JOHNS HOPKINS UNIVERSITY

2017 Year in Review

Physics & Astronomy

2017 marked the first-ever Bloomberg Art from Science Innovation Contest (BASIC) in an effort to soften the vast expanses of concrete in Bloomberg Center for Physics & Astronomy. Department members were invited to submit visually striking art works derived either from course work or research relevant to the main branches of study within the department: Particle Physics, Condensed Matter/Plasma Physics, and Astronomy. Many submissions were selected to adorn the walls of Bloomberg Center and also appear throughout this newsletter.

The image on the front cover was submitted by Associate Research Scientist Joshua Peek and is derived from a survey of neutral hydrogen in the galaxy. The bright slashes are of areas the galactic plane that are abundant in hydrogen. Shimmery color comes from narrow neutral hydrogen lines from cold gas; gray comes from broader, warm neutral hydrogen features.

Inside cover: **Submitted by graduate student Joel Clemmer, this image represents a simulation of a 2D sheared disordered solid. Each ellipsoid is a Lennard-Jones particle. The orientation and length correspond to the direction and magnitude of the non-affine displacement that occurs over a small strain interval. The color reinforces the orientation by mapping it to a color wheel.**

Small inset, right: **Postdoctoral Fellow MinSu Kim, a member of Assistant Professor Francesca Serra's research group, submitted three photographs. The photos are optical microscopy of liquid crystalline blue phases that could be located on one of the most "crystalline" lattice structures in the range of ordering from "liquid" to "crystal", so-called "structured fluids."**

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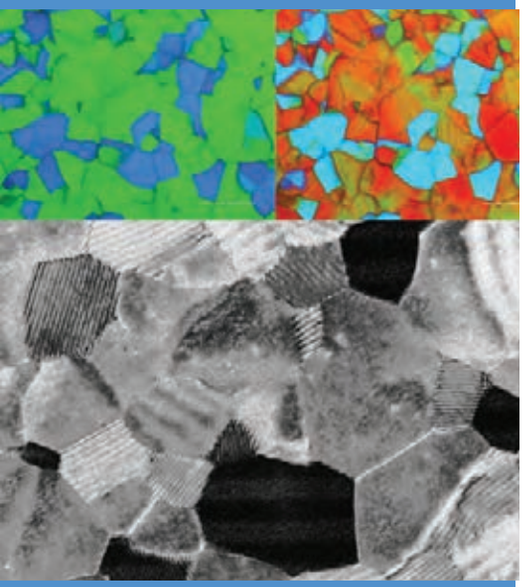

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Physics and Astronomy **is an annual publication of the Johns Hopkins University Zanvyl Krieger School of Arts and Sciences Department of Physics and Astronomy. Send correspondence to: jon.schroeder@jhu.edu.**

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JOHNS HOPKINS
KRIEGER SCHOOL
of ARTS & SCIENCES

Letter from the Chair

Dear alumni, colleagues, and friends,

I am pleased to bring you this newsletter that reports on many of the exciting developments that have happened in our department over the past year. In this letter, I want to give some of the especially gratifying highlights.

First, I am very happy indeed that three new young faculty members joined our department during this time, and another is on the way. Prof. Francesca Serra, who is an experimental condensed matter physicist, Prof. Kevin Schlaufman, who is an observational astronomer, and Prof. Ibou Bah, who is a theoretical particle physicist, all arrived in January. They joined Prof. Yi Li, a theoretical condensed matter physicist, who arrived in July 2016. Brian Camley, who studies the physics of living systems using numerical simulations, will arrive soon with a joint appointment with the Department of Biophysics. We are in the process of appointing a new Bloomberg Distinguished Professor in the field of extra-solar planets, jointly with the Department of Earth and Planetary Sciences. With additional searches underway this year, we are in the midst of an unprecedented infusion of young talent and energy. The future looks great!

I am also pleased to say that Toby Marriage and Nadia Zakamska received tenure and promotion to the rank of Associate Professor, and that Peter Armitage was promoted to the rank of Full Professor. The cases were so strong, that I was invited to meet with our Provost, Sunil Kumar, to discuss the how we have been able to assemble such an extraordinarily strong group of young and mid-career faculty and brain-storm about how we can make sure they continue to thrive and grow.

Our faculty, scientists, and students continue to rack up a treasure trove of awards, honors, and grants. You will learn more about these throughout this newsletter. Here are a few highlights:

- Prof. Rosemary Wyse was elected AAAS Fellow by her peers at the American Association for the Advancement of Science, and APS Fellow by her peers at the American Physical Society. They recognized her pioneering contributions to the field of galactic archaeology and near-field cosmology.
- Bloomberg Distinguished Professor Chuck Bennett was the recipient of both the 2017 Isaac Newton Medal and Prize, awarded by the Institute of Physics in London, and of the Breakthrough Prize in Fundamental Physics. The details are in the short article later in the newsletter.
- Our graduate student, Julián Munoz, was awarded a Dan David Prize Scholarship for his research conducted under the guidance of Prof. Marc Kamionkowski.

Next, I'd like to update you on a some of the news regarding projects and activities in the department of special interest to you.

- In the past year, the department has expanded its offerings in active learning for general physics held in the Witten Active Learning Physics Classroom, going from one section of 85 students to two sections. Both sections are fully enrolled and we had to turn away waitlisted students this fall. The students really seem to prefer this new way of learning physics, and we working to expand our offerings.
- The first telescope of the Cosmology Large Angular Scale Surveyor (CLASS) completed its first year of surveying the sky. CLASS measures the polarization of the Cosmic Microwave Background (CMB) to improve our understanding of cosmology. The new observations cover 70% of the sky every day— a first for ground-based CMB telescopes. The second of four telescopes was shipped from JHU to Chile. Two CLASS grad students completed Ph.D.s and five undergraduates joined for summer internships.
- Our PARADIM program set a new world record of 300 standard atmospheres of Argon or Oxygen gas pressure for crystal growth, (see https://tinyurl.com/jhu-paradim for the press release from the manufacturer we worked with to make it happen).
- In a challenging funding environment, the Institute for Quantum Matter (IQM) was renewed by the Department of Energy for a fourth three-year period. The group of PIs was expanded from 6 to 10 to encompass a full range of expertise from world class materials synthesis and crystal growth to advanced spectroscopy and theory of quantum materials.
- Our departmental ties to the Institute for Data Intensive Engineering and Science (IDIES) continue to grow. Two of new young faculty members, Brian Camley and Kevin Schlaufman, were appointed through joint faculty searches with IDIES. Kevin strengthens the existing link between astrophysics and big data, while Brian opens up new opportunities in data intensive computational biological physics.

In closing, let me thank you all for your continuing interest in, and support of, our mission of pushing back the frontiers in research and of educating and training leaders of tomorrow in science and technology. I am looking forward to working with you in the coming year. Your enthusiasm is contagious!

Best,

Timothy Heckman, Chair

The Henry A. Rowland Department of Physics and Astronomy

Jared Kaplan and the Martial Art of Research

BY JON SCHROEDER

Each week, Assistant Professor Jared Kaplan steps away from his field of expertise, theoretical physics, and focuses on another subject: Brazilian Jiu-Jitsu. As part of the JHU Brazilian Jiu-Jitsu club team, Kaplan has earned a blue belt in the sport. It's Kaplan's scientific discipline, however, that has earned him honors and accolades from the National Science Foundation, the brightest minds in theoretical particle physics, and his students. After publishing dozens of peer-reviewed articles over the last twelve years, Kaplan is poised to execute one of the biggest takedowns the physics world has witnessed in over century.

"There's this transition 100 years ago from understanding the universe in terms of classical physics, with objects moving around, baseballs and spaceships, and things like that," says Kaplan, cheerfully gestures with his hands, "and then comes the discovery of quantum mechanics, which basically said that the way that the world appears to us is being replaced with this much more abstract, weirder, quantum realm. For physicists today, there's some envy of getting to discover something that cool."

Kaplan practices thought exercises in the arena of quantum gravity, and it's clear that his target is to make an indelible mark on physics, as we know it. "The main reason why I've been thinking about quantum gravity," says Kaplan in his office, after swapping his gi, another word for a Jiu-Jitsu uniform, for jeans and a t-shirt, "is because some of the ideas that seem to be required to understand it are very counterintuitive, and perhaps revolutionary, and that's what I like about it. Can I make a prediction about some thought experiment that no one could make before? Can I point to a new way of thinking about something? I'm most excited about things like that."

Currently, Kaplan is betting that his best chance of making a discovery on par with the paradigm shift toward quantum mechanics lies within a subset of theories associated with quantum gravity called holography, which focuses on the idea that the world we

experience may be the byproduct of a grand system of physics that scientists have not yet discovered. As Kaplan puts it, "Although the universe might appear to have three spatial dimensions, there might be some fundamental description of [our universe] where there are actually fewer dimensions than that, and the fact that we experience space-time is somehow an 'emergent' feature of physics."

