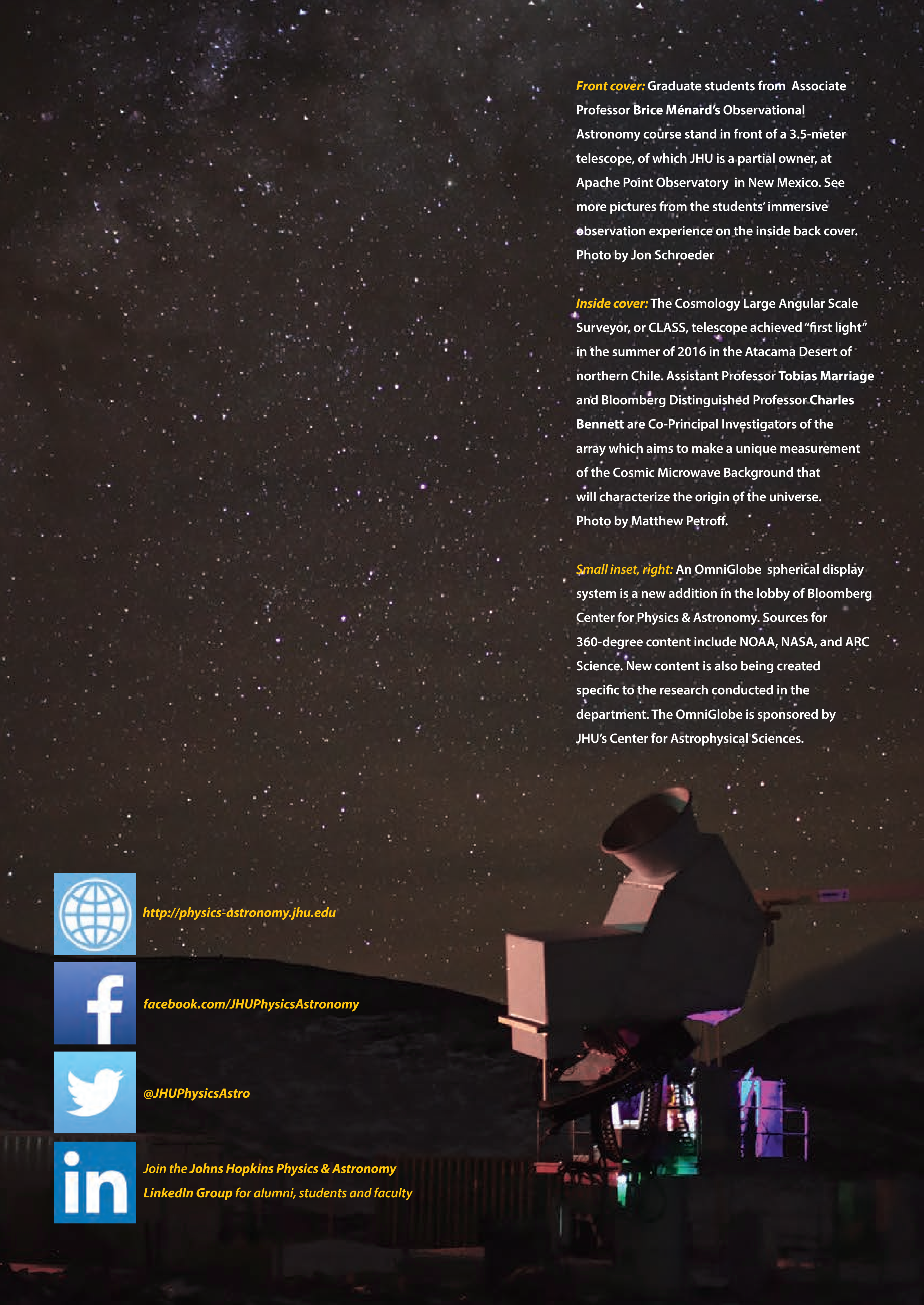
JOHNS HOPKINS UNIVERSITY

2016

Physics & Astronomy



Front cover: Graduate students from Associate Professor **Brice Ménard's** Observational Astronomy course stand in front of a 3.5-meter telescope, of which JHU is a partial owner, at Apache Point Observatory in New Mexico. See more pictures from the students' immersive observation experience on the inside back cover. Photo by Jon Schroeder

Inside cover: The Cosmology Large Angular Scale Surveyor, or CLASS, telescope achieved "first light" in the summer of 2016 in the Atacama Desert of northern Chile. Assistant Professor **Tobias Marriage** and Bloomberg Distinguished Professor **Charles Bennett** are Co-Principal Investigators of the array which aims to make a unique measurement of the Cosmic Microwave Background that will characterize the origin of the universe. Photo by Matthew Petroff.

Small inset, right: An OmniGlobe spherical display system is a new addition in the lobby of Bloomberg Center for Physics & Astronomy. Sources for 360-degree content include NOAA, NASA, and ARC Science. New content is also being created specific to the research conducted in the department. The OmniGlobe is sponsored by JHU's Center for Astrophysical Sciences.

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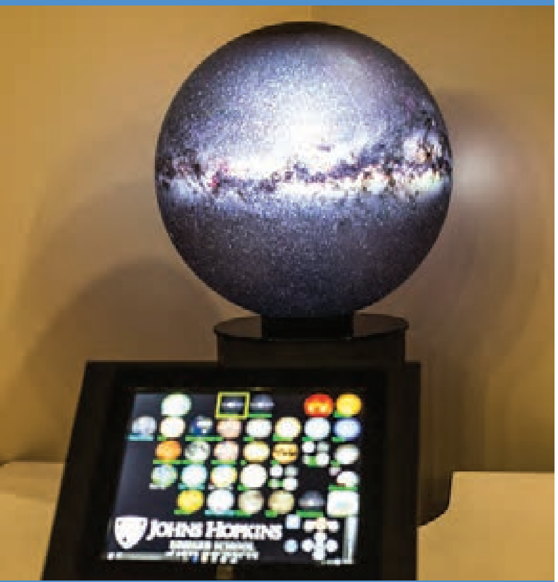

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Physics and Astronomy is an annual publication of the Johns Hopkins University Zanvyl Krieger School of Arts and Sciences Department of Physics and Astronomy. Send correspondence to: jon.schroeder@jhu.edu.

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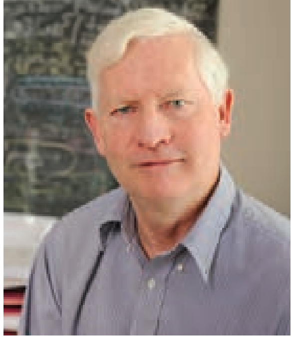


Letter from the Chair

Dear alumni, colleagues, and friends,

I am delighted to bring you this newsletter that reports on all the exciting things that have happened in the department during my first year as chair. In the pages to follow you will learn all about the major awards, accolades, and accomplishments of our students, research staff, and faculty. In this letter I just want to touch on a few of the highlights.

First, I am excited to let you know that four new brilliant young faculty members are joining us. Prof. Yi Li (theoretical condensed matter physics) arrived in July, Prof. Francesca Serra (experimental condensed matter physics) arrived in November, and Profs. Ibu Bah (theoretical particle physics) and Kevin Schlaufman (observational astrophysics) will arrive in January. This is a tremendous infusion of talent and energy!

