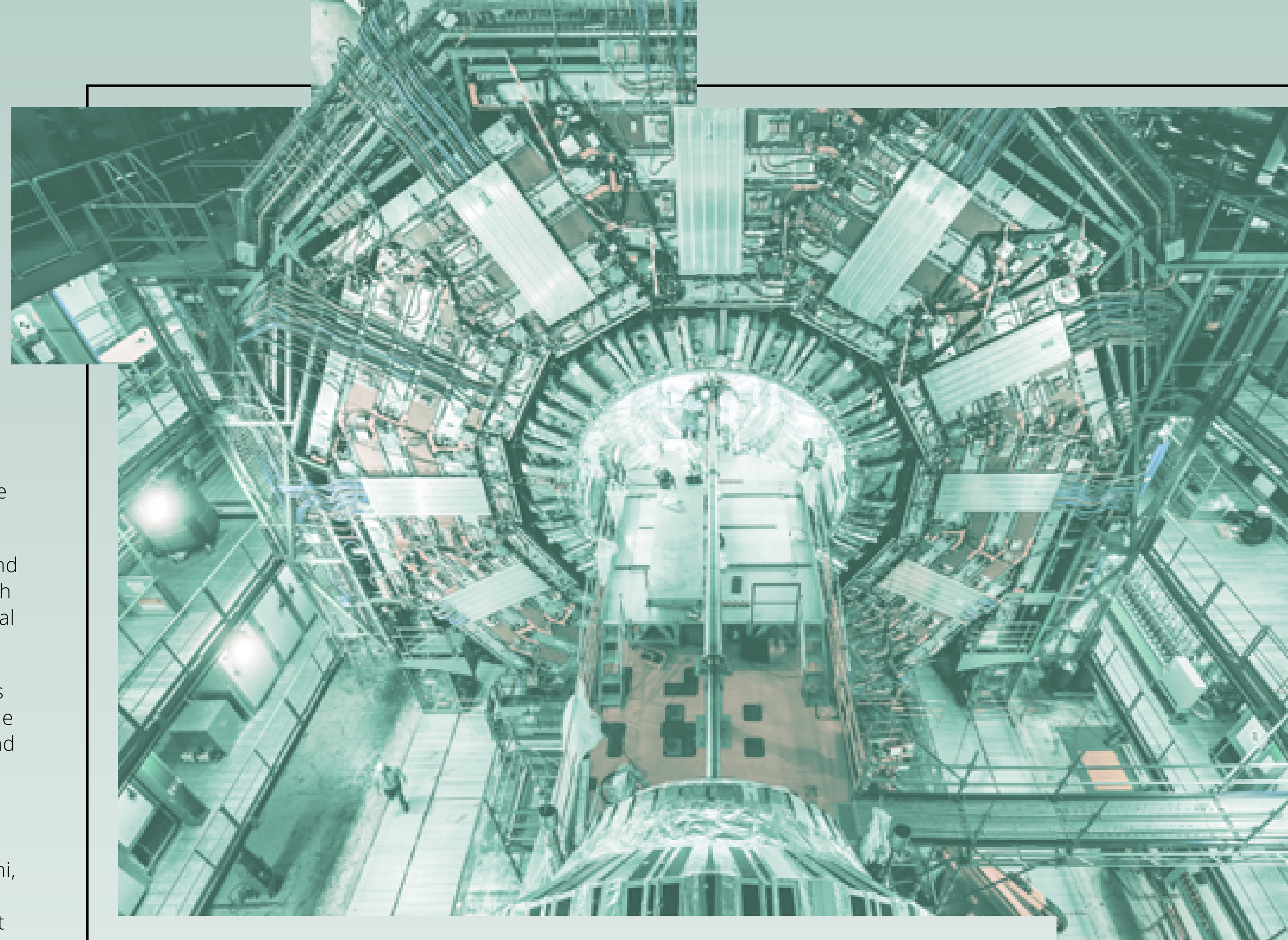
cmu.is/PakeFellowKT

FULBRIGHT SCHOLARSHIP

Ian Daugherty

cmu.is/MCSFulbrights23

Research Feature



DOE Awards High-Energy Physics Researchers Nearly $5M

The Department of Energy (DOE) has awarded 12 Carnegie Mellon University Department of Physics faculty members a $4.98M grant to study high-energy physics (HEP). This grant is part of 80 years of near-continuous support of high energy physics research at Carnegie Mellon, with the last three-year grant awarded in 2020.

HEP is a wide-reaching field that investigates the fundamental building blocks of matter and their interactions in what is known as the Standard Model of particle physics. This research encompasses everything from the smallest elementary particles to the largest cosmological scales.

Awarded through the HEP program of DOE's Office of Science, the grant not only supports research at the Large Hadron Collider (LHC), the world's largest and highest-energy particle collider, but also research at other particle accelerator facilities as well as in cosmology and particle theory.

"In their goal to explore the elementary constituents of the universe, members of the HEP group at Carnegie Mellon collaborate outside of physics with researchers in statistics and machine learning in a typical CMU interdisciplinary fashion," said Professor Manfred Paulini, Mellon College of Science associate dean for research and the principal investigator for the grant. "It is particularly encouraging to see some of our young faculty receive their first external funding through this grant renewal."

The award recipients include faculty from experimental and theoretical physics research backgrounds. Professors Scott Dodelson, head of the Department of Physics, and Rachel Mandelbaum, deputy department head, are cosmologists investigating dark matter, dark energy and the expansion of the universe.

"High Energy Physics brings humanity's most powerful tools — our minds and facilities like the Large Hadron Collider — to address the most fundamental questions that can be asked: What is matter made of? What is in the universe and how did it form?" said Dodelson, who is co-PI on the grant. "CMU brings our specific expertise in computer science and artificial intelligence to make unique contributions to the large collaborations that study these questions."

