U Researchers Help Create the Largest 3D Map of the Universe
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Message from the Chair

Due to the ongoing pandemic, 2020 will be remembered as a challenging time for students but also faculty and staff at the University of Utah and the Department of Physics & Astronomy. In preparing for a return to campus for fall semester, the university developed coronavirus guidelines in partnership with the university's public health professionals, with the primary goal of helping students continue their academic course work and research activities throughout the entire semester. The health and safety of students, faculty, and staff have been and will continue to be the top priority.

During the summer, the decision was made to have most students continue to learn online for fall semester. Faculty and department staff have continued to use teleworking arrangements. In addition to online classes, our instructors have been using other formats to enhance the learning experiences of our students, including small in-person classes; interactive video classes; and a hybrid of the two. We anticipate using these same models for spring semester classes.

Despite these challenges, I'm pleased to say that the fall semester has gone remarkably well. I want to express my thanks and gratitude to our faculty, students, and staff for making everything run as smoothly as possible. In fact, research activities among faculty, postdocs, and students remain vigorous and strong.

Our talented faculty continue to win awards and recognition from the U for their outstanding teaching and accomplishments, and I encourage you to read about their successes in the magazine.

While the challenges of the coronavirus are still with us and may remain so for the months to come, I remain optimistic that the university and the department will not only move past them successfully and continue to provide and achieve excellence in teaching and research, I even believe that the experiences we gather during these hard times may eventually allow us to emerge stronger and better prepared for the future. Still, at this time, we need to focus on the immediate challenges, and one is helping support Physics & Astronomy students who have encountered COVID-19 related difficulties. To accomplish this, we invite you to contribute to our Student Emergency Fund. You may donate at: giving.utah.edu/physics.

As always, thank you for your support. The generosity of donors drives the department forward in providing educational and research opportunities. Thank you for all you do.

Sincerely,

Christoph Boehme
Professor and Chair
Department of Physics & Astronomy
U Researchers Help Create the Largest 3D Map of the Universe

Jordan Raddick, SDSS public information officer

“We know both the ancient history of the universe and the recent expansion history fairly well, but there’s been a troublesome gap in the middle 11 billion years,” said cosmologist Kyle Dawson of the University of Utah. “For five years, we have worked to fill in that gap, and we are using that information to provide some of the most substantial advances in cosmology in the last decade.”

Dawson has led a team from multiple universities associated with the Sloan Digital Sky Survey (SDSS), a decades long project that uses multi-spectral imaging and spectroscopic techniques to chart the skies. (The survey is named for the Alfred P. Sloan Foundation, which has been a major source of funding.) SDSS has a number of component surveys, including the extended Baryon Oscillation Spectroscopic Survey (eBOSS) to which Dawson has contributed. An international collaboration of more than 100 astrophysicists, eBOSS, together with SDSS as a whole, recently announced the creation of the largest, most detailed 3D map of the universe so far.

We know what the universe looked like in its infancy thanks to thousands of scientists from around the world who have measured the relative amounts of

PHOTO CREDIT: Anand Raichoor (EPFL), Ashley Ross (Ohio State University) and SDSS

The SDSS map is shown as a rainbow of colors, located within the observable universe (the outer sphere, showing fluctuations in the Cosmic Microwave Background). We are located at the center of this map. The inset for each color-coded section of the map includes an image of a typical galaxy or quasar from that section, and also the signal of the pattern that the eBOSS team measures there. The bump visible in each panel is at the characteristic scale of about 500 million lightyears. As we look out in distance, we look back in time. So, the location of these signals reveals the expansion rate of the universe at different times in cosmic history.
elements created soon after the Big Bang and who have studied the Cosmic Microwave Background. We also know its expansion history over the last few billion years from galaxy maps and distance measurements, including those from previous phases of the SDSS.

“The analyses have also provided measurements on how the diverse structures in the universe grow over time,” says Zheng Zheng, professor of physics and astronomy at the University of Utah. “The story underneath the structure growth is amazingly consistent with what we learn from the expansion history.”

The final map is shown in the image on page 2. A close look reveals the filaments and voids that define the structure in the universe, starting from the time when it was only about 300,000 years old. From this map, researchers measured patterns in the distribution of galaxies, which gave several key parameters of the universe to better than 1% accuracy. The signals of these patterns are shown in the insets in the accompanying image.

The map represents the combined effort of hundreds of scientists mapping the universe using the Sloan Foundation telescope for nearly twenty years. The cosmic history showed that about six billion years ago, the expansion of the universe began to accelerate, and has continued to get faster and faster ever since. This accelerated expansion seems to be due to a mysterious invisible component of the universe called “dark energy,” consistent with Einstein’s General Theory of Relativity, but extremely difficult to reconcile with our current understanding of particle physics.

Combining observations from eBOSS with studies of the universe in its infancy revealed cracks in this picture of the universe. In particular, the eBOSS team’s measurement of the current rate of expansion of the universe (the “Hubble Constant”) was about 10% lower than the value found from distances to nearby galaxies. The high precision of the eBOSS data means that it is highly unlikely that this mismatch was due to chance, and the rich variety of eBOSS data gave us multiple independent ways to draw the same conclusion.

“Imprinted in the galaxy or quasar distribution is a particular pattern that serves as a ruler,” said Zheng. “With eBOSS maps, such a ruler has achieved its best-ever performance and enabled us to measure distances with unprecedented precision, which makes it possible to most clearly reveal the mismatch in the Hubble Constant.”

There is no broadly accepted explanation for this discrepancy in measured expansion rates, but one exciting possibility is that a previously unknown form of matter or energy from the early universe might have left a trace on our history.

In total, the eBOSS team made the results from more than 20 scientific papers public today. Those papers describe, in more than 500 pages, the team’s analyses of the latest eBOSS data, marking the completion of the key goals of the survey.