Marc Kamionkowski, William R. Kenan, Jr. Professor, and an award-winning and renowned theoretical physicist in his own right, is optimistic about Kaplan's ability to grapple with the core tenets of physics. "Jared is a major asset for our department," says Kamionkowski, "He's a deep thinker making significant advances in some of the deepest questions in physics today." Those advances in physics emerge from the scores of new equations that Kaplan has authored in his relatively short academic career. Demonstrating the discipline of a martial artist, Kaplan has a self-imposed rule for his publications: they must include a new equation.

"I want to be confused on some basic level; are we asking the right question? Are we asking in the right way?" ponders Kaplan. "And can I answer that question in a precise enough way that I can convince other scientists that I made progress?" It's clear that Kaplan has a strong understanding of the questions he needs to ask himself in order to produce publishable papers at a lightning clip, not unlike a focused training regimen ultimately leading to a bout at a Brazilian Jiu-Jitsu meet.

Third generation Brazilian Jiu-Jitsu instructor Rener Gracie once described the defensive nature of Brazilian Jiu-Jitsu like this: "You want to be all the way out, too far away to get struck, or you want to be so close that any strikes that are directed at you are not effective." Kaplan echoes that philosophy, but from the offensive stance; he aims to make sure his published articles land in the strike zone. "I think there are two extremes: I think there's an extreme where people do extremely intense calculations with existing theories… and I think there's another extreme where people write papers that don't have any precise prediction," Kaplan says of his voluntary scientific rigor test. "I try to guide myself toward somewhere in the middle. Genuinely new ideas should lead to new equations."

Kaplan's career in the competitive circuit started early on, but his first bouts were battles of the mind. "I went to a really nerdy high school, Illinois Mathematics and Science Academy, and they were really involved with math and physics competitions. I went to a summer camp with about 20 people, and we were the U.S. high school physics team. There were these written tests that I did for fun," Kaplan reminisces. "I did well enough to get invited. There are a bunch of kids from my high school who ended up having successful science careers."

"[Holography suggests] the world we experience may be the byproduct of a grand system of physics that scientists have not yet discovered."

—Assistant Professor Jared Kaplan

From there, Kaplan went on to earn his undergraduate degree in mathematics and physics from Stanford University and his Ph.D. in physics from Harvard University. It was around this time that the young researcher discovered his appreciation for the martial arts, taking up Muay Thai, a discipline often described as "the art of eight limbs" because of its concentrated focus on pairs of fists, elbows, knees, and shins.

After three years as a research associate at the Department of Energy's SLAC National Accelerator Laboratory in Menlo Park, California, and two years back at Stanford as a postdoctoral fellow, Kaplan joined the faculty at JHU in 2012. His discovery of the JHU Brazilian Jiu-Jitsu club provided a calming venue for Kaplan to escape the stresses that come along with publishing papers and applying for research grants. "It distracts me from [my research] completely for a couple of hours so I can relax," says Kaplan.

The relaxation technique has paid off. To date, Kaplan has received a total of nearly one million dollars in support from the National Science Foundation, thanks to his CAREER award titled "Conformal Field Theory and Quantum Gravity from the Bottom-Up," his Simons "Bootstrap" Collaboration Award from the Simons Foundation, and his Alfred P. Sloan Foundation Award. He is also a referee for two peer-reviewed journals: Journal of High Energy Physics and Physical Review.

Kaplan teaches Quantum Field Theory and Advanced Particle Physics, and while he may teach in the same casual clothes that many of students wear, his laid-back style belies his focus on the material that his students appreciate. "He always manages to intuit or extract the answer or physical principle from very complicated problems," says graduate student Nikhil Anand. "So a lot of how I tackle research now is guided by that approach, to seek the bigger physical picture amidst the chaos and push ideas as far as they will go."

The collaboration award from the Simons Foundation, of which Kaplan was integrally involved, takes a bottom-up, or "bootstrap," perspective on quantum gravity. The collaborating group includes over fifteen quantum gravity experts from around the world all trying to secure a better grip on the budding field. Kaplan's leadership in the collaboration and his excitement surrounding quantum gravity has inspired a new generation of researchers. As Anand puts it, "The Bootstrap collaboration, as a whole, is great. It's mostly a bunch of young, open-minded theorists who just want to better understand quantum gravity." Kaplan's disciplined research regimen has helped to create a new, "emergent," team of physicists examining a new corner of the field. With Kaplan's tutelage, they'll be ready for the fight.

Assistant Professor Jared Kaplan (top row, center) with members of the JHU Brazilian Jiu-Jitsu club team

Tobias Marriage is in a CLASS of His Own

BY EMILY MULLIN

Tobias Marriage wants to answer the most basic question about the universe, one that people have wondered about for thousands of years—how it all began.

To do that, Marriage is using a high-powered telescope designed and built at the Johns Hopkins Homewood campus in Baltimore that now stands more than 4,000 miles away in Chile. Called the Cosmology Large Angular Scale Surveyor, or CLASS, the instrument is one of the most effective ever constructed to help characterize the origin of the universe.

Marriage, an associate professor of physics and astronomy, is the co-principal investigator of the CLASS project. Colleagues and students alike say his expertise in experimental physics as well as in data analysis make him an effective leader and role model, both with CLASS and in his teaching duties in the Physics and Astronomy Department.

Marriage's main area of research is on the cosmic microwave background, the faint glow of ancient electromagnetic radiation leftover from a very early stage of the universe that permeates the night sky. This electromagnetic radiation, originally high energy but now microwaves due to the expansion of the universe, was emitted when the universe was only four hundred thousand years old, long before stars or galaxies formed.

"The cosmic microwave background essentially gives us a picture of how the universe looked early on," Marriage says. "The entire [visible] observable universe began in a very compressed state, a subatomic volume smaller than an atom."

From this very small state, the universe experienced quantum fluctuations then underwent an extraordinarily rapidly expansion in a fraction of a second. This event fed into the Big Bang expansion. The cosmic microwave background is the 13.8 billion-year-old vestige of that infant universe. Marriage and his team is using CLASS to seek the subtle patterns in this relic energy, which holds clues about how the universe began.

"We're trying to understand this initial event that happened in an inconceivably short amount of time at the beginning of the universe that we call 'inflation,'" Marriage says. Using CLASS, Marriage and his team will test inflation theory and additionally determine when the first stars appeared.

The speed of light provides an innate tool for studying this ancient energy. Since it takes time for light to travel to distant objects, astronomers observing deep space are looking into the past. "We're literally looking back in time in this way. We're seeing the universe as it was billions of years ago," Marriage says.

> *"We're literally looking back in time this way. We're seeing the universe as it was billions of years ago."*
>
> —Associate Professor Tobias Marriage

What's unique about CLASS is its ability to quickly survey most of the sky in the region of the electromagnetic spectrum where microwave emission from our own Milky Way galaxy is at a minimum. That's different from other telescopes that cover a much smaller sky area and/or operate where the Milky Way emission is much stronger. Using the telescope, Marriage and his team will be able to reconstruct the cosmic microwave background polarization (a directional pattern) of over 70 percent of the sky.