Assistant Professors John Alison, Matteo Cremonesi and Valentina Dutta together with Paulini work on the Compact Muon Solenoid (CMS) experiment at the LHC. The faculty members search for new particles with the potential to be candidates for dark matter that are not predicted by the standard model and study the Higgs boson, a particle which was discovered in 2012 and is essential to explaining why elementary particles have mass.

Cremonesi is a delegate for the CMS experiment to the LHC Dark Matter Working Group and uses machine learning algorithms to enhance the CMS experiment's potential to discover dark matter.

"This grant will give us the possibility to start a new activity on the upgrade of one of the most important components of the CMS experiment, its trigger system. Using machine learning we will improve the capability of the trigger to select dark matter candidate events in real-time."

Dutta also is interested in leveraging machine learning techniques to improve sensitivity toward new physics. A portion of the funding will support her work on the planned Light Dark Matter eXperiment (LDMX) that will search for light dark matter particles.

LDMX will be located at the Stanford Linear Accelerator Center (SLAC) in California and aims to decisively test a variety of scenarios with hypothetical light dark matter particles, which roughly have masses in the range between those of electrons and protons. The design for LDMX is being developed, with the goal of constructing the experiment and beginning operation in the next few years.

"This award from the DOE will support my group in contributing to the finalization of the LDMX design and playing a role in the activities toward building and running the experiment," Dutta said. "This work is highly complementary to my work on the CMS experiment at the LHC, where I also explore scenarios of new physics that could potentially provide an explanation for dark matter."

Professor Roy Briere, Associate Professor Diana Parno and Dutta received funding for their work in the "intensity frontier." Briere explores the properties of particles containing heavy charm and beauty quarks, also known as "heavy flavor physics, " while Parno is involved in the COHERENT collaboration, which studies the properties of elusive neutrino particles.

Finally, Assistant Professors Riccardo Penco and Grigory Tarnopolskiy, Associate Professor Rachel Rosen and Professor Ira Rothstein — all theorists conducting HEP research — are engaged in phenomenological and formal work developing effective field theories. The effective field theory paradigm explains the laws that govern a system taking into account the fact that we cannot know every small-scale detail of the system. Through the use of effective field theories, they aim to further the phenomenological understanding of the Standard Model and gravity, as well as phenomenological and formal work including subatomic physics, cosmology, black holes and even quantum phenomena in condensed matter systems.

For Penco the grant will fund two directions of his research. He will continue to explore a network of hidden symmetries of black holes, which he and collaborators helped uncover over the last couple of years. These symmetries explain, for instance, why black holes don't have tides like the earth does. The second direction is the study of various aspects of systems at finite density out of equilibrium using effective field theory techniques. Progress in this direction can also have implications beyond HEP.

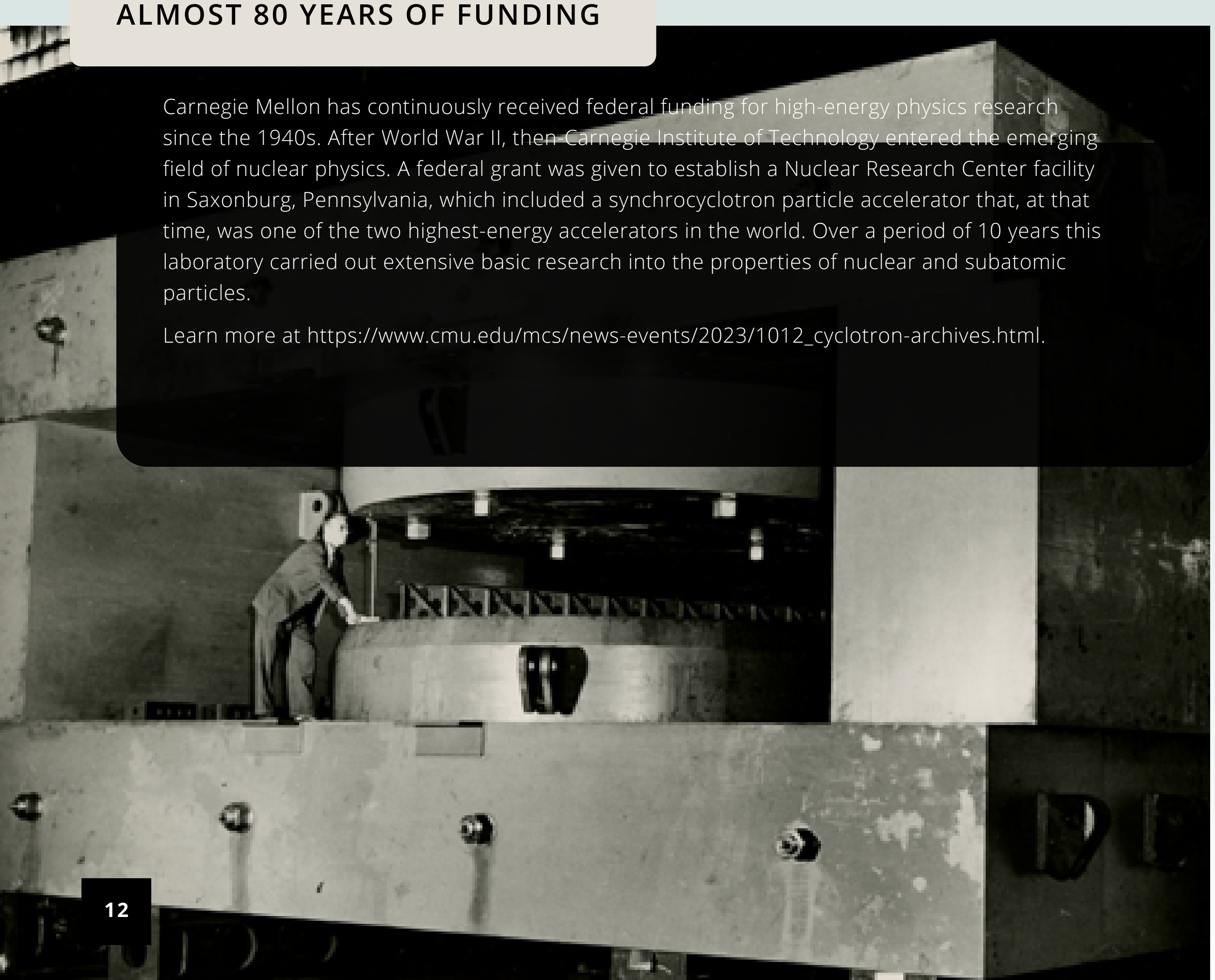
"CMU's long-standing commitment to interdisciplinary research has given me the freedom to pursue my interests in different directions," Penco said. "The department and MCS have recently made substantial investments in theoretical physics, developing expertise in effective field theories and promoting collaboration across subfields. It's an exciting time to be a theoretical physicist at CMU."