The University of Utah has been a key contributor to SDSS over the last decade. The massive samples of spectroscopic data that went into the final eBOSS cosmological result were processed and located at the U, within the Science Archive Server hosted by the U’s Center for High-Performance Computing.

“We have made a series of developments in the data analysis, leading to greater precision in the cosmological map. This team effort was made possible by our cutting-edge science archive system. The final eBOSS data products will remain a legacy, helpful to a broad range of users, from young students to amateur and professional astronomers,” says SDSS-IV science archive scientist Joel Brownstein, research associate professor at the U.

Within the eBOSS team, individual groups at universities around the world focused on different

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U Physicists Find Technique that Offers Improved Resolution and Characterization of Perovskite-based Photovoltaics

Researchers have developed a method for directly measuring the electronic transport at interfaces within a perovskite-based solar cell.

The work of Associate Professor Andrey Rogachev and Associate Instructor Kevin Davenport was recently featured in the June 26, 2020, issue of Applied Physics Letters, a weekly peer-reviewed scientific journal published by the American Institute of Physics. Its focus is rapid publication and dissemination of new experimental and theoretical papers regarding applications of physics in all disciplines of science, engineering, and modern technology.

By Alane Lim

Perovskite-based solar cells are promising alternatives to traditional silicon cells. However, the current research only offers a limited understanding of these complex devices, since the electron transport within the device is physically difficult to probe.

Davenport et al. have adapted a spectroscopic method to capture a “big picture” look at the carrier dynamics within a perovskite-based solar cell. Using cross-correlation current noise spectroscopy, the team measured signals that they could localize to specific locations, including the absorption layer, the transport layer, and the interfaces in between, inside the device.

For the study, the authors used a modified form of noise spectroscopy, a method that characterizes the movements of electrons via the fluctuations or noise in an electrical signal. Using this technique, the team measured their device’s current to find signals, such as those coming from electrons at the device’s interfaces that would normally have been drowned out by much stronger ones. The technique also exhibited spatial selectivity: the resistance measured in one region correlated to the strength of the signal coming from that region. As such, the team could determine the origins of their signals.
Overall, the technique allows researchers to directly and nondestructively probe electron movements throughout a perovskite cell, including its interfaces.

Coauthor Kevin Davenport said the method can complement more traditional techniques, such as impedance spectroscopy, to obtain a more complete understanding of the physical processes occurring within solar cells.

“In a world where we are competing for fractions of a percent in increased efficiency, any additional information is critical,” Davenport said.

Davenport added the authors plan to continue their work in several ways, including testing different perovskites and improving the resolution and range of their technique.


Largest 3D Map of the Universe Ever Created

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aspects of the analysis. To create the part of the map dating back six billion years, the team used large, red galaxies. Farther out, they used younger, blue galaxies. Finally, to map the universe eleven billion years in the past and more, they used quasars, which are bright galaxies lit up by material falling onto a central supermassive black hole. Each of these samples required careful analysis in order to remove noise and reveal the patterns of the universe.

“The SDSS data allow unique insights into the evolutionary history of our universe” says Dawson. “Using these data, along with data from the Cosmic Microwave Background and supernovae, we have made the largest advances of any experiment in the last decade to determine the intrinsic curvature of space. We have explored the energy contents of the universe, the laws of gravity, and the physics of some of the smallest particles, the neutrinos, and now have a model for these components that allows us to estimate the local expansion rate to 1% precision.”

eBOSS, and SDSS more generally, leaves the puzzle of dark energy, and the mismatch of local and early universe expansion rates, as a legacy to future projects. In the next decade, future surveys may resolve the conundrum, or, perhaps, will reveal more surprises.

Meanwhile, the SDSS is nowhere near done with its mission to understand the universe. Gail Zasowski, the spokesperson for the next generation of SDSS, described her excitement for the next steps.

“We’re upgrading the hardware and instruments needed to keep the tremendous impact of SDSS going into the 2020s,” Zasowski says. “We’ll be focusing on the history of our own Milky Way Galaxy, the architecture of multi-star and planetary systems, how galaxies make their stars, and how black holes grow over the lifetime of the universe. These are some of the most exciting questions in astrophysics, and we’re looking forward to the next decades of discovery!”

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Viruses are scary. They invade our cells like invisible armies, and each type brings its own strategy of attack. While viruses devastate communities of humans and animals, scientists scramble to fight back. Many utilize electron microscopy, a tool that can “see” what individual molecules in the virus are doing. Yet even the most sophisticated technology requires that the sample be frozen and immobilized to get the highest resolution.

Now, physicists from the University of Utah have pioneered a way of imaging virus-like particles in real time, at room temperature, with impressive resolution. In a new study, the method reveals that the lattice, which forms the major structural component of the human immunodeficiency virus (HIV), is dynamic. The discovery of a diffusing lattice made from Gag and GagPol proteins, long considered to be completely static, opens up potential new therapies.

When HIV particles bud from an infected cell, the viruses experience a lag time before they become infectious. Protease, an enzyme that is embedded as a half-molecule in GagPol proteins, must bond to other similar molecules in a process called dimerization. This triggers the viral maturation that leads to infectious particles. No one knows how these half protease molecules find each other and dimerize, but it may have to do with the rearrangement of the lattice formed by Gag and GagPol proteins that lay just inside of the viral envelope. Gag is the major structural protein and has been shown to be enough to assemble virus-like particles. Gag molecules form a lattice hexagonal structure that intertwines with itself with miniscule gaps interspersed. The new method showed that the Gag protein lattice is not a static one.
“This method is one step ahead by using microscopy that traditionally only gives static information. In addition to new microscopy methods, we used a mathematical model and biochemical experiments to verify the lattice dynamics,” said lead author Ipsita Saha, graduate research assistant at the U’s Department of Physics & Astronomy. “Apart from the virus, a major implication of the method is that you can see how molecules move around in a cell. You can study any biomedical structure with this.”

