Physics and Astronomy
Communiqué
Autumn 2017

Bill Brinkman Selected for Inaugural Alumni Award

By Linda Godwin

The Department of Physics and Astronomy has established an annual alumni award for either mid- or lifetime career exceptional achievement, research, and service.

We are pleased to announce that William (Bill) Brinkman, a highly distinguished condensed-matter physicist and department alumnus, is the first recipient of the Distinguished Alumni Lifetime Career Award.

Brinkman received his doctorate in physics from the University of Missouri in 1965. His career since has spanned innovative research and high-level management and leadership.

He joined Bell Laboratories in 1966 after spending one year as a National Science Foundation postdoctoral fellow at Oxford University. He left Bell Labs in 1984 to serve as vice president of U.S. Department of Energy's Sandia National Laboratories. Brinkman returned to Bell Laboratories in 1987, where he served as head of the Physics Research Division, later becoming physical sciences research vice president and then vice president of research.

Brinkman joined Princeton University in 2001, playing an important role in organizing and guiding the physics department's condensed matter group. He was nominated by President Barack Obama and confirmed by the senate to head the Department of Energy's Office of Science in June 2009, where he served until 2013.

Alumnus William F. Brinkman, shown addressing an Accelerators for America's Future symposium, will be the first recipient of the Distinguished Alumni Lifetime Career Award.

Brinkman's research involved theories of condensed matter, and his early work included the theory of spin fluctuations in metals and other highly correlated Fermi liquids. His subsequent theoretical work on liquid crystals and incommensurate systems contributed to the theoretical understanding of condensed matter.

Brinkman has long served as a leader of the physics community, including as president of the American Physical Society in 2002 and on numerous national committees, including chairing the National Academy of Sciences' Physics Survey, the eight-volume collection known as the "Brinkman Report." He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and a past president of the American Physical Society. He was a recipient of the 1994 George E. Pake Prize.

Future nominations for this award will be solicited from current and emeritus faculty and alumni.

From the Chair

Dear Physics Alumni and Friends,
Despite the challenges and upheavals that the university has faced over the past few years, the Department of Physics and Astronomy continues to do well, under the circumstances, and we remain cautiously optimistic for the future. The productivity of our faculty and students remains high, and our faculty continue to reach milestones and garner impressive awards, many of which are listed in the body of the newsletter.

Department Chair Sashi Satpathy

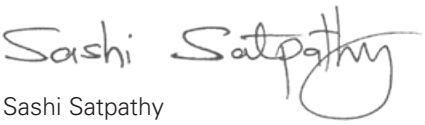
An important achievement has been the hiring of three new faculty members over the past three years. I am happy to report that our faculty search last year was successful. Assistant Professor Yicheng Guo, with specialization in observational astronomy, has just joined the department this fall. Professor David Singh, an internationally recognized condensed-matter theorist, and Guang Bian, an up-and-coming condensed-matter experimenter, joined us last fall. Also beginning this fall, Bowen Loftin, former MU chancellor, became a full-fledged faculty member in the department. All of these new additions bring important expertise to our department. At the same time, we lost Professor Peter Pfeifer to retirement this year. Peter retired after 30-some years of service to the department, during which he also served as chair for six years. We wish Peter success in his new endeavors during retirement.

Our graduate student number has remained stable, fluctuating between 50 and 55 students per year over the past decade. We admitted eight new graduate students this semester, making the total 54 for the current academic year. We have 110 declared undergraduate physics majors this year, down slightly from 120 last year. The department has some 18 postdoctoral fellows working with various faculty members.

Despite the budget cut that has reduced support to all departments at MU, including physics, by about 12 percent, the department has been able to maintain its activities thanks to the new revenue streams such as the supplemental fees and online teaching and generous donations from alumni and friends. Last year, we established the Jim Fergason Graduate Student Fellowship, which supports an incoming graduate student for a year. We also created a Staff Recognition Fund for non-academic staff in the department. Finally, we instituted a new award this year: the Distinguished Alumni Award. Each year, a member of our alumni will be honored with this accolade for his or her mid-career or lifetime achievement. The honoree will receive an award plaque and travel expenses for the honoree and a guest. The first recipient of the award will be Bill Brinkman, PhD '65, a theoretical condensed-matter physicist who has had an illustrious career culminating in service as the head of the U.S. Department of Energy Office of Science prior to his retirement in 2013. We look forward to presenting him with this award at the Physics Leaders' meeting this October.

On behalf of the department, I sincerely thank the physics alumni, leaders, and friends for their continued support. Generous donations over the years continue to build a strong foundation for the department, which helps us in both good times and bad. Additionally, we appreciate that our alumni and friends show continuous interest in and provide encouragement for our new and ongoing work. This continued commitment to the department's well-being is truly invaluable and deeply appreciated.

Wishing you all continued personal and professional success in the upcoming year,



Sashi Satpathy
Chair and Curators' Distinguished Professor of Physics

Welcome, Yicheng Guo!

Assistant Professor Yicheng Guo obtained his doctorate from the University of Massachusetts Amherst. Before joining MU, he worked as a postdoc at the University of California, Santa Cruz. Guo is an observational astronomer, using ground-based and space-based telescopes to study distant galaxies. He was involved in proposing and designing CANDELS (Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey), the largest survey program of the Hubble Space Telescope (HST), and then served as the leader of its multi-wavelength working group, managing the efforts of generating photometric catalogs for CANDELS.

Guo's research focuses on how galaxies, such as our own Milky Way, were formed and evolved from small, irregular blobs in the early universe into today's massive systems with diverse morphology. He is particularly interested in how star formation activity is turned on and off in galaxies. He is now using CANDELS and other deep HST extragalactic surveys to measure the mass, star-formation rate, metal abundance, and morphology of distant low-mass galaxies, which are believed to be the progeni-

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Nanotechnology a "Green" Approach to Treating Liver Cancer

By Jeff Hoelscher, previously published in MU Health *online, February 2017*

Justin Kelley, MU Health

Curators' Professor of Radiology and Physics Kattesh Katti working at the MU School of Medicine.

According to the American Cancer Society, more than 700,000 new cases of liver cancer are diagnosed worldwide each year. Currently, the only cure for the disease is to surgically remove the cancerous part of the liver or transplant the entire organ. However, an international study led by University of Missouri School of Medicine researchers has proven that a new minimally invasive approach targets and destroys precancerous tumor cells in the livers of mice and invitro human cells.