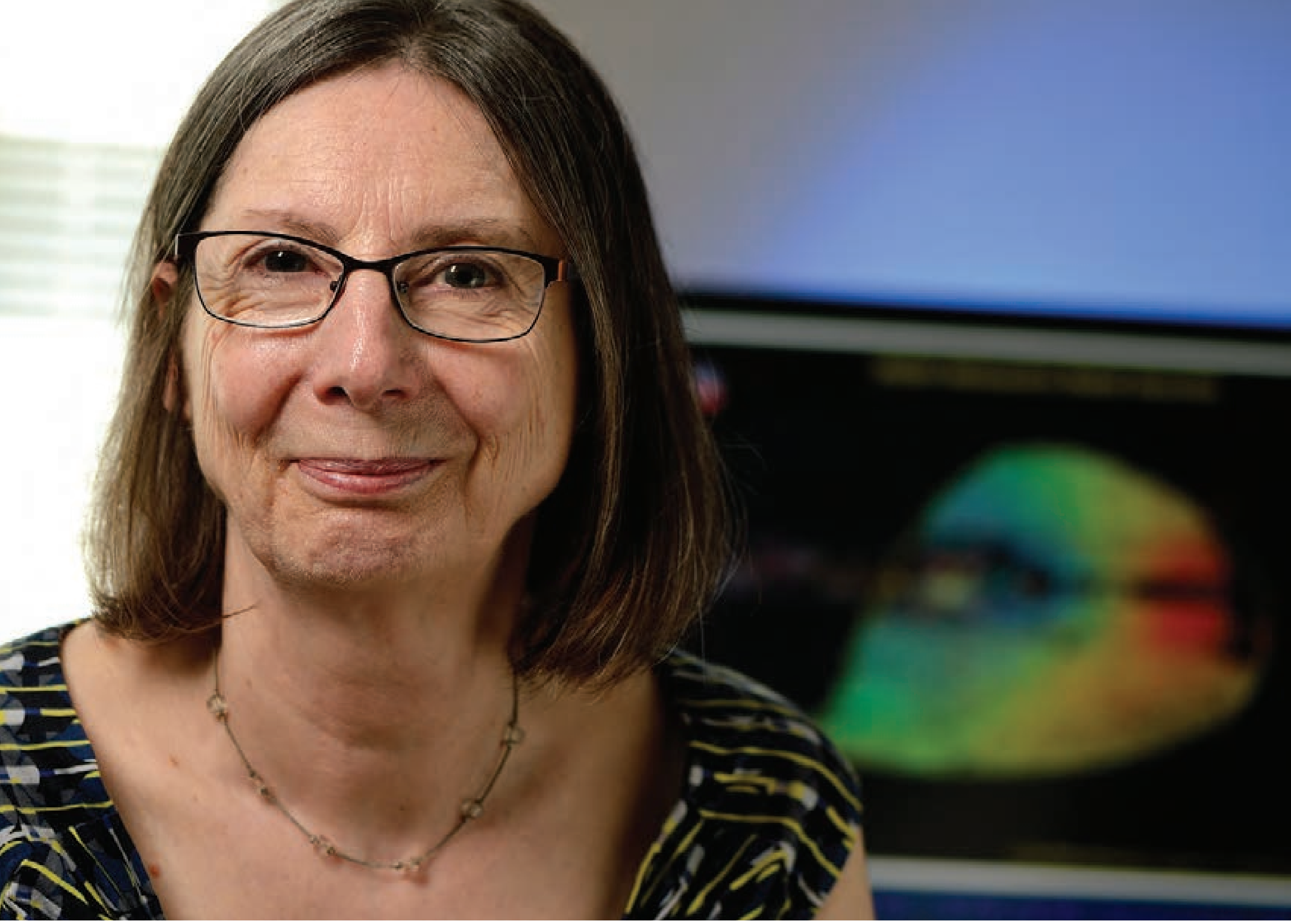
My colleagues continue to astonish me with all the ways they are pushing the frontiers, and here are some examples. The Cosmology Large Angular Scale Surveyor (CLASS) has achieved "first light" from its perch at 17,000 feet in the Atacama Desert of Chile, thanks to the efforts of Professors Toby Marriage, Chuck Bennett, and their Hopkins team. Over the coming years CLASS will be probing the physics of the ultra-early universe during the epoch of inflation. Also, we have received major funding from the National Science Foundation to create a cutting-edge crystal growth facility as part of a national research project meant to revolutionize technology used in consumer products, industry, and medicine. This project is called PARADIM (Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials) and Professor Tyrel McQueen will direct the facility here.

Having told you some of our most exciting news, I want to draw your attention to a new feature of the newsletter, Alumni News, in which you tell us yours! We love hearing from you, and are sure that all of you will enjoy this new feature as well.

In closing, let me again thank you for your interest in our department, and for all of your support. We have an exciting future ahead, and I am pleased that you are a part of it.

Best,

Timothy Heckman, Chair
The Henry A. Rowland Department of Physics and Astronomy



ROSEMARY WYSE LOOKS TO THE STARS TO BETTER UNDERSTAND THE UNIVERSE

BY EMILY MULLIN

When Rosemary F. G. Wyse found out in 1986 that her research on the formation of galactic discs, the flattened circular part of galaxies that contains clusters of stars, was accepted for publication in the prestigious journal Nature, it was one of the happiest moments of her life.

The paper, "Chemical Evolution of the Galactic Disk and Bulge," built on Wyse's doctoral thesis, which described the first theoretical model for how a thick galactic disk would form. These disks are composed of old stars, and appear to be distinct from the thin disks that are where star formation takes place.

Thick disks were first observed in other galaxies, but just as Wyse was finishing her Ph.D. at the University of Cambridge, researchers discovered the Milky Way Galaxy's thick disc in 1983. Wyse partnered with one of the discoverers, Gerard Gilmore, to test her formation theory as well as other models that were being developed at the time.

With that seminal work, Wyse was the first to recognize the galactic thick disc as a consequence of the dynamical evolution of the young Milky Way. Now a professor in the department of Physics and Astronomy at Johns Hopkins, Wyse has become a pioneer the field of galactic archaeology, the study of the history of the Milky Way galaxy and all its contents.

Professor Wyse arrived at Johns Hopkins in 1988 after completing fellowships at Princeton University, the University of California at Berkeley and the Space Telescope Science Institute in Baltimore. But Wyse's interest in astronomy began even before she started her studies in astrophysics as an undergraduate at the University of London.

"I'm from a place in Scotland where the skies are very dark at night. I liked to look at the stars growing up," Wyse says. On those evenings, she would wonder why the sky looked the way it does.

That sense of curiosity drove Wyse to become an early advocate of large-scale spectroscopic surveys of stars, a technique that disperses the light that emanates from stars and other astronomical objects into its constituent wavelengths. These spectroscopic surveys can help determine the speed, temperature, surface gravity and composition of stars and are central to progress in understanding the evolution of our Milky Way Galaxy

Wyse says these surveys are revealing more and more about the formation of stars in the galaxy as researchers become able to collect more data and data of higher quality. Twenty years ago, sample sizes for these surveys consisted of hundreds of stars, she says. Now, surveys like the Radial Velocity Experiment (RAVE), can look at sample sizes of many hundreds of thousands of stars.

Beginning in 2002, RAVE measured the radial velocity of stars using the Doppler effect (the shift between observed and emitted wavelength due to relative motion) together with chemical composition from key features in the spectra. It is one of the largest spectroscopic surveys of Milky Way stars to date. A key member of the project, Wyse has been analyzing data released from RAVE for the past several years.

"One of the insights from RAVE has been that the way the stars are moving shows significant groups of stars moving together, which we had not appreciated before. So even old stars are not as smoothly distributed in either space or velocity as had been shown in smaller surveys," she says.

What exactly that finding means is still being studied, but Wyse says it indicates the presence of disturbances in the gravitational field. Small satellite galaxies, or possibly large transient spiral arms, could cause those disturbances.

Wyse is also examining the RAVE data to understand the distribution of the chemical composition of stars, and how that depends on location within the Galaxy and how it correlates with the velocity distribution.

While RAVE has already generated some important insights into the galaxy, the project is still limited in that it measures only one component of space motion, the radial velocity. So Wyse and other astronomers are now examining new data released in September from European Space Agency's Gaia satellite, which uses astrometric data to measure the second and third components of space motion—proper motion, or the movement of stars across the sky, plus distance. With Gaia, scientists have constructed the largest and most precise three-dimensional map of the galaxy.

> *"One reason to get the radial velocity and the motions of the stars is to map out the distribution of the matter that's providing the gravity, and in large part, that's the dark matter,"*
>
> —Professor Rosemary F.G. Wyse

Wyse's research emphasis on Galactic stars aims to answer bigger questions about both our own galaxy and others. She is particularly interested in old, low-mass stars that could have existed since the onset of star formation, when the universe was much younger. These low-mass stars are characteristically faint and, at present, can only be studied individually in our own Local Group of galaxies - the Milky Way, the Andromeda Galaxy and their satellite galaxies.

"Professor Wyse has shown how the analysis of the properties of these old stars can be used to decipher how our Milky Way formed and evolved. Her background in theoretical cosmology and galaxy formation has provided her with the perspective to use these detailed results for the Milky Way to inform and shape the 'big picture,'" says Physics and Astronomy Department Chair Timothy Heckman.

The author of five major, influential reviews of the Milky Way and nearby galaxies, Wyse has made significant contributions to the astronomy field. She is the winner of several awards, include the American Astronomical Society's Division of Dynamical Astronomy's 2016 Dirk Brouwer Award and the Annie Jump Cannon award from the American Association of University Women. Most recently, Wyse was named the 2016 Blaauw Professor and gave the Blaauw lecture in October 2016. The honor is bestowed to internationally renowned astronomers by the University of Groningen in the Netherlands.

Another honor for Wyse in 2016 came when the Council of the American Association for the Advancement of Science elected her to the rank of AAAS Fellow. Each year AAAS elects members whose "efforts on behalf of the advancement of science or its applications are scientifically or socially distinguished."

In addition to her leadership and influential research, Wyse's mentorship has also earned praise. Kathryne Daniel, an assistant professor in Bryn Mawr College's Department of Physics, worked with Wyse for five years as her doctoral student. Daniel describes Wyse as a "fantastic" role model. She recalls weekly lunches with her adviser and other graduate students at which Professor Wyse would often ask their opinion on newly published studies and how they would approach various problems in astrophysics.

