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Astronomy in the News

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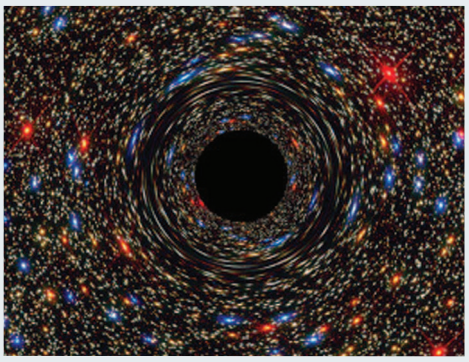
SUPERMASSIVE BLACK HOLES MAY BE LURKING EVERYWHERE IN THE UNIVERSE

APRIL 6, 2016–Bob Sanders, Media Relations

A near-record supermassive black hole discovered in a sparse area of the local universe indicate that these monster objects — this one equal to 17 billion suns — may be more common than once thought, according to UC Berkeley astronomers.

Until now, the biggest supermassive black holes — those with masses at or near 10 billion times that of our sun — have been found at the cores of very large galaxies in regions loaded with other large galaxies. The newly discovered black hole is in a galaxy, NGC 1600, in the opposite part of the sky from the Coma Cluster in a relative desert, said lead discoverer Chung-Pei Ma, a UC Berkeley professor of astronomy and head of the Massive Survey, a study of the most massive galaxies in the local universe with the goal of understanding how galaxies form and grow supermassive. While finding a gigantic black hole in a

Continued on page 2



Black holes bend light like a lens, distorting the stars behind them, as portrayed in this simulation. The black center represents the event horizon of the black hole, from which nothing, not even light, can escape.

LONG-TERM, HI-RES TRACKING OF ERUPTIONS ON JUPITER'S MOON IO

OCTOBER 20, 2016–Bob Sanders, Media Relations

Jupiter's moon Io continues to be the most volcanically active body in the solar system, as documented by the longest series of frequent, high-resolution observations of the moon's thermal emission ever obtained.

Using near-infrared adaptive optics on two of the world's largest telescopes — the 10-meter Keck II and the 8-meter Gemini North, both located near the summit of the dormant volcano Maunakea in Hawaii — UC Berkeley astronomers tracked 48 volcanic hot spots on the surface over a period of 29 months from August 2013 through the end of 2015. Without adaptive optics — a technique that removes the atmospheric blur to sharpen the image — Io is merely a fuzzy ball. Adaptive optics can separate features just a few hundred kilometers apart on Io's 3,600-kilometer-diameter surface.

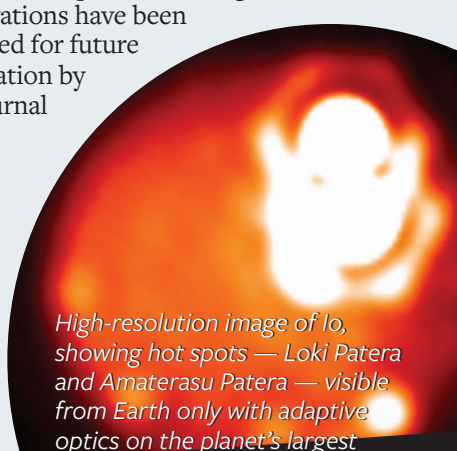
"On a given night, we may see half a dozen or more different hot spots," said Katherine de Kleer, a UC Berkeley graduate student who led the observations. "Of Io's hundreds of active volcanoes, we have been able to track the 50 that were the most powerful over the past few years."

She and Imke de Pater, a UC Berkeley professor of astronomy and of earth and planetary science, observed the heat coming off of active eruptions as well as cooling lava flows and were able to determine the temperature and total power output of individual volcanic eruptions. They tracked their evolution over days, weeks and sometimes even years.

Interestingly, some of the eruptions appeared to progress across the surface over time, as if one triggered another 500 kilometers away.

"While it stretches the imagination to devise a mechanism that could operate over distances of 500 kilometers, Io's volcanism is far more extreme than anything we have on Earth and continues to amaze and baffle us," de Kleer said.

De Kleer and de Pater discussed their observations at a media briefing on Oct. 20 during a joint meeting of the American Astronomical Society's Division for Planetary Sciences and the European Planetary Science Congress in Pasadena, California. Papers describing the observations have been accepted for future publication by the journal Icarus.



High-resolution image of Io, showing hot spots — Loki Patera and Amaterasu Patera — visible from Earth only with adaptive optics on the planet's largest telescopes, Keck and Gemini.

(Image courtesy of NASA, ESA, and D. Coe, J. Anderson, and R. van der Marel (STScI))

CONTENTS

WHAT HAPPENED AFTER THE LIGHTS CAME ON IN THE UNIVERSE?

SEPTEMBER 14, 2016–Bob Sanders, Media Relations

An experiment to explore the aftermath of cosmic dawn, when stars and galaxies first lit up the universe, has received nearly $10 million in funding from the National Science Foundation to expand its detector array in South Africa.

The experiment, an international collaboration called the Hydrogen Epoch of Reionization Array, or HERA, currently has 19 14-meter (42-foot) radio dishes aimed at the southern sky near Carnarvon, South Africa, and will soon up that to 37. The $9.5 million in new funding will allow the array to expand to 240 radio dishes by 2018.

Led by UC Berkeley, HERA will explore the billion-year period after hydrogen gas collapsed into the first stars, perhaps 100 million years after the Big Bang, through the ignition of stars and galaxies throughout the universe. These first brilliant objects flooded the universe with ultraviolet light that split or ionized all the hydrogen atoms between galaxies into protons and electrons to create the universe we see today.