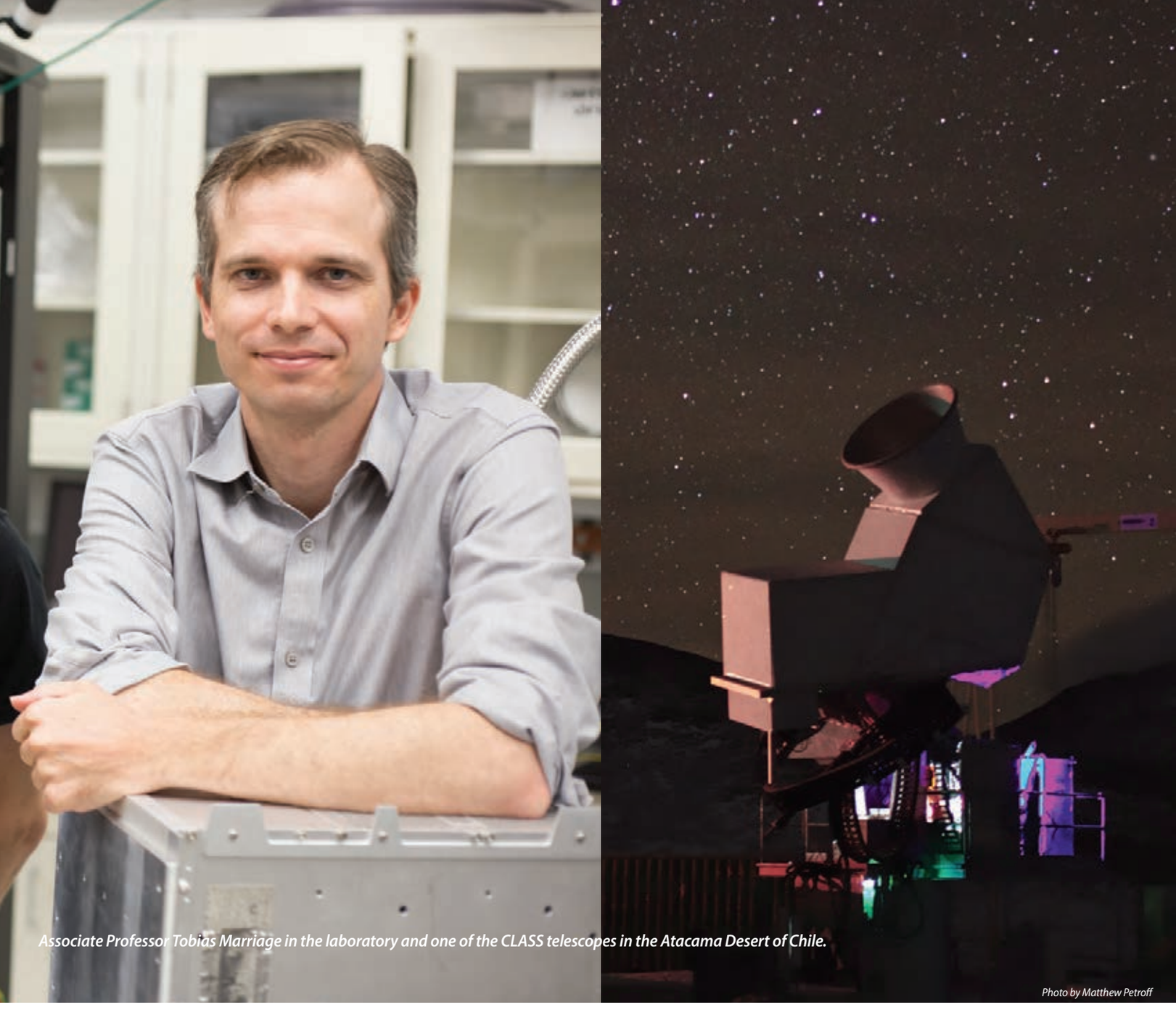
The CLASS observatory stands at 17,000-foot elevation in the Atacama Desert of northern Chile, a spot that was chosen, Marriage says, because it was "high and dry." At that elevation, "we're above most of the atmosphere," he says. That's good, because microwaves are best detected in the absence of water vapor.

Marriage says CLASS has so far been in operation for a year, having officially started its survey in September 2016. Eventually, there will be four total telescopes that make up CLASS. A second one is being installed now. The whole survey will take five years. About 20 research staff members, graduate students and undergraduate students are involved in the project. In addition to the team at Hopkins, Marriage and his colleagues collaborate with the NASA Goddard Space Flight Center, National Institute of Standards and Technology laboratory in Boulder, Colorado, and other universities in the U.S., Canada, and Chile.

With CLASS, Marriage says he is not only motivated by the basic science but the opportunity to educate graduate and undergraduate students who are also involved in the survey. "One of the great things about this project is not just the science but that we're training next-generation scientists," Marriage says.

Charles L. Bennett, Bloomberg distinguished professor, alumni centennial professor, and a Johns Hopkins University Gilman Scholar in the Department of Physics and Astronomy, praises Marriage's leadership of the CLASS project. "In his time as a faculty member at Johns Hopkins, Toby has used his experimental skills in advancing CLASS and his data analysis skills with both CLASS and his cluster research," says Bennett, who co-leads the CLASS survey with Marriage.

Before CLASS, Marriage played a major



Associate Professor Tobias Marriage in the laboratory and one of the CLASS telescopes in the Atacama Desert of Chile.

Photo by Matthew Petroff

part in building the Atacama Cosmology Telescope, or ACT, a collaboration between Princeton University and several other academic institutions. Marriage's involvement with the ACT began when he was completing his PhD in physics at Princeton University. Also located in Chile, ACT takes high-resolution, microwave-wavelength surveys of the sky in order to study radiation emanating from the cosmic microwave background.

After coming to Hopkins, Marriage and his group continue to work with ACT data. Bennett says this enables Marriage to "study the nature of clusters of galaxies and even the universe as a whole."

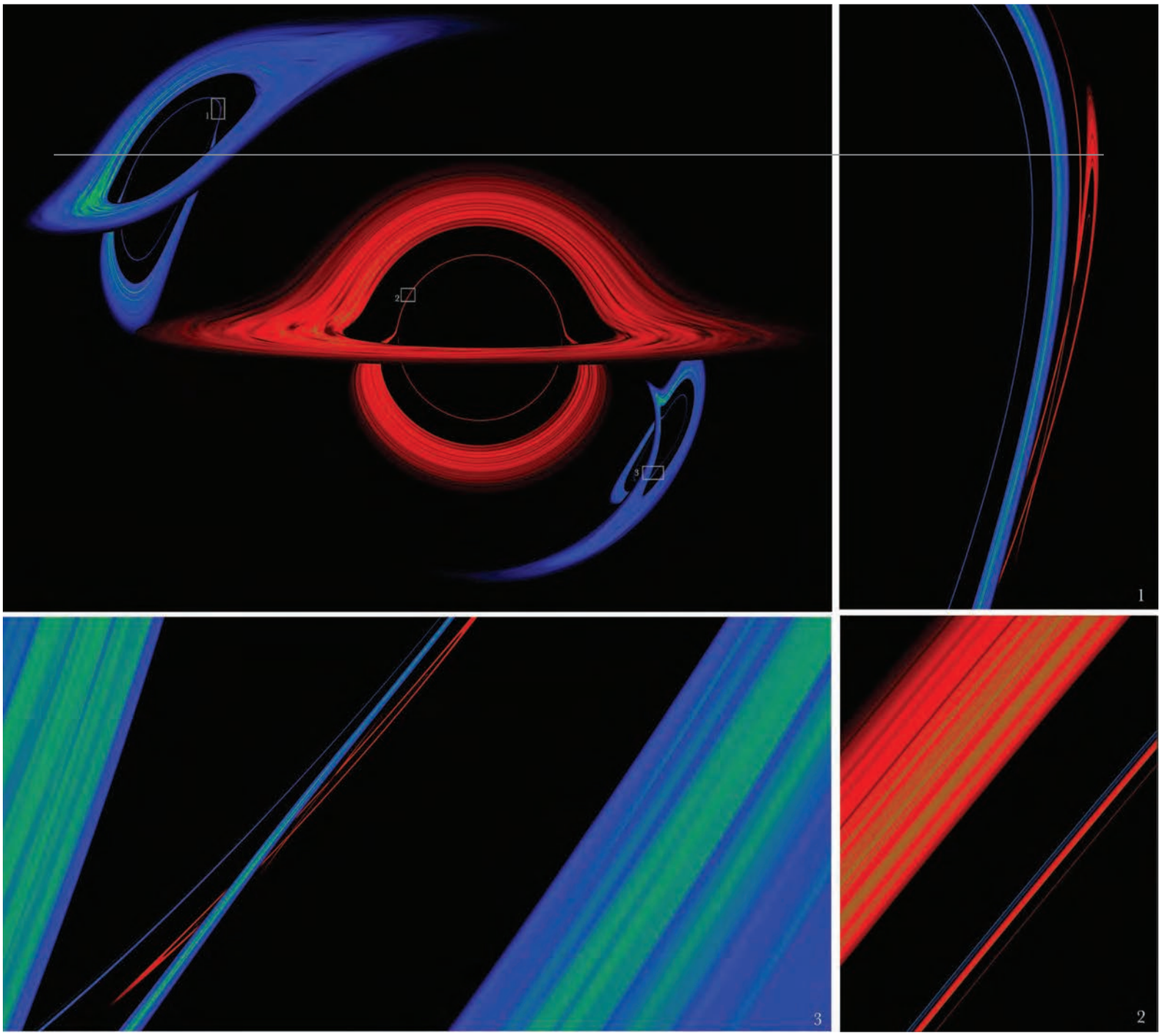
Beyond CLASS, Bennett emphasizes Marriage's dedication to his work and students. "Toby is particularly capable at mentoring students and postdocs. He has mentored an unusually large number of young people and he is always sought out as a mentor," Bennett says.

In addition to teaching several classes, Bennett says Marriage has been particularly effective at revamping the Physics and Astronomy department's advanced laboratory class for upper-level undergraduates. He has also been instrumental in the efforts to recruit top graduate students to the program, Bennett notes.

