ASTROPHYSICAL AND PLANETARY SCIENCES

Fall 2017 University of Colorado Boulder

From the Desk of the Chair

APS Alumni, Colleagues, and Friends,

We continue to see an influx of new faces in the department. We have two new junior faculty members coming on board soon. Paul Hayne, a planetary scientist with a focus on planetary thermal processes, geophysics, and climate, will join us in January 2018. Maria Kazachenko, a solar physicist working on modeling the corona and understanding the Sun-Earth connection, will join us in Fall 2018.

We also welcome our new Undergraduate Program Assistant Jose Aburto. Jose recently moved to Colorado from Michigan, where he received his B.A. in Public Relations from Northern Michigan University. He replaces Susan Ramirez-Armstrong, who retired from her position after 7 years of service in APS and a long career here at CU Boulder. Her role as "Astro Mom" touched the lives of many students, providing a warm and caring face to our department, and contributed greatly to student recruitment, retention, and success.

Prof. John Stocke retired in May, after a 32-year career at CU Boulder. Prof. Stocke is an extragalactic observer with wide ranging interests. His major contributions include the identification of over a hundred blazars (active nuclei of galaxies with black holes and beamed jets) with the Cosmic Origins Spectrograph (COS) aboard the Hubble Space Telescope. Over the last decade, he has also investigated the star knowledge of ancient and indigenous cultures in the Americas and Australia and shared this information with the public through talks at the Fiske Planetarium and a popular undergraduate course on ancient astronomies.

Also, after 15 of service, Dr. Doug Duncan will retire as Director of Fiske Planetarium this December. His many accomplishments as director include securing funding for an HD digital upgrade of the facility. Fiske Planetarium currently has the highest resolution digital projection system in the nation. Dr. Duncan will continue to teach in the department. Our new director, Dr. John Keller, will join us in January. Dr. Keller is currently an Associate Professor in Physics and Co-Director of the Center for Engineering, Science, and Mathematics Education at Cal Poly. He has a strong background in astronomy education research, outreach, and teacher development, and he has ambitious plans for Fiske.

Our undergraduate program continues to thrive, and we are introducing new courses to give our undergraduates hands-on experience in research and instrumentation development. Prof. Jason Glenn has developed a new astronomical instrumentation class in which students work in teams to design, build, and test a solar spectrometer. Also, we are introducing a new course in research methods for astronomy that will give students experience in developing and executing research projects, from proposal-writing to reporting results. Together with our popular courses on scientific programming and data analysis, we are giving our students broadly applicable skills that prepare them for a range of careers in science, industry, and education.

Nils Halverson
Professor
Chair, APS Department

Congratulations to our 2016-2017 Graduates!

Bachelor of Arts

Nicholas Joseph Alexander
Casey Allan Matthew Backes
Ethan Baker
Tanner Anthony Biglione
Kaleb Michael Bodisch
Michael Bostwick
Zarah Brown
Melissa Jiao Buckley
Travis Patrick Byrne
Christian Michael Carter
Alysa Danielle Derks
Kelly Michelle Enloe
Samuel Esbin
Megan Elizabeth Fitzwater
Michael Joseph Frankovic
Sean Cullen Galvin
Kathleen Gwen Hanley
Jacob Conrad Hermann
Max Christian Hermann
Gerardo Luis Hidalgo-Cuellar
Emily Hill
Elise Marguerite Hobbs
Justin Lee Hoover
Jacob A. Jost
Wallis Kinney
Amanda Jean Koziol
Emily Marie Levis
Haeyoung Lim
Megan Maguire
Christian Carl Mariz
Catherine Elizabeth McNeely
Phillip Menel
Kevin Nadeau
Shannon Barbara Osborne
Katherine June Pellicore
Cameron Tyler Pratt
Tayler Quist
Willow Mae Reed
Lonnie Rickel
Emily Hawthorne Rives
Jason Patrick Ryan
Marvin Tann
Samantha Anne Valenteen
Nicholas Kenneth VanderVegt
Cho Youngbum