■ *Heidi Opdyke*

ALMOST 80 YEARS OF FUNDING

Carnegie Mellon has continuously received federal funding for high-energy physics research since the 1940s. After World War II, then-Carnegie Institute of Technology entered the emerging field of nuclear physics. A federal grant was given to establish a Nuclear Research Center facility in Saxonburg, Pennsylvania, which included a synchrocyclotron particle accelerator that, at that time, was one of the two highest-energy accelerators in the world. Over a period of 10 years this laboratory carried out extensive basic research into the properties of nuclear and subatomic particles.

Learn more at https://www.cmu.edu/mcs/news-events/2023/1012_cyclotron-archives.html.



CMU Hosts U.S. Physicists Working on CMS Experiment

Carnegie Mellon alumna Patricia McBride oversees one of the largest scientific collaborations in history, the Compact Muon Solenoid (CMS) experiment at CERN's Large Hadron Collider (LHC). She recently returned to Pittsburgh for the U.S. CMS annual meeting May 31-June 2.

"It was nice to be back to support and discuss with the faculty and students," said McBride, a 1977 physics graduate.

Since being elected CMS spokesperson in 2022, the distinguished scientist at Fermi National Accelerator Laboratory (Fermilab) has spent most of her time in Geneva, Switzerland. Housed at CERN's LHC, the CMS collaboration uses a five-story detector that searches for particles not predicted by the Standard Model of particle physics and provides information about, e.g., the properties of the Higgs boson particle. McBride leads more than 4,000 particle physicists, engineers, computer scientists, technicians and students from 57 countries who are working together to advance knowledge of the universe's most basic laws.

The LHC's Run 3 began in July 2022 and will operate for close to four years.

"We're running at a slightly more instantaneous rate than before, and we're hoping to get double the amount of data we already have to analyze from Runs 1 and 2," McBride said. "There are interesting, rare processes of which we have some possible first hints," said Manfred Paulini, professor of physics and Mellon College of Science Associate Dean for Research. "We hope that during Run 3 we'll have more definitive data to clarify our understanding about the Higgs Boson and the Standard Model."

More than 50 U.S. institutions are involved in the CMS experiment. The collaborators meet annually.

Paulini, along with Assistant Professors John Alison, Matteo Cremonesi and Valentina Dutta organized the 2023 U.S. CMS Meeting.

"This is the first time that Carnegie Mellon has hosted this gathering," Paulini said. "The opportunity to interact with longtime colleagues, see younger researchers showcase their work and share what Carnegie Mellon and Pittsburgh has to offer the physics community is tremendous."

Along with academic colleagues, representatives from Fermilab, the National Science Foundation and the Department of Energy participated in the meeting. Funding for the meeting was provided by the Department of Physics and the Mellon College of Science.

■ *Heidi Opdyke*

Pictured: Aleesha Kallil Tharayil

Particle Detectors Project Moves Closer to Production

Carnegie Mellon University physicists are moving closer to building new particle detectors for the Compact Muon Solenoid (CMS) experiment at CERN's Large Hadron Collider (LHC).

A team led by John Alison, assistant professor of physics, and Manfred Paulini, professor of physics and Mellon College of Science associate dean for research, are nearing the final stages of refining designs and materials for prototypes for the High-Granularity Calorimeter (HGC), an upgrade to the current CMS detector. Building functional prototypes is a major milestone several years in the making.

"CMS can be thought of as a large 3D camera that records the products of the proton-proton collisions provided by the LHC," Alison said. "For example, images collected from the detector were used to discover the Higgs boson in 2012."

Since the discovery of the Higgs boson, a major focus has been in studying the properties of the Higgs boson in detail and searching for new particles not predicted by the Standard Model of particle physics.

The LHC has a 15-year program to increase the total number of proton collisions by a factor of 20. This program requires collecting more data faster and comes at a significant cost: increased radiation. In addition to producing new exotic states of matter — like the Higgs boson — LHC proton collisions produce large amounts of ionizing radiation.

Built almost 20 years ago, the current CMS detector was not designed to handle the amount of radiation damage anticipated during future LHC runs. New, upgraded detectors are needed to improve the quality of the recorded images and cope with the more challenging environment. This is where the High-Granularity Calorimeter upgrade comes in.