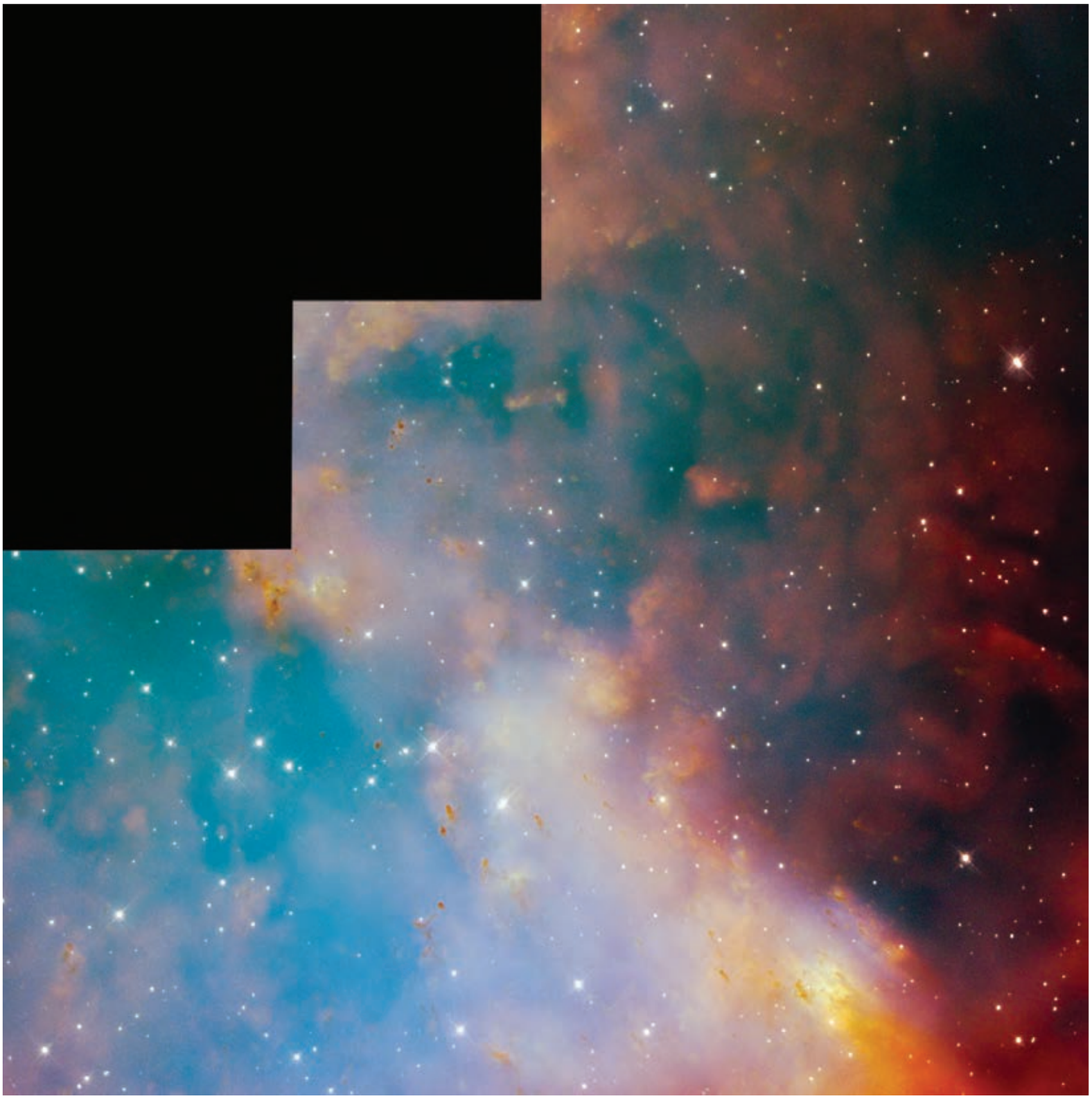
Kirsten Hall, a space fellow and PhD student in the Department of Physics and Astronomy, is one student who has benefited from Marriage's teaching and guidance. Hall does astrophysics research that uses datasets in which Marriage specializes. She and her thesis advisor, Nadia Zakamska, have been collaborating closely with Marriage and a former graduate student since she arrived at Hopkins. Through that experience, Hall says she has had the perspective of working with Marriage in a smaller group setting.

"He is an excellent advisor who values regular communication about his students' work," she says, "Though I do not work on CLASS, Prof. Marriage continues to hold weekly meetings with me to discuss my work and has made it a priority to help me grow as a scientist and successfully complete my PhD. Despite his busy schedule, he is readily available to offer his advice both in regards to research and my career."

Bennett agrees that Marriage is peerless. "Everyone who gets to know him, colleagues and students alike, soon appreciates that he is highly effective and capable and has solid judgment without any accompanying bluster. He is well known and respected internationally, and this adds to the reputation of our department," he says.



This set of four images was submitted to the Bloomberg Art from Science Innovation Contest (see inside front cover) by visiting Research Scientist Jeremy Schnittman. The main image is that of a binary black hole, with an accretion disk around each black hole, viewed at a nearly-edge on inclination of 85 degrees. The extreme gravity of each black hole strongly distorts the image of its accretion disk. Additionally, the near black hole (red disk) lenses the far black hole, doubly-distorting its image and splitting it into two separate images. The three other frames are zoomed-in insets of the main image, showing the intricate and rich patterns of multiple images and caustic structure from the gravitational lensing.



Undergraduate student Sophia Porter explains how she generated the image above of M27 for the Bloomberg Art from Science Innovation Contest (see inside front cover): "I spent last summer at Space Telescope Science Institute in an internship with Zolt Levay, the Hubble Imaging Lead. After choosing M27 as my "final project", I combed the Hubble Legacy Archive and selected four crisp FITS files from the WFPC2 instrument: 502nm, 656nm, and 658nm, and a broadband image. Applying my artistic intuition, I stretched each file in FITSLiberator to best showcase the detail in the nebula, then converted each to a JPEG image. In Photoshop, I assigned blue color to the 502nm data, green to the 656nm data, red to the 658nm data, and luminance to the broadband, and stacked them, creating a full-color image from black and white data."

NEWS BRIEFS

Three Professors Promoted and New Professor Joins Faculty with Joint Appointment

Peter Armitage promoted to Professor

Peter Armitage was promoted to full Professor in March 2017. His research elucidates how strong, but fundamentally simple particles act collectively in large quantities to exhibit quantum phenomena. A recent technological breakthrough pioneered by Armitage using low-frequency microwave and THz range radiation allows him to investigate the electronic states of material systems at low temperatures. Since joining the department in 2006, he has made significant contributions to the field of condensed matter physics, with numerous published journal articles; he has also been the recipient of numerous awards and grants.

Nadia Zakamska receives tenure and promotion to Associate Professor

Nadia Zakamska received tenure and a promotion to Associate Professor in July 2017. A recipient of an Alfred P. Sloan Fellowship and of the Newton Lacy Pierce Prize of the American Astronomical Society, Zakamska has worked on a wide range of topics in astrophysics, both theoretical and observational. Her research at JHU resulted in the discovery and characterization of galactic winds powered by supermassive black holes and provided key missing pieces in understanding galaxy formation.

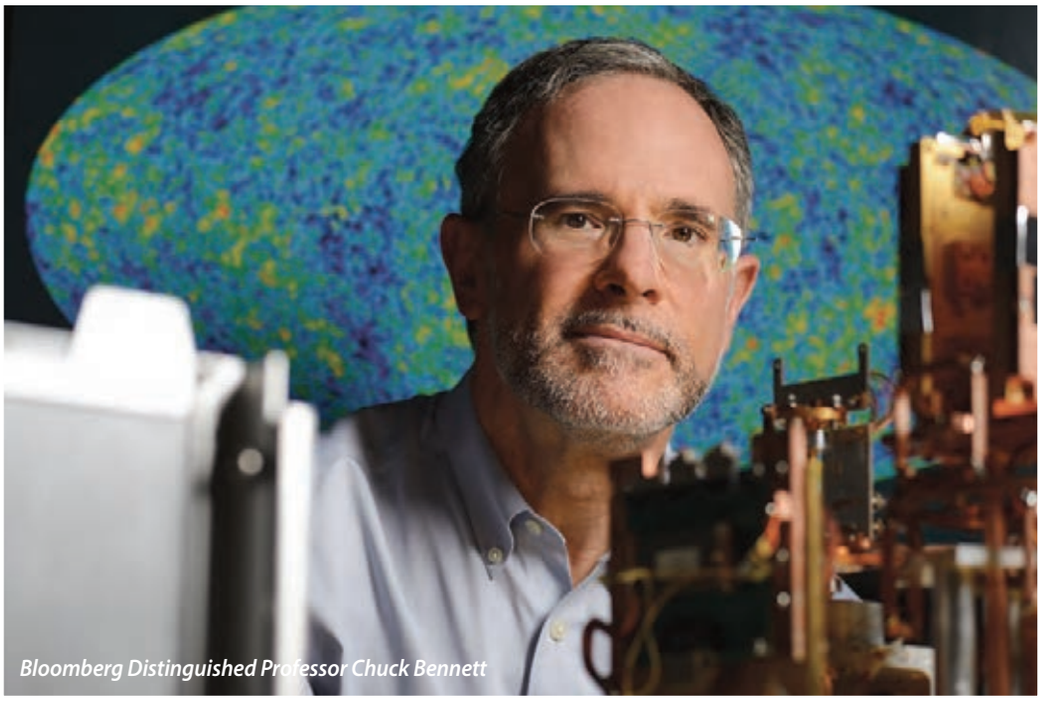
Tobias Marriage receives tenure and promotion to Associate Professor

Tobias Marriage received tenure and a promotion to Associate Professor in 2017. With interests in cosmology and astrophysics, Marriage has focused his attention on research of the cosmic microwave background (CMB). He played a large role in the construction of the Atacama Cosmology Telescope (ACT), which studies fine-angular scale structure in the CMB. Marriage is also a Co-PI of the Cosmology Large Angular Scale Surveyor (CLASS) project, which studies the CMB on a large-angular scale (more on page 4). CLASS provides an array of unique measurements to transform our understanding of the origins of the universe, and probe other cosmic epochs.