"The limitations when treating most forms of cancer involve collateral damage to healthy cells near tumor sites," said Kattesh Katti, Curators' Professor of Radiology and Physics at the MU School of Medicine and Department of Physics and Astronomy, and lead author of the study. "For more than a decade, we have studied the use of nanotechnology to test whether targeted treatments would reduce or eliminate damage to nearby healthy cells. Of particular interest has been the use of green nanotechnology approaches pioneered here at MU that use natural chemical compounds from plants."

The study was conducted in the United States and Egypt, and it involved the use of gold nanoparticles encapsulated by a protective stabilizer called gum Arabic. The nanoparticles were introduced to the livers of mice intravenously and were heated with a laser through a process known as photothermal therapy.

"Gum Arabic is a natural gum made of the hardened sap from acacia trees," said Katti, who also serves as director of the MU Institute of Green Nanotechnology and is the Margaret Proctor Mulligan Distinguished Professor of Medical Research at the MU School of Medicine. "It is FDA-approved for human consumption and is primarily used in the food industry as an additive. It also promotes adhesion of gold nanoparticles engineered to attract to precancerous and malignant cells—which are much more susceptible to lower levels of heat than healthy cells. Once the nanoparticles travel and adhere to cancerous cells, they are heated to a temperature that destroys them but leaves healthy tissue unaffected."

Katti's team studied a total of 224 mice. Half were identified as having precancerous cells in their livers. The other half had normal liver tissue. Outside of the control group, the mice received either an intravenous injection of gum Arabic alone or gum Arabic-encapsulated gold nanoparticles with or without laser therapy.

"The administration of gum Arabic, gold nanoparticles and photothermal therapy caused no change to healthy tissue, which confirmed the safe use of these treatments," Katti said. "However, the use of gum Arabic-encapsulated nanoparticles combined with photothermal therapy resulted in the targeted eradication of the precancerous cells and their genetic code in both our mice model and the human-invitro-cell model we developed for this study."

Katti said the next step for further developing the technique into a cancer treatment for humans will be a clinical trial.

"The components for this new therapy are inexpensive, do not have any issues associated with a shelf-life and are easy to produce," Katti said. "Most importantly, it does not involve the use of harsh chemotherapy drugs or radiation. It is a 'green' approach that also may lead to successful treatment of other forms of cancer."

The study, "Photothermal Therapy Mediated by Gum Arabic-conjugated Gold Nanoparticles Suppresses Liver Preneoplastic Lesions in Mice," recently was published in the *Journal of Photochemistry and Photobiology B: Biology.* Co-authors from the research group include Menka Khoobchandani, Sagar Gupta, Kavita Katti, and Ravi Shukla. Support for the study was provided by the MU School of Medicine, the MU Interdisciplinary Intercampus Research Program and the National Research Centre in Cairo, Egypt.

tors of today's Milky Way-like galaxies.

In the future, Guo hopes to develop a research group at MU to use current and upcoming advanced telescopes, such as the HST, Keck Observatory, James Webb Space Telescope, and the Square Kilometer Array, to obtain a comprehensive view of the physical mechanisms that regulate star formation and control the mass-energy-chemical cycles in galaxies. He will also work with theorists to establish a direct comparison between observations and the state-of-the-art numerical simulations of galaxy formation.

Faculty Updates

Professor **Linda Godwin** was one of the inaugural alumni inductees of the Mizzou Homecoming Hall of Fame during the 2017 Homecoming.

Professor **Suchi Guha** was on a research leave during academic year 2016–17. She spent two months at the Federal University of ABC near Sao Paulo, Brazil, as part of a prestigious research fellowship (Pesquisador Visitante Especial) from the Brazilian government, working with Professor Wendel Alves in the area of biosensors. She also visited the University of Western Cape (UWC) in South Africa for a month, where she taught and conducted research. The UWC visit was made possible through an internal grant from the University of Missouri South Africa Education Program. She was awarded two new grants from the National Science Foundation in spring 2017: Carrier Dynamics and Fast Switching by Dipole Engineering in Solution Processed Thin Film for approximately $360,000 for three years and U.S.–Brazil Workshop on Biosensors: Bioanalytics to Device Integration for approximately $48,000 for one year. As part of her second NSF grant, she will be organizing a workshop in Brazil in November. The goal of the workshop is to provide a roadmap for the development of low-cost sensitive detectors for vector-borne diseases by integrating biomaterials research with semiconductor technology, involving researchers from the U.S. and Brazil with complementary skills. Guha was also awarded the Excellence in Education Award from the MU Division of Student Affairs in spring 2017 recognizing MU educators who contribute to student learning and personal development through out-of-the classroom experiences and by quality interaction by students with faculty and staff.

Curators' Professor of Physics and Radiology **Kattesh Katti** and his team have developed a non-toxic delivery method using gold nanoparticles that may revolutionize Ayurveda, a holistic medicine system and one of the world's oldest, originating in India more than 5,000 years ago. His technique for producing the nanoparticles was recently licensed by Dhanvantari Nano Ayushadi, a company based in Tamil Nadu, India. Katti's green nanotechnologies are used to produce phytonano medicines, which are compounds that form the basis for India's Ayurvedic medicine. Gold salts are mixed with cinnamon and stirred with water to synthesize gold nanoparticles. These green therapies are less toxic to the body and could provide alternatives to current treatments for diseases including cancer, arthritis, and diabetes among others.

For more details, please visit coas.missouri.edu/news/new-mu-school-medicine-partnership-indian-company-could-help-produce-holistic-medicine.

News from Associate Professor **Gavin King's** research group:

Tina Matin defended her PhD this past spring and is now a postdoctoral researcher in biophysics at Weill Cornell Medicine, in New York City. After performing undergraduate research in our group for the past four years, **Brendan Marsh** also graduated this spring and, beginning this fall, is pursuing a one-year master's degree in applied mathematics at the University of Cambridge before he starts a doctoral program at Stanford University. Marsh received numerous awards including a Goldwater Scholarship, a National Science Foundation Graduate Research Fellowship, and the Mark Twain Fellowship, which provides funding for advanced studies abroad.

Missouri Student Association awarded Assistant Teaching Professor **Karen King** the MU Chancellor's Excellence Award for creating open educational resources. King was recognized for developing curriculum materials for Physics 2330 and making them available to students.