The HERA array in South Africa consisted of 19 dishes on March 7, 2016, but continues to grow, replacing an earlier experiment called PAPER (small dishes in the background). (Images courtesy of the HERA team)

"The first galaxies lit up and started ionizing bubbles of gas around them, and soon these bubbles started percolating and intersecting and making bigger and bigger bubbles," said Aaron Parsons, a UC Berkeley associate professor of astronomy and principal investigator for HERA. "Eventually, they all intersected and you got this über bubble, leaving the universe as we observe it today: Between galaxies the gas is essentially all ionized."

That's the theory, anyway. HERA hopes for the first time to observe this key cosmic milestone and then map the evolution of reionization to about 1 billion years after the Big Bang.

"We have learned a ton about the cosmology of our universe from studies of the cosmic microwave background, but those experiments are observing just the thin shell of light that was emitted from a bunch of protons and electrons that finally combined into neutral hydrogen 380,000 years after the Big Bang," he said. "We know from these experiments that the universe started out neutral, and we know that it ended ionized, and we are trying to map out how it transitioned between those two."

"Before the cosmic dawn, the universe glowed from the cosmic microwave background radiation, but there weren't stars lighting up the universe," said David DeBoer, a research astronomer in UC Berkeley's Radio Astronomy Laboratory. "At some point the neutral hydrogen seeded the stars and black holes and galaxies that relit the universe and led to the epoch of reionization."

The HERA array, which could eventually expand to 350 telescopes, consists of radio dishes staring fixedly upwards, measuring radiation originally emitted at a wavelength of 21 centimeters – the hyperfine transition in the hydrogen atom – that has been redshifted by a factor of 10 or more since it was emitted some 13 billion years ago. The researchers hope to detect the boundaries between bubbles of ionized hydrogen – invisible to HERA – and the surrounding neutral or atomic hydrogen.

By tuning the receiver to different wavelengths, they can map the bubble boundaries at different distances or redshifts to visualize the evolution of the bubbles over time.

"HERA can also tell us a lot about how galaxies form," Parsons said. "Galaxies are very complex organisms that feed back on themselves, regulating their own star formation and the gas that falls into them, and we don't really understand how they live, especially at this early time when flowing hydrogen gas ends up as complex structures with spiral arms and black holes in the middle. The epoch of reionization is a bridge between the cosmology that we can theoretically calculate from first principles and the astrophysics we observe today and try to understand."

UC Berkeley's partners in HERA are the University of Washington, UCLA, Arizona State University, the National Radio Astronomical Observatory, the University of Pennsylvania, the Massachusetts Institute of Technology, Brown University, the University of Cambridge in the UK, the Square Kilometer Array in South Africa and the Scuola Normale Superiore in Pisa, Italy.

Other collaborators are the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, the University of KwaZulu Natal, the University of Western Cape and Rhodes University, all in South Africa, and California State Polytechnic University in Pomona.

SUPERMASSIVE, continued from page 1

massive galaxy in a crowded area of the universe is to be expected–like running across a skyscraper in Manhattan–it seemed less likely they could be found in the universe's small towns.

"Rich groups of galaxies like the Coma Cluster are very, very rare, but there are quite a few galaxy groups the size of NGC 1600 and its satellites," Ma said. "So the question now is, 'Is this the tip of an iceberg?' Maybe there are a lot more monster black holes out there that don't live in a skyscraper in Manhattan, but in a tall silo somewhere in the Midwestern plains."

Ma and her colleagues will report the discovery of the black hole, which is located about 200 million light-years from Earth in the direction of the constellation Eridanus, in the April 6 issue of the journal Nature.

UNIVERSE EXPANDING FASTER THAN EXPECTED

JUNE 2, 2016–Bob Sanders, Media Relations

Astronomers have obtained the most precise measurement yet of how fast the universe is expanding, and it doesn't agree with predictions based on other data and our current understanding of the physics of the cosmos.

The discrepancy–the universe is now expanding 9 percent faster than expected–means either that measurements of the cosmic microwave background radiation are wrong, or that some unknown physical phenomenon is speeding up the expansion of space, the astronomers say.

"If you really believe our number–and we have shed blood, sweat and tears to get our measurement right and to accurately understand the uncertainties–then it leads to the conclusion that there is a problem with predictions based on measurements of the cosmic microwave background radiation, the leftover glow from the Big Bang," said Alex Filippenko, a UC Berkeley professor of astronomy and co-author of a paper announcing the discovery.

"Maybe the universe is tricking us, or our understanding of the universe isn't complete," he added.

The cause could be the existence of another, unknown particle — perhaps an often-hypothesized fourth flavor of neutrino — or that the influence of dark energy (which accelerates the expansion of the universe) has increased over the 13.8 billion-year history of the universe. Or perhaps Einstein's general theory of relativity, the basis for the Standard Model, is slightly wrong.

"This surprising finding may be an important clue to understanding those mysterious parts of the universe that make up 95 percent of everything and don't emit light, such as dark energy, dark matter and dark radiation," said the leader of the study, Nobel laureate Adam Riess, of the Space Telescope Science Institute and Johns Hopkins University, both in Baltimore. Riess is a former UC Berkeley post-doctoral fellow who worked with Filippenko.

The results, using data from the Hubble Space Telescope and the Keck I telescope in Hawaii, will appear in an upcoming issue of the Astrophysical Journal.