Biophysicist Brian Camley Joins Department

Brian Camley, who studies the physics of living systems using numerical simulations, joined the department in January 2018 with a joint appointment in the Department of Biophysics. As a biophysicist, Camley is interested in problems in cell motility, hydrodynamics, and soft condensed matter physics. He uses theory and simulation to better understand the physics of living organisms. He received a Ph.D. and M.A. in Physics from the University of California, Santa Barbara, and a B.A. from University of Colorado, Bounder. He was a Postdoctoral Fellow at University of California, San Diego from 2012 through 2017.

Chuck Bennett Shares $3 Million Award for Breakthrough Prize in Fundamental Physics; Receives Isaac Newton Medal & Prize From the Institute of Physics



Bloomberg Distinguished Professor Chuck Bennett

Bloomberg Distinguished Professor **Charles L. Bennett** has been named a recipient of the Breakthrough Prize in Fundamental Physics for his work that established the Standard Model of Cosmology—a precise, physics-based description of the contents, dynamics, and shape of the universe.

Bennett was the leader of the Wilkinson Microwave Anisotropy Probe, or WMAP, space mission. The entire mission science team shared the $3 million prize, the most lucrative prize in science.

Bennett received the award at a star-studded black-tie ceremony in Palo Alto, California, hosted by actor Morgan Freeman. Actresses Kerry Washington and Mila Kunis, actor Ashton Kutcher, and hip-hop artist Wiz Khalifa also took part in the ceremony. Awards in physics, life sciences, and mathematics were presented at the NASA Ames Research Center in the Silicon Valley.

The Hollywood touch is part of an effort to draw public interest to science by the Breakthrough Prize, which was established by, among others, the founders of Google and Facebook. Bennett said he's all for that, especially if it encourages young people to pursue science, even though the ceremony was outside of his usual experience.

Using WMAP, a NASA project that launched in 2001 and ended in 2013, Bennett and his team provided the first-ever detailed, full-sky "baby picture" of the universe when it was only 380,000 years old. The patterns in this picture provided precise answers to many long-standing questions about our universe. Bennett's team used the sky map to determine that the age of the universe is 13.8 billion years and that the universe is made up of only 5 percent atoms, with an additional 25 percent of dark matter, which exhibits gravity but gives off no light. Seventy percent of the universe was measured by WMAP to be dark energy, which acts as antigravity and seems to be consistent with the "cosmological constant" introduced by Albert Einstein.

Chuck Bennett and Professor Renée Marlin-Bennett along with President Ron Daniels at the Breakthrough Prize award ceremony

Photo by Jason Kravitz

"The WMAP mission took us far beyond our physical reach. By carefully measuring the oldest light in the universe, we determined the key properties of our universe," Bennett said. "We are humbled but pleased that our research has been recognized by the Breakthrough Prize Foundation."

WMAP is widely recognized as being transformational by turning a collection of loose facts into a highly constrained model of the universe: the Standard Model of Cosmology. Bennett received the NASA Outstanding Leadership Medal for his role as the Principal Investigator of WMAP.

"We are immensely proud of Chuck Bennett," said Johns Hopkins University President Ronald J. Daniels, who was in California to celebrate Bennett's win. "Chuck and his WMAP team's discoveries are both galactic and humbling in their significance for science and humanity. They inspire awe and ignite the imaginations of so many—particularly young scientists—with a passion to understand how our universe began and where it is headed."

Bennett is the third member of the Johns Hopkins faculty to receive the Breakthrough Prize since it was first awarded in 2012. Johns Hopkins Medicine researcher Bert Vogelstein received the Breakthrough Prize in Life Sciences in 2013 for his work on cancer genomics and tumor suppressor genes. In 2014, astrophysicist and Nobel laureate **Adam Riess** shared the Fundamental Physics Award for his discovery of the acceleration of the universe.

Janet Weiland, a Johns Hopkins University research scientist, also shared in the prize, as did two former JHU Postdoctoral Fellows who worked with Bennett, David Larson and Ben Gold.

Bennett was also the recipient of the 2017 Isaac Newton Medal and Prize for his research having a "transformative effect in cosmology." The Institute of Physics in London cited Bennett's work leading WMAP at NASA as a key factor for his recognition, as it provided integral data to support the Standard Model of Cosmology. The Isaac Newton Medal was presented to Bennett in a ceremony in London in November.

— Arthur Hirsch

NEWS BRIEFS

Stephan McCandliss and Team Awarded Astrophysics Research Analysis Grant from NASA for FORTIS

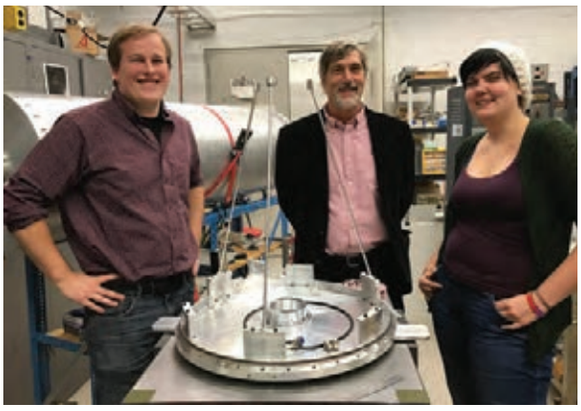
NASA has awarded Physics and Astronomy Research Professor **Stephan McCandliss,** and his co-investigators at Goddard Space Flight Center led by S. Harvey Moseley, a 5-year, $4.4M Astrophysics Research Analysis (APRA) grant to develop the next generation of a sounding rocket borne experiment called the Far-UV Off Rowland-circle Telescope for Imaging and Spectroscopy (FORTIS). The second generation of FORTIS will demonstrate the scientific utility of multi-object spectroscopy over wide angular fields in the far-UV, while providing inflight testing for the next generation of microshutter arrays and large area microchannel plate detectors.

Investigation targets will include the blue straggler population in the globular cluster M10; low metallicity star formation in the Magellanic Bridge; shock structures Cygnus Loop supernova remnant; a search for unidentified emissions in star forming galaxies; and potentially an, as yet, unnamed comet as a target of opportunity. FORTIS is a pathfinder for developing the technologies necessary to enable far UV spectroscopic surveys. Such surveys will allow us to probe problems relevant to the formation of large scale structures, the origin and evolution of galaxies, and the formation and evolution of stars from interstellar gas. In combination with existing and future spectroscopic surveys, they will provide a complete and compelling panchromatic picture of the observable universe.

Next generation FORTIS will fly as a sounding rocket borne instrument and incorporate a number of unique technologies, including the Next Generation MicroShutter Array (NGMSA), which provides for the simultaneous acquisition of spectra from multiple objects within a wide angular field. The NGMSA will be controlled by an autonomous targeting system capable of identifying multiple objects on the fly for further spectral analysis in the short time afforded to far UV observations from a sounding rocket ~ 400 seconds.

The team will also incorporate long life microchannel plate (MCP) detectors that have high open area ratios, providing for increased quantum efficiency, and improved resistance to gain sag, allowing operation at higher count rate. Recent flight experience with the first generation FORTIS has provided guidance to improving the science return of the next generation FORTIS. The team plans for a rigorous validation and verification of the science and technology is detailed.

This program will serve as the basis of doctoral theses for several graduate students in addition to providing hands on experience with space science missions to a number of undergraduates. It will enable new science thrusts, made possible by new technologies while cultivating new skill sets in the next generation of space scientists.



Research Professor Steve McCandliss (center) with FORTIS team members graduate student Keith Redwine and undergraduate student Anna Carter

Marc Kamionkowski and Mark Robbins Named Fellows of American Association for the Advancement of Science

Marc Kamionkowski and **Mark Robbins** are among 396 Fellows of the American Association for the Advancement of Science named this year, an honor presented to AAAS members by their peers.

Kamionkowski was selected for his contributions to theoretical astrophysics and cosmology, specifically his work on the theory of the cosmic microwave background, or CMB. The CMB is the faint electromagnetic radiation remaining in the cosmos as a relic of the first, super-heated microseconds of the life of the universe.

Robbins, who specializes in the physics of condensed matter—solids and liquids are the most familiar examples—was recognized for "using simulations to reveal the microscopic origins of macroscopic behavior" of matter.