BIG DATA GETS BIGGER

The HGC will replace current CMS detectors in regions that face the most radiation. A next-generation imaging calorimeter, the HGC will significantly increase the precision with which the LHC collisions are imaged. The number of individual measurements per picture will increase from about 20,000 in current detectors to about 6 million in the HGC. The measurements of individual particles will go from the handful of numbers that the current detector provides to a high-resolution 3D movie of how the particles interact when traversing the detector.

The HGC will be built in the next five years, and Carnegie Mellon is playing a leading role in its construction. The HGC will be composed of 30,000 20-centimeter hexagonal modules. The modules — essentially radiation tolerant digital cameras — will be tiled to form wheels several meters in diameter. The wheels will then be stacked to form the full 3D detector. In total, the HGC will require 600 square meters of active silicon sensors.

Alison, Paulini and Valentina Dutta, assistant professor in physics, will build and test 5,000 of these modules in a Wean Hall laboratory with the help of engineers, technicians and students.

"This offers opportunities for graduate and especially undergraduate students to obtain hands-on instrumentation experience working in our lab during the semester or for summer research," Paulini said.

Full-scale module production is anticipated to begin in 2024. CMU will produce 12 modules per day until 2026.

"To meet production needs we have to grow the group with hiring more full-time technicians and engineers who will work on the daily production line," said Jessica Parshook, the lead engineer for Carnegie Mellon's project team. Electronics engineer Eva Kloiber is the team's most recent hire.

The remaining modules will be produced by CMS collaborators at UC Santa Barbara and Texas Tech University in the United States and by groups in China, India and Taiwan. Each module consists of a silicon sensor attached to a printed circuit board housing readout electronics and to a base plate, which provides overall stability.

Module construction will be performed with a series of automated robots that use pattern-recognition algorithms for assembly and then the required 500 electrical connections per module are established. After a series of testing at CMU the modules are tiled onto wheels at Fermilab — a particle physics lab outside of Chicago — and then sent to CERN in Switzerland for installation in the CMS detector.

The CMU group established a class 1000 cleanroom on the eighth floor of Wean Hall, expanding an existing space used by the medium-energy physics group. They have installed and commissioned an 8,000-pound gantry robot to attach the different module layers and an automated wire bonder to make the electrical connections within the modules. The prototype modules allowed the group to test its automated assembly procedures and exercise the full production chain.

Recent advances in image processing from machine learning will be crucial in assuring quality control during production.

"This work, a mix of computer science, machine learning and robotics, is a perfect fit for CMU and we plan to tap into resources throughout the university," Alison said.

■ *Heidi Opdyke*

Research Roundup

Interdisciplinary AI Conference Brings Experts Together

On Jan. 12 and 13, the NSF AI Planning Institute for Data-Driven Discovery in Physics hosted the 2023 Biophysics and Quantitative Biology in the AI Era Workshop. The workshop convened experts from institutions around the world who are using artificial intelligence to advance research in biology and biophysics.

The NSF AI Planning Institute for Data-Driven Discovery in Physics builds on Carnegie Mellon University's long history of leadership and collaboration in physics, artificial intelligence, machine learning, statistics and data science. The institute's workshops promote interdisciplinary collaboration and the creation of the next generation of scientists.

The workshop included four sessions over the two days: High Throughput Experimental Tools, Learning Models from Data, AI for Image Analysis and Quantification of Behavior and Decision Making. Speakers and participants included an interdisciplinary mix of biologists, physicists and computer scientists.

"As an organizer of the image analysis session of the conference, I'm very excited to see a large number of external and local participants and speakers in my session, with active communications and discussions," said Min Xu, assistant professor of computational biology in the School of Computer Science. "This indicates that there is a very fast-growing community in biomedical imaging and image analysis, and a strong interest in combining imaging and artificial intelligence for quantitative biology and biophysics research."

Other organizers included Mellon College of Science faculty Shiladitya Banerjee, assistant professor of physics; Fangwei Si, an assistant professor of physics; and Eric Yttri, the Eberly Family Associate Professor of Biological Sciences.

Banerjee, a member of the NSF AI Planning Institute whose research focus is biophysics, was excited to bring speakers from a myriad of fields together for one goal.

"I think one of the successes was that we were able to bring together physicists, engineers, computational biologists, system biologists and theorists as well as experimentalists who work on various areas within biology, but they use AI and machine learning to solve problems," Banerjee said. "The talks ranged from understanding animal behavior and decision making, to single cell dynamics and image analysis, so we were able to bring together people from different communities so they can transfer knowledge from across different fields for better use of AI tools."

Between the talks, researchers could talk to each other over coffee and lunch. Yttri enjoyed the ability to talk to researchers within and outside of his field.

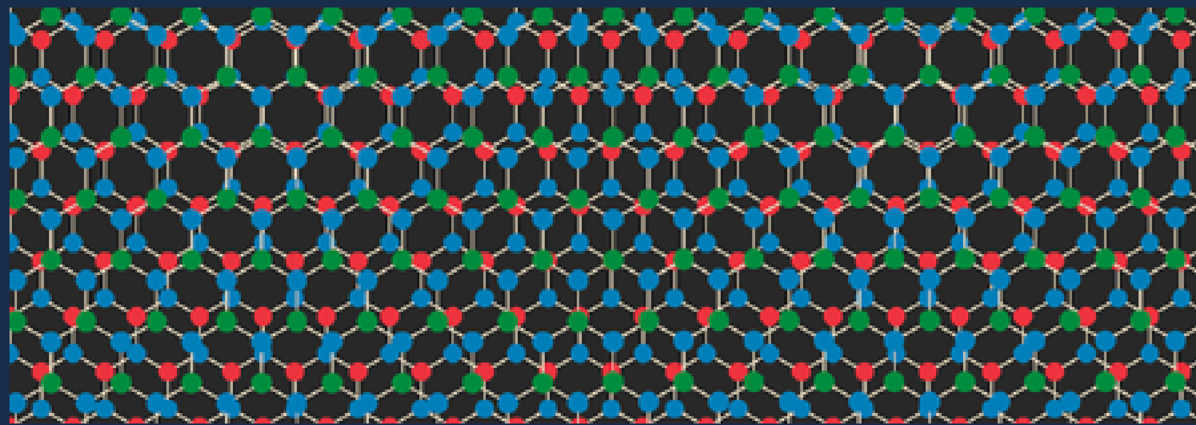
"It was fascinating to talk to all of the outside speakers that are asking very different questions and using very different models," Yttri said. "Despite some people are looking at proteins, RNA, or neuroscience, the methods and thought processes we all use are remarkably similar."