A Hubble Space Telescope image of the galaxy UGC 9391, one of the galaxies in the new survey. UGC 9391 contains the two types of stars – Cepheid variables and a Type 1a supernova – that astronomers used to calculate a more precise Hubble constant. Click on the image to see the red circles that mark the locations of Cepheids. The blue "X" denotes the location of supernova 2003du, a Type Ia supernova. The observations for this composite image were taken between 2012 and 2013 by Hubble's Wide Field Camera 3. (Image by NASA, ESA, and A. Riess [STScI/JHU])

BREAKTHROUGH LISTEN TO SEARCH FOR INTELLIGENT LIFE AROUND WEIRD STAR

OCTOBER 25, 2016—Bob Sanders, Media Relations

Andrew Siemion, Director, Berkeley SETI Research Center

Tabby's star has provoked so much excitement over the past year, with speculation that it hosts a highly advanced civilization capable of building orbiting megastructures to capture the star's energy, that UC Berkeley's Breakthrough Listen project is devoting hours of time on the Green Bank radio telescope to see if it can detect any signals from intelligent extraterrestrials."The Breakthrough Listen program has the most powerful SETI equipment on the planet, and access to the largest telescopes on the planet," said Andrew Siemion, director of the Berkeley SETI Research Center and co-director of Breakthrough Listen. "We can look at it with greater sensitivity and for a wider range of signal types than any other experiment in the world."

Breakthrough Listen, which was created last year with funding over 10 years from the Breakthrough Prize Foundation and its founder, internet investor Yuri Milner, won't be the first to search for intelligent life around this star.

"Everyone, every SETI program telescope, I mean every astronomer that has any kind of telescope in any wavelength that can see Tabby's star has looked at it," he said. "It's been looked at with Hubble, it's been looked at with Keck, it's been looked at in the infrared and radio and high energy, and every possible thing you can imagine, including a whole range of SETI experiments. Nothing has been found."

While Siemion and his colleagues are skeptical that the star's unique behavior is a sign of an advanced civilization, they can't not take a look. They've teamed up with UC Berkeley visiting astronomer Jason Wright and Tabetha Boyajian, the assistant professor of physics and astronomy at Louisiana State University for whom the star is named, to observe the star with state-of-the-art instruments the Breakthrough Listen team recently mounted on the 100-meter telescope. Wright is at the Center for Exoplanets and Habitable Worlds at Pennsylvania State University.

Siemion, Wright and Boyajian traveled to the Green Bank Observatory in rural West Virginia to start the observations, expecting to gather around 1 petabyte of data over hundreds of millions of individual radio channels.

"The Green Bank Telescope is the largest fully steerable radio telescope on the planet, and it's the largest, most sensitive

Continued on page 9

From the Chair's Desk

If you have not yet visited New Campbell Hall, you should: this beautiful, safe, modern, LEED-certified building, brought to us — on schedule — by the unstinting efforts of our previous Department Chair Imke de Pater, has been our proud and happy home for the past two years. Here we have enjoyed Summer Department Lunches on the 6th floor roof and lounge; slaved away at Astro 120 and 121 in the 5th floor Undergraduate Labs; built supercomputers out of paper clips in Professor Aaron Parsons's 4th floor Radio Astronomy Lab; searched for extraterrestrial life from the swanky 3rd floor offices of Breakthrough SETI; carved out a new optical instrumentation lab on the 2nd floor for one of our newest faculty members, Professor Jessica Lu; and taught record numbers of astrophysics majors in our 1st floor classrooms.

We have welcomed not only Jessica Lu but also Dan Weisz to our faculty ranks. Jessica is among that most rarefied class of observers, those with extensive understanding of the technologies that underlie all astronomical discoveries; as such, she is a generalist, ready to go anywhere in the universe that her instruments and adaptive optics expertise will take her, from free-floating stellar-mass black holes to young stars orbiting the Galactic Center. Dan is the premier observer in the blossoming field of "near-field cosmology"—the use of nearby stellar populations to understand the formation of stars and galaxies across cosmic time—and has led deep mining expeditions of Hubble Space Telescope and Keck data using statistically sophisticated tools that draw on his intimate knowledge of stellar life-cycles. We are exceptionally fortunate that these two brilliant scientists and teachers have joined our Department.

This past year has seen an unprecedented degree of communication and coordination between administrators, staff, faculty, postdocs, students, and the public in advancing our research and teaching missions. With our new "Small Council" meetings (yes, "Game of Thrones" makes for instant common ground) that regularly bring together representatives from all constituencies, we have worked to open all of Campbell Hall to all undergraduate majors; funded Department activities from Colloquium Tea to Astro CDS (Career Development Series); and addressed issues ranging from the role of the GRE in graduate admissions, to faculty hiring, to the use policy of the undergraduate research lab. Drawn from an equally broad cross-section of Campbell Hall residents are the new Astronomy Climate Advisors who have worked tirelessly to raise awareness of issues related to gender equity and inclusion through one-on-one interventions, a Department-wide survey, and Town Hall discussions. And in our Astrophysics Roundtables and Evenings with the Stars programs—opportunities to thank our generous donors on whom we critically depend—we have showcased, for the first time, students and postdocs and their world-class research.

...“Small Council” meetings (yes, “Game of Thrones” makes for instant common ground)...

Consider coming to one of our monthly Astro Nights which exemplify the highest ideals of our University and the Astronomy Department in particular. Created by our ever enterprising and supremely self-organized graduate students—especial thanks to Carina Cheng and Lea Hirsch—it features free public lectures from faculty, postdocs, and graduate students, followed by an opportunity to stargaze using the Treffers rooftop telescope with enthusiastic and knowledgeable student guides. I can think of no finer crew for a voyage of discovery through the Universe, and no finer Department to chair.