"It's of course a great honor," Kamionkowski said. "The members of the JHU faculty and of the Space Telescope Science Institute who have already been inducted as AAAS Fellows are each very accomplished scientists—people who have done great things for science. It's nice to be counted among them."

The new fellows will be formally recognized during the 2018 AAAS Annual Meeting in Austin, Texas, in February.

Joint JHU / UMD team to Kickoff James Webb Space Telescope Observations

James Webb Space Telescope, the next-generation observatory scheduled to launch in 2019, announced selection of 13 teams to lead Early Release Science programs Among them is a team led by a recent JHU postdoctoral researcher **Dominika Wylezalek** (Akbari-Mack Fellow, JHU Provost Fellow), Associate Professor **Nadia Zakamska** (JHU) and Prof. Sylvain Veilleux (UMD College Park) to study galactic winds launched by supermassive black holes. The Early Release Science programs will be executed in the first few months of the operations of the telescope to test the capabilities of the instruments and provide the community with cutting-edge datasets to analyze and use in planning further observations. The Early Release Science teams will lead development of analysis tools to optimize the use of the data from the telescope and provide these tools to the astronomical community.

James Webb Space Telescope set to launch in 2019.

Space@Hopkins Hosts Astronaut Dr. Kate Rubins in Schafler Auditorium

Astronaut Kate Rubins, the first person to ever sequence DNA in space, touched down at Bloomberg Center to discuss experiments she conducted aboard the International Space Station and to share her experiences as an astronaut in an event sponsored by **Space@Hopkins** (spacestudies.jhu.edu).

Rubins performed her DNA sequencing in August of 2016 with samples prepared in a Johns Hopkins lab at the School of Medicine by Bloomberg Distinguished Professor Andrew Feinberg and postdoctoral fellow Lindsay Rizzardi, among others. The samples were sent to the ISS within a SpaceX Dragon supply capsule.

Launched aboard a Soyuz rocket, Rubins successfully sequenced samples of mouse, bacteria, and virus DNA in microgravity during ISS Expeditions 48 and 49, during which she spent 115 days in space and conducted two spacewalks totaling 12 hours and 46 minutes. Rubins, a microbiologist with a PhD in cancer biology, used a small, customized tool to conduct the DNA sequencing called the MinION. The USB-powered device can perform a sequencing run in as little as 10 minutes and has been used in field labs in some of the most remote locations on earth.

Rubins' work aboard the ISS helps scientists to better understanding the process for sequencing DNA in microgravity to measure the effects of spaceflight on the human body. As a result of her experiments, scientists may also be better equipped to diagnose diseases on extremely long space flights.

Left to right: graduate student Kirsten Hall, Dr. Kate Rubins, Bloomberg Distinguished Professor Andrew Feinberg, and Space@Hopkins Director/Bloomberg Distinguished Professor Chuck Bennett

Dr. Kate Rubins presenting about experiments she conducted and her experience in space.

Photo by NASA

NEWS BRIEFS

Celebrating the Great American Eclipse

To witness the Great American Eclipse that swept across the U.S. on August 21, 2017, members of the department set up telescopes with filters in the courtyard of Bloomberg Center. Students, faculty, and staff alike gathered to view the eclipse. Similar gatherings happened all over Baltimore. JHU's Homewood Campus also hosted students, faculty, and members of the community to watch from the Beach, where people could make their own eclipse viewer using cardboard boxes. The eclipse's path of totality spanned from Oregon to South Carolina. Baltimore was treated to 80% totality, which occurred at approximately 2:43 PM. The images below were captured by graduate student **Erini Lambrides**.

Marc Kamionkowski Gives 'Hans Jensen Lecture' at University of Heidelberg

Professor **Marc Kamionkowski** was invited to give the Hans Jensen Lecture at the University of Heidelberg as part of their doctoral program's biannual "Heidelberg Physics Graduate Days," which offers graduate and Ph.D. students the opportunity to take courses that both broaden their physics knowledge, and teach specialized techniques. The lecture is named for Hans Jensen, who shared the 1963 Nobel Prize for the nuclear shell model, and is intended to honor speakers who have made fundamental contributions to a research area in modern physics. The lecture Kamionkowski gave was entitled, "Gravitational Waves, Black Holes, Dark Matter, and the Early Universe."

Tobias Marriage Receives National Science Foundation CAREER Award

Associate Professor **Tobias Marriage** received a CAREER Award from the National Science Foundation to research and understand how the universe began. The CAREER Award supports research by early-career faculty who serve as academic role models in research, education, and their integration to serve their organization's mission. Marriage hopes that analyzing data from the JHU-led Cosmology Large Angular Scale Surveyor (CLASS) will lead them closer to the answer (more on page 4).

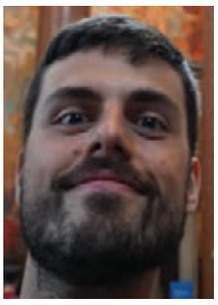
Kim Berghaus Named 2017 Recipient of the Gardner Award

Ph.D. student **Kim Berghaus** is the recipient of the 2017 Gardner Award for her research on high energy particle phenomenology with Professor **David Kaplan**. Her research attempts to solve the 'hierarchy problem' in particle physics, which posits why the mass of the Higgs particle is so small; this is responsible for the large discrepancy between the comparative weakness of gravity and the other fundamental forces. Berghaus' research employs the Relaxion Model which takes a new approach in explaining why the Higgs mass is small by making its evolution dynamical in the early universe, and predicts a new fundamental force. Berghaus' research takes data collected at the Large Hadron Collider (LHC) to find hints of this new force. No other search currently being conducted in experimental particle physics is calibrated to the type of unique signature predicted by this model.

With the LHC constantly collecting more data this has been time-sensitive research, as it is most relevant to the community right before it becomes accessible to measure (or be ruled out). The Gardner award has allowed Berghaus to keep up with the demanding time line. It has also allowed her to shift her focus solely on research very early on in her Ph.D. program in theoretical particle physics.

Berghaus is the ninth 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.

Graduate Student Julián Munoz Awarded a Dan David Prize Scholarship



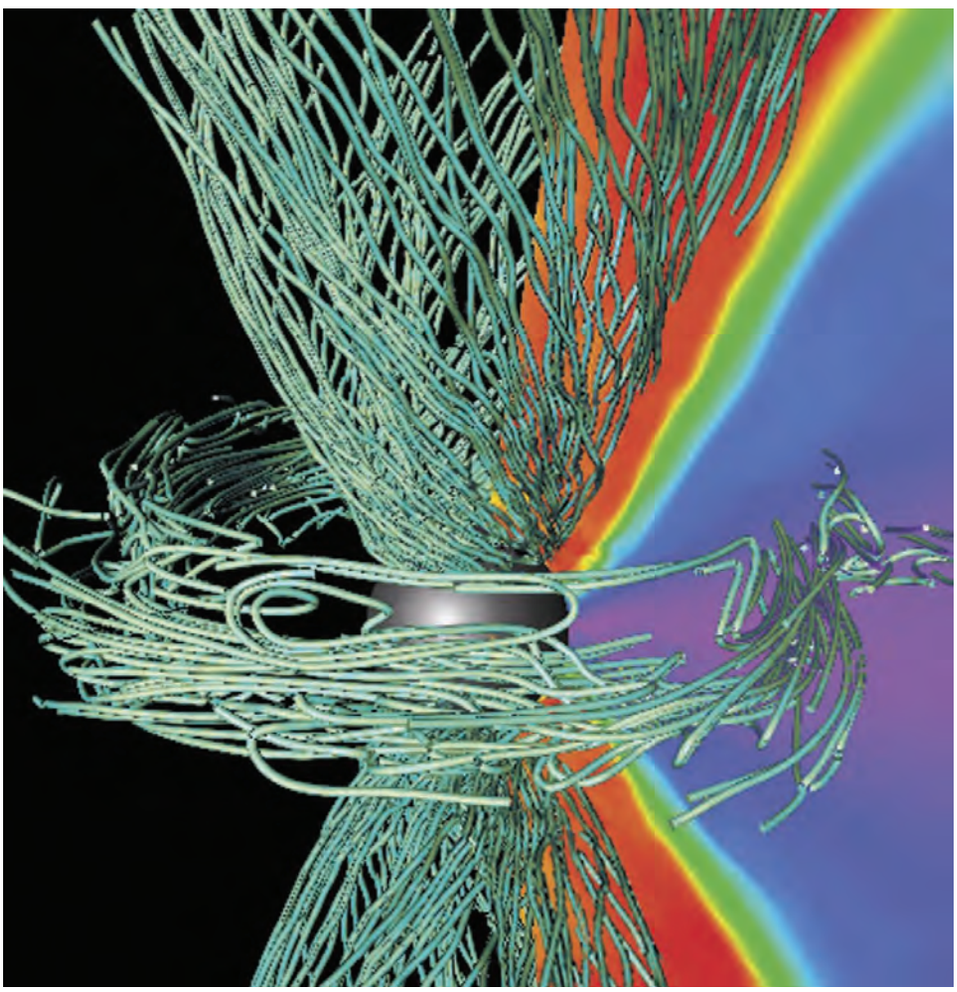
Graduate student, **Julián Munoz**, has been awarded a Dan David Prize Scholarship for his research conducted under the guidance of his faculty mentor William R. Kenan, Jr. Professor **Marc Kamionkowski**. Munoz was recognized for researching "new cosmological probes for old fundamental questions." Each year, Dan David Prize laureates donate 10 percent of their prize money to scholarships for outstanding Ph.D. students and postdoctoral fellows from around the world for outstanding research.