One of Yttri's graduate students, Alex Hsu, was able to speak on his research, which uses artificial intelligence tools to analyze large amounts of data from neuroscience experiments. He participated in the session on Quantification of Behavior and Decision Making where he gave a presentation, "Behavioral classification for single and multiple agents."

"It was a pleasure attending and discussing the common techniques used across neuroscience and biophysics," Hsu said. "I was approached by Cincinnati Children's Hospital researchers after my talk and discussed the potential of applying our algorithm on data from pediatric patients."

The workshop was funded through a National Science Foundation grant.

■ *Kirsten Heuring*



Researchers Discover New Uses for Moiré Superlattices

An international group of researchers have used moiré superlattices to answer theoretical questions in physics, which could lead to future developments in quantum computing.

"The fact that we can manipulate excitons with strong interactions with each other is a big advantage," said Sufei Shi, associate professor of physics at Carnegie Mellon University. "It would allow us to construct quantum states of excitons that are different from those arising from interacting electrons."

Previously, physicists have demonstrated that electrons can form crystal structures under specific circumstances. They theorized the same crystal structures could be formed by excitons, a form of electrons elevated to a higher energy state by light.

Shi and colleagues overlaid a monolayer of tungsten disulfide (WS_2) on a monolayer of tungsten diselenide (WSe_2) to create a moiré superlattice, an overlapping periodic pattern of crystals that can influence election motion. The researchers found that excitons can form the same kinds of crystal structures electrons do. The superlattice also allows the excitons to interact with electrons and each other.

Yongtao Cui, associate professor of physics and astronomy at the University of California, Riverside, said that the moiré superlattices could be a breakthrough for physicists studying excitons.

"Excitons are short-lived states with neutral electric charge, so they are typically hard to control," Cui said. "The use of Moiré superlattices can now provide a power means to achieve that."

Besides finding that the superlattice can control excitons, Shi said that the superlattice can be used to help solve theoretical physics problems with experimental means.

For example, a Hamiltonian interaction known as the bosonic Hubbard model, which describes how subatomic particles interact in a lattice, is extremely difficult to simulate. The model can grow complex very quickly, to the point where even supercomputers could take an infinitely long time to finish the simulation.

Using a moiré superlattice with the proper conditions, Shi said physicists can now work with the bosonic Hubbard model experimentally, removing the necessity for computational modeling.

"We can just run the experiment and see the results," Shi said. "It's a lot easier, and it's robust because the experiment is tolerant to a single defect."

Shi said that the next steps in the research involve investigating how excitons can be manipulated and what their functions are. He said that if they can increase the lifetime of excitons, it could open up a potential future for quantum computing.

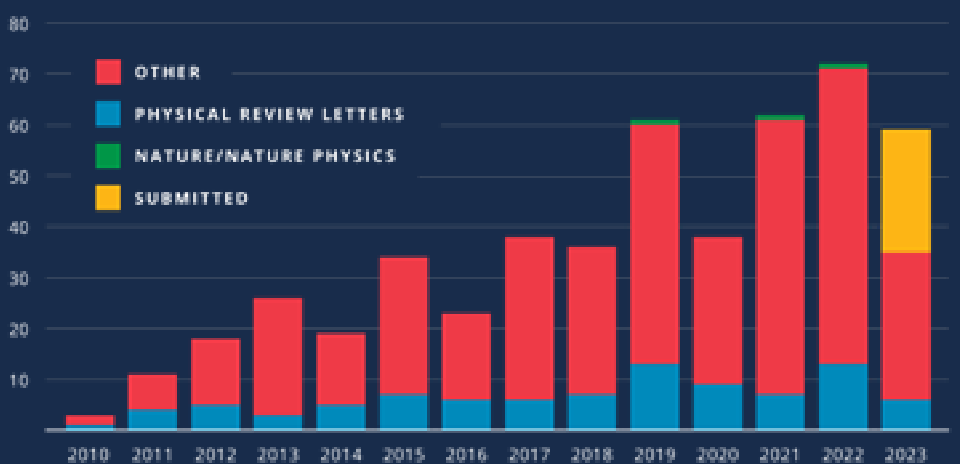
Shi and Cui were joined by Zhen Lian, Yuze Meng, Lei Ma, Indrajit Maity, Li Yan, Qiran Wu, Xiong Huang, Dongxue Che, Xiaotong Chen, Xinyue Chen, Mark Blei, Takashi Taniguchi, Kenji Wantanabe, Sefaattin Tongay and Johannes Lischener on the project, "Valley-Polarized Excitonic Mott Insulator in WS_2/WSe_2 Moiré Superlattice." The project was funded by the National Science Foundation.