Eugene Chiang

Getting to Know

A Q&A WITH OUR NEWEST MEMBER OF THE ASTRONOMY FACULTY, JESSICA LU

You are a professor of astrophysics—how would you describe your everyday job?
Everyday, I have the pleasure of working with some of the brightest and most capable students and colleagues on difficult puzzles to help us understand the universe. I work with computers, statistics, mathematics, and data visualization and I read extensively to keep up with research going on around the world. While I spend more time than I would care to admit writing proposals, managing money, people, and projects, and running meetings, I still spend at least some time every day in problem solving and creative thinking.

What drew you to astronomy?
Astronomy is often a visual science and I have a strong spatial learning style and awareness. I also like being a modern day explorer and having the freedom to come up with new questions to pursue.

Some of your areas of expertise include adaptive optics and astrometry. What do those mean?
Have you noticed that stars twinkle? Our Earth's precious atmosphere is actually quite pesky for astronomers. Our atmosphere is windy and turbulent and blurs our view of the stars just as a penny is blurred at the bottom of a fast-running stream. Adaptive optics is a technological innovation that removes much of this blurring and enables the largest ground-based telescopes to deliver images just as sharp as if they were in space. Adaptive optics requires very fast and low-noise cameras to sense the aberrations in the wave-fronts of light, deformable mirrors that change shape on milli-second timescales to correct the wave-front, and high-powered real-time computers to process the wave-front sensor data and calculate the commands needed to drive the deformable mirror to the right shape. Adaptive optics requires a bright "guide" star to measure the irregular wave-fronts and when a natural star is not available, we make our own artificial star using a laser to excite a thin layer of neutral sodium atoms, deposited by micro-meteorites, at 90 km above the Earth's surface.

Astrometry is measuring the positions and motions of stars on the sky. Astrometry is a very powerful technique; but it is extremely difficult to measure precisely and I spend a lot of time working on new techniques and methods for improving astrometry in crowded star fields.

Continued on page 5

JESSICA LU, continued from page 4

What projects are you working on now?
My students and I are working on using adaptive optics in a number of areas of astrophysics. We are looking for free-floating black holes in our Galaxy using "astrometric microlensing" where the black hole's gravity acts as a lens to bend the light of a background star. As a result, the background star appears to move in an elliptical pattern on the sky (rather than a straight line) and the size of this effect lets us weigh the mass of the lens and determine if it is a black hole. We are also working on how stars are born in extreme environments such as in the most massive star clusters and around the supermassive black hole at the Galactic Center — environments very different from the neighborhood around the Sun. And we are working on advances in adaptive optics, including pushing to very large fields of view or improving the quality of science measurements that can be extracted from current adaptive optics systems.

What/where are the tools you use for your research?
I use large ground-based telescopes, such as those at the W. M. Keck Observatory in Hawaii, equipped with adaptive optics. I also use the Hubble Space Telescope.

What scientific discovery or advance would you like to see in your lifetime?
There are many scientific discoveries I hope to see in my lifetime including: understand what black holes really are and how they are made, develop a theory of star and planet formation that accurately predicts what we observe in the universe. However, my biggest hope is that we continue to build new telescopes and more advanced instruments as new technology often leads to unpredicted discoveries that we couldn't even imagine in advance.

If you weren't a professor, what would you be doing/studying, etc?
In high school, I was a fairly serious ballet dancer so I might have taken a very different path in the arts. I also worked as a software engineer in silicon valley for several years prior to graduate school; so I would also enjoy working on software infrastructure for science and art.

How can we encourage more women to enter the sciences?
We can offer good role models and an inclusive science-learning environments to children at young ages. At the university level, we can educate ourselves and our students (who include the next generation of scientists and science educators) on how to accommodate diverse learning styles, how to foster inclusion in the classroom and research lab, and the benefits to science if we do.

Best things (other than Astro) about being at Berkeley?
I enjoy living on a coast and I look forward to sailing and paddling on the bay, hikes with great water views, and enjoying seafood from the Pacific coast.

What keeps you inspired?
There is so much we don't know about the universe we live in that it is easy to be inspired! If I need an inspiration boost, I read a few new science papers, look at some new images from the Hubble or Keck telescopes, or watch a science-fiction movie set in space. I also have a young daughter and I am often inspired when I talk with her and her friends and classmates about science and see their excitement.

Faculty Awards and Highlights

Chris McKee is the recipient of the prestigious Russell Lectureship for the AAS (American Astronomical Society). Awarded annually, the Russell Lecturer is chosen on the basis of a lifetime of eminence in astronomical research. Professor McKee is honored for his innovative ideas, powerful theoretical insights, and practical models that have had significant impact on many areas of astrophysics.

Imke de Pater has been named a spring recipient of the Oort Professorship from the Leiden Observatory. The Oort Professorship is a highly prestigious international award within the astrophysics community, named for the Dutch astronomy and radio astronomy pioneer who made significant contributions to our understanding of the Milky Way.

Gibor Basri won the Carl Sagan Prize for Science Popularization.

The Sagan prize specifically recognizes and encourages researchers who, "have contributed mightily to the public understanding and appreciation of science." This honor recognizes Basri's 200+ technical papers and advanced efforts at outreach via public lectures, appearances on informational media outlets, and volume of lectures, specifically those to promote careers in science for underserved youth in the Bay Area.

Dan Weisz has been awarded a Humboldt Fellowship to carry out six months of research at the Max Planck Institute for Astronomie in Heidelberg, Germany.

Alex Filippenko was among six UC Berkeley faculty to be elected a member of the American Academy of Arts and Sciences.

Imke de Pater was elected a fellow of the American Geophysical Union (AGU), an honor bestowed on AGU members who have made significant contributions in the study of Earth and space science.