The paper was published in *Biophysical Journal* on June 26, 2020.

The scientists weren’t looking for dynamic structures at first—they just wanted to study the Gag protein lattice. Saha led the two-year effort to “hack” microscopy techniques to be able to study virus particles at room temperature to observe their behavior in real life. The scale of the virus is miniscule — about 120 nanometers in diameter — so Saha used interferometric photoactivated localization microscopy (iPALM).

First, Saha tagged the Gag with a fluorescent protein called Dendra2 and produced virus-like particles of the resulting Gag-Dendra2 proteins. These virus-like particles are the same as HIV particles, but made only of the Gag-Dendra2 protein lattice structure. Saha showed that the resulting Gag-Dendra2 proteins assembled the virus-like particles the same way as virus-like particles made up regular Gag proteins. The fluorescent attachment allowed iPALM to image the particle with a 10 nanometer resolution. The scientists found that each immobilized virus-like particle incorporated 1400 to 2400 Gag-Dendra2 proteins arranged in a hexagonal lattice. When they used the iPALM data to reconstruct a time-lapse image of the lattice, it appeared that the lattice of Gag-Dendra2 were not static over time. To make sure, they independently verified it in two ways: mathematically and biochemically.

First, they divided up the protein lattice into uniform separate segments. Using a correlation analysis, they tested how each segment correlated with itself over time, from 10 to 100 seconds. If each segment continued to correlate with itself, the proteins were stationary. If they lost correlation, the proteins had diffused. They found that over time, the proteins were quite dynamic.

The second way they verified the dynamic lattice was biochemically. For this experiment, they created virus-

*Continued on page 22*
Scientists in the VERITAS Collaboration have measured the angular diameter of stars using Stellar Intensity Interferometry for the first time in nearly 50 years. They have demonstrated both improvements to the sensitivity of the technique and its scalability using digital electronics.

Led by astronomers from the University of Utah and the Center for Astrophysics | Harvard & Smithsonian, VERITAS (Very Energetic Radiation Imaging Telescope Array System) scientists measured the angular diameters of Beta Canis Majoris—a blue giant star located 500 light-years from the sun—and Epsilon Orionis—a blue supergiant star located 2,000 light-years from the sun.

“A proper understanding of stellar physics is important for a massive range of astronomical fields, from exoplanet studies to cosmology, and yet they are often seen as point sources of light due to their great distances from Earth,” said Nolan Matthews, graduate research assistant at the University of Utah. “Interferometry has been widely successful in achieving the angular resolution needed to spatially resolve stars, and we’ve demonstrated the capability to perform optical intensity interferometry measurements with an array of many telescopes that in turn will help improve our understanding of stellar systems.”

Michael Daniel, operations manager at VERITAS, added, “Resolving something the size of a coin on the moon is a marvelous thing. Knowing if that coin is a dime or a nickel is something even more special still. If you want that level of detail, then you want intensity interferometry to work on this scale.”

VERITAS used all four of its gamma-ray telescopes, located at the Fred Lawrence Whipple Observatory in Amado, Arizona, to increase its coverage and provide greater resolution for observation.
“This is the first demonstration of the original Hanbury-Brown and Twiss technique using an array of optical telescopes,” said principal investigator David Kieda, professor at the University of Utah. “Modern electronics allow us to computationally combine light signals from each telescope. The resulting instrument has the optical resolution of a football-field-sized reflector.”

Typically observing dark, moonless skies for Cherenkov light—blue flashes indicative of the presence of gamma-rays—VERITAS scientists made use of the nights surrounding the full moon to conduct the study. “The moon doesn’t disrupt observations for intensity interferometry,” said Daniel. “This opens up new scientific horizons for the VERITAS telescopes and similar facilities.”

The first telescopes to perform stellar measurements using intensity interferometry were the Narrabri telescopes in the 1970s. “Narrabri measured 32 stars in the southern hemisphere, and to significantly improve upon that result required a large leap in technology,” said Wystan Benbow, director of VERITAS. “Right now we are pathfinding for the future Cherenkov Telescope Array (CTA); we have proven that we can add 100 telescopes to this design, enabling astronomers to image features on stellar surfaces with unparalleled optical resolution.”

The future for intensity interferometry is bright, and VERITAS scientists have a few ideas about where it could go, from creating a larger catalog of stars, to measuring space objects and phenomena, like the properties of interacting binary star systems, rapidly rotating stars, and potentially the pulsation of Cepheid variables, among others.

Having previously measured the apparent diameter of some very small stars in the sky using the asteroid occultation method, the study is one more indicator that gamma-ray telescopes, and their scientists, are more than meets the eye.

“The VERITAS Collaboration consists of about 80 scientists from 20 institutions in the United States, Canada, Germany and Ireland.

For more information about VERITAS visit http://veritas.sao.arizona.edu

About the Center for Astrophysics | Harvard & Smithsonian

Headquartered in Cambridge, MA, the Center for Astrophysics (CfA) | Harvard & Smithsonian is a collaboration between the Smithsonian Astrophysical Observatory and the Harvard College Observatory. CfA scientists study the origin, evolution, and ultimate fate of the universe. For more info visit http://cfa.harvard.edu
Grad Student: Henna Popli

Physics graduate student Henna Popli was born in the vibrant city of New Delhi, India. She had an inquisitive mind from an early age, and her family always supported her curiosity. This led to her fascination with science and technology. In high school, she wanted to be an astronaut and idolized Kalpana Chawla, an American astronaut, engineer, and the first woman of Indian origin to go into space, though, unfortunately, her endeavor ended with the accident of the Space Shuttle Columbia in 2003.