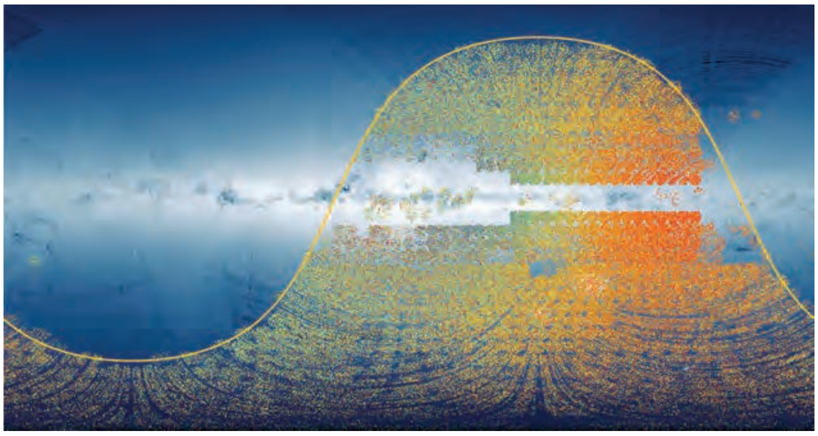
"She was able to shape me into the physicist that I wanted to be," Daniel says.

In her pursuit to study and understand star and galaxy formation, Wyse is vexed by one big, unanswered question: What is the nature of dark matter?

"Dark matter in our galaxy makes the stars move the way they do. So one reason to get the radial velocity and the motions of the stars is to map out the distribution of the matter that's providing the gravity, and in large part, that's the dark matter," Wyse says.

Wyse looks forward to continuing to analyze the RAVE data as well as the newly released the Gaia data.

"I am continually being surprised," she says.



The Milky Way overplotted with stars colored by heliocentric radial velocity. Professor Rosemary F. G. Wyse uses data like this to better understand the evolution of our galaxy.

Credit: Maarten Breddels, Kristin Riebe, RAVE team

Squishiness on the Nanometer Scale

Bob Leheny uses X-rays to discern the hidden properties of soft-condensed matter

BY JOE SUGARMAN

Robert Leheny doesn't actually study toothpaste in any of his experiments, but a tube of Crest or Colgate serves as a useful example for the types of substances that he investigates.

Leheny is what's known as a soft-condensed matter physicist, as opposed to a hard-condensed matter physicist. Or, as he puts it, he investigates the "squishy side of things."

"That may seem a frivolous way of distinguishing different classes of materials from a physics point of view," he says, "but I think 'squishiness' goes to the very nature of why this class of materials is so interesting."

Leheny has made a career of probing the softer side of matter -- gels, emulsions, clays, colloids. In our everyday world, soft matter is everywhere--paint, blood, lubricants, Jell-O, and, yes, toothpaste. What all these substances have in common is that their molecules are disordered or out of equilibrium. "Systems left to their own devices achieve a state of low energy, which is a general physics principle," says Leheny, "but these materials, due to their own deficiencies can't find equilibrium—at least on human time scales. They behave in ways not seen elsewhere in nature."

Take toothpaste, for example. "You squeeze the toothpaste tube and it flows out like a liquid and then you stop squeezing and its internal forces are just strong enough so that it holds on your toothbrush. So when it comes to gentle forces, like gravity, toothpaste behaves like a solid, but apply a little stronger force and it behaves like a liquid. Squishy systems like this are often in fragile states. They're close to falling into a different configuration, a different structure."

What's happening on a molecular level with these substances is what Leheny and his team are trying to find out. "If I told you what is in toothpaste, you wouldn't necessarily be able to build a model to show it behaves as it does. Connecting the microscopic to the macroscopic in such cases is challenging."

To help understand what's happening at the smallest levels, Leheny frequently employs the Advanced Photon Source (APS) at the U.S. Department of Energy's Argonne National Laboratory outside of Chicago. APS provides the ultra-bright, high-energy X-ray beams necessary for exploring what's going on inside of these materials.

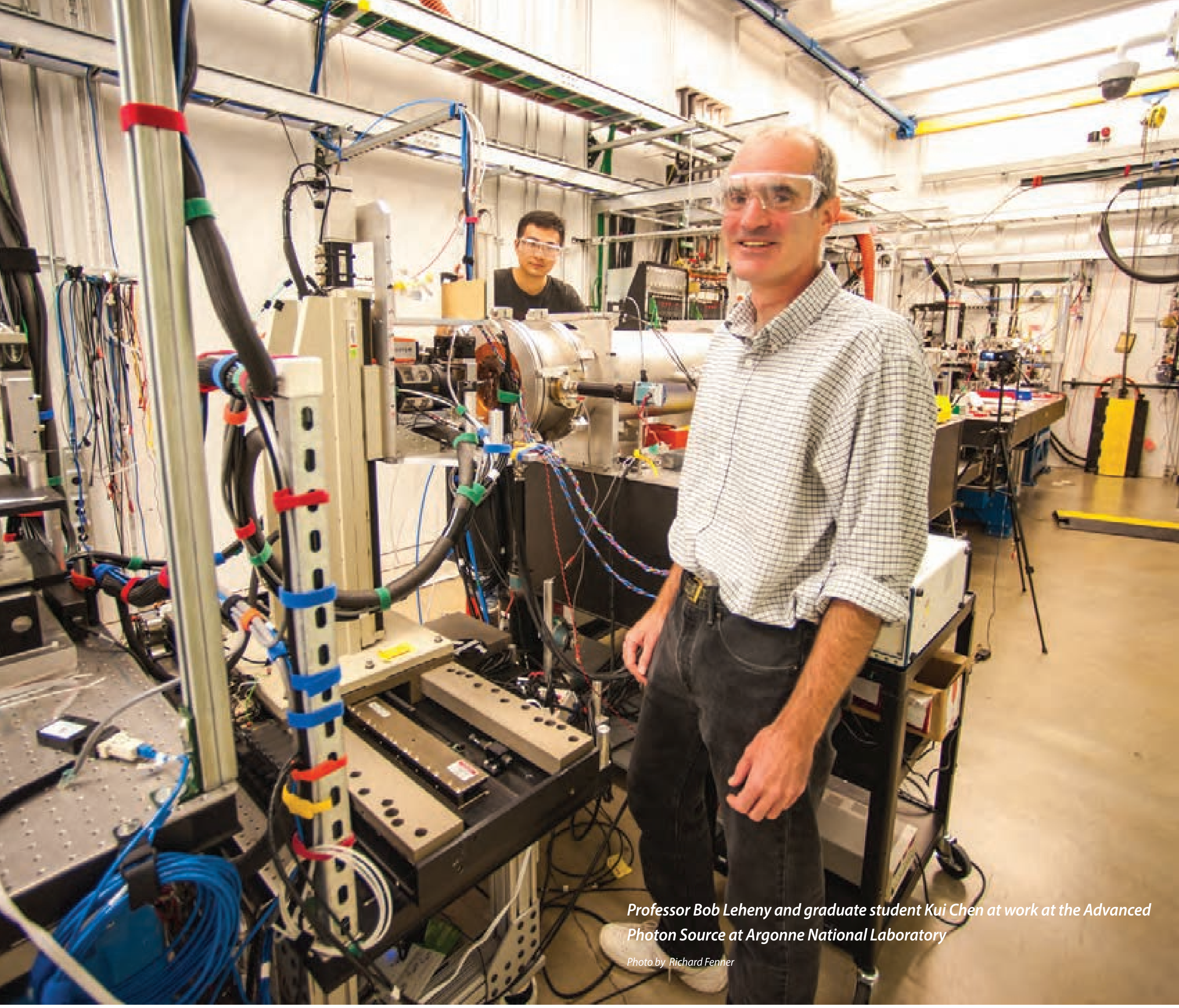
The specific technique Leheny has helped to develop, known as X-ray Photon Correlation Spectroscopy (XPCS), involves configuring a beam of ultra-luminous X-rays, projecting it through a substance, and onto a detector. What results is a speckle pattern of light and dark, as the X-rays scatter from the molecules. From that flickering speckle pattern, Leheny and his team can infer mathematically how molecules are moving around. The technique has been employed for decades with visible light, but by concentrating X-rays, researchers can visualize objects as small as a nanometer in size as opposed to approximately 500 nanometers.

> *"[X-ray Photon Correlation Spectroscopy] is opening new windows for the study of the dynamics of soft matter systems."*
>
> —Professor Daniel Reich

Leheny became a pioneer in using the technique after he arrived at Johns Hopkins in 2000, following graduate studies at the University of Chicago and postdoctoral work at Massachusetts Institute of Technology. The field has advanced significantly since then, and today, there are six such facilities around the world, including the newly opened National Synchrotron Light Source II at New York's Brookhaven National Laboratory, a project on which Leheny advised.

"Bob has really been instrumental in the development of XPCS," says his JHU colleague and fellow condensed matter physicist, Professor Dan Reich. "This technique is opening new windows for the study of the dynamics of soft matter systems, and Bob is leading the way in realizing its potential, both through his science and through his intellectual leadership in guiding instrumentation development at facilities like Argonne and Brookhaven National Laboratories."

Leheny's most recent focus has been trying to understand what happens when forcing a disordered material to yield. An amorphous alloy like metallic glass is a disordered material, with atoms occupying generally random positions in the structure as opposed crystalline structures. "If you take a metal object like a paper clip or an airplane wing and bend it to where it doesn't bend back, you've done something to the arrangement of its atoms," says Leheny. "It yields. That's well understood. But imagine I have some disordered material and make it yield to the point it fails. Its atoms were all jumbled around randomly to begin with, so it's much harder to understand what has changed. Our idea is to use this technique to



Professor Bob Leheny and graduate student Kui Chen at work at the Advanced Photon Source at Argonne National Laboratory

Photo by Richard Fenner

understand what's moving when you force a disordered material to yield."