Mariska Kriek's latest paper, entitled, "A massive, quiescent, population II galaxy at a redshift of 2.1" was recently accepted for publication in the journal *Nature*. A corresponding article was published in *New Scientist* magazine and can be found on the department's news page, www.astro.berkeley.edu/news

James Graham and **Paul Kalas** are currently leading one of 16 new NASA funded projects to search for and characterize more efficiently for exoplanets. UC Berkeley is part of the Nexus for Exoplanet System Science initiative and will benefit through Graham's involvement as project scientist for the Gemini Planet Imager (GPI), which can track planets as they move around their stars. A priority of this endeavor will be to focus on the overlap between teams and search techniques in order to maximize effort and make the search for habitable planets more efficient.

Peter Nugent and **Alex Filippenko** were recipients Supernova Cosmology Project Team Breakthrough Prize. Additionally, **Alex Filippenko** received the High-Z Supernova Search Team Breakthrough Prize. The goal of the Breakthrough Prizes is to celebrate scientists and generate interest in the field of science as a career. They are funded by the Brin Wojcicki Foundation, the Silicon Valley Community Foundation, the Jack Ma Foundation, and the Milner Foundation.

Department Welcomes New Faculty Appointments

Jessica Lu arrived in our department in summer 2016. Her research specialties include star and cluster formation, black holes, adaptive optics, galactic centers, astrometry, and infrared instrumentation. Dr. Lu received her undergraduate degree in physics from MIT, and worked as a software engineer in Silicon Valley for three years before returning to academia to pursue her PhD in astronomy and astrophysics from UCLA. She completed research under a Millikan Postdoctoral Fellowship at CalTech, and later went on to a postdoctoral position at the University of Hawaii, Manoa. She remained at UH as a faculty member prior to joining the faculty of Astronomy at UC Berkeley.

Astronomy welcomes **Daniel Weisz**, who joined the department as Assistant Professor in July 2016. Dr. Weisz's research interests are focused in three broad categories: the lowest mass galaxies over cosmic time, the interplay between gas and stars in galaxies, and the environmental sensitivity of the stellar initial mass function. Weisz received his undergraduate degree from UC Berkeley and his PhD in Astrophysics from University of Minnesota. As a Hubble Fellow, at both UC Santa Cruz and the University of Washington, he researched novel techniques to combine spectroscopic and photometric observations of stars, star clusters, and galaxies.

RETIREMENTS

Carl Heiles

After 49 years as a pillar of the Astronomy Department, Professor Carl Heiles officially retired in June 2015, simultaneously stepping down as Director of the Radio Astronomy Lab. During his tenure on faculty, Professor Heiles was a preeminent radio astronomer with broad-reaching interests in interstellar matter, particularly in understanding the diffuse interstellar gas and magnetic fields through research and observation of the 21-cm hydrogen line. In recent years he has developed calibration techniques for single-dish spectral and polarization measurement.

He was a recipient of the Heineman Prize for outstanding work in astrophysics (1989), the Noyce Prize for Excellence in Undergraduate Teaching (2002), and is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the California Academy of Sciences.

As Emeritus Professor, Heiles continues his research mapping Galactic hydrogen using the Arecibo, Green Bank, and Chinese FAST telescopes, and taught the Undergraduate Radio Astronomy Lab course in the spring of 2016--a course he began with Dr. David Cudaback more than 20 years ago that won the Berkeley Campus Educational Initiative Award in 1995.

Gibor Basri

Professor Gibor Basri retired in December 2015 after over 33 years of dedicated service on the UC Berkeley campus. This includes 8 years as Berkeley's first Vice Chancellor for Equity and Inclusion.

As a faculty member in Astronomy, Basri's research focused on stars, stellar activity, star formation, and low mass objects. He was an early pioneer and widely recognized world expert in the study of brown dwarfs. In 2001, NASA selected the Kepler mission, of which Basri served as co-PI, to discover extrasolar terrestrial planets, and characterize inner extrasolar planetary systems. This mission successfully evidenced that planets are very common around stars.

Appointed VC after an extensive nationwide search, Basri grew Equity & Inclusion from a three-person office to a thriving division of over 150 staff, with over $20 million in annual revenue. He spearheaded one of the most comprehensive initiatives on promoting diversity through institutional change, via the UC Berkeley Strategic Plan for Equity, Inclusion and Diversity: Pathway to Excellence. In addition to buoying the Division through the 2008 budget crisis (preserving student services and moving forward on implementation of its initiatives), he saw the Division exceed its $40 million fundraising goal. He was instrumental in launching the Haas Institute for a Fair & Inclusive Society, whose research clusters explore pressing societal issues related to marginalized populations.

After stepping down in 2015, he was awarded the Berkeley Citation, campus' highest honor, in recognition of his pioneering research, mentorship, and extensive efforts at science education and outreach in the wider community to encourage the participation of minorities in science. Basri continues to be an effective instructor and mentor in his post-retirement appointment as Professor of the Graduate School.

Leo Blitz

Professor Blitz retired in 2016 after a long career at Berkeley as an observational astrophysicist, specializing in galaxy formation and evolution. His research contributed greatly to the field's understanding of star formation, galactic structure, and galactic dynamics in the Milky Way and distant galaxies. During his 20-year tenure as Professor of Astronomy, Blitz served as Director of the Radio Astronomy Lab (RAL) from 1996 through 2008. His leadership and work with RAL was instrumental in the creation of several groundbreaking developments in the field, including the merging of the Berkeley-Illinois-Maryland (BIMA) millimeter-wave array with the Owens Valley millimeter-wave array to form the 15-element CARMA Combined Array for Research in Millimeter-Wave Astronomy in the Inyo Mountains.