Popli’s ambition of becoming an astronaut led her to pursue an undergraduate degree in physics from Khalsa College at the University of Delhi, India. Following graduation, she continued to explore her passion for physics by working on a master’s degree from the School of Physical Science at Jawaharlal Nehru University, New Delhi.

“My exposure to physics research came through interactions with professors, researchers, and scientists, as well as attending lectures, workshops, and summer schools,” she said. While writing her master’s thesis, she was exposed to the field of condensed matter physics and decided to get a Ph.D. She was accepted to the U and was thrilled to join an R1 research university. Popli is a member of the Boehme Group, a research group led by Christoph Boehme, professor of Physics & Astronomy and chair of the department.

Research in spintronics

At the U, Popli studies how electron spins move around in condensed matter materials. The research field is called spintronics, short for spin electronics, where the electron spin is used to carry information. Electrons behave as tiny bar magnets as they orbit around the nucleus of an atom. Using quantum mechanics (the science dealing with the behavior of light and matter at scales smaller than atoms) to measure the orientation of the spin, we get two answers—often called spin up or spin down or 1 and 0—and a spintronic device utilizes the intrinsic property of the electrons and its associated magnetic moment. “What this means is that in addition to using the charge properties of particles like electrons, their spin can also be exploited,” said Popli. Traditional electronics make use of the mobility of electrons to process information. Spintronics offers an alternative, relying on the electron’s magnetism, or spin, to encode information. Various external magnetic fields can be applied to control their magnetic states, and Popli studies how this works.
She also studies spin polarization propagation in organic semiconductors, and the group has had success in demonstrating that an organic-based magnet can carry waves of quantum mechanical magnetization, called magnons, and convert these waves into electrical signals. One technique used intensively in her lab is called “electron magnetic resonance spectroscopy,” a spin spectroscopy technique similar to MRI (magnetic resonance imaging), used by physicians to show images inside our bodies. “What I find fascinating about my research is the ability to manipulate and control minuscule particles by means of electricity and magnetism and then observe them through electronic processes,” she said.

The group is hopeful their work in spintronics will lead to more progress in having magnonics surpass electronics, since magnonic systems could be smaller and faster, with less heat loss and less energy required. Spintronics devices have applications ranging between quantum computing and sensor technologies.

During her graduate years, Popli has enjoyed teaching and participating in outreach activities. “It’s been exciting to show high school students and undergraduates really cool science experiments and discuss creative ideas,” she said. Teaching is something she feels strongly about, and she hopes in the future she can introduce new teaching methodologies to physics education to inspire and nurture scientific curiosity in young minds.

**Mentors and career plans**

She has enjoyed working with Professor Boehme and Dr. Hans Malissa, a research assistant professor of physics and astronomy. “I feel fortunate to be a graduate student in Dr. Boehme’s research group,” she said. “He is extremely smart, excels in his field, and is a very kind person—it’s reflected in the way he mentors students. I am always amazed by his time-managing capabilities, attention to details, and his optimism. His advice has really helped me advance in my career. Another special mention is Dr. Malissa. I have enjoyed countless discussion sessions with him, and his dedication to science inspires me very much.”

Popli feels fortunate to have been part of some exciting research projects with the Boehme Group and has collaborated with several other research groups, including the Vardeny research group in the Department of Physics & Astronomy and also research groups in Berlin and Regensburg in Germany, which resulted in her being included as one of the co-authors in more than six publications in peer-reviewed journals, including a first-author publication.

Popli has been active in WomPA (Women in Physics and Astronomy), which provides a forum to share her experiences with other women physicists. She also has served as a member of the department’s GSAC (Graduate Student Advisory Committee), where she was involved in reforming opportunities for graduate students, especially international students. Most recently, she represented graduate students on the College of Science Dean Search Committee in 2019. When she isn’t in the lab, she relaxes with music and food, bringing a bit of India to Salt Lake City through her mother’s recipes. She also enjoys hiking and taking long walks.

After she completes her Ph.D. in the summer of 2021, Popli will explore career opportunities in scientific and industrial research.
For as long as he can remember, Carsten Rott, who will join the department as a full professor of physics and astronomy in early 2021, has been fascinated by the night sky, the stars, and the planets. As a child growing up in Germany, he could see the Orion nebula, the Andromeda galaxy, and star clusters. He wondered what these objects were and what else was in the night sky waiting to be discovered.

He combined his love of astronomy with learning computer programing, which gave him the ability to write computer simulations for biological systems, fluid dynamics, and astrophysics. By comparing the outcomes of his simulations, he could check to see if his intuition was correct or if he got the physics right, which was invaluable in training his logical thinking skills. “I spent many months when I was younger trying to understand why my simulations of rotating galaxies would not maintain spiral arm structures or why my models of stars weren’t stable,” he said. Struggling with such questions made him want to understand the underlying phenomena.

Rott studied physics as an undergraduate at the Universität Hannover and went on to receive a Ph.D. from Purdue University in 2004. “Becoming a physicist is a challenge and often a struggle, but it has broadened my horizons so much, and I’m extremely happy I decided to pursue a career in science,” he said.

High-energy neutrinos

His research is on understanding the origins of high-energy neutrinos, which are tiny, subatomic particles similar to electrons, but with no electrical charge and a very tiny mass. Neutrinos are abundant in the universe but difficult to detect because they don’t interact much with matter. These particles originate from distant regions of the universe and can arrive on the Earth more or less unhindered, providing scientists with information about distant galaxies. High-energy neutrinos are associated with extreme cosmic events, such as exploding stars, gamma ray bursts, outflows from supermassive black holes, and neutron stars, and studying them is regarded as a key to identifying and understanding cosmic phenomena.

“One of my main research focuses is to look for signatures of dark matter with high-energy neutrinos. By studying them, we can explore energy scales far beyond the reach of particle accelerators on Earth,” he said.