Leheny says that one of the aspects of the field he enjoys most is its interdisciplinary nature. In past years, he has collaborated with researchers in chemical and biomedical engineering, and he and a graduate student recently worked with Justin Hanes, director of the Center for Nanomedicine at the Johns Hopkins School of Medicine. The researchers were investigating the nature of another soft matter material -- mucus. Hanes has been trying to figure out new methods to deliver medicine to patients with lung disorders, like cystic fibrosis, via an inhaler. The challenge is to deliver those nanoparticle-sized particles effectively through the lung's mucus layer, whose specific purpose is to protect the lungs from such foreign objects. "That raises the question of what is mucus at the nanometer scale?" Asks Leheny. "What's its structure? What are the microscopic origins of its flow properties? That leads us directly to some of the questions we're trying to answer with our X-ray technique. We have expertise in tracking how nanoparticles move through a material like mucus, so the collaboration makes sense."

"If I told you what is in toothpaste, you wouldn't necessarily be able to build a model to show it behaves as it does. Connecting the microscopic to the macroscopic in such cases is challenging."

- Professor Bob Leheny

With XPCS technology advancing every year (a planned upgrade at Argonne proposes to increase X-ray brightness by 50-100 times), Leheny says the future of the field is brighter than ever, and he's hopeful that some of the mysteries of soft matter will be unraveled. "We understand these disordered, out-of-equilibrium materials so poorly given how ubiquitous they are in nature and the roles they play in technology and biology," he says. "There are all these prosaic materials, yet scientists have such deep ignorance of why they are the way they are."

Toothpaste, included.

NEWS BRIEFS

Kamionkowski Appointed the William R. Kenan, Jr. Professorship and Elected a Fellow of the International Society for General Relativity and Gravitation

Professor **Marc Kamionkowski** was appointed as the William R. Kenan, Jr. Professor in the department, effective January 1, 2016. A North Carolina native, William R. Kenan, Jr. traveled throughout the region to attend to his wide-ranging business interests in railroads, real estate, and the Standard Oil Company. After his death in 1965, the Kenan Trust sought to promote his strong interest in enhancing student-teacher relationships at prominent educational institutions through the creation of chairs in his memory. Prof. Kamionkowski is a theoretical physicist who specializes in cosmology and particle physics. He is best known for work on dark matter and the development of the cosmic microwave background as a probe of the early Universe, but his interests extend to several other areas of physics and astrophysics as well. His contributions have been recognized by a number of major awards, including the 2006 Department of Energy's Ernest O. Lawrence Award for High-Energy and Nuclear Physics, the American Astronomical Society's 2015 Dannie Heineman Prize, and election in 2013 to the American Academy of Arts and Sciences.

In 2016 Professor Kamionkowski was also elected a Fellow of the International Society on General Relativity and Gravitation. Kamionkowski was recognized, "for his contributions to contemporary cosmology and general relativity, particularly the development of the theoretical foundation for the detection of relic gravitational waves from inflation in the Cosmic Microwave Background polarization."

Peter Armitage Awarded 2016 Ludwig-Genzel Prize

Associate Professor **Peter Armitage** has been awarded the 2016 Ludwig-Genzel Prize. This prize "is awarded to a young scientist for exceptional contribution to the field of condensed matter spectroscopy." The prize selection committee selected Armitage for "the development and application of low-frequency electrodynamic probes to quantum correlated matter." The prize is awarded every two years during the International Conference on Low Energy Electrodynamics in Solids. Armitage's spectroscopic studies of correlated electron systems have made a major impact on the field. Most recently he developed high-precision THz polarimetry and THz ellipsometry in order to study quantum correlated matter.

Timothy Heckman Elected to National Academy of Sciences

Dr. A. Hermann Pfund Professor and Department Chair, **Tim Heckman**, was elected to the National Academy of Sciences in 2016. Heckman was elected in recognition of his distinguished and continuing achievements in original research. Membership is a widely accepted mark of excellence in science and is considered one of the highest honors that a scientist can receive. The NAS membership totals approximately 2,250 members and nearly 440 foreign associates.

Dominika Wylezalek Receives JHU Provost's Postdoctoral Diversity Fellowship

Dr. **Dominika Wylezalek** has been awarded the JHU Provost's Postdoctoral Diversity Fellowship. The Provost's Diversity Postdoctoral Fellowship Program will prepare postdocs for tenure-track faculty positions at JHU or peer institutions, particularly in fields where there are fewer women and/or underrepresented minorities. The fellowship will enable Wylezalek to continue her exciting research on feedback from supermassive black holes.

Wylezalek also currently holds the Akbari-Mack Postdoctoral Fellowship that is made possible by the generous support of Dr. Homaira Akbari and Mr. Roszell Mack. Dr. Akbari is a former postdoctoral researcher in particle physics at JHU and is currently Chair of the JHU Physics and Astronomy Advisory Council.

Wylezalek arrived at Johns Hopkins in October 2014 as a member of the research group led by Professor **Nadia Zakamska**. Wylezalek's current research centers on analyzing observations from the Gemini Observatory and the Hubble Space Telescope that will allow her to measure the galaxy-wide impact of actively accreting black holes.

Wylezalek earned her Bachelor of Science degree in Physics from the University of Heidelberg in 2010. From there she moved to the University of Cambridge where she completed a Master of Science degree in 2011. Wylezalek was then awarded an international Max Planck Graduate Fellowship in Astrophysics and embarked on her Ph.D. studies at the European Southern Observatory near Munich, Germany.

McQueen Becomes Director of PARADIM Crystal Growth Facility Backed by the National Science Foundation

The National Science Foundation announced in March 2016 that JHU is establishing a cutting-edge crystal growth facility as part of a national research project under the NSF's new Materials Innovation Platform. Dubbed PARADIM — Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials — the program's goal is to revolutionize technology used in consumer products, industry, and medicine. JHU, Cornell, Princeton, and Clark Atlanta universities form a team of institutions that the NSF chose for the $25 million program over five years. Associate Professor **Tyrel McQueen** will lead the JHU portion of the platform as Facility Director for crystal growth. PARADIM will join the Hopkins Extreme Materials Institute, the Institute for Quantum Matter and the Institute for Nanobiotechnology, bolstering Johns Hopkins' status as a national leader in materials research.

"Materials science is the basis for so much of what we have accomplished technologically — computers, superconductors, advances in medical imaging, and even our space program," said McQueen, associate professor in the departments of Physics & Astronomy, Chemistry, and Materials Science and Engineering. "Future technologies will also depend on making new materials with new properties — we need better materials for catalysts and batteries, for example, and better materials for medical implants."

The PARADIM project stems from a report issued in 2009 by the National Academy of Sciences. The report found that while research laboratories at large U.S. corporations once led the way in advanced materials development, in the past few decades several factors caused these capabilities to shrink to "near disappearance." In 2015, the NSF called on research institutions for proposals to pick up the pace of research and development of new materials.

JHU will be closely collaborating with the other three universities. Cornell will develop programs in thin film crystalline materials — currently used, for example, in semiconductors and many electronic materials. Clark Atlanta will focus on the theoretical aspects of the research and Princeton will direct overall project research.

"Materials science is the basis for so much of what we have accomplished technologically — computers, superconductors, advances in medical imaging, and even our space program"

—Tyrel McQueen
ASSOCIATE PROFESSOR AND FACILITY DIRECTOR OF PARADIM

A key part of the new Johns Hopkins crystal growth center will be a new piece of laboratory equipment now being custom built in Germany. Called an optical floating zone furnace, the instrument – a bit larger than a household refrigerator – will be the first of its kind in the United States, allowing scientists to make materials that have never been made before. The machine will allow researchers to put materials under enormous pressure — up to 300 times normal atmospheric pressure and 30 times the pressure possible at furnaces now in use at Johns Hopkins. Crystals will be grown in the presence of gases that have liquid properties, known as supercritical fluids. Supercritical fluids are ideal for aiding crystal growth because they dissolve chemical species very differently than their non-supercritical counterparts, and, there is no surface tension in the fluid. A second furnace is to be equipped with an X-ray computed tomography, or CT, scanner, which will allow researchers to watch crystals as they grow.

McQueen said the new instrumentation will sharply cut down on the trial and error usually involved in crystal growth, vastly improving production speed. Now, he said, it takes one to three days to grow a pinky-sized crystal "if you know how to do it. … If you don't know how to do it, months."

An integral component of the PARADIM program is education and collaboration. The laboratories will be open to researchers from universities around the country, who will be taught the techniques developed there. The first summer school program for graduate students, held in July 2016 in the Bloomberg Center, was oversubscribed, though the program is still in its infancy.