Blitz published 154 articles in refereed journals, 80 articles in conference proceedings, and 20 popular and semi-popular articles; edited 6 books; and wrote a lab manual for introductory astronomy. In 1991, he was featured in the six-part PBS series "The Astronomers." As Professor of the Graduate School, Blitz will continue to mentor and complete research on galaxy formation and evolution.

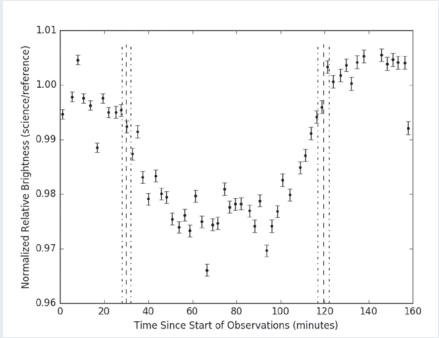
Leuschner Observatory Update

The Leuschner Observatory, part of the Astronomy Department's arsenal of research and teaching equipment, continues to receive attention from its hidden home in the hills above Lafayette, CA.

A feature article in the July 2015 Lamorinda Weekly was followed by another short review in the Lafayette Weekly in February 2016, introducing this wonderful little gem to the community, many of whom had no idea it sits right in their backyard.

As the department continues to review and map out much needed upgrades and repairs to the observatory's infrastructure, students in the Astronomy 120 lab, taught this semester by Gaspard Duchene, have been accomplishing great things using the 30" telescope at Leuschner. Thanks to the hard work and ingenuity of our lab engineer, Frank Latora, students this semester were able to measure the transit light of an exoplanet.

In an image captured by student Melissa Marquette, we see the apparent brightness of the nearby Sun-like star HD 189733 in the V band (0.55 micron) over the course of a little under 3h, each data point being the average of 12 individual exposures with the Leuschner CCD. The vertical dashed lines mark the beginning and end of the transit of the planet (which lasts about 1.5h). Outside of these lines, we see the "normal" brightness of the star, normalized to 1 for visual purposes. In between the two lines, the star appears to dim by about 2.5% because the planet, roughly 10% bigger than Jupiter, blocks that much of the star. Because of it's proximity to the Berkeley campus and ideal location high above city lights and the fog line, plans are currently underway for various repairs and updates that will allow the observatory to continue operating as a hands-on research tool for UC Berkeley astronomy students and possibly as a community resource. One project, already underway, involves upgrading the image feeds that send data from the telescopes located at Leuschner back to the labs in Campbell Hall on campus. To accomplish this upgrade, lab engineer Frank Latora, along with time and effort donated by Gary Brandt of Conco Pumping, replaced several conduit posts that will provide a consistent and stronger power source between the feed and the domes.



To contribute to the mission of Leuschner, consider a gift to the Student Observatory Fund. For more information, please visit the Astronomy website: http://astro.berkeley.edu/research-facilities.

Guests Attend Evening with the Stars, featuring Alex Filippenko

The department hosted our spring Evening with the Stars in March, featuring a lively talk by Alex Filippenko and his research group. Attendees arrived to partake in cocktails and hors d'oeuvres while mingling with Astronomy Department faculty, including Eliot Quataert, Jack Welch, and other notable researchers.

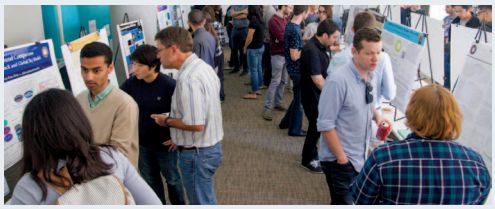
This year's lecture was focused on our increasing knowledge about the origins and evolution of the universe, dramatically expanding our understanding of such topics as supernovae, dark matter, dark energy, and gravitational lensing. Professor Filippenko began with a short introduction explaining efforts underway to comprehend how stars explode and how to use them for cosmology, before inviting various members of his group to present their extraordinary results obtained through research.

Alex Filippenko is the Richard & Rhoda Goldman Distinguished Professor in the Physical Sciences. His accomplishments, documented in about more than 800 research papers, have been recognized by several major prizes, and he is one of the world's most highly cited astronomers. He has also won the top teaching awards at UC Berkeley and has been voted the "Best Professor" on campus a record 9 times. He has produced five astronomy video courses with "The Great Courses," coauthored an award winning textbook, and appears in numerous TV documentaries including about 50 episodes of "The Universe" series.

Speaker Alex Filippenko talks with guests

Undergrad Research Symposium

In July, Astronomy undergraduate students presented their research projects at a summer symposium held in Campbell Hall. The session was an opportunity for students to interact with department postdocs, researchers, and faculty and to learn more about the varied research projects that take place in the department.



Welcome to our newest Graduate Students

The Astronomy community is excited to welcome several new graduate students to the department!

FALL 2015

Saundra Albers, received her B.S. in Astrophysics from UCLA, Los Angeles, CA. Her interests are galaxy formation and evolution, adaptive optics, stellar populations.

Max Genecov, received a B.S in Astrophysics and Non-Fiction Writing Honors in English from Brown University, Providence, Rhode Island. His research interests are in observational astroparticle physics, gamma ray bursts and observational cosmology.

Deepthi Gorthi, received her B.A. in Electronics and Electrical Engineering & Master of Science in Physics from the Birla Institute of Technology and Science, Pilani Rajasthan India. She is interested in radio astronomy instrumentation, dark matter, large-scale structure formation.