Professor **Sergei Kopeikin** continues to explore the applications of atomic clocks, quantum sensors, and fiber optics for constructing the world height system based on the global geoid. He and Professor J. Mueller, director of the Institute of Geodesy in Hanover, Germany, have organized an international team of scientists working on this subject experimentally. The team is supported by funding from the International Space Science Institute located in Bern, Switzerland. The project website is www.issibern.ch/teams/spacetimemetrology/.

Kopeikin was principle investigator of Relativistic Geodesy, a project supported by the Russian Science foundation during 2014–17.

He used this support to conduct a gravitational red shift experiment with atomic clocks and GNSS in the Altai Mountains. The results of the experiment confirmed a feasibility of application of the atomic clocks for the purpose of determination of the difference between gravitational potentials of two points separated on land by a long baseline. Results of the experiment have been published in "Chronometric Measurement of Orthometric Height Differences by Means of Atomic Clocks," *Gravitation and Cosmology* 22:234–244 (2016).

Another paper recently published by Kopeikin, along with M. Soffel and W.-B. Han, is "Advanced Relativistic VLBI Model for Geodesy," *Journal of Geodesy* 91:783–801 (2017). Han was Kopeikin's visiting scholar in 2015–16.

This paper provided significant contribution to geodesy and improved the precision of determination of the Earth's rotation parameters measured by the International Earth Rotation Service.

Along with Kopeikin's visiting scholar, E. Mazurova (2015–17), he has collected information about the development of a terrestrial reference frame in the Russian Federation and published a review paper in *Studia Geophysica et Geodaetica* 61:1–23 (2017). This paper provides western scientists with the methods, techniques, and results on the topic under discussion, which were not previously available in English.

News from Professor **Paul Miceli's** research group:

Three graduate students who were supported on the NSF-IGERT grant, Neutron Scattering for the Science and Engineering of the 21st Century, have received GO! internships at the Spallation Neutron Source at Oak Ridge National Lab. This fall, **James Torres** (physics, advised by Hak Taub and Helmut Kaiser) began a one-year internship, and **Alessandro Mazza** (physics, advised by Miceli) and **Emily Armbruster** (biochemistry, advised by Peter Cornish) began two-year internships.

News from Professor **Peter Pfeifer's** research group:

Andrew Gillespie defended his dissertation in April and is now a postdoctoral researcher in physics at Texas Tech University.

Doctoral candidate **David Stalla** was appointed senior research laboratory technician at MU's Electron Microscopy Core Facility in September 2016.

The patent High Surface Area Carbon and Process for its Production by J. Romanos, J. Burress, P. Pfeifer, T. Rash, P. Shah, G. Suppes, was issued Dec. 13, 2016.

Colleagues and adjunct faculty in the department, including Lucyna Firlej, University of Montpellier, France; Bogdan Kuchta, University of Marseille, France; alumnus Jimmy Romanos (PhD '12), Lebanese American University; and Pfeifer have been invited to edit a special topics book, *Sorption Technologies for Methane Storage*, for the journal *Frontiers in Energy Research*.

Following his retirement from the department, Pfeifer launched his new company, Pfeifer Consulting, LLC, with offices in Columbia and Zurich, in July 2017.

Professor **David Singh** was named a fellow of the Royal Society of Chemistry this summer. He has been a fellow of the American Physical Society since 1997.

His physics students **Cory Honer, Aditya Putatunda** and **Matthew Prosniewski** co-wrote a paper with him based on outstanding work that they did as part of the course Structure, Electronic Structure and the Properties of Condensed Matter (Physics 8101). Their work, undertaken as an assignment in the course, resolved an important puzzle about the stability of perovskites and provided an explanation for the magnetic properties of the compound $MnSeO_3$. The paper, "Properties of the Antiferromagnetic Selenite $MnSeO_3$ and its Non-Magnetic Analogue $ZnSeO_3$ from First Principles Calculations" was published in the *Journal of Physics: Condensed Matter*, and it can be found here: iopscience.iop.org/article/10.1088/1361-648X/aa7f89.

Professor **Angela Speck** devoted the last year to extensive outreach and education activities for the August 21 solar eclipse. She was the recipient of an MU Faculty Achievement Award in Diversity recognizing members of the MU faculty who are working to elevate diversity and inclusion at Mizzou. She was selected to receive this award by a panel of seven student leaders representing various student organizations including Four Front, The Legion of Black Collegians, Queer People of Color, the National Association of Black Journalists, and the Mizzou Student Veterans Association.

Professor **Carsten Ullrich** was on research leave for the 2016–17 academic year. In fall 2016, he spent two months visiting the Max-Planck Institute for the Structure and Dynamics of Mat-

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Faculty Updates

Continued from previous page

ter in Hamburg, Germany, and the University of York in the U.K. In spring 2017, he visited the University of Western Cape (UWC) in South Africa for a month, supported by an internal grant from the University of Missouri South African Education Program. At UWC, he taught master's and bachelor's honors-level courses in condensed-matter physics and materials science. In June 2017, he was a visiting scientist at the European Theoretical Spectroscopy Facility at the Ecole Polytechnique in Paleaiseau, France.

Professor **Carlos Wexler** has received an award from the joint American Physical Society-Sociedade Brasileira de Física U.S.-Brazil Professorship/Lectureship Program to spend four weeks at the Universidade Federal do Ceará in Brazil this fall. As part of this program, he will teach a graduate course on computational physics for modeling adsorption in porous materials.

Associate Professor **Haojing Yan** received a 2017 Provost's Outstanding Junior Faculty Research and Creative Activity Award, which gives special recognition to junior faculty, who are in the early phases of their careers, for superior research and creative activity on the MU campus.

In other news from Yan's group, **Jacob Brown** graduated with his doctorate this past May, and now he is a faculty member at the North Carolina School of Science and Mathematics. Haojing's group continues their MizzouWINS program at the WIYN telescope. They have finally overcome a slew of technical difficulties in data reduction, and science production is expected soon.

Congratulations to Professor **Ping Yu** for receiving an MU Excellence in Advising Award, which promotes and encourages recognition of outstanding advising services to the students of the University of Missouri. Yu's undergraduate research student, **Romanus Hutchins,** has been awarded the IMSD EXPRESS fellowship for 2017–18. He will continue his work in Yu's group on a bio-optical project. In summer 2017, he was selected as an Amgen Scholar to go to Caltech for a summer internship. F**engfei Wang,** PhD '17, from Yu's group, had a successful doctoral defense in May. Her dissertation was *Airy Beam for Three Dimensional Imaging.* She works as a faculty member in an institute in Jiangsu Province, China.