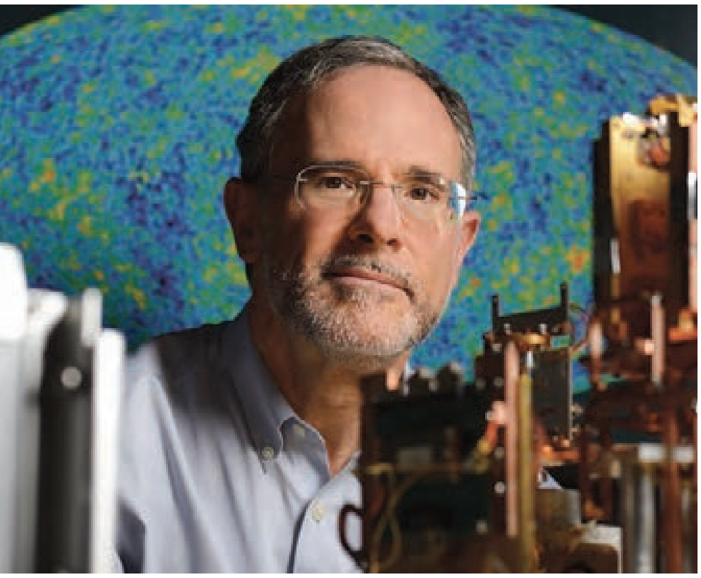
"Part of what this platform will do is to become a resource for scientists at all universities, not just Hopkins," McQueen said. "A critical component of the program is that the platform will serve a broad purpose in both research and education.

W. Adam Phelan, Ph.D, Associate Director of the PARADIM-Bulk Crystal Growth Facility, pictured with a radio frequencey indcution furnace.

Photo by Jon Schroeder

NEWS BRIEFS

Charles Bennett Becomes a Bloomberg Distinguished Professor, Launches Space@Hopkins, and Receives the International Space Science Award from the Committee on Space Research



Johns Hopkins University named Professor **Charles "Chuck" Bennett** a Bloomberg Distinguished Professor in late 2015. He is the first Bloomberg Distinguished Professor to hold a joint appointment with the Johns Hopkins Applied Physics Laboratory. The appointment of Bloomberg Distinguished Professors is made possible from a record-setting gift from former New York City Mayor Michael Bloomberg. JHU President Ron Daniels said, "This latest initiative allows us to greatly accelerate our investment in talented people and bring them together in a highly creative and dynamic atmosphere."

A world-leading researcher in experimental astrophysics and cosmology, Bennett focuses on understanding of the universe by observing the cosmic microwave background. He designs and builds novel instruments to study this faint afterglow of the infant universe.

Bennett joined Johns Hopkins in 2005 after 20 years at the NASA Goddard Space Flight Center, where he held the roles of Infrared Astrophysics branch head, senior scientist for experimental cosmology, and Goddard Senior Fellow. While at Goddard, he was a deputy principal investigator on NASA's Cosmic Background Explorer (COBE) and principal investigator for the Wilkinson Microwave Anisotropy Probe (WMAP) space missions.

Through his observations of light traveling across the observable universe, Bennett is able to observe the large scale properties of the universe. WMAP provided spectacular and unprecedented results, precisely revealing the curvature, age, history, and composition of the universe. The series of papers that present the revolutionary WMAP results have together been cited more than 40,000 times, making them among the most influential series in the history of modern science.

"Chuck's vast experience with new technologies, instrumentation, and scientific space mission design and development uniquely qualifies him to bridge the Applied Physics Laboratory with the Krieger School," says Ralph Semmel, director of APL. "He is exactly the type of scientist who exemplifies the interdisciplinary goals of the Bloomberg Distinguished Professorships, and we look forward to many meaningful collaborations."

Bennett serves as co-director of the undergraduate minor in space science and engineering, which is open to students of both the Krieger and Whiting schools. With his newly expanded role, he will now be able to connect Homewood students to research opportunities at APL. He will continue to teach undergraduate courses and provide substantive undergraduate research experiences.

Over the years, Bennett's conversations with colleagues have revealed a shared interest in somehow uniting disparate activities in space studies—which span dozens of Hopkins divisions, from the Applied Physics Laboratory's space missions to physicists studying black holes. Along with naming Bennett a Bloomberg Distinguished Professor, the University also initiated the new Space@Hopkins initiative aimed at knitting together the University's diverse space-research activities. The effort celebrates Johns Hopkins' rich history with space studies, from Professor Henry Rowland's 1883 invention of concave grating—which would become a basic tool for observations in space—to last year's New Horizons mission to Pluto led by the Applied Physics Lab.

Building on previous research, Bennett seeks to learn dramatically more about the very first moments of the universe. Bennett is co-principal investigator, along with Assistant Professor **Tobias Marriage**, of the Cosmology Large Angular-Scale Surveyor, or CLASS (see inside front cover). The international team is developing and employing an innovative next-generation facility that has started to observe the cosmic microwave background from Chile's Atacama Desert. The CLASS telescope received "first light" in May 2016, CLASS is now scanning the sky night and day, searching for a pattern of cosmic microwave background polarization imprinted by primordial gravitational waves generated at the beginning of the universe. Detecting and characterizing this signal has become a central goal of physics: It will not only test the quantum-to-cosmos theory called "inflation" about how the universe began, it also may provide evidence on the connection between the two great pillars of modern physics: Einstein's theory of general relativity and quantum mechanics.

In the summer of 2016, Bennett received the international "Space Science Award" from the Committee on Space Research (COSPAR). The COSPAR Award honors a scientist who has made outstanding contributions to space science. The Space Science Award is presented every other year. The 2016 award went to Bennett and Anatoly I. Grigoriev, the Director of the Institute for Biomedical Problems (IBMP) in Moscow, who has a long history in space medicine. Professor Bennett was awarded the COSPAR Space Science Award for his leadership of WMAP, which determined robustly that of the three possible cosmological geometries, our Universe is flat to within 0.4%; that the Universe is 13.8 $\pm$ 0.1 billion years old; that only 4.6 $\pm$ 0.1% of the Universe is baryonic; that 24 $\pm$ 1% is dark matter, and 71 $\pm$ 1% is dark energy.

Guy Marcus Named by Forbes Magazine as One of Their "30 Under 30" Scientists

Third-year Ph. D. student, **Guy Marcus**, was chosen in 2016 as one of Forbes Magazine's "30 Under 30" scientists. Marcus, who was 24 years old when selected by Forbes, is an active member of the Institute for Quantum Matter, led by Professor Colin Broholm. Marcus' research focuses on understanding quantum magnetism and the development of chemically-tuned magnetic materials. These new materials could ultimately be put to use to build more stable hard drives, more efficient power grids, and better solar cells in the future.

"It's a very cool process," Marcus told Forbes, "to be creating new parts of the world."

Thomas O'Connor Receives the Ken Hass Outstanding Student Paper Award from the American Physical Society

Ph.D. candidate **Thomas O'Connor** received the Ken Hass Outstanding Student Paper Award from the American Physical Society in 2016. O'Connor is working toward his Ph. D. with Professor **Mark Robbins**, and O'Connor's published paper that earned the recognition was titled "Chain Ends and the Ultimate Tensile Strength of Polyethylene Fibers." The purpose of the Ken Hass Outstanding Student Paper Award is to recognize the best student paper addressing the subject of industrial applications of physics. It is named in recognition of the many contributions of Ken Hass to the industrial applications of physics, especially automotive applications of theoretical solid-state physics.

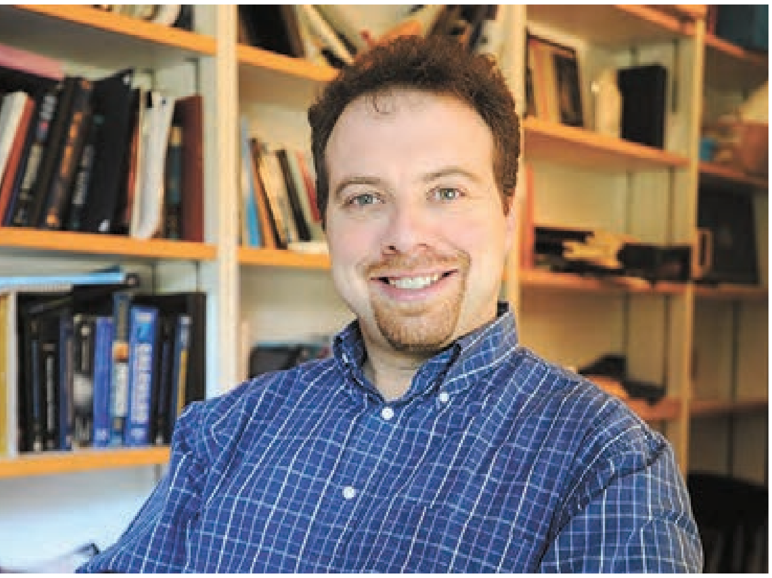
Roskes Named 2016 Gardner Fellow

Graduate student, and former undergratuate in the department, **Jeffrey "Heshy" Roskes**, is the recipient of the 2016 William Gardner Fellowship. Roskes will be supported by the fellowship to further his research on the Compact Muon Solenoid detector at the Large Hadron Collider at CERN.