■ *Kirsten Heuring*

BES III Publishes 500th Paper

The Beijing Spectrometer (BESIII) Experiment recently hit a landmark of 500 publications, something its collaborators celebrated. A standing member of the publications committee, Carnegie Mellon Physics Professor Roy Briere has read many of the articles written by the more than 600 collaborators from 85 institutions. BESIII — sometimes called a tau-charm factory — spent several years collecting data focused on well-known hadrons containing charm quarks and also special data runs for tau leptons. It then shifted to "energy scans" designed to study new exotic hadronic states. "We spend a lot of time studying hadrons. We knew it was a possibility, but it's worked out incredibly well," Briere said.

■ *Heidi Opdyke*



Data is from October 13, 2023

Tina Kahniashvili Searches for Clues from Universe's First Moments

Relics of primordial gravitational waves could provide deep insights into the early universe, and Carnegie Mellon University's Tina Kahniashvili is at the forefront of an effort to understand more about the origin and evolution of the universe.

"The work is high-risk but highly rewarding," said Kahniashvili, associate research professor in the Department of Physics and a member of the McWilliams Center for Cosmology. "We are looking for messengers from the very early epochs and reconstructing the newborn universe picture."

Axel Brandenburg, an adjunct faculty member at Carnegie Mellon and professor of astrophysics at Nordita and the University of Stockholm, is co-principal investigator with Kahniashvili for a grant from the NASA Astrophysics Theory Program. Along with collaborators, their goal is to provide robust predictions for gravitational wave spectra from early universe sources, guidance for distinguishing different potential sources given the observational data and a clear understanding of how new physics can be probed with gravitational wave detection.

■ *Heidi Opdyke*

Carnegie Mellon to Develop Software Infrastructure for Roman Space Telescope

Carnegie Mellon University physicists Rachel Mandelbaum and Matthew Walker are part of NASA-funded Project Infrastructure teams to help to develop the software infrastructure for the Nancy Grace Roman Space Telescope's experiments.

The Roman Space Telescope is a NASA observatory estimated to launch in 2027. It will measure light from a billion galaxies over the course of the mission's lifetime, performing both wide-field surveys and high contrast imaging and spectroscopy. From this data, scientists working with the telescope will look for new information about our universe and the objects within it.

■ *Jocelyn Duffy*

Alumni News

Carnegie Mellon Remembers Trustee Bruce McWilliams

The Carnegie Mellon University community is mourning Trustee and triple-alumnus Bruce Marshall McWilliams, who passed away after a short illness on September 22.

McWilliams, a resident of Silicon Valley, was a passionate advocate and supporter of Carnegie Mellon, where he earned three degrees in physics over seven years: bachelor's and master's degrees in 1978 and a Ph.D. in 1981 — and later was a Mellon Institute Fellow. He had come to Carnegie Mellon at the advice of his older brother, Thomas M. McWilliams, who is a CMU double alumnus in electrical and computer engineering, Hertz Fellow and entrepreneur.

McWilliams later was elected to the university's Board of Trustees, serving continuously from 2007 until the time of his passing, lending his expertise to the Research, Innovation and Entrepreneurship and the Advancement Committees. In addition, he volunteered in multiple roles, including as a member of the Mellon College of Science Dean's Council and the advisory boards for the Human Computer Interaction Institute and Departments of Mathematical Sciences, Physics and Psychology.

"Bruce brought his contagious enthusiasm and optimism to everything he did on behalf of Carnegie Mellon University," said CMU President Farnam Jahanian. "He was a great friend, brilliant scientist and exceptional entrepreneur. He was also immensely proud of his alma mater and our Tartan community's global impact. While this is an immeasurable loss, I am grateful that Bruce's legacy will continue through his many contributions to CMU."

McWilliams was a serial entrepreneur who led numerous technology companies as CEO, including CMU spinoff Bossa Nova Robotics, Intermolecular, SuVolta, Tessera Technologies (Xperi) and S-VISION. McWilliams and Carnegie Mellon physics double-alumnus Nicholas Colella met in graduate school, collaborated as Mellon Institute Fellows and later partnered at Lawrence Livermore National Laboratory (LLNL) under Drs. Edward Teller and Lowell L. Wood. There, McWilliams led the Laser Pantography Program to laser-write ultra-dense semiconductor interconnections.

McWilliams and Colella spun out the technology and co-founded nChip with several LLNL colleagues, their first startup, launching McWilliams' career arc in semiconductor packaging that led him to Tessera, where he and Colella teamed up to achieve their first initial public offering. At LLNL, their collaboration on an ultrawide-angle telescope inspired McWilliams' lifelong interest in computational astronomy.

"Bruce believes patterns in the cosmos can be discovered by numerically analyzing large sectors of the detectable universe," Colella said. "He believes the universe will tell us its story."

Most recently, McWilliams was serving as CEO of Ultron.AI, a CMU-affiliated startup developing software innovations for the retail sector founded by Marios Savvides, the Bossa Nova Robotics Professor of Artificial Intelligence at Carnegie Mellon. Savvides and his CMU team first began working with McWilliams while he was CEO of Bossa Nova Robotics, partnering to develop the artificial intelligence that would allow the company to scale up production from 15 robots to 550 robots to be used in Walmart stores across the country in less than two years.

"It was no easy feat — it was one mission impossible after another. Bruce drove us hard, but he knew he could count on us. He was 007, and our team was his Q," Savvides said, referencing the iconic James Bond partnership. "He loved CMU, and he loved that fact that the technology at Bossa Nova was done at CMU. Bruce always wanted to give back to CMU; he wanted to make sure that CMU had a mark in everything that he did."