REU Update

By Karen King and Sashi Satpathy

This summer marked the fourth consecutive year that Assistant Teaching Professor Karen King and Professor Sashi Satpathy have directed a National Science Foundation–funded Research Experiences for Undergraduates in Physics program. Faculty from our department have mentored 42 students from across the nation and within MU.

After engaging in research projects for nine weeks, the students presented their work at an annual oral presentation for the physics department and a separate poster presentation for the entire MU community. Six participants have also presented their work at national or regional meetings, and we hope to greatly increase this number in the upcoming academic year.

After contacting past participants, we have learned that 14 of those who graduated (82% of the graduates we reached) have begun graduate programs in physics or related fields, and at least one has earned an NSF graduate fellowship. We are especially pleased to be welcoming two of our past REU participants, **Todd Lombardi and John Barron,** back to the MU physics department as they begin our graduate program this fall!

We are currently seeking NSF funding to continue this promising program.

Congratulations to students who have been admitted to these graduate schools.

Colorado State University
MIT
Princeton University
University of Alaska
University of Iowa
University of Michigan
University of Minnesota
University of Missouri
University of Wyoming
Vanderbilt University

Department Departures

Deborah Hanuscin, an associate professor with a joint appointment in the Department of Learning, Teaching, and Curriculum in the College of Education and the Department of Physics and Astronomy has accepted a new position at Western Washington University with a joint appointment in elementary education and SMATE (science, math, and technology education) beginning this fall.

Hanuscin had been at MU since 2004. Her contributions during her time at MU included serving as principal investigator of the Quality Elementary Science Teaching (QuEST) program, funded through the Missouri Department of Higher Education's Improving Teacher Quality grants program. This program received $2.6 million from the National Science Foundation (NSF)to study a model of professional development that gives teachers the chance to develop new science skills and then immediately practice implementing them. She was a co-principal investigator and research director for the A TIME for Physics First Project, a $5-million project, funded by NSF, that prepared a cadre of 80 teacher–leaders to spearhead the implementation of high school freshman physics throughout Missouri. Additionally, Hanuscin collaborated with Associate Professor Gavin King to create a middle school outreach program on biophysics.

She earned such honors as a 2012 Gold Chalk Award and a 2011 William T. Kemper Fellowship for Teaching Excellence. She was also named the 2014 Outstanding Science Teacher Educator of the Year by the Association for Science Teacher Education.

The department wishes Hanuscin well in her new position.

Peter Pfeifer retired from the Department of Physics and Astronomy Sept. 1, 2017. He joined the department in 1986 as a condensed-matter theorist, with research programs in surface physics and porous media, later also biological physics and quantum dynamics/computing. He was the architect and principal project leader of the Alliance for Collaborative Research in Alternative Fuel Technology (ALL-CRAFT, 2004–17), a multidisciplinary effort. He served as department chair 2008–14. To take the technologies he pioneered at MU to industry after leaving MU, Pfeifer launched his own company, Pfeifer Consulting, LLC, in 2017.

He began his work at MU as an unabashed fractalist, interested in structure–function relations of disordered materials with non-integer (fractal) dimension. Transport and reaction–diffusion in porous media were among them, but also wetting and phase transitions in noninteger dimensions.

In the area of hard condensed matter, Pfeifer worked closely with Professor Paul Schmidt in the department. Using small-angle x-ray and neutron scattering and capillary condensation of inert gases, Pfeifer and Schmidt (in collaboration with many others) investigated the structure of a wide range of porous solids over a wide range of length scales. This led to the discovery of some of the best-established fractals and laboratories for physics in noninteger dimensions.

One of them was a nearly space-filling network of carbon nanopores, which became a model for efficient storage of hydrogen and natural gas for future clean vehicles. It also became the turning point for Pfeifer to turn into an experimentalist. In the ALL-CRAFT Project, which was a partnership of MU, MRIGlobal in Kansas City, the Universities of Aix-Marseille and Montpellier in France, the University of Coburg in Germany, and industrial partners, Pfeifer and his team of colleagues and students developed carbon materials criss-crossed by channels a few molecular diameters wide that adsorb gas molecules, like a sponge, as a high-density film at low pressure.

Pfeifer's work led to several patents and contracts of nearly $8 million from DOE, DOD and the California Energy Commission to fund the work and tht support numerous graduate and undergraduate students in physics and other departments.

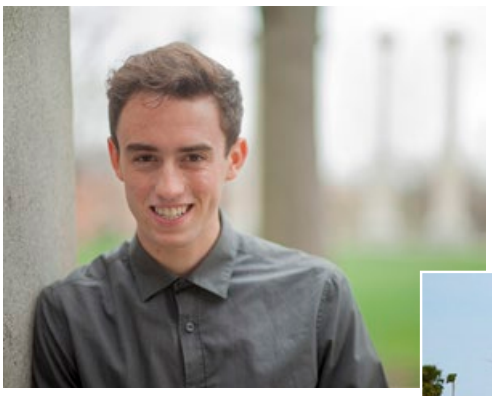
The department wishes Pfeifer well in his new endeavors.

Physics research interns, summer 2017. Front, from left: Jenna Lin, Madison Schwinn, Zachary Jermain, and Patrick Mooney. Back: John Roger, Adam Smith, Pierce Bloebaum, Noah Schwartz, and Chandler Osborne.

Alumnus Brendan Marsh—Mark Twain Fellow

Excerpted from an article by Maggie Teson, MU Fellowships Office

The Mark Twain Fellowship is an MU-sponsored award that provides support to Mizzou students and recent alumni seeking to pursue graduate study abroad in any discipline. It covers full tuition and fees at a foreign university and offers a stipend for housing, other living costs and transportation. Individuals who apply for a Rhodes, Marshall, Mitchell, Fulbright, Gates-Cambridge, Churchill or other comparable, nationally recognized fellowship programs, and are not selected, qualify to apply for the Mark Twain award.