Roskes is the eighth Gardner Fellow. The fellowship was founded by **William Gardner** (Ph.D., '68), who received his Ph.D. in physics under Professor Warren Moos and had a successful career in fiber optics and telecommunications at Bell Laboratories. Gardner now generously provides support for one of the department's highest priorities—enabling graduate students to dive into research from the start.

NEWS BRIEFS

Adam Riess Becomes Bloomberg Distinguished Professor and Leads Study that Demonstrates that the Universe is Expanding Faster Than Many Expected



Professor **Adam Riess**, an internationally renowned observational cosmologist working on the measurement of the expansion of the universe and a recipient of the 2011 Nobel Prize in physics, was named a Bloomberg Distinguished Professor at JHU in 2016. Riess—also the Thomas J. Barber Professor in Space Studies in the department and a distinguished astronomer at the Space Telescope Science Institute—is now jointly appointed in the Department of Earth and Planetary Sciences at JHU's Krieger School of Arts and Sciences.

Bloomberg Distinguished Professorships are supported by a $350 million gift to the university by Johns Hopkins alumnus, philanthropist, and three-term New York City Mayor Michael R. Bloomberg. The majority of this gift is dedicated to creating 50 new interdisciplinary professorships, galvanizing people, resources, research, and educational opportunities to address major world problems.

Riess won the 2011 Nobel Prize in physics—an honor he shared with Saul Perlmutter and Brian Schmidt—for his team's discovery that the expansion rate of the universe is accelerating, a phenomenon widely attributed to a mysterious, unexplained dark energy filling the universe. A form of dark energy was originally predicted by Einstein's General Theory of Relativity.

He currently uses NASA's Hubble Space Telescope to continue his measurements of distant supernovae, and to provide important independent probes of the nature of dark energy through very precise measurements of the present rate of expansion of the universe. His goal is to determine the behavior of dark energy, and to see if it has been changing with time. Such measurements are crucial to understand the remarkable physics that underlies dark energy.

Riess recently led a widely circulated study that found the universe appears to be expanding faster now than predicted by measurements of the rate as seen shortly after the Big Bang by the Planck cosmic microwave background Satellite, Riess said the results compiled using the Hubble Space Telescope could shed light on the composition of the universe and address questions about Einstein's theory of gravity.

"This surprising finding may be an important clue to understanding those mysterious parts of the universe that make up 95 percent of everything and don't emit light, such as dark energy, dark matter, and dark radiation," said Riess, who conduced the study published with 14 co-authors from 11 research institutions, including JHU, in *The Astrophysical Journal*.

The study takes a more precise measure of the universe's expansion rate using novel techniques, building on Riess' earlier research. The result is unprecedented accuracy of the expansion rate, reducing uncertainty to only 2.4 percent. The improved Hubble constant value—the measure of the speed of the expansion of the universe—is 73.2 kilometers per second per about 3 million light years. In other words, for every 3.26 million light years out, the universe is expanding 73.2 kilometers per second faster. The new value means the distance between cosmic objects will double in another 9.8 billion years.

Since 2007, Riess has taught the highly popular undergraduate course Stars and the Universe: Cosmic Evolution. An introduction to astronomy that is open to all majors, students learn about key discoveries in astronomy and astrophysics that have shaped our current understanding of the universe. The class incorporates insights from physics, astronomy, geology, chemistry, biology, and anthropology, and has seen enrollment double three times.

"This surprising finding may be an important clue to understanding those mysterious parts of the universe that make up 95 percent of everything and don't emit light, such as dark energy, dark matter, and dark radiation"

—Adam Riess
BLOOMBERG DISTINGUISHED PROFESSOR

In addition to the Nobel Prize, Riess has been awarded the Albert Einstein Medal, Shaw Prize in Astronomy, NASA Exceptional Scientific Achievement Award, Breakthrough Prize in Fundamental Physics, Gruber Prize in Cosmology, Raymond and Beverly Sackler Prize, and Helen B. Warner Prize, among others. He was also named a MacArthur Fellow in 2008 and elected to both the National Academy of Sciences and the American Academy of Arts & Sciences.

Four Early-Career Faculty Members Receive 2016 JHU Catalyst Awards for their Research

Jared Kaplan

Tobias Marriage

Tyrel McQueen

Nadia Zakamska

Assistant Professor **Jared Kaplan**, Assistant Professor **Tobias Marriage,** Associate Professor **Tyrel McQueen**, and Assistant Professor **Nadia Zakamska** have each received Johns Hopkins University Catalyst Awards and $75,000 grants for their innovative, faculty-led research endeavors. The goal of the Catalyst Awards is to launch early-career faculty on a path to a sustainable and rewarding academic career. Thirty other early-career faculty members from across JHU were also awarded a 2016 Catalyst Award. The cohort will participate in mentoring sessions and opportunities organized to spur connections between these colleagues at a similar stage in their careers. The program is open to any full-time faculty member who was first appointed within the last three to 10 years.

David Kaplan's *Particle Fever* Documentary Receives Inaugural Stephen Hawking Medal for Science Communication

The documentary *Particle Fever*, which Professor **David Kaplan** co-produced, became one of three inaugural recipients of the Stephen Hawking Medal for Science Communication. In collaboration with the Starmus Festival, Stephen Hawking personally selected the awardees for "outstanding contributions in the articulation and portrayal of science to the public, within the three categories of science, art, and film."

With a mission to bring science to the people and to position it in our daily lives, the Stephen Hawking Medal of Science was born in late 2015 to honor individuals and entities that had contributed, in an eminent way, to popularizing science. The other recipients of the award in this first edition were Jim Al-Khalili, physicist, writer and broadcaster, and Hans Zimmer, film and television composer.

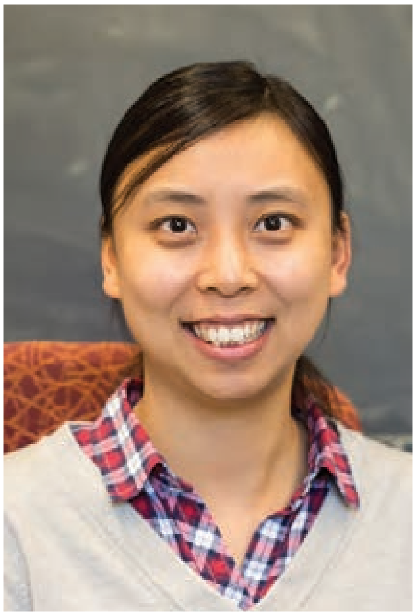
According to Garik Israeli, astrophysicist, founder and director of the Starmus Festival: "these three medals enclose a fundamental message: the importance of disseminating Science and all its achievements to the general public and to inspire too, young people to show interest in the world of Science. The winners have not only understood the dimension of this challenge, but also have led in different disciplines, the transmission and development of knowledge, beating the barriers between science and communication...The documentary film, *Particle Fever*, directed by Mark Levinson and produced by David E. Kaplan, Mark Levinson, Andrea Miller and Carla Solomon, is the winner in the category of Film, for insights into the life and work of physicists at the Large Hadron Collider at CERN. Culminating in the discovery of the Higgs Boson."

The award ceremony award took place at the Starmus Festival in Tenerife, Canary Islands in June of 2016. The festival brings together the brightest minds from astronomy with tech business leaders and creative industries thinkers to debate the future of humanity. The program included the participation of eleven Nobel laureates in disciplines such as Physics, Chemistry, Medicine, and Astronomy. Professor Stephen Hawking presented the awards, along with astrophysicist and lead guitarist of the rock band Queen, Brian May.

NEWS BRIEFS

Four New Assistant Professors Join Faculty

Theoretical Condensed Matter Physicist Yi Li



Yi Li joined the department as a new Assistant Professor in the summer of 2016. As a condensed matter theorist, Li is interested in exploring exotic quantum phases of matter and their organizing principles. She obtained a Ph. D. in Physics from the University of California, San Diego, and a B.S. in Physics from Fudan University in Shanghai, China. Li was a Postdoctoral Fellow at Princeton University from 2013 to 2016. She has made extensive contributions to published journal articles and has been invited to share her research at physics seminars throughout the United States and China.

Experimental Condensed Matter Physicist Francesca Serra

Francesca Serra will begin her appointment as a new Assistant Professor in January. Serra is a soft-condensed matter experimental physicist and her research focuses on liquid crystals. She earned her Ph.D. from the University of Cambridge and her M.S. in Biological Physics from the University of Parma in Italy. More recently, Serra has worked as a postdoctoral researcher at the University of Pennsylvania and the University of Milan. She has contributed to many publications and has been invited to present her research at several institutions throughout the United States, Europe, and Japan.