While most of his work is considered pure research and doesn’t have immediate applications, Rott did figure out a new way to use neutrino oscillations to study the Earth’s interior composition. He spent several months at the Earthquake Research Institute at the University of Tokyo to collaborate with researchers on the topic, and he hopes this new method can help scientists better understand and predict earthquakes.
IceCube Neutrino Telescope

Rott is involved with the IceCube Neutrino Telescope, which is the world’s largest neutrino detector designed to observe the cosmos from deep within the South Pole ice. The telescope uses an array of more than 5,000 optical sensor modules to detect Cherenkov light, which occurs when neutrinos interact in the ultra-pure Antarctic ice. When a neutrino interaction occurs, a faint light flash is produced, allowing them to be detected.

Approximately 300 physicists from 53 institutions in 12 countries are part of the IceCube Collaboration, which addresses several of the most fundamental questions of our time, such as the origin of cosmic rays, nature of dark matter, and the properties of neutrinos. The science spectrum covered by the IceCube Neutrino Observatory is very broad, ranging from cosmic ray physics, particle physics, and geophysics to astroparticle physics.

The team of scientists has already made some amazing discoveries with the telescope. For example, they discovered a diffuse astrophysical neutrino flux in 2014 and recently achieved the first step in identifying the sources of astrophysical neutrinos associated with a highly luminous blazar, which was discovered in 2018. A blazar is an active galaxy that contains a supermassive black hole at its center, with an outflow jet pointed in the direction of the Earth. Over the next years, the team looks forward to making more discoveries by observing the universe in fundamentally new ways.

Life in Korea

Before joining the U, Rott was invited to Korea to begin a tenure-track faculty position at Sungkyunkwan University (SKKU). He had the opportunity to build an astroparticle physics program at one of the major research hubs in Asia. “I was excited to be part of a university that had the vision and determination to become a world-leading university, and I was able to build one of the largest astroparticle physics efforts in Asia, while accomplishing many of my research objectives,” he said.

He enjoys Korean culture and life in Korea, which is very practical and straightforward. “In Korea, people like to get things done fast,” he said. “It’s great to get rapid feedback, for example, on a proposal. You know quickly if your proposal is funded or not.” Being based in Korea has allowed him to collaborate more closely on other projects, including the COSINE-100 dark matter experiment in Korea and the JSNS2 sterile neutrino search and Hyper-Kamiokande neutrino program in Japan. He hopes to spearhead initiatives to establish stronger ties between the University of Utah and leading universities in Asia and Korea.

Future research

Currently, the IceCube team is in the middle of preparing an upgrade to the IceCube Neutrino Telescope. This new telescope will be installed within two years in Antarctica. For the IceCube upgrade, Professor Rott’s team has designed a more accurate camera-based calibration system for the Antarctic ice. Improved calibration will be applied to data collected over the past decade, improving the angular and spatial resolution of detected astrophysical neutrino events.

“The origin of high-energy neutrinos and any new phenomena associated with their production remains one of the biggest challenges of our time,” Rott said. “I’m extremely excited about correlating observations of high-energy neutrinos with other cosmic messengers. To establish any correlation, it’s essential that we can accurately point back to where neutrinos originated on the sky.”
Dr. Pearl Sandick, associate professor in the Department of Physics & Astronomy and associate dean of the College of Science, has been named a Presidential Scholar. The award recognizes the extraordinary academic accomplishments and promise of mid-career faculty, providing them with financial support to advance their teaching and research work.

“These scholars represent the exceptional research and scholarship of mid-career faculty at the University of Utah,” said Dan Reed, senior vice president for Academic Affairs. “They each are outstanding scholars and teachers in their fields of specialty. Their scholarship is what makes the U such a vibrant and exciting intellectual environment.”

Presidential Scholars are selected each year, and the recipients receive $10,000 in annual funding for three years. The program is made possible by a generous donor who is interested in fostering the success of mid-career faculty.

Sandick is a theoretical physicist who works at the intersection of particle physics, astrophysics, and cosmology. She is expert in models of dark matter, a substance known only through its gravitational influence on stars, galaxies, and the largest structures in the universe. Professor Sandick earned her Ph.D. at the University of Minnesota and held a postdoctoral appointment in Nobel Laureate Steven Weinberg’s group at the University of Texas, Austin, before joining the U in 2011.

“I love that my work involves thinking of new explanations for dark matter, checking that they’re viable given everything we know from past experiments and observations, and proposing new ways to better understand what dark matter is,” she said. “I find this type of creative work and problem solving to be really fun on a day-to-day basis, and the bigger picture — what we’ve learned about the universe and how it came to look the way it does — is just awe-inspiring.”

In addition to her research, Sandick is passionate about teaching, mentoring students, and making science accessible and interesting to non-scientists. She has given a TEDx talk, been interviewed on KCPW’s Cool Science Radio, and NPR’s Science Friday. Sandick has been recognized for her teaching and mentoring work, with a 2016 University of Utah Early Career Teaching Award and a 2020 University of Utah Distinguished Mentor Award. She recently served on the American Physical Society (APS) Committee on the Status of Women in Physics and as the Chair of the National Organizing Committee for the APS Conferences for Undergraduate Women in Physics (CUWiPs). She will chair the Four Corners Section in 2021-2022.

“One of the great joys of working at the U is our commitment to engaging students at all levels in research,” Sandick said, “and I’ve been thrilled to work with amazing undergraduate and graduate students.”
Oleg Starykh, professor of physics and astronomy, has been elected a fellow of the 2020 Class of Fellows for the American Physical Society (APS). The APS Fellowship Program recognizes members who have made exceptional contributions to the physics enterprise in physics research, important applications of physics, leadership in or service to physics, or significant contributions to physics education. Each year, no more than one half of one percent of the Society membership is recognized by their peers for election to the status of fellow in the American Physical Society.