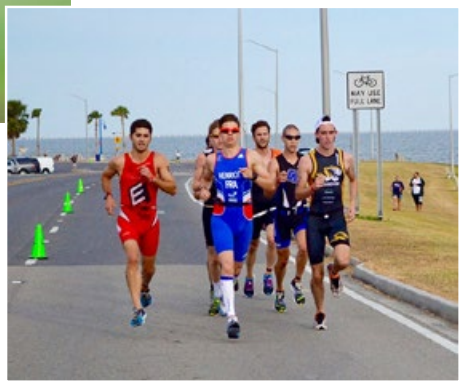
Brendan Marsh, BS '17, received a 2017 Mark Twain Fellowship.

Marsh applied for four major fellowships. While he did not receive any of them, he was not discouraged. Resolute in his aspiration to study at Cambridge, he applied for the Mark Twain Fellowship.

"The Mark Twain Fellowship is extremely generous, but I view it not as a gift but an investment in both the recipient and their passions," Marsh says.

At Cambridge, Marsh will pursue a master's degree in applied mathematics and theoretical physics. He will be taking a one-year course called Part III of the Mathematical Tripos, which is regarded as one of the most difficult and intensive mathematics courses in existence. Legendary scientists have taken the course, and some of the world's leading mathematicians have taught it. The distinguished theoretical physicist Stephen Hawking is a current faculty member.

"Some of the founding fathers of modern physics have taken the course, and I want to follow in their footsteps," Marsh says. "I want to get the best training in applied mathematics and theoretical physics the world has to offer. I find nothing more exciting than the thought of attending, and the Mark Twain Fellowship is going to make it happen."



Marsh, far right, competes at the New Orleans World Championship Qualifier this past fall.

Marsh is passionate about improving people's lives through physics and mathematics. In an effort to accomplish that goal, he learns as much as he can by majoring in both subjects, while also pursuing a minor in computer science. He has taken a variety of challenging courses, including a graduate course in mathematical physics and a one-on-one course in advanced theoretical physics, maintaining a 4.0 grade point average even with the rigorous coursework.

Marsh applies what he learns in the classroom to the research he conducts in Gavin King's physics laboratory. King is an associate professor of physics and a joint associate professor of biochemistry at MU. Marsh has been working in King's lab since he was a freshman. Currently, he uses atomic force microscopy to study membrane proteins, which dictate what passes in and out of cells. The research aids in developing drugs that are more effective and improving the understanding of how the human body works.

"In addition to pushing my research group and me into new areas, Brendan is also laudable for pushing himself into new areas," King says. "He pushes himself out of his comfort zone and seeks new challenges."

Marsh spent the last two summers exploring the frontiers of physics research. In 2015, he worked at the Stanford Research Institute to develop a hyperspectrtal imaging device designed to quickly diagnose cancer from a blood sample. During summer 2016, Marsh conducted research at the University of Goettingen, in Germany, where he created an artificial intelligence system to detect subatomic particles.

However, there is more to Marsh than classes and research; he is also the captain of Mizzou's triathlon team.

"My escape is the team," Marsh says. "Whenever things start to become a bit much, I go run or bike or swim or lift weights for a while, and I usually feel better."

As team captain, Marsh has increased membership and helped the team gain recognition. Along with four of his teammates, Marsh earned a position on Team USA at the amateur triathlon World Championships in August 2017.

"It's been extremely rewarding to produce not just a close-knit team of students, but also an increasingly elite group of athletes," Marsh says.

The Mark Twain Fellowship adds to a long list of accomplish-

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PAGSA News

By Alec Pickett, PAGSA president

Outreach

In September 2016, members of the Physics and Astronomy Graduate Student Association traveled to local Benton Elementary School to participate in their STEM Workshop. Members talked about physics with the elementary students, showed them fun demonstrations, fueled their curiosity, and answered their questions. It was very rewarding to see the children get excited about physics at such a young age!

Journal Club

PAGSA has a tradition of providing valuable time to practice public presentations. Journal Club provides the opportunity for graduate students to present their work or another topic of interest, whether it is something related to one's research or something completely unrelated. Many students utilize this time to practice their APS March meeting presentations as well. Presenters and their topics are listed below.

Erica Hroblak: "Negative Compressibility in 2-D Materials"

Travis Hurst: "Universality in Math and Physics from a Non-technical Perspective (Terence Tao's article)"

James Jones: "Chemical Oscillators"

Zhiwei Ma: "Mechanistic Understanding of Small-molecule Binding to Protein and Molecular Selectivity"

Zhiyuan Ma: "FAST: Five-hundred-meter Aperture Spherical radio Telescope"

Alec Pickett: "Drawbacks to Renewable Energy"

Eddie Pluhar: "Using the Particle-hole Map to Analyze Charge Transfer Excitations in Molecular Complexes"

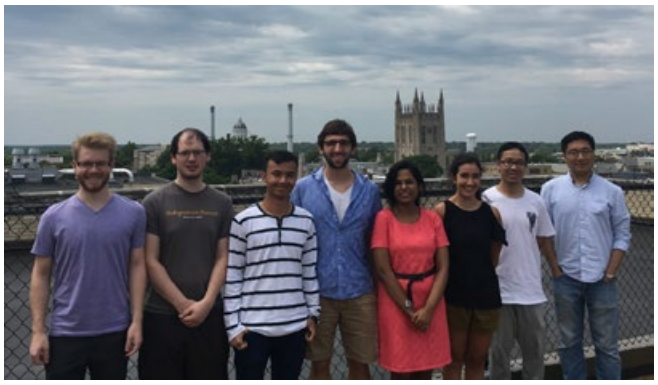
Lisa Shepard: "Ten Ways 'Proxima b' Is Different from Earth" and "Galactic Recycling: The Life Cycle of Stardust"

Angela Speck: "The Eclipse of a Generation — Don't Get Left out of the Dark"

James Torres: "Water Contact and Growth at the Surface of Cupric Oxide Using Low-Vac SEM"

Social Events of 2017

2017 has been a fun year for social events. PAGSA planned and prepared the annual spring and fall picnics for everyone in the department and an enjoyable bowling night for graduate students. Social Events Chair **Matt Prosniewski** ran away with the competition in no time at all. In addition, PAGSA held its third annual float trip the weekend of July 20. Three members, accompanied by two friends, went to Blue Springs Ranch outside of Bourbon, Missouri, to float down the Meramec River for a day of fun and relaxation.