McWilliams was a longtime champion of the sciences at Carnegie Mellon, regularly

meeting with university faculty and leadership to learn about science initiatives and recent research developments. Through his extensive philanthropy, he endowed multiple funds that will impact science research and education and continue his legacy at Carnegie Mellon for decades to come.

In 2007, following a series of conversations with CMU faculty about the potential to answer profound questions about the origin of the universe, he provided the gift to endow the McWilliams Center for Cosmology. The center brings together researchers in particle physics, astrophysics, computer science and statistics to expand humanity's understanding of dark energy and dark matter. Its endowment provides support for faculty and postdoctoral fellows affiliated with the center. Over the years, McWilliams provided additional gifts to fund a series of public lectures featuring prominent figures in the field to help the center's work reach a broader audience.

"Bruce was more than a benefactor; he was a friend, a mentor and a cherished member of our community. When it came to expanding our intellectual horizons, Bruce was relentless. His involvement extended beyond financial support; he was personally invested in the growth of our center. Whether it was the recruitment of faculty or postdoctoral researchers, Bruce was there, making time to speak with potential colleagues and candidates, offering his insights and unwavering support," said Tiziana Di Matteo, professor of physics and director of the McWilliams Center. "He played a pivotal role in shaping the academic community of the center, nurturing its growth with the same passion he held for the cosmos and physics."

In addition, McWilliams endowed a presidential fellowship for chemistry and physics graduate students in the Mellon College of Science; partnered with alumnus Alexander Knaster to create a scholarship for mathematics undergraduate students; and provided numerous gifts to MCS as well as other areas of the university, including the arts, over his many years of support. His interest in providing fellowship and scholarship support was inspired by his experience receiving a scholarship that made possible his own CMU education. In recent years, he was assisting the university with raising support for its future of science initiative.

"Bruce was always on our side," said Scott Dodelson, head of the Department of Physics. "He thought that fundamental science was really important to be a great university. He was trying to make us — the department and the university — better. And personally, what I learned of him: He was humble, he was optimistic, and he strove to be fearless."

In a 2007 profile, McWilliams said this about his relationship with his alma mater: "By day, I'm a business guy, but at heart, I'm a scientist. My involvement with Carnegie Mellon allows me the opportunity to live out my passion for science and research, and also help to build and support the next wave of technology advancements. I get to learn all the time about the future, which I love."

"Bruce was a successful businessman and entrepreneur, but as he often noted, deep down he was a physicist and mathematician. All of that, plus his great love for Carnegie Mellon, informed the passion and expertise he brought to his service to the university," said David Coulter, alumnus and chair of the CMU Board of Trustees. "He was one of the biggest champions for the sciences at CMU, and we will miss his energy, his devotion and his originality."

■ *Brian Thornton*

Vivian Chang Empowers AAPL Workers

For Carnegie Mellon University alumna Vivian Chang, life so far has been a series of unexpected intersections.

A Sciences and Humanities Scholar, she couldn't choose between biological physics and Hispanic studies. So she didn't, instead connecting the two subjects as a dual degree in the Dietrich College of Humanities and Social Sciences and the Mellon College of Science.

Her experience as a member in organizations like Alpha Phi Omega and Circle K highlighted another unexpected crossover — her love of learning and intense interest in community building.

"My path has always been a zigzag, and I didn't know that community service could morph into a profession," said Chang, who graduated in 2013. "I began to realize that I spent more time thinking about my volunteer work than my homework."

Now, her volunteer work is her career.

As the civic engagement and racial justice director at the Asian Pacific American Labor Alliance, AFL-CIO (APALA), she oversees programs on voting, redistricting, immigration advocacy and political engagement.

"People are realizing that they suddenly have the power to reimagine a better workplace for themselves and their coworkers," she said.

Chang began community organizing as a career after earning a master's degree in environmental policy from Princeton University in 2017. After graduation, she worked with the Union of Concerned Scientists in Washington, D.C., and then pivoted to election engagement during the 2018 midterm elections. Soon afterward, she joined a fellows program with the APALA, focusing on and succeeding in increased voter registration and voter turnout.

Founded in 1992, APALA is the first and only national organization of Asian American and Pacific Islander (AAPI) workers. Its national headquarters is located in the nation's capital; the organization maintains 22 volunteer-run chapters with more in the pipeline.

APALA is a labor constituency group. Membership is open to anyone in the labor movement: union members, workers who lack access to unions and anyone who supports workers' rights.

"We are broad-based," Chang said. "Part of our job is to address many misconceptions head-on. We have to overcome the lack of education about unions while simultaneously confronting the purposeful miseducation about unions."

Voter outreach revealed to her that people intensely desire recognition by others who care. She regularly witnesses the profound difference it makes to talk to communities who have never been heard or feel left out.

"When knocking on doors of AAPI households, you will probably hear either 'You're the first person who has ever talked to me about this!' or 'I've always wanted to talk to someone about this issue!' It's so meaningful for people to talk to and be heard by someone who looks like them," Chang said.

■ *Amanda Hartle*

Planning for Life on Mars

The soft beeps from the handheld radiation dosimeter kept Kristine Ferrone company as she mapped the remote, barren landscape deep in the desert of southern Utah. She almost felt like she was on another planet. That was the goal.

The Carnegie Mellon University alumna commanded Crew 269 at the Mars Desert Research Station (MDRS) near Hanksville, Utah. For two weeks, Ferrone led the six-person crew, who lived and worked like astronauts at the MDRS, a Mars analog run by the Mars Society.

"When we go on a Mars mission, we really need to be prepared before we go," said Ferrone, associate system director at The Aerospace Corporation. "Analogs can bring a lot to the knowledge base and add to the overall preparations that we would make to go on an actual planetary mission."