Nicholas Kern, received his B.S. in Astronomy and Physics from the University of Michigan, Ann Arbor, Michigan. His interests are in cosmology through large-scale structure and galaxy clustering: observational and theoretical approaches, radio astronomy: observations and instrumentation.

Alexander Krolewski, received a B.A. in Astrophysics and Physics from Harvard University, Cambridge, Massachusetts. He is interested in observational cosmology, extragalactic astronomy, theoretical astrophysics.

Michael Medford, received his B.S. in Communication, Physics and Theatre from Northwestern University, Evanston, Illinois. He brings an interest in observational cosmology, specifically dark energy, cosmic microwave background and large-scale structure.

Katherine Suess, received her B.A. in Physics from University Colorado Boulder, Boulder, Colorado. Her interests are in galaxy formation and evolution, cosmology, large-scale structure.

FALL 2016

Fatima Abdurrahman received her B.S. in physics, and astronomy, and a B.A in Arabic studies from the University of Maryland, College Park, College Park, Maryland. Her research interests are hosmology, High-energy astrophysics, stellar astrophysics.

Kareem El-Badry received his BS in Astrophysics from Yale University, New Haven Connecticut. His research interests are galaxy formation and evolution, cosmology, interstellar medium/star formation.

Siyao Jia received her BS in Astrophysics from Peking University, Beijing, China, Peoples Republic. Her research interests are young stars in our galactic center within 0.5pc, especially their dynamical structure and stellar populations.

David Khatami received his BA in Physics from Pomona College, Claremont, CA. His areas of interest are computational/ theoretical astrophysics, galaxy formation, and compact objects.

Kara Kundert received her BS in Honors Astrophysics, Physics from the University of Michigan-Ann Arbor, Ann Arbor, Michigan. Her research interests are cosmology and instrumentation.

Edward (Ned) Molter received his BA in Physics from Macalester College, St. Paul Minnesota. His research interests are in exoplanet atmospheres, galaxy evolution, and Titan.

Spring 2016 Commencement

On May 15th 2016 the Departments of Astronomy and Physics held their joint commencement ceremony in Zellerbach Hall. The Department of Astronomy congratulates our 38 undergraduate students receiving their A.B. degrees, two graduate students who have completed their Master's, and four PhD recipients for the 2015-16 academic year. Dr. Xiaowei Zhuang, the David B. Arnold Jr. Professor of Science at Harvard University, gave the commencement speech. Making this year's commencement even more meaningful, we celebrated our graduates and their families with a brunch in beautiful Campbell Hall. Prizes and awards were announced during brunch – it was a great way to end the academic year!

M.A. DEGREES • FALL 2015

Jesse Wayne Nims
Jason Jinfei Wang

PH.D DEGREES • SPRING 2016

Francesca Fornasini
Advisers: John Tomsick and Mariska Kriek
The faint, the poor, and the steady: studies of low-luminosity, metal-poor, and non-pulsating populations of high-mass X-ray binaries

Garrett Kent Keating
Adviser: Carl Heiles
The Undiscovered CO: Charting the Molecular Gas of the Early Universe

Aaron Thomas Lee
Adviser: Chris McKee
Star and Planet Formation Through Cosmic Time

Lauren Michelle Weiss
Advisers: Geoff Marcy and Andrew Howard
The Masses, Densities, and Orbital Dynamics of Exoplanets

2016 GRADUATE AWARDS

Uhl Award for outstanding scholarly achievement by a graduate student close to finishing his/her dissertation in Astronomy or in Physics with preference to Astronomy —**Daniel Lecoanet** and **Josiah Schwab**

Trumpler Award in recognition of academic excellence and outstanding record of involvement in the department or wider astronomical community—**Katherine de Kleer**

Outstanding GSI awards—**Jake Duncan, Heidi Fuqua, and Joshua Tollefson**

2016 UNDERGRAD AWARDS

Commencement Speaker—**Mackenzie Moody**

Department Citation for "outstanding scholarship"—**Nathanan Tantivasadakarn**

Klumpke-Roberts for outstanding scholarly achievement—**Kevin Hayakawa**

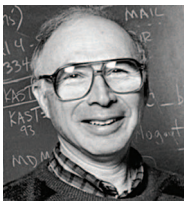
Wark award for astro majors in excellent academic standing—**Diana Kossakowski**

2016 Sackler Lecture Speaker Mike Brown and the Search for Planet Nine

The department hosted its annual Sackler Lecture in September, featuring Professor Mike Brown from Caltech. His mesmerizing talk was centered on recent evidence suggesting that a massive body is lurking at the outskirts of our solar system, far beyond the orbits of the known giant planets. This object, at a distance approximately 20 times further than Neptune and with a mass approximately 5000 times larger than Pluto, is the real ninth planet of the solar system. In his lecture, Brown will talk about the observation that led his team to the evidence for this Planet Nine and discuss how so massive an object could have been hiding in the outer solar system for so long. Finally, he will discuss the international effort to pinpoint this newest member of our planetary family.

Mike Brown is the Richard and Barbara Rosenberg Professor of Planetary Astronomy at the California Institute of Technology, where he specializes in the discovery and study of bodies at the edge of the solar system. Brown received his AB from Princeton and his MA and PhD from UC Berkeley in 1994. Among his numerous scientific accomplishments, he is best known for his discovery of Eris, the most massive object found in the solar system in 150 years, which led to the debate and eventual demotion of Pluto from a real planet to a dwarf planet. In 2006 he was named one of Time Magazine's 100 Most Influential People. He was inducted into the National Academy of Sciences in 2014.