“It means so much to be recognized as a fellow, and it implies the recognition of my research by my peers and colleagues in the U.S. and, more generally, worldwide. I appreciate it greatly,” Starykh said. The specific citation from the APS is for Starykh’s “work on the theory of quasi-one-dimensional quantum magnets and the magnetization physics of frustrated antiferromagnets,” which refers to the research Starykh has carried out during the past 15 years, which coincides with his career in the department and at the University of Utah. “Being named a fellow reflects positively on a productive and transformative stretch of my scientific career associated with my moving to Utah and joining the U in 2004,” he said.

His main research area, and the one recognized by the fellowship, is known as quantum magnetism. It deals with magnetic properties of numerous materials and theoretical models inspired by them. The primary goal of his research is to understand the quantum dynamics of microscopic magnetic moments (known as spins), which are present in essentially every material around us and on specific kinds of magnetic materials, known as frustrated antiferromagnets, in which microscopic quantum spins never settle in any one particular rigid pattern (as they do, for example, in the macroscopic magnets that populate the doors of our refrigerators and are known as ferromagnets) but continue their quantum “dance” down to the absolute zero of temperature. The practical side of this research, known as spintronics, seeks to create and control quantum motion of spins, with the goal of replacing basic electron current based devices with spintronics, in which spin currents will be used to transport quantum information encoded in quantum spin-based qubits. While Starykh isn’t closely involved with this kind of research, he finds spintronics’ goals motivating and inspiring.

He became curious about physics in middle school, but it became a passion by the time he finished high school. “I just liked reading and thinking about it, and enjoyed working out physics problems,” he said. “It always amazes me how a few key notions and laws govern the diverse and immense number of natural phenomena around us. When you really understand something, it becomes a part of you. It’s a great feeling to experience.”

Starykh enjoys reading history and good science fiction. His favorite museum is the Musée d’Orsay in Paris. He likes hiking with his family in Utah deserts, mountains, and elsewhere. Like many of us during COVID, he misses traveling and visiting new places and countries.

He received a master’s degree in physics and engineering from the Moscow Institute of Physics and Technology in 1988, and a Ph.D. in physics in 1991 from the Institute for High Pressure Physics, Russian Academy of Sciences, Moscow. He joined the University of Utah in 2004 as an associate professor and was promoted to professor in 2012.
The COVID-19 pandemic forced faculty, students, and staff at the university to shift in one week—literally over spring break in March—from traditional in-person lectures and student outreach to Zoom calls and online testing modules.

**Bryce Nelson**, graduate coordinator for the Physics & Astronomy Department, rose to the challenge—maintaining educational integrity for the Physics Graduate Program by redesigning courses and student orientation sessions, while still providing support for colleagues and other instructors in the department. For her outstanding efforts, Nelson has been awarded the U’s 2020 Online Excellence Staff Award by Dan Reed, senior vice president for Academic Affairs.

In announcing Nelson as a recipient, Reed praised her creativity and innovation, noting her work “will help form a foundation for the future of higher education here at the U, both in terms of course design and in the educational outreach and support we provide to the community around us. The university will be able to better prepare our students for a global, and increasingly digital, economy, thanks to your [Nelson’s] efforts.”

Originally from northern California, Nelson received a Bachelor of Science degree in geology from Portland State University. She joined the Physics & Astronomy Department in October 2018.

She will be recognized at the University’s 2021 Commencement next May. Please join us in congratulating her on receiving this well-deserved award.

**About the Online Excellence Awards**

Digital innovation awards for Excellence in Online Education have been created to recognize faculty and staff creativity in the transition to online-only education during the COVID-19 pandemic of 2020. More broadly, these awards are to recognize digital innovations in academic units across the U, not only during the emergency changes made necessary during the worldwide pandemic, but also as the University of Utah prepares for the global economy of the future.
Ramón Barthelemy Awarded
NSF Grant for STEM Education Research

Ramón Barthelemy, assistant professor of physics and astronomy, recently was awarded a National Science Foundation (NSF) Building Capacity for STEM Education Research grant to complete a longitudinal study on women in physics and to begin a new longitudinal study on people of color in STEM programs at the University of Utah. A longitudinal study is an observational study that follows the same subjects repeatedly over a period of time.

The grant will follow up on the careers of 21 women who were in graduate physics and astronomy programs a decade ago when Barthelemy first interviewed them. As part of the grant, Barthelemy also will begin building a new cohort of participants to investigate—people of color in STEM at the U.

“The results of both studies will be useful in constructing department and university policies to further support women in physics and astronomy and people of color in STEM,” said Barthelemy. “This knowledge is crucial in creating a more positive and inclusive climate for underrepresented students in physics and STEM as well as fostering a diverse pool of talent for the U.S. STEM workforce.”

In revisiting the women he interviewed earlier, Barthelemy will uncover their career trajectories and compare them to their earlier stated goals and ideas. He will also discover the kinds of career experiences the women have had in the decade following his first interviews.

The other part of the grant will look at a second cohort of people of color in STEM to understand their experiences at the U, including the mentoring they have received and their career goals. The study will follow these students for two years and act as the foundation for a future longitudinal project. The results will be disseminated in both academic publications and professional workshops to train faculty in supporting underrepresented students in physics and STEM.