New graduate students from left: John Barron, Mitchel Vaninger, George Yumnam, Todd Lombardi, Payal Bhattacharya, Katie Schaefer, Sicheng Zhang, and Qiangsheng Lu.

New Students

This fall, we welcomed eight new graduate students to the department.

Student Awards

PAGSA congratulates members **Masoud Valizadeh, James Runge, Fengfei Wang,** and **Alex Bretaña** on their award wins this past fall and spring.

Valizadeh was the recipient of the Teaching Assistant (TA) Choice Award for the third semester in a row. The TA Choice Award is an opportunity for students to recognize a teaching assistant who has gone above and beyond what is expected of a TA. Valizadeh often held review sessions for his students to reinforce the material being learned in the class, and he did his best to accommodate students by having longer office hours to clarify difficult material. Besides making himself available outside of the classroom, Valizadeh's students also enjoyed the way he taught the material. He explained the concepts and mathematics in a very concise manner, which made it simpler for his students to understand, with some saying he's the best teaching assistant he or she had ever had.

Valizadeh was also awarded the Harry E. Hammond Award for excellence in undergraduate teaching in the fall semester of 2016. Joining Valizadeh in recognition for excellence in undergraduate teaching and receiving the Hammond Award are James Runge (fall 2016), Fengfei Wang (spring 2017), and Alex Bretaña (spring 2017). The Hammond Award is given to a graduate student in the Department of Physics and Astronomy who has made significant contributions to the undergraduate teaching program in physics.

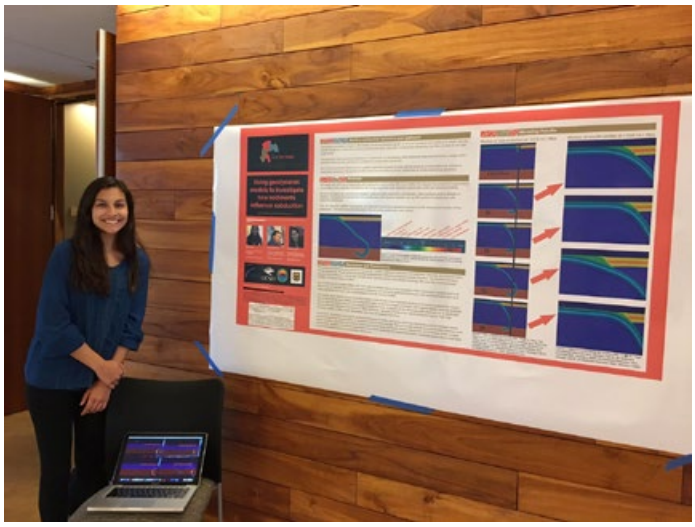
My REU Experience at Scripps Institute of Oceanography

By Amrit Bal, senior undergraduate physics major

This summer, I was a SURF student at Scripps Institution of Oceanography (SIO) at the University of California, San Diego. SURF (Scripps Undergraduate Research Fellowship) is a 10-week summer research experience for undergraduates that is focused on engaging students in Earth, ocean, and atmospheric sciences. My adviser for SURF was Dave Stegman, associate professor of geophysics at SIO. He was also director and creator of the Geodynamics of the Lithosphere and Deep Earth (GLADE) program, which provides undergraduate research opportunities in computational geodynamics. As his student, I was able to take part in both SURF and GLADE programs. My first week in La Jolla was with GLADE students, where we received tutorials on high-performance computing, numerical modeling, and scientific visualization.

After other GLADE students dispersed to their host research institutions for the summer, I remained at SIO to continue my work for the SURF program. My project started with finding correlations between published sediment and subduction data that govern overall dynamics at convergent plate boundaries. Later we used geodynamic modeling on the UCSD supercomputer COMET in order to model 2-D simulations of the Earth's dynamics. My research concentrated on using geodynamic models to investigate how sediment thickness and viscosity influence subduction dynamics. At the end of the SURF program, we presented our findings at a poster symposium. Below is the abstract for my poster that I will present at the AGU fall meeting in New Orleans this December.

"The details of the boundary between the subducting and overriding plates may strongly influence the tectonics and evolution of convergent margins. At the surface, these boundaries begin in the forearc as an accretionary prism or erosive interface. At depth, they continue into the mantle wedge as subduction channels. Sediments play a key role in subduction and its associated processes, including: mechanical coupling at the plate interface and stress transfer to the back-arc, viscous coupling and dehydration in the mantle wedge, orogeny, and volcanism. Therefore, it is expected that local, along-trench variations in the sediments on the downgoing plate—such as sediment type and thickness, wedge width, and sediment delivery rate—can lead to variations in subduction dynamics. How such sediment parameters correlate with subduction parameters is not well understood. In this study, we collected published data from the global subduction system to help identify particular aspects of how sediments influence subduction dynamics and perform 2-D numerical simulations of free subduction to probe the underlying dynamics. We used 221 trench segments with subduction parameters (Wu et al. 2008) and reduced the number of segments to a population that could be directly compared to the 30 trench segments of Clift and Vannucchi (2004), which were subdivided into 12 accretionary and 18 erosive margins. Our global compilation of subduction margins focuses on significant correlations between sediment data and subduction parameters. The LaMEM code was used to produce 2-D mechanical models of free subduction. The models include a pseudo-free surface, a weak crust, and non-linear viscoplastic rheology. The thickness and viscosity of the incoming sediments are varied as well as parameters on the subducting plate such as plate thickness, viscosity, and density."



Senior Amrit Ball and the poster she will present at the AGU fall meeting in New Orleans.

References Cited

Clift, P., and P. Vannucchi (2004), Controls on tectonic accretion versus erosion in subduction zones: Implications for the origin and recycling of the continental crust, *Rev. Geophys.*, 42, RG2001, doi:10.1029/2003RG000127.

Wu, B., C. Conrad, A. Heuret, C. Lithgow-Bertelloni, and S. Lallemand (2008). Reconciling strong slab pull and weak plate bending: The plate motion constraint on the strength of mantle slabs. *Earth and Planetary Science Letters*, 272: 412-421. 10.1016/j.epsl.2008.05.009.

Mark Twain Fellow

Continued from Page 8

ments for Marsh. As a sophomore, he received the Goldwater Scholarship, which is the most prestigious undergraduate award given in the sciences. He also earned the University of Missouri Award for Academic Distinction, which recognizes undergraduate students who go above and beyond expectations to contribute to the academic atmosphere.