Physics Major Austin Granmoe Receives Department of Defense SMART Scholarship

Austin Granmoe, an undergraduate junior physics major, received the Science, Mathematics And Research for Transformation (SMART) Scholarship established by the Department of Defense (DoD) with the aim of "increasing the number of civilian scientists and engineers working at DoD laboratories." The SMART Scholarship supports graduate and undergraduate students who are pursuing degrees in Science, Technology, Engineering, and Mathematics (STEM). As a recipient of the scholarship, Granmoe will receive full tuition and other benefits from the Department of Defense with employment by the DoD upon graduation.

Joseph Silk's Colleagues Gather in Paris to Celebrate His 75th Birthday

In December 2017 the Institut d'Astrophysique de Paris hosted an international conference to celebrate **Joe Silk's** 75th birthday, providing a unique occasion to bring together the world's top experts in Joe's topics of interest, in particular his many former students and postdocs who have now become leaders in the fields of Astrophysics and Cosmology.



Professor Julian Krolik was a finalist in the inaugural Bloomberg Art from Science Innovation Contest (see inside front cover) thanks to his famous image above which also adorns the cover of a textbook. The graphic was generated from Krolik's research focused on the physics of accretion disks surrounding black holes. The magnetic field line structure in both the accretion disk surrounding a black hole and its outflow, is superimposed on logarithmic color contours of gas density.

ALUMNI UPDATE

Erich Willen (Ph.D., '63) has recently has an article published in the journal Physics in Perspective, entitled 'Building Magnets,' which describes the effort to build superconducting magnets for the Superconducting Supercollider (SSC) and Relativistic Heavy Ion Collider (RHIC). He led the magnet R&D for these projects as the head of Brookhaven National Laboratory's Magnet Division from 1984 to 1993.

Irvin M. Miller (Ph.D. '64) founded the Math & Physics Exploration in 2009 to be the first of only two math museums in the US. The Exploration center, which provides its services for free, has educated students from learning challenged to gifted, by reshaping the way that math is taught through special programs and online video. Additionally, he has a math patent developed at IBM, has written a landmark article on computers and economics for the Harvard Business Review, and developed an exhibit for the NYS visitor center. At IBM he was one of the worldwide leaders in computer graphics.

R. Paul Drake (Ph.D., '79) is the 2017 recipient of the Edward Teller Medal, awarded by the American Nuclear Society Fusion Energy Division, which recognizes pioneering research in fusion energy. The Teller Medal was given to Drake for his seminal work in radiation hydrodynamics and laser-plasma interactions, and for educational contributions, advancing fundamental high-energy-density physics and its applications to astrophysics.

The prize is sponsored by the Fusion Energy Division of the American Nuclear Society and recognizes pioneering research and leadership in the use of laser and ion-particle beams to produce unique high-temperature and high-density matter for scientific research and for controlled thermonuclear fusion. It was established in June 1999 and is funded by an endowment fund established by the Fusion Energy Division of ANS. They have approved the vote of the IFSA Awards Committee and have forwarded their approval to the American Nuclear Society for preparing the award. He is currently a professor of Applied Physics at the University of Michigan.

James Castracane (Ph.D. '82) is a Professor of Physics and Biological Sciences and Head of Nano biosciences at SUNY Polytechnic Institute. He is a 2017 recipient of the SUNY Chancellor's Award for Scholarship and Creative Activities, an award given annually to one member of each SUNY campus. The award recognizes outstanding scholarly and creative productivity in addition to teaching. Castracane's research is focused on Materials Science/Physics, Nanobioscience, M/NEMS, 3D Wafer integration/packaging, and Optoelectronics.

Ed Synakowski (B.A. '82) has just accepted a new position as the Vice President for Research and Economic Development at the University of Wyoming with an additional academic appointment as a Professor of Physics and Astronomy there. He received his Ph.D. in physics in 1988 from the University of Texas at Austin. From there, he conducted research at Princeton before joining the U.S. Department of Energy as the Associate Director of Science for Fusion Energy Sciences, in 2009. His research is focused on fusion energy science and plasma physics.

Kimberly Ennico (B.A., '94) is the SOFIA Project scientist at NASA. The Stratospheric Observatory for Infrared Astronomy helps astronomers learn more about the formation and compositions of celestial objects in our solar system and beyond by enabling scientific observations that are impossible for Earth-based telescopes, while offering more flexibility than space-based telescopes. Ennico has been at NASA Ames since September 2000, working on many projects, including detectors for James Webb Space Telescope, building a payload that discovered water on the moon, pushing new telescope concepts, and most recently deputy project scientist for NASA's New Horizons mission which flew by Pluto in July 2015.

Trisha Muro (née Borgman) (B.S. , '96) was recently invited to give a presentation and star party for the 2017 solar eclipse in the town of Arrow Rock, Missouri, which was in the path of totality. The event was attended by over 100 people, and brought together family, friends, visitors, and locals. Prior, she worked at the Space Telescope Science Institute.

Christina Williams (B.S. '03) is a member of the James Webb Space Telescope near-infrared camera team at the University of Arizona. She received her Ph.D. in Astronomy from the University of Massachusetts-Amherst in 2014, and was recently awarded a National Science Foundation Postdoctoral Fellowship to continue her research on galaxy evolution in the early universe with James Webb Space Telescope.

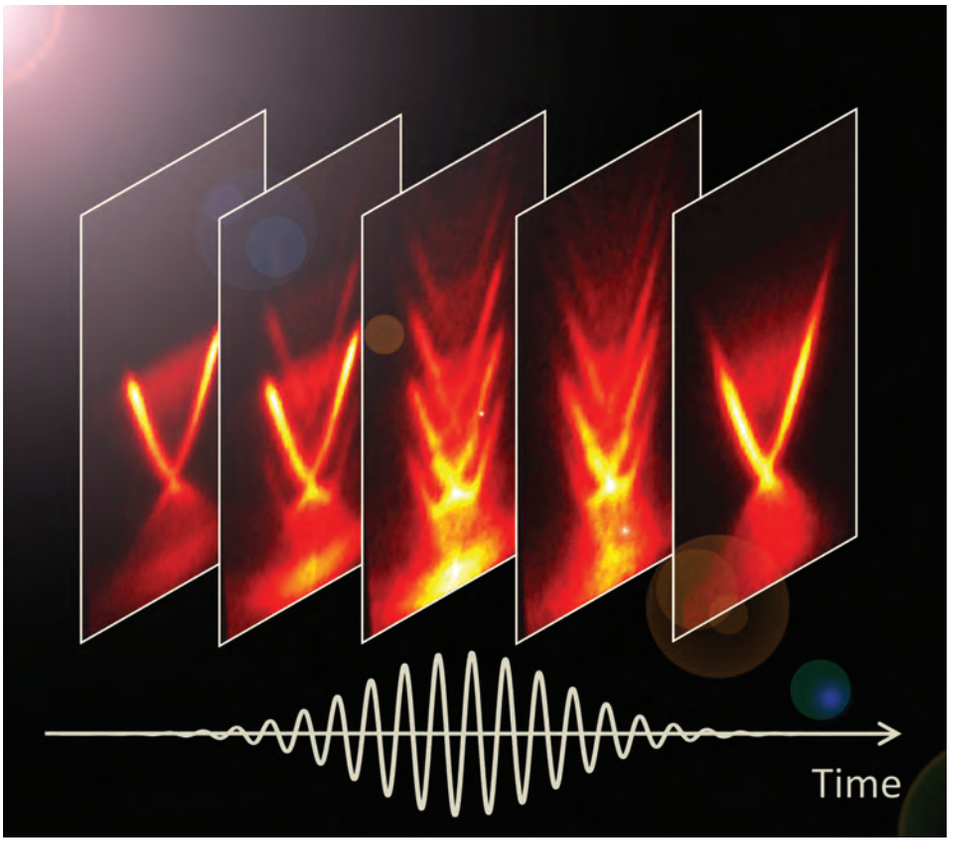
Matthew Stone (Ph.D. '03) is an Instrument Scientist at the Oak Ridge National Laboratory at the neutron scattering facilities. His team received the "Directors Award for Outstanding Team Accomplishment" and another "Team Research Accomplishment Award" for a research project that examined the antiferromagnet $RuCl_3$ using neutron scattering measurements. The results were published the journal *Nature Materials* in 2016.