Astronomer Kevin Schlaufman

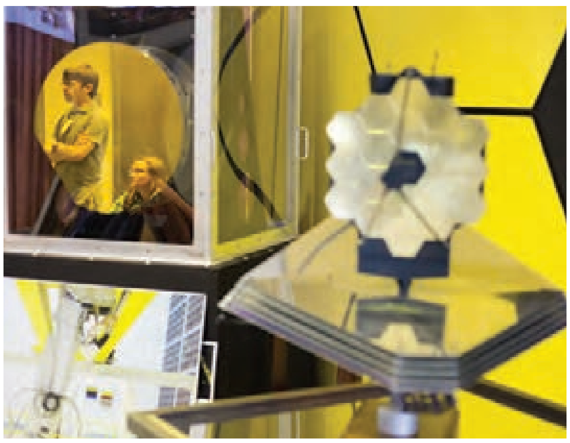
Kevin Schlaufman will arrive in the department as a new Assistant Professor in January 2017. As a theoretically-oriented observational astronomer, Schlaufman is working at the intersection of galactic astronomy and exoplanets. Before coming to Johns Hopkins University, he worked as a senior data scientist at LinkedIn, as a Kavli Fellow at MIT, and as a Carnegie-Princeton Fellow at the Observatories of the Carnegie Institution for Science. Schlaufman earned his Ph. D. from the University of California, Santa Cruz in astronomy and astrophysics, and his M.S. from Stanford University in scientific computing and computational mathematics. Schlaufman is currently leading the first all-sky search for the oldest and most chemically primitive stars in the Milky Way, with a special focus on the inner Galaxy.

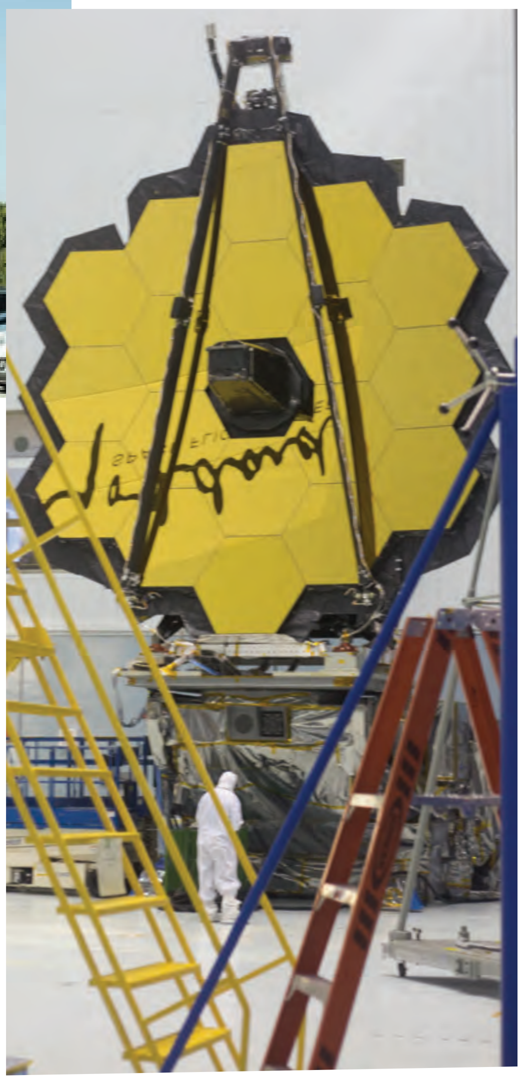
Theoretical Particle Physicist Ibrahima Bah

Ibrahima (Ibou) Bah will join the department as a new Assistant Professor in January 2017. Bah is a theoretical physicist interested in the unification of fundamental forces and the mathematical structure of theories to describe such unification. He earned an M.S. and Ph. D. in Physics from the University of Michigan and a A.B. in mathematics and a B.S. in physics from Lafayette College. Bah then did postdoctoral study at the University of Southern California, SPhT-Saclay, and the University of California, San Diego, where he was a UC President's Postdoctoral Fellow. Bah has authored many published journal articles and lectured at university seminars and workshops throughout the United States and Europe.

Students, Researchers, and Faculty Visit Goddard Space Flight Center for Annual Interaction Day

An annual tradition of over a dozen years continued in October with the 2016 JHU/Goddard Space Flight Center (GSFC) Interaction Day. The event, hosted at GSFC this year, afforded students, researchers, and faculty members the opportunity to exchange research, meet fellow scientists, and witness the construction of the James Webb Space Telescope.



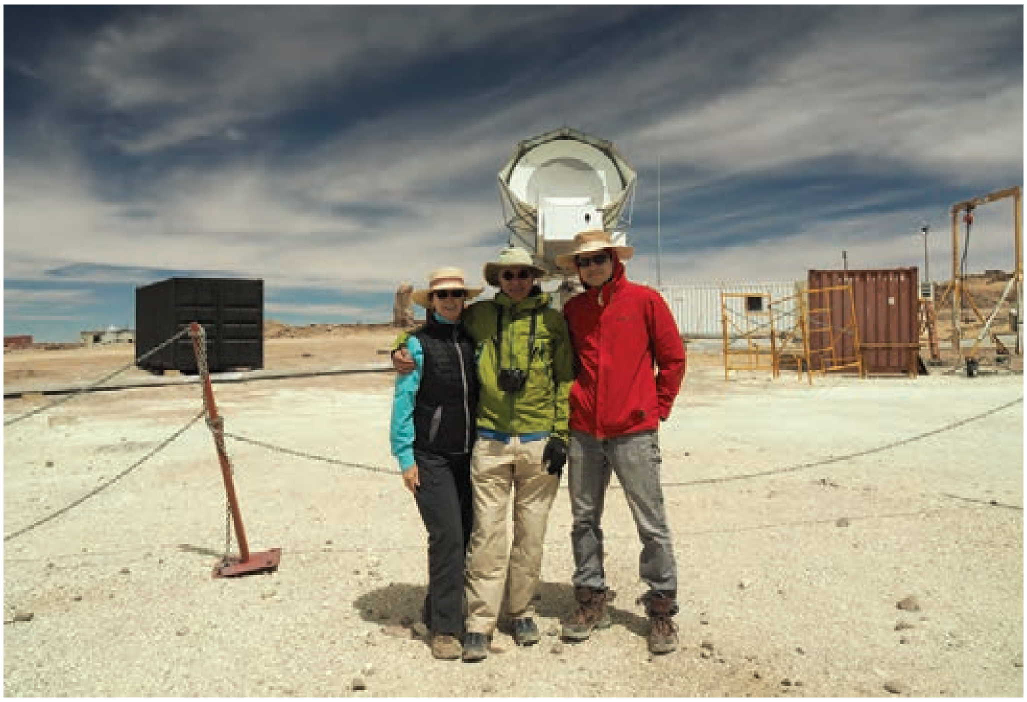


Andy Ptak (B.S., '92), left, Research Astrophysicist at GSFC, and Bloomberg Distinguished Professor Chuck Bennett, right, have organized JHU/GSFC Interaction Day in recent years.

Photos by Jon Schroeder

ALUMNI NEWS

Matt Polk ('71) Visits Hopkins' CLASS Telescope in Chile



Left to right: Amy Gould, Matt Polk, and Assistant Professor Tobias Marriage near the CLASS Telescope high site in Chile's Atacama Desert in late 2015.

When asked to recall the moment he first saw the CLASS Telescope site high in Chile's Atacama Desert, **Matt Polk**, (B.S., '71), pauses, then chuckles.

"It's a bit like being drunk — but not as fun," he says, referencing the oxygen-deprivation level at the site's 17,000-foot summit. "It's not an easy place to work."

Yet that's the place Hopkins scientists behind the Cosmology Large-Angular Scale Surveyor (CLASS) Telescope (see inside front cover) are plying their trade. Polk, co-founder of Polk Audio, Inc. and a member of the advisory council for the Henry A. Rowland Department of Physics and Astronomy, was one of the first donors to CLASS. The initiative seeks to pinpoint how the universe started and, in the process, uncover a link between the seemingly incompatible theories of quantum mechanics and relativity — a nexus considered the holy grail of cosmology.

Polk and his wife, Amy, visited CLASS' home base in late 2015 to see the impact of their generosity. At first, they stood awed at the view — a rocky, desolate moonscape that felt frigid even at the start of the Southern Hemisphere's summer. But more arresting was the sight of Hopkins faculty, graduate students, and postdoctoral fellows building the telescope with their own hands.

"You usually picture top scientists sitting in labs or standing in front of chalkboards, not out in the trenches pulling electrical wire through conduits and twisting wrenches, especially in these harsh conditions," Polk says.

The Polks also were able to see the breakthrough their gift made possible. Assistant Professor **Tobias Marriage**, a co-principal investigator on the project, and Associate Research Scientist Thomas Essinger-Hileman led a team that developed a novel aluminum-silicon alloy for the telescope's feed horns — the devices that direct light to the telescope's detectors. The silicon material previously used for this purpose is well matched to the detector's material properties, but it is fragile. The new alloy also matches well with the detector, but is more durable.

"The alternative way to make these detectors — precise cuts into individual layers of silicon — is expensive and time-consuming," Marriage explains. "With our new material, we can drill funnels straight through and attach the material firmly to the detectors, saving time and money."

"This was a perfect example of American academic entrepreneurship," Polk says. "Toby's team saw an obstacle and came up with a solution that combines good physics and good engineering."

Polk and several other donors — including university trustee Heather Murren, A&S '88, and her husband, Jim, and alumnus and three-term New York City Mayor Michael Bloomberg — played important roles in bringing CLASS this far. Additional gifts are needed to complete the four-telescope array's construction and its survey of the sky, and "extract the full science to answer these big-picture questions about our universe," Marriage says.