Dr. Barthelemy has also been named a visiting scholar by the Association for Women in Science for 2020-2021 and will be synthesizing research on the experiences and perspectives of gender and sexual minority persons in STEM higher education. Barthelemy is a former Fulbright scholar and an American Association for the Advancement of Science Policy Fellow dedicated to equity and inclusion in STEM. He joined the U in July 2019.
Armed with optimism and a degree in physics, Jim Kaschmitter, BS’72, showed up for his first day on the job at Anaconda Copper’s Research Facility in Salt Lake City only to be told by his supervisor to go home because Chile had just nationalized its copper mines. Undeterred, Kaschmitter found a job at OmniLift Corporation, a Salt Lake City startup that was developing a new type of conveyor system in the Mechanical Engineering Department at the U. While working at the U, Kaschmitter bought one of the first Hewlett Packard HP25 calculators and became fascinated by computers. This fascination has led to a long and successful career in Silicon Valley.

Silicon Valley beckons

In 1976, Kaschmitter earned a master’s degree in electrical engineering from Stanford University and began a Ph.D. program in Applied Physics but dropped out to take a job at Stanford Telecommunications, Inc. (STI) in Mountain View, Calif. STI was founded by the late James Spilker, Jr., who hired Kaschmitter as an early employee. Spilker was one of the inventors of GPS.

Kaschmitter was recruited to Elxsi Corporation, a San Jose startup founded by ex-Digital Equipment Corporation engineers, where he designed the disk subsystem and worked on the IEEE floating point processor and high-speed bus. He became interested in integrated circuit packaging, which led him to apply for a position at Lawrence Livermore National Laboratory (LLNL).

At LLNL, Kaschmitter undertook several projects, including laser pantography for integrated circuit packaging, image processing, and redundant computing for orbital satellites, solar electric aircraft, and energy storage. In 1987, he co-founded nChip Corporation to commercialize hybrid wafer-scale integration; this technology was later sold to Flextronics. In 1989, Kaschmitter assumed responsibility for developing a low-cost power system for President Reagan’s Star Wars satellite system, but he was frustrated by the expensive, heavy batteries then used in satellites, so he began to investigate lithium-ion, or Li-ion batteries, which were still in the research and development phase. He co-founded PolyStor Corporation in 1993, with a grant from President Clinton’s Technology Reinvestment Project program, and his company subsequently established the first commercial Li-ion manufacturing facility in the U.S. In 1997, he spun off PowerStor Corporation from PolyStor to commercialize a carbon aerogel supercapacitor he’d co-invented at LLNL. PowerStor was subsequently acquired by Cooper Bussmann, Inc.

Today, Kaschmitter is CEO of SpectraPower (which he founded in 2002) in Livermore, Calif., in order to apply PolyStor’s high-energy Nickel-Cobalt technology for high-altitude electric drones. Initially, the market wasn’t yet ready for the technology,
so Kaschmitter subsequently founded UltraCell Corporation to work on reformed methanol micro-fuel cell technology. UltraCell’s fuel cells are deployed today with the U.S. military. In the meantime, Kaschmitter has continued with SpectraPower and now focuses his efforts there on supporting users and developers of Li-based battery technologies.

Memories of the U

“The U is a great school with strong technical departments and academics, especially in the area of physics. The department always had an international outlook but with a supportive small-school atmosphere,” said Kaschmitter. “The students and professors were friendly, approachable, and focused on science. Physics has truly provided the foundation for my career.” He also appreciated the advice provided by Professor Orest Symko, whose insights helped Kaschmitter set personal goals and priorities.

His advice for undergraduate students is twofold: set career goals and be prepared to work hard to achieve them. “As Edison famously said, ‘Genius is 1% inspiration and 99% perspiration,’” he says.

When he isn’t working, he makes time for his other love: flying. He has a longtime interest in aviation and first did a solo flight at age 16 at the Salt Lake International Airport. “Later in my career, while at LLNL, I developed lightweight wing-mounted solar panels for the Pathfinder and Helios solar electric aircraft, which AeroVironment subsequently used to set altitude records,” said Kaschmitter. He currently owns, maintains, and flies an experimental Velocity XL-RG: N568Y (see photo below).

In summing up his career, Kaschmitter notes his favorite adage: “If you love your work, you’ll never work a day in your life, and that’s certainly how I feel about my career.” He admits physics is not the easiest path academically, but studying it gives students a fundamental understanding of science and technology that will give them an edge over the competition. “I’ve dealt with many venture capitalists in Silicon Valley and worldwide throughout my career,” he said. “Having a technical background is a real asset—the ones without it are at a disadvantage in today’s technology-reliant world.”
Alumni: Aris Silzars

While attending Reed College as a physics major, Aris Silzars knew he wanted to continue with his education and obtain an advanced degree. Born in Riga, Latvia, but raised in Portland, Ore., Silzars had chosen Reed because it was close to home. By chance, he happened to meet Professor B. Gale Dick, who taught physics at the University of Utah.

Dr. Dick was visiting Reed (his alma mater) to encourage students to apply to the U for graduate school. Silzars applied to the U, along with other schools, and found the U gave him the best opportunity by providing a teaching assistant position that allowed for modest financial support. “The late Dr. Dick was influential for me,” said Silzars. “He was simply a great teacher. His lectures were clear and presented with care and enthusiasm. He met my every expectation and was instrumental in getting me to come to the U. He kept me inspired with his teaching.”

Silzars obtained a master’s in physics—his research was on laser light interacting with sunlight—and his advisor was the late Dr. Grant Fowles. He went on to complete a Ph.D. in electrical engineering from the U.

Following graduation in 1969, Silzars joined Watkins-Johnson Company in Palo Alto to work on microwave and electron optical devices, primarily for government contracts. In 1974, he moved back to the greater Portland area and joined Tektronix Inc. in Beaverton. At the time, Tektronix was the preeminent company in oscilloscopes, which were used widely in engineering and research laboratories. He was able to contribute his knowledge of microwave circuitry to the design of their products. As his career progressed, he took on more engineering management responsibility, leading groups of more than 900 people.