"Mizzou has taught me everything," Marsh says. "So many professors and friends and advisers have been incredibly caring and supportive of me and have helped me achieve all these opportunities, which is something I want to reflect going forward."

After graduating from MU and obtaining his master's degree from the University of Cambridge, Marsh will pursue a doctorate at Stanford University, then he hopes to become a professor and conduct research.

"It was obvious I wanted to spend my life doing research after just a few months working in Dr. King's lab," Marsh says. "I love the creativity it affords me to come up with solutions to attack pressing problems in science. What I like most is discovering new things and figuring out how those discoveries can be used to help people or the world."

Scholarship Recipients

Many funds have generously been established and supported by our alumni. These students are the recipients for the academic year 2017–18.

Undergraduate Students

Melvin Y. Mora Undergraduate Scholarship
Ivan Garcia Hernandez

Donald L. and Lona Lewis Packwood Endowed Undergraduate Scholarship in Physics
Noah Schwartz and Abigail Warden

Clifford W. Tompson Scholarship in Physics
Joshua Miles and Abigail Warden

Dr. Eugene B. Hensley Scholarship in Physics
Pierce Bloebaum

Paul E. Basye Undergraduate Scholarship
Adam Smith, Blake Goehman, Chandler Osborne

Newell S. Gingrich Physics Scholarship
Michael Dotzel and Phillip Hegeman

O.M. Stewart Scholarship
Sean Burke, Matthew David Graham, Richard McClure, Madison Schwinn, Zach Valleroy, Jack Weakly

Graduate Students

Harry E. Hammond Prize in Physics
Alex Bretaña, James Runge, Massoud Valizadeh, Fengfei Wang

Summer Support
O. M. Stewart Scholarship
Matthew Anderson, Sean Baldridge, Arka Banik, Alex Bretaña, Zach Buck, Nagaraju Chada, Kanokporn Chattrakun, Alexander Daykin, Sean Fayfar, Hannah Groom, Rodney Helm, Travis Hurst, Griffin Johnson, Aditya Putatunda, Pratik Kumar Sahu, Yuanzhe Zhou

H. Phillip Graduate Fellowship
Alec Pickett, Anna Pittman

Eli Stuart Haynes and Nola Anderson Haynes Scholarship
Zack Buck, Chenxiaoji Ling

Ernest W. Landen Fellowship in Physics
Erica Hrobiak, Gregory Kissinger

Newell S. Gingrich Physics Scholarship
Anna Pittman, Eddie Pluhar, Matthew Prosniewski, Milica Utjesanovic, Massoud Valizadeh, Fengfei Wang

Chandrasekhar Endowment Fund
Soma Khanra

Rose Marie Dishman Scholarship in Physics
Soma Khanra, Chenxiaoji Ling, Chenhan Zhao

Guy Schupp Scholarship
Marat Musin

H. R. Danner Fellowship
Zach Buck, Ernest Knight, Amrit Laudari, Marat Musin

Society of Physics Students News

By Patrick Mooney, SPS President

Our local chapter of the Society of Physics Students (SPS) was as active as ever in the 2016–17 school year. Roughly once per month, SPS brought MU physics students and enthusiasts together for career planning, socializing, and to satiate scientific curiosity. The year started on the fun side with a staple of SPS: liquid nitrogen ice cream. Later in the fall came student discussions on our physics classes here at MU; those with seniority passed wisdom on to younger undergraduates. Before Thanksgiving break, the club made popcorn and watched Hollywood science classic *Real Genius*. After Thanksgiving comes exams, so SPS went on hiatus until the spring semester. In February, the club first met to play with both ferrofluids and non-newtonian fluids (Oobleck!). Later, in the spring, the club met more frequently to include: a three-hour tour of the MURR facilities, a grad student Q&A panel, a teaching physics panel, and a conversation with our own Professor Linda Godwin. At the end of the semester, students met at Shakespeare's Pizza for a senior send-off.

Making homemade ice cream with liquid nitrogen, clockwise, from bottom left, Abuzar Mahmood, Tyler Kling, Angelynn Simenson, unidentified, Amrit Bal, and Nick Madison (far right).

SPS sponsor Dorina Kosztin with students. Front: Sarah Van Hoesen and Amrit Bal; back: Peter Kampschroeder, Abuzar Mahmood, Professor Kosztin, and Abigail Warden.

SPS is more than just a social resource for students. The club sent its treasurer, **Peter Kampschroeder,** to present his research under Professor **Deepak Singh** at the APS March meeting in New Orleans. Even more students planned on attending but had to cancel because of schedule conflicts.

Under new leadership starting in the summer, SPS encouraged members to read two popular science books: *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality* by MIT physicist Max Tegmark and *Surely You're Joking, Mr. Feynman!* These books were the content of the first meeting this fall.

After a productive year for our local chapter, the SPS National Council recognized us as a Notable SPS Chapter. Good to know we've done Big Brother proud! MU SPS hopes to continue to inspire students to become good scientists and good people.

Congratulations, Graduates!

Fall 2016 BS in Physics
Ian Crawford-Goss, *Magna Cum Laude, Department Honors*
Julieann Hall
Brett Heischmidt, *Summa Cum Laude, Department Honors*
Scott Hodnefield
Levi Holmes
Alexander Tate

Spring & Summer 2017 BS in Physics
Jonathan Becker, *Magna Cum Laude*
Kaylina Breig, *emphasis in biophysics, Honors Certificate*
Collin Crain
Eric Cropp, *Summa Cum Laude, Department Honors*
Jeremy Hunn
Brendan Marsh, *Summa Cum Laude, Department Honors*
Gibraun Mitchell, *emphasis in astronomy*
Justine Plummer, *emphasis in astronomy*
Supawadee Pongsua
Kara Schulte
Angelynn Simenson, *emphasis in biophysics*
Michelle Wickman
Connor Wolenski, *Magna Cum Laude*
Peter Kampschroeder
Abuzar Mahmood, *Summa Cum Laude, Certificate in General Honors*

Spring & Summer 2017 BA in Physics
Jonathan Hummel

For Reference:
3.7–3.799 Cum Laude
3.8–3.899 Magna Cum Laude
3.9–4.0 Summa Cum Laude

Departmental Honors requires 3.5 or higher GPA in physics courses, completion of six credit hours of research, and a publication or presentation (oral or poster).