The six-person crew were all from Aerospace, a nonprofit corporation that operates a Federally Funded Research and Development Center that addresses activities from spacecraft design and launch to operations in space.

While at the MDRS, the crew conducted experiments, including Ferrone, who mapped the radiation levels around the site. She used tools one might use on Mars, all while in a space suit. Practical details are important because scientists are not familiar with how the Martian terrain and its limited atmosphere might shield an astronaut from space radiation. On Mars, astronauts would need to map the area to find which locations are particularly protected from and exposed to radiation.

Ferrone graduated with a bachelor of science degree in physics/astrophysics from Carnegie Mellon in 2004. She went on to earn an MBA from the University of Florida, Gainesville, a master of science degree in sports medicine from the United States Sports Academy, a master of science degree in space architecture from the University of Houston, and a Ph.D. in medical/radiation physics from the University of Texas MD Anderson Cancer Center Graduate School of Biomedical Sciences.

At Aerospace she's been involved in projects including NASA human spaceflight, space nuclear power and concept design for new vehicles. She currently is working on Department of Defense human spaceflight payloads. Before joining Aerospace, she was a senior mission scientist and a flight controller for the International Space Station.

"All of the things that I've worked on in my career have been to become better qualified to work in human spaceflight and to help further human spaceflight," Ferrone said, adding that her goal is to be an astronaut. She has applied to NASA's astronaut training program and plans to apply when the next application process opens. "I keep trying to add skills and experiences that would make me a better candidate, so we'll see what happens this next time they have a call."

■ *Amy Pavlak Laird*

Frank DiBianca has Led a Life in Motion

Newton's first law of motion — an object in motion stays in motion — applies to people, too. Carnegie Mellon University alumnus Frank DiBianca (S'66, 71) constantly pushes forward in his life.

A faculty member at the University of North Carolina at Chapel Hill and dean of the College of Health Science Engineering at the University of Tennessee Health Science Center, Memphis, DiBianca led teams through advancements in computerized tomography and biomedical engineering. For the past decade, he has been pushing himself through physical feats such as competitive running and hammer throwing.

"I know that my step isn't as secure as it used to be, but just sitting down, I don't feel much different than I did in high school," DiBianca said.

Originally from New Jersey, DiBianca attended Rensselaer Polytechnic Institute to earn his bachelor's degree in physics. A member of the Naval reserve, he was promoted to lieutenant junior grade and served on a U.S. destroyer as part of the Naval Quarantine of Cuba in 1962. He applied for graduate school in physics from the ship.

"I applied to half a dozen programs and was fortunate to have been accepted into all of them," DiBianca said. "I considered mainly the quality of the educational and research programs, the faculty and the financial aid offers. CMU — then Carnegie Institute of Technology — won hands down."

After earning his master's and Ph.D. in high-energy physics under the guidance of Robert W. Kraemer, he accepted postdoctoral fellowships at Case Western Reserve University and Fermilab.

"I really loved my time at CMU. Especially the people I worked with. We didn't have a lot of competitiveness amongst ourselves. The graduate students would take time from the projects to help each other, and the faculty would also come in and take time to help."

DiBianca joined General Electric Medical Systems as the first member of its Applied Sciences Lab. The lab's mission was to perfect the computerized tomography (CT) scanner. While versions were already on the market the devices were slow and inefficient.

"GE wanted to get all of the data in 10 seconds that everyone else was getting in five minutes," he said.

He and the team refined GE's approach and since 1981, the 9800 CT scanner system, which DiBianca designed, has been used in tens of millions of examinations. At GE, he also invented two types of X-ray detectors. He holds more than 20 patents garnered throughout his career.

"The mathematics and complexity of understanding modern physics is more difficult than any other technical field that exists," DiBianca said. DiBianca took knowledge he learned during his high energy nuclear physics studies and used that to calculate how x-rays were interacting with humans being scanned. "Some of the time, the x-rays bounce around multiple times before they come back out. I understood all of that and could calculate what that would look like to remove the scattered radiation and create more crisp images."

DiBianca also applied physics to his hobbies. In his 50s, DiBianca learned to fly sailplanes and ran 5Ks. In his 70s, his started his track and field career, following the footsteps of his wife of 53 years, Kay. DiBianca's latest event was the 2023 National Senior Games, an Olympic-style competition for athletes older than 50. For the event, which took place in Pittsburgh in July, DiBianca qualified for the 400m and 800m races as well as the discus and hammer throw events.

"One of the physical principles that we're very interested in both for discus and the hammer throw is called angular momentum," he said.

Angular momentum is the property of any rotating object given by moment of inertia times angular velocity. Most discus throwers spin around prior to the point of release. The farther their hand is from their body, or the faster a thrower spins, then the more angular momentum is created.

"So if you increase your hand distance from your body by 10% while you're turning around, it's the same as spinning 10% faster," DiBianca said. "With the hammer, of course, you've got the same deal."

DiBianca picked up the hammer in 2013 after watching competitors in the National Senior Games in Cleveland. In 2015 and 2017, he placed third and earned bronze medals at nationals. In 2019, his throw of 90' 5.04" earned him silver.

"There are other guys who are much bigger and stronger than Frank, but because he really appreciates the technique, that's how he can get the distance," said Kay DiBianca of her husband's achievements.

Now in his 80s, DiBianca is adding novelist to his list of accomplishments. His first book, "Laser Trap," is a thriller that draws inspiration from his time as a graduate student, and a couple of characters are recognizable to a few Carnegie Mellon friends of his.

"The name of the chief character's adviser is R.W. Kromer," DiBianca said. "So as soon as Robert W. Kraemer saw the book, he knew it was representing him. And he got a big kick out of that."

■ *Heidi Opdyke*

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