After standing on a Chilean mountaintop and seeing the potential of the CLASS Telescope in person, Polk offers his full endorsement.

"The CLASS Telescope presents a unique opportunity to make a major, major impact on some of the fundamental questions of our time, at an institution with precisely the capabilities to find the answers," Polk says. "This project might be the best application of venture capital I can think of."

To learn about how you can make a gift to support the CLASS Telescope project, please contact John Cook, director of principal and major gifts for the Krieger School of Arts and Sciences at **cook@jhu.edu**.

— Kristin Hanson

Meg Urry (Ph.D., '84) is currently the Israel Munson Professor of Physics and Astronomy in the Department of Physics at Yale University and is also Director of the Yale Center for Astronomy and Astrophysics. In 2016, she was elected to the National Academy of Sciences in recognition of her distinguished and continuing achievements in original research. Urry's research focuses on active galaxies, which host accreting supermassive black holes in their centers.

Andy Gavrin (Ph.D., '92) is currently Chair of the Department of Physics at Indiana University–Purdue University Indianapolis. In 2016, he received the "David Halliday and Robert Resnick Award for Excellence in Undergraduate Physics Teaching" from the American Association of Physics Teachers.

Robert Welsh (Ph.D., '92) became Associate Professor at the University of Utah Department of Psychiatry in June 2016. His research focuses on advanced neuroimaging methodology, translational research, and advance analytic methods.

Dana Hurley (B.A., '93) is a Senior Professional Staff Member at Johns Hopkins University Applied Physics Lab as a planetary scientist. In 2016, she received the Michael J. Wargo award from the NASA Solar System Exploration Research Virtual Institute. The annual award honors a scientist or engineer who has significantly contributed to the integration of exploration and planetary science throughout their career.

Taner Edis (Ph.D., '94) is Professor of Physics at Truman State University. His latest book, Islam Evolving: Radicalism, Reformation, and the Uneasy Relationship with the Secular West, was published in June of 2016.

Timothy Meyer (B.S., '96) is currently Chief Operating Officer for Fermi National Accelerator Laboratory. In 2016, he was selected to participate in the inaugural cohort of the Department of Energy's "Energy Sciences Leadership Group" (ESLG). The ESLG picks the most promising future leaders of the DOE and provides a one-year leadership training and development program designed to build stronger networks, skills, and experiences.

Kia Liu (Ph.D., '98) is Professor of Physics at the University of California, Davis. In 2016, he was named Fellow at the Institute of Electrical and Electronics Engineers. He is being recognized for contributions to the understanding of magneto-transport effects and magnetization reversal in nanostructures. His research interest is in experimental studies of magnetism and spin transport in nanostructured materials.

Leslie Hebb (Ph.D., '05) is currently an Assistant Professor in the Department of Physics at Hobart and William Colleges. In 2016, she was selected as one 13 new "Scialog Fellows." These awards were made by the Research Corporation for Science Advancement, and are to support innovative work in the area "Time Domain Astrophysics: Stars and Explosions."

James McIver (B.S., '07) is currently a Postdoctoral Fellow at the Max Planck Institute for the Structure and Dynamics of Matter in Hamburg, Germany. In 2016, he received a fellowship from the Alexander von Humboldt Foundation to fund his research for 2 years. McIver graduated with a Ph.D. in physics from Harvard University in 2014.

Yaohua Liu (Ph.D., '09) is currently an Instrument Scientist at Oak Ridge National Laboratory. In 2016, he received first prize in the inaugural Excellence in Research Awards by the American Institute of Physics journal "APL Materials." Liu's research focuses on neutron and x-ray scattering, magnetoelectric coupling, interfacial magnetism, permanent magnetic materials and complex oxides.

Jeff Dandoy (B.S., '11) earned his Ph.D. in high-energy physics from the University of Chicago in 2016. He also began a postdoctoral fellowship with the University of Pennsylvania, working on the ATLAS experiment, in September.

Jian Su (Ph.D., '12) is currently a Computer Vision Engineer. In 2016, he began an additional position as Adjunct Faculty Member at Goucher College, Department of Physics, teaching Astronomy.

Se Kwon Kim (Ph.D., '14) is currently a Postdoctoral Associate at UCLA. In 2016, he received the "Outstanding Young Researcher Award" from the American Korean Physicist Association. Kim is a condensed matter theorist who has largely been concerned with understanding the transport of spin and spin related degrees of freedom in mesoscopic systems.

Liang Wu (Ph.D., '15) is currently a Postdoctoral Researcher in the Department of Physics at the University of California, Berkeley. In 2016, he was among 500 individuals globally who were awarded the Chinese Government Award for Outstanding Self-Financed Students Aboard.

Please keep in touch! We would love to hear from you. Please contact Pam Carmen in the Chair's Office at pcarmen@jhu.edu

IN MEMORIAM

Remembering James Calvin "Cal" Walker

On January 15, 2016, The Johns Hopkins University lost Professor **James Calvin "Cal" Walker**, an emeritus faculty member in the Department of Physics and Astronomy, to cancer.

Cal Walker was born Jan 16, 1935, grew up in North Carolina, and graduated from Harvard majoring in physics in 1956. After receiving his Ph.D. in nuclear physics from Princeton, 1961, he came to Hopkins in 1963 and stayed ever since. He served as the Chair of the Department from 1987 to 1993. He also served on the Homewood Academic Council.

Photo courtesy of Ann Finkbeiner

During the 1960s, in the heyday of the study of recoilless nuclear gamma ray resonances, better known as Mössbauer spectroscopy, Prof. Walker made several notable contributions. In particular, he and his JHU colleagues, Professors Yung K. Lee and Leon Madansky, pioneered the Mössbauer effect after Coulomb excitation of the atomic nucleus, using the Van der Graaf accelerator located in then Rowland (now Krieger) Hall. In the 1970s his interest shifted to condensed matter physics, in particular to ultrathin epitaxial films fabricated by the then newly developed molecular beam epitaxy (MBE) technique, which he termed "money-burning evaporator." His best-known work probably was in the area of the magnetic properties of ultrathin iron (Fe) films. By placing isotopic ^{57}Fe, (which exhibits the Mössbauer effect) at different locations in a thin Fe film made of ^{56}Fe (which does not), Prof. Walker and his students were able to map out for the first time the variation in materials' magnetic properties near surfaces with atomic-scale resolution.

Cal was legendary for his love of flying, first of gliders and later of a variety of powered aircraft. Some of his colleagues and visitors, and most of his Ph.D. students, had the most memorable experience of their lives with Cal in the cockpit. His ability to walk away unscathed from disasters was equally legendary, as he survived several serious glider crashes, and a few forced landings with the World War II vintage Taylorcraft that he had rebuilt with canvas and wood.

Professor Walker had major impact on the Department of Physics and Astronomy during his time as Chair, guiding the department's move to its current home in the Bloomberg Center for Physics and Astronomy, and playing a leading role in numerous faculty hires during a time of important growth for the department. His tireless efforts and can-do attitude during this time were crucial in setting the department on the path it has followed in the past 25 years.

We extend our deepest sympathy to Cal's wife Ann Finkbeiner, whose interest in our department, and unique perspective as a leading science writer have greatly enriched our academic and personal lives.

Cal's colleagues and friends will always remember his immense energy and enthusiasm, and his complete unwillingness to accept that anything he set his sights on could not be accomplished. We have lost a colorful and unique colleague.

Observational Astronomy Students Operate 3.5-meter Telescope at Apache Point Observatory

Apache Point Observatory is home of the Sloan Digital Sky Survey, pictured above with local residents.

Photos by Jon Schroeder

Students from Associate Professor **Brice Ménard**'s Observational Astronomy course (above) gained valuable hands-on experience at the Apache Point Observatory in New Mexico over the course of two 12-hour observation nights in November. Operating a 3.5-meter telescope (pictured center), the group detected exoplanet transits, imaged a globular cluster, planetary nebulae, galaxies, and even tracked a comet. They also conducted spectroscopy of galaxies and quasars. All told, over a dozen targets were identified by the students with optical and spectroscopic instruments affixed to the telescope. The three images below of the Horsehead Nebula, barred spiral galaxy NGC 1300, and the Dumbbell Nebula, were captured by the students and enhanced by Postdoctoral Fellow Mubdi Rahman. Every student of the course became certified in remote operation the telescope by way of the immersive experience.

Photo by Brice Ménard

Horsehead Nebula

Barred spiral galaxy NGC 1300

Dumbbell Nebula

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Freshmen Measure Forces at Six Flags America

Freshmen from the department's Classical Mechanics Laboratory course headed to Six Flags America in Bowie, MD to study the laws of physics in full swing. The park opened early exclusively for the students so that they could skip the lines and collect data on several different rides. Using the accelerometers in their smart phones, the students measured g-force, centripetal acceleration, and kinetic energy as they zoomed around the park. Instructional Resource Advisor Reid Mumford (center) is pictured below, along with students Ryan Koronkowski (left) and Jason Fan (right), taking the plunge on "Dare Devil Dive."