The Raymond and Beverly Sackler Distinguished Lecture in Astronomy is a free annual event made possible by an endowment from Raymond and Beverly Sackler in efforts to bring notable speakers to the Berkeley campus.



IN MEMORIAM Hyron Spinrad

Galactic researcher Dr. Hyron "Hy" Spinrad, 81, passed away on December 7, 2015 in Walnut Creek, CA.

Born in 1934 in Brooklyn, NY, Hyron soon made his way to California, where he later obtained his degree in Astronomy and Ph. D at UC Berkeley, accomplishments that bookmarked his time in the U.S. Army. He joined the Jet Propulsion Laboratory, where he specialized in stellar planet atmosphere compositions, most notably discovering water vapor in the atmosphere of Mars in 1963.

The University of California, Berkeley recruited Hyron as an astronomy professor in 1964, a position he held for the rest of his long career. Hy was known at Cal for his research on stellar composition, formation and evolution of galaxies, and comets. He was elected to the National Academy of Sciences and was honored with the 1986 Heineman Prize for outstanding work in astrophysics. Asteroid 3207 Spinrad was named for him. Even after his retirement in 2005, Hy never lost his passion for teaching astronomy, delivering lectures in the mid-stages of his illness and answering questions from anyone who was curious to learn more about the subjects he loved.

The Department is grateful for Hy's years of never-ending dedication and hard work; he will be immensely missed.

BREAKTHROUGH LISTEN, continued from page 3

telescope that's capable of looking at Tabby's star given its position in the sky," Siemion said. "We've deployed a fantastic new SETI instrument that connects to that telescope, that can look at many gigahertz of bandwidth simultaneously and many, many billions of different radio channels all at the same time so we can explore the radio spectrum very, very quickly."

The results of their observations will not be known for more than a month, because of the data analysis required to pick out patterns in the radio emissions.

Breakthrough Listen is monitoring many other stars using three telescopes that can peer into all segments of the cosmos: the Parkes Telescope in Australia and the Green Bank Telescope to search for radio transmissions, and the Automated Planet Finder at Lick Observatory in California to search for optical laser transmissions.

Free Monthly Lectures and Star Gazing–Astro Nights!

Astro Night is a free stargazing and lecture event open to the public. The monthly event is usually held on the first Thursday of each month (during select months, as weather permits), starting with a lecture and Q&A session, followed by guided stargazings using our fleet of telescopes, including our 17-inch roof-top telescope observatory. Members of the astronomy department are on hand to answer your questions and tell you more about the goings-on in Campbell Hall!

The fall 2016 semester featured lectures given by Professors Imke de Pater, Aaron Parsons, Eliot Quataert, and Alex Filippenko, as well as Miller Fellow Ryan Trainor, and Director of the Breakthrough Listen project, Andrew Siemion. Spring talks will resume in April 2017—details can be found at: http://astro.berkeley.edu/i/astro-night.

UNIVERSITY OF
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DEPARTMENT OF ASTRONOMY
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UPCOMING EVENTS

Evening with the Stars Spring 2017

Cal Day April 16 2017

Commencement May 16, 2017

2017 Raymond and Beverly Sackler Distinguished Lecture in Astronomy Fall 2017

Astronomy Faculty Roundtable Fall 2017

Astro Night Public Lecture and Star Viewing April 2017; first Thursday of each month

Science @ Cal Monthly Lectures
3rd Saturday of each month
UC Berkeley location changes each month
Visit http://scienceatcal.berkeley.edu

Newsletter Credits: *Lochland Trotter, Marissa Dominguez, Eugene Chiang, Robert Sanders*

Photos: *Lea Hirsch, Rayna Helgens, Frank Latora, Gina Spindler*

Support Berkeley Astronomy

On behalf of the faculty, students, and staff we extend our greatest thanks to our friends and donors for helping to preserve and enhance the scholarship, teaching, and research excellence of the Berkeley Astronomy Department.

Berkeley Astronomy is home to world-renowned scientists and researchers and is universally regarded as one of the top astronomy departments in the world. Our award winning faculty and outstanding students are engaged in some of the most fascinating research today– from studying the relationship between planets and moons in our solar system, to discovering new planets, galaxies, and black holes, to creating a road map for exploring the structure of the Universe.

As a friend of the department, you already know the important role private funding has in supporting our endeavors toward excellence. Over the past decade, state funding has continued to decline and the Astronomy Department has increasingly relied on the generosity of our alumni and friends to maintain our mission of award-winning teaching and research. Without the support of our extended family, we would be unable to maintain our standard of providing the best resources for our faculty, researchers and students.

We invite you to make a gift to any of the following funds, each a critical component in the investment of our future. Visit http://give.berkeley.edu/#astronomy to make an online gift, or use the enclosed envelope.

Student Observatory Fund assists with the purchase and maintenance of the latest instrumentation and teaching observatories managed by the Astronomy Department. The fund also provides support for the department's upper-division undergraduate laboratory course - the capstone experience for all astronomy majors.

Friends of Astronomy Fund supports all facets of the department's program budget, from research travel for students, to recruitment of top faculty, to the day-to-day material needs of the classrooms and teaching labs.

Graduate Student Support Fund directly benefits our students. Funding for fellowships is a top priority in the department, as a full year fellowship can cost more than $35,000 and will only continue to increase. Offering student support is one of our best tools for attracting the brightest and most promising students.

Thank you for your generosity!

Did you know–many employers match gifts to UC Berkeley? To discuss matching or other opportunities to support Astronomy at Berkeley, contact Maria Hjelm, Director of Development and College Relations, mhjelm@berkeley.edu.

GO BEARS!