Emma Marcucci (B.S. '08) earned her Ph.D. in Geological Sciences from the University of Colorado at Boulder, before moving to the University of Alaska, Fairbanks Geophysical Institute for a Postdoctoral Fellowship, spending 3.5 years there. She is currently an Education and Outreach Scientist with the Office of Public Outreach at the Space Telescope Science Institute.

Matthew Pines (B.S. '09) received his Master of Science degree from the London School of Economics, and is currently a Senior Associate at the Cadmus Group Inc. where he supports government clients on science and technology operational assessments, risk analysis, and designing war games and exercises. He previously worked as a Science Assistant at the National Science Foundation, before becoming a management consultant working on homeland security and defense issues.

David Bjergaard (B.S. '11) is working in the Department of Defense, having just successfully defended his Ph.D. thesis at Duke University. His research was focused on the production of charm quarks in hadron collisions at the Large Hadron Collider. He also married fellow Hopkins alum, Swarnali Sengupta.

Liang Wu (Ph.D. '16) was selected one of Forbes's "30 Under 30" for his research in the field of condensed matter physics with advancements made in topological materials, and optical responses. His work could lead to breakthroughs in quantum computing and solar cells respectively. The American Physical Society awarded Wu for his work on electrodynamics of topological insulators. He was also awarded the Michaelson Prize, which is given annually by the Physics Department of Case Western Reserve University to a junior scholar active in any field of physics. The award cites his "ground-breaking experimental studies of topological materials. He is a postdoctoral fellow at University of California, Berkeley.



Postdoctoral Fellow Fahad Mahmood submitted the series of images above to the Bloomberg Art from Science Innovation Contest (see inside front cover). These images are snapshots of the band structure of the topological insulator Bismuth selenide (Bi_2Se_3) as it is radiated by light below its bulk band gap. The series is captured using an ultrafast time resolved photoemission setup. Dynamic gaps in the electronic structure open up at positions where the replica cones intersect the original cone. The replica bands disappear once the driving field shuts off.

Please keep in touch!

We would love to hear from you.

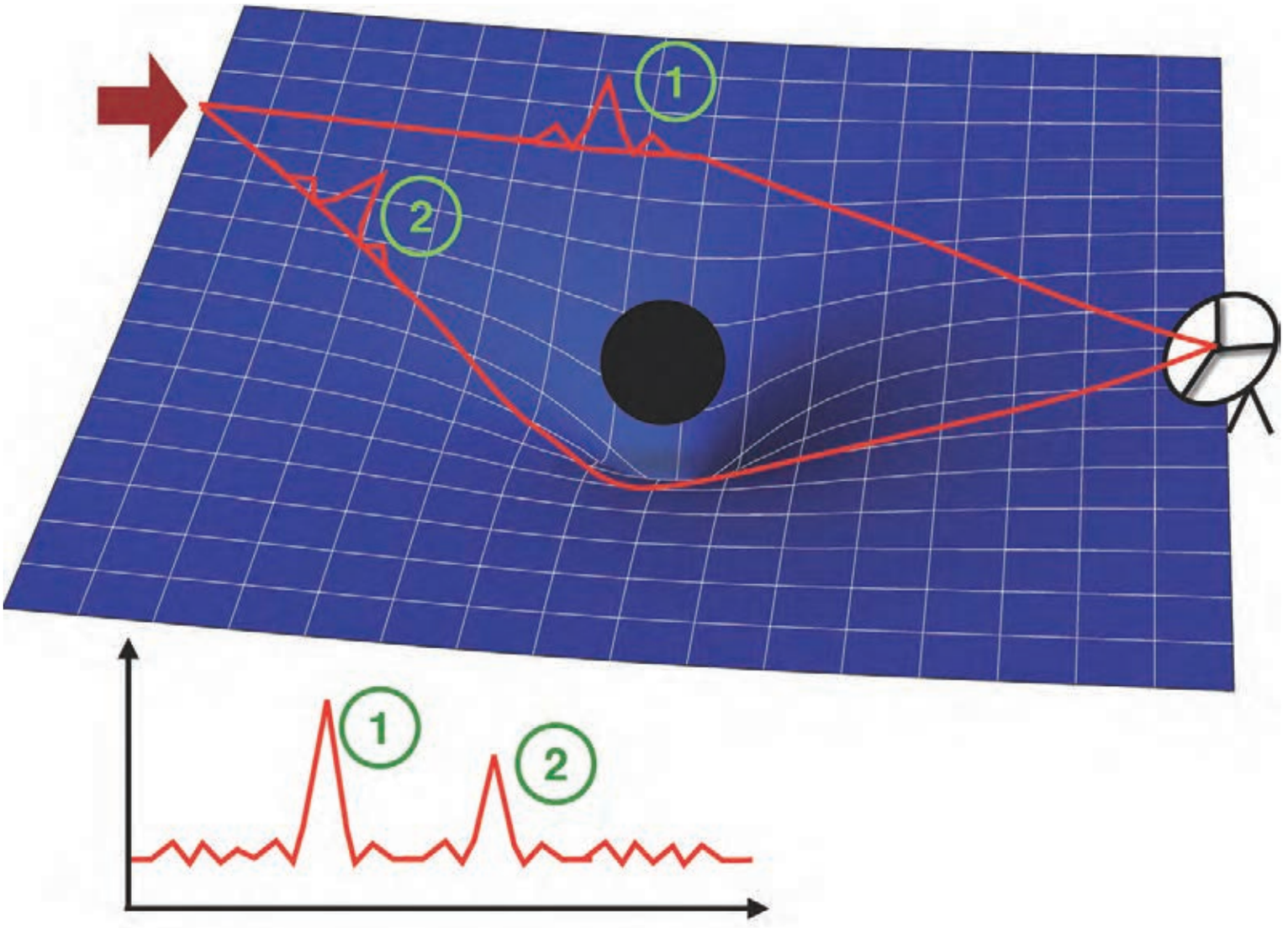
Please contact Pam Carmen in the Chair's Office at:

pcarmen@jhu.edu

Donors to the Department in 2017

We would like to thank the friends of the department who generously provided support in the form of gifts and donations in the last year. These funds play a vital role in the success of the department. They support the research and training of graduate students and postdocs, who represent the lifeblood of our research and the futures leaders in physics and astronomy. They provide the "seed-corn" to develop high-risk/high-reward new ideas for future federal support. This enables some of our best and most creative faculty to continue to push back the frontier. Your contributions also support our continued innovation in the ways we teach physics. These funds are truly invaluable. If you would like to learn more, please contact the Chair: Tim Heckman, theckma1@jhu.edu, 410-516-7346.

Homaira Akbari, Edward J. Belting III, Renée Marlin-Bennett and Charles L. Bennett, Bernard Bogema, Jr., Michael Botlo, Ari Buchalter, Shane Irving Burn, Howei Chan, Thomas Chapuran, Pui-Yu Alice Cheung, William V. Dixon, Jay R. Dorfman, R. Paul Drake, Laurie Evans, William Bentley Gardner, Andrew D. Garwin, Ilya Golubovich, Mohammed N. Islam, David Kupperman, Joseph F. Lacetera, Xing-Qi Lu, John Mather, Heidi Messer, Merrill E. Milham, Jr., H. Warren and Doris M. Moos, David Nicholson, John and Brooke Peoples, Matthew S. Polk, Jr,, Gillian P. Sandler, Charles N. Silver, Ronald T. Versic, John Qjiang Xiao, Kia Liu and Ashley Wang, Simon P. Wing, Vernon B. Yelch, and Adam Zeldin



Graduate student Julián Munoz created the graphic above. If dark matter is composed of compact objects, such as 30-solar-mass black holes, it will bend light when it passes near it. This effect, known as gravitational lensing, also produces multiple images of a single source, with a time delay between them. In the paper for which Munoz used this graphic, he and his fellow researchers proposed using the gravitational lensing of cosmological radio bursts to detect black holes as dark matter.

Adjunct Professor Peter McCullough in an astronomer at the Space Telescope Science Institute. He assembled this mosaic using images generated by the Hubble Space Telescope (HST). For calibration purposes, the HST looks down at Earth's dark side with its near infrared detector of its Wide Field Camera 3 instrument. Mostly it picks up the smooth glow of OH molecules in the mesosphere. Sometimes it flies over city lights, leaving brighter streaks. Sometimes a charge persistence effect in the detector leaves the imprint of images it took before in the current images; these generally are small brighter rectangles near the center of some images. Other cosmetic defects in the detector or the optics are evident.

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The Beauty of Plastic at the Molecular Level

Graduate student Thomas O'Connor submitted the image below to the inaugural Bloomberg Art from Science Innovation Contest (see inside front cover). The image portrays a plastic material that is made of long chains of molecules intertwining and entangling with each other to make a solid "molecular felt." This image is taken from a simulation of a polymer fiber being stretched until it breaks open. When these materials are stretched, this complex and beautiful molecular network of chains is pulled apart, a process called crazing. It is what causes clear plastic to turn white when you tear it open. The network voids scatter visible light, making clear plastics turn cloudy white when torn open.