A Certificate in General Honors requires students to complete 20 or more honors credit hours and have a 3.3 MU GPA

Fall 2016 PhD in Physics
Matt McCune
Chengfei Yan

Spring 2017 MS in Physics
Kelly Gnadinger
Marat Musin
Anna Pittman
Edward Pluhar
Matthew Prosniewski
Brock Summers
Rik Williams

Spring 2017 PhD in Physics
Jacob Brown
Andrew Gillespie
Tina Rezaie Matin

Summer 2017 MS in Physics
Chenhan Zhao

Summer 2017 PhD in Physics
Fengfei Wang

Jacob Brown and Associate Professor Haojing Yan, graduation, spring 2017.

News from the Past

MU Physics Team Tracked *GEOS 1* Satellite

By Robert Cunningham, MS '66, PhD '70

Some people may think that Professor Linda Godwin is the closest relationship that the MU Department of Physics and Astronomy has had with NASA. However, in 1965, MU entered into a $45,000 contract with NASA to do satellite tracking for one and a half years. Professor Louis V. Holroyd, chair of the physics department, was director of the project.

The *GEOS 1* satellite was launched on Nov. 6, 1965. Geodetic satellites were designed to study the earth's size, shape, mass, and variations in gravity. However, MU's project was only concerned with pinpointing the flashing lights on *GEOS 1* against a star background. This satellite high point was 1,300 miles and the low point was 700 miles. It could measure distances on earth within an accuracy of 33 feet. Some of this tracking capability was instrumental to the existence of our current highly used GPS technology.

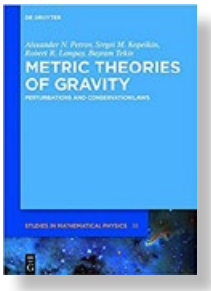
The satellite tracking station was built as a small dome-shaped building on the University of Missouri's Bradford Farm, about nine miles southeast of Columbia, to get away from the city lights. The dome could be rotated 360 degrees, and one section of the dome could be opened to allow a large special Minitrack Optical Tracking System (MOTS) camera with telescopic lens to be positioned to take pictures of the satellite's flashing lights. Also within the dome was a radio that relayed the exact time from station WWV at the National Bureau of Standards. A teletype that was connected to NASA's Goddard Space Flight Center in Greenbelt, Maryland, was set up in the Physics Building to receive the instruction for the specific camera angle setting and the exact time for triggering the camera to photograph the multiple flashes from the satellite. After the tracking was complete, the physics graduate students operating the camera would bring the 8-x-10 photograph plate back to the Physics Building to be developed. These same students, a day later, would circle the flash of lights on the photograph amongst a star background. This was not an easy task because one possible flash might show up on the plate but another flash could be behind a cloud. Multiple flashes with similar gaps between them had to be identified to be able to get a good recording, as a single flash looked identical to a distant star. As multiple passes of the satellite could occur in a night, the long hours could require handing over to a second team.

Professor Alan W. Peterson was Holroyd's assistant, and Kenneth H. Cavcey was the onsite NASA tracking station technician. Graduate students who manned the tracking station were Ronald Boain, Robert Cunningham, John Gault, Phillip Klamm, Robert Kost, Donald Martins, Walter Schwartz, Steve Sowers, and Keith Weaver. Cunningham was not new to working with NASA. During summer 1963, he worked at the Satellite Tracking Station in Santiago, Chile, doing electronic repair work on the newly designed circuit boards with transistors that were then replacing vacuum tubes. During summer 1964, he worked at NASA's research center at Langley Air Force Base in Hampton, Virginia, designing test equipment for rockets. MU has truly been a part of what NASA has done over the decades.

The author is pictured with visiting friends. 1966 caption from the *Kansas City Star*: "The Orbiting Geodetic Satellite *Geos 1* launched on Nov. 6, 1965, will have its picture taken from this dome-shaped concrete structure on the University of Missouri's Bradford farm, southeast of Columbia. The camera is in the tube in the center."

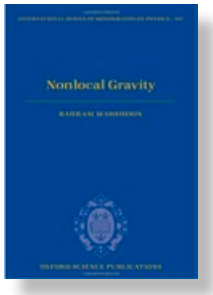
From left: Frances West, Sally Smith, Karen Peck, and Linda Cunningham, ca. 1966.

Faculty Bookshelf



Sergei Kopeikin et al. *Metric Theories of Gravity: Perturbations and Conservation Laws. De Gruyter Studies in Mathematical Physics,* Vol. 38. De Gruyter, 2017.
Written with colleagues Alexanderr Petrov, Robert Lompay, and Bayram Tekin, the book was the culmination of Kopeikin's work as principal investigator of the Relativistic Geodesy project supported by the Russian Science Foundation during 2014–17. Kopeikin used this support to conduct a gravitational red shift experiment with atomic clocks and GNSS in the Altai Mountains. The results of the experiment confirmed a feasibility of application of the atomic clocks for the purpose of determination of the difference between gravitational potentials of two points separated on land by a long baseline. Results were also published in prior papers.

He continues to lead an International Space Science Institute exploring this subject experimentally. The project website is www.issibern.ch/teams/spacetimemetrology/. The book is available on amazon.com.



Bahram Mashhoon. *Nonlocal Gravity.* Oxford University Press, 2017.
Relativity theory assumes locality without accounting for the observer's past history. This book, the culmination of Mashhoon's work at the University of Missouri over the past 30 years, introduces non-locality, or history dependence, into relativity theory. Inertia and gravitation are deeply tied, suggesting gravity may be non-local. The gravitational memory of past events must then be taken into account.

The book is available through Oxford University Press and amazon.com.

August 21, 2017

Jordan Yount

At left: The dome of Jesse Hall during the eclipse.

On back cover: Photo taken by drone of the crowd assembling on Francis Quadrangle before the eclipse.

The long-anticipated total solar eclipse swept across the continental United States Aug. 21, 2017, with Columbia well placed at almost centerline in the path of totality. We experienced around 2:30 minutes of totality on the first day of fall classes. Faculty were encouraged to cancel afternoon classes to allow students to experience the rare event, and plenty of safe viewing glasses were provided by MU. Local citizens and students were well-prepared for the event due to yearlong outreach effects by Professor Angela Speck.

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The department appreciates hearing from alumni and friends. Send announcements or milestones to the address listed above.

Eclipse Day at Mizzou