Doctor of Philosophy

Matteo Crismani
Christopher Fowler
Katy Goodrich
Keri Hoadley
Bryan Holler
R. O. Parke Loyd
Joshua Moloney
Morgan Rehnberg
Evan Tilton
Allison Youngblood

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Recent Undergraduate Student Awards

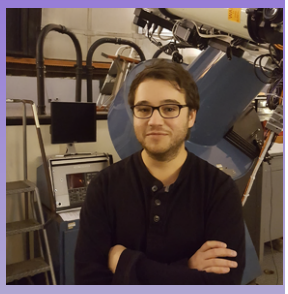
Zarah Brown	Susan E. Wesley Scholarship
Christopher Creery	Scherpenseel Family Scholarship
Elise Hobbs	Susan E. Wesley Scholarship
Zachariah Milby	Susan E. Wesley Scholarship
Katherine Pellicore	Theodore Snow Scholarship

APS Highlights

Dr. Jack Burns

APS Professor Jack Burns was invited to serve on the Presidential Agency Transition Team for NASA last December and January. He functioned as the senior scientist for the so-called "Landing Team," working on a NASA Action Plan for the space and earth sciences for the new Administration. Burns was the first astronomer to be selected for a Presidential Transition Team. The team constructed a roadmap for NASA's next decade and beyond including next generation space-based telescopes, exploration to cis-lunar space and eventually to Mars, new technologies, along with potential restructuring of components of the Agency to facilitate, for example, more collaboration between the human and science programs. The team also drafted a five-year funding outline for NASA that was partially reflected in the recent President's proposed budget.

Zachariah Milby



Zachariah Milby, one of the recipients of the Susan E. Wesley Scholarship, is an APS undergraduate working with Professor Nick Schneider on data from the Imaging UltraViolet Spectrograph (IUVS) on NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) mission to Mars. MAVEN's primary goal is to figure out how most of Mars' atmosphere has disappeared over billions of years. To do so, MAVEN must first understand the workings of Mars' atmosphere today. Zac was recognized for his important role in data analysis of Mars "nightglow," an unusual process in which chemical reactions cause the atmosphere itself to glow at ultraviolet wavelengths. The rate of chemical reactions was expected to vary smoothly over the nightside, but Zac's work has showed waves, splotches, and streaks which underscore our poor understanding of this phenomenon. Zac presented the team's results at the International Mars Aeronomy Conference last May and traveled to the Division for Planetary Sciences conference in October to report on the latest results.

Dan Gole

Dan Gole, this year's recipient of the Ray Mace Smith Fellowship, is a graduate student in APS who has been working with Dr. Jake Simon and Professor Phil Armitage to model the environment of planet formation in disks of gas and dust around young stars. His initial work, in collaboration also with Dr. Steve Lubow of the Space Telescope Science Institute, showed how disk turbulence excites large-scale fluid motions that may affect the speed with which planets grow. He is now following up this study with numerical simulations of the outer regions of protoplanetary disks, in order to make predictions for the level of turbulence that can be measured from sub-mm observations. He is also working to understand how magnetic fields evolve in disks over long time scales and whether changes in the star's magnetic field can trigger outbursts in young stars known as EXors. Dan has been an early and major user of CU's new "Summit" supercomputer, which with 9,120 processor cores, is a powerful tool for simulations of protoplanetary disks and for many other types of astronomical phenomena.