Display technology and consulting

Silzars has always been interested in display technology, which is used in cell phones, laptop and desktop computers, televisions, and other display technology applications. In 1994, he became director of display research at the Sarnoff Labs in Princeton, N.J. Sarnoff Corporation was the original RCA laboratory where color television and later liquid crystal displays were invented. “It was always interesting to wander the hallways and think about the well-known researchers who had worked there in past years,” he said. Working at Sarnoff proved challenging because external contracts had to be found to support the research and the high overhead. In discussions with companies, Silzars realized they would be happy to hire him as an independent consultant to avoid the overhead. “At the time, my wife and I were trying to decide where we might like to settle on a more permanent basis,” he said. The attraction of the Pacific Northwest, with a daughter working in the Seattle area, made the decision easier. In 1995, they moved to the Seattle metro area, where he became a consultant.

Career as expert witness and his own lab

One day he received an unexpected call from a major law firm asking if he could help on a patent case. Silzars had no idea this call would change his life and lead to a career as an expert witness on patent litigation cases. “I had never even heard of such a career, and it was one that
came to me out of the blue—not one that I actively sought,” he said. His business grew as word spread that he was knowledgeable, thorough, and a good presenter at depositions and trials.

Since 1995, Silzars has been the founder and president of Northlight Displays, based in Sammamish, Wash. He has his own laboratory to provide testing and analysis of anything related to display technology. Most of his work is done for clients who hold patents or are defending patents. He continues to be active in the Society for Information Display, serving as president in 2000-2002 and general chair of the International Symposium in 2004.

Value of a physics degree

Silzars says studying physics has made a huge difference in his life. “In order to do expert witness work, you need a Ph.D. because you’re going up against faculty members from well-known institutions, who of course have their Ph.D.,” he said. “Physics has made my career possible in so many ways. Without the degree from the U, my career opportunities would have been much more limited—I wouldn’t have had all these interesting opportunities.”

In looking back, he is reminded that life’s journey has many twists and turns and times of uncertainty. “My advice is to look deep within yourself to find what really motivates you—your interests and enthusiasms—because that’s the key to helping you find and respond to something you may never have imagined or envisioned,” he said.

In his free time, Silzars indulges his love of music, photography, and painting. He has a corner of his lab set up with large speakers and an easel for doing oil painting. He runs at least five miles every other day and enjoys the outdoors.

In 2012, the U’s Beacons of Excellence Award, through a partnership between the Office of Undergraduate Education and the Division of Student Affairs, was introduced to recognize and celebrate the outstanding people, programs, or projects that help make the university a Beacon of Excellence through a commitment to providing an exceptional student education.

This year, the U has given a Beacons of Excellence Award to the REFUGES Afterschool and REFUGES Bridge Programs. Tino Nyawelo, associate professor (lecturer) of Physics & Astronomy, directs both REFUGES programs, and Jordan Gerton, associate professor of Physics & Astronomy and director of the Center for Science and Mathematics, administers them. The award is based on student nominations, with students describing both REFUGES programs as “an absolutely transformative educational experience.”

More than a decade ago, Nyawelo and others in the South Sudanese community became aware of refugee kids dropping out of school. With the help of others, Nyawelo started an after-school program to help refugee kids with homework, expose them to math and science, and help them attend college. This program eventually became the REFUGES Afterschool and REFUGES Bridge Programs.
Pioneering Method Reveals Dynamic Structure in HIV

Continued from page 7

like particles whose lattice consisted of 80% of Gag wild type proteins, 10% of Gag tagged with SNAP, and 10% of gag tagged with Halo. SNAP and Halo are proteins that can bind a linker which binds them together forever. The idea was to identify whether the molecules in the protein lattice stayed stationary or if they migrated positions.

“The Gag-proteins assemble themselves randomly. The SNAP and Halo molecules could be anywhere within the lattice—some may be close to one another, and some will be far away,” Saha said. “If the lattice changes, there’s a chance that the molecules come close to one another.”

Saha introduced a molecule called Haxs8 into the virus-like particles. Haxs8 is a dimerizer—a molecule that covalently binds SNAP and Halo proteins when they are within binding radius of one another. If SNAP or Halo molecules move next to each other, they’ll produce a dimerized complex. Saha tracked these dimerized complex concentrations over time. If the concentration changed, it would indicate that new pairs of molecules found each other. If the concentration decreased, it would indicate the proteins broke apart. Either way, it would indicate that movement had taken place. They found that over time, the percentage of the dimerized complex increased; HALO and SNAP Gag proteins were moving all over the lattice and coming together over time.

A new tool to study viruses

This is the first study to show that the protein lattice structure of an enveloped virus is dynamic. This new tool will be important to better understand the changes that occur within the lattice as new virus particles go from immaturity to dangerously infectious.

“What are the molecular mechanisms that lead to infection? It opens up a new line of study,” said Saha. “If you can figure out that process, maybe you can do something to prevent them from finding each other, like a type of drug that would stop the virus in its tracks.”

Saveez Saffarian, professor in the Department of Physics & Astronomy at the U, was senior author on the paper.
The emergence of the coronavirus has changed our lives. Unfortunately, the pandemic has created serious economic disruptions worldwide. These changes have been especially hard on some of our students. For many of them, family support has dwindled, and many of the sectors that traditionally hired working students have been severely hit. Recognizing the need, the College of Science launched a Student Emergency Fund to help our physics students.

As we close 2020, we’re inviting alumni and friends of the Department of Physics & Astronomy to assist our students facing difficulties. Two alumni supporters, Nicholas and Courtney Gibbs, and other department champions are matching up to $10,000 in gifts to the Student Emergency Fund. Please help us support students who have lost jobs, are struggling to pay tuition, or who need extra monetary support during this difficult time. To make a donation, visit giving.utah.edu/physics.

Thank you for your generosity.

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Christoph Boehme
Chair, Department of Physics & Astronomy
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