Recent Graduate Student Awards

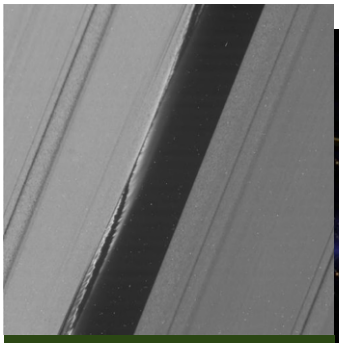
Nicole Arulanantham	NASA Earth and Space Sciences Fellowship in Astrophysics
Eric Coughlin (PhD 2016)	2016 IAU PhD Prize in High-Energy Phenomena and Fundamental Physics
	2017 AAS High-Energy Astrophysics Division Dissertation Prize
Matteo Crismani	Chance Irick Cooke Graduate Fellowship
Addrienne Dove (PhD 2012)	Susan Mahan Niebur Early Career Award
Dan Gole	Ray Mace Smith Graduate Fellowship
	RN Thomas Award
Loren Matilsky	Carl Hansen Graduate Fellowship
Joshua Moloney	APS Award for Excellence in Teaching
Christopher Moore (PhD 2017)	2018 AAS Rodger Doxsey Dissertation Travel Prize
David Schenck	APS Award for Excellence in Teaching
Avery Schiff	NSF Graduate Research Fellowship
Aaron Stemo	NSF Graduate Research Fellowship
Samantha Walker	NASA Earth and Space Sciences Fellowship in Astrophysics
	NSF Graduate Research Fellowship

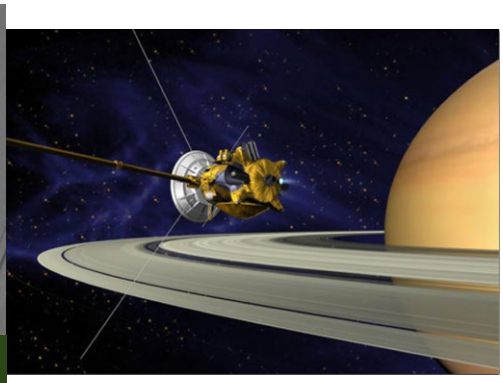
Recent Faculty & Post-Doctoral Researcher Awards

Daniel Baker	Governor's Award for High-Impact Research in Earth Systems and Space Sciences
David Brain	Provost's Faculty Achievement Award
Doug Duncan	Chancellor's Award for Excellence in STEM Education
Seth Hornstein	Chancellor's Award for Excellence in STEM Education
Nick Schneider	NASA Exceptional Scientific Achievement Medal

Cassini's Fiery Finish *by Dr. Larry Esposito*

NASA's Cassini spacecraft orbited Saturn since 2004, exploring the planet, its moons and rings, and the not-quite empty space around them. The mission – launched in 1997 – ended on September 15, 2017 when the spacecraft dove into Saturn's atmosphere and burnt up like a meteor.





Cassini image which shows places where the rings are torn apart by the gravity of nearby moons.

The grand finale began with close flybys of Saturn's F ring, followed by 22 orbits inside the rings where no spacecraft has travelled before. Cassini gathered unprecedented information on the internal structure of Saturn, its magnetic field, and the total amount of material in the rings, providing clues to its mysterious origin … and the formation of planets elsewhere.

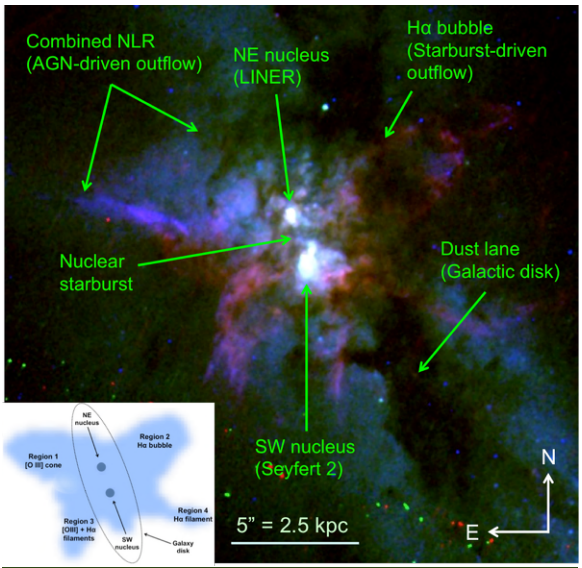
Cassini discovered amazing structures within Saturn's rings and on its moons. The LASP-built and controlled Ultraviolet Imaging Spectrograph (UVIS) – one of 12 Cassini instruments – made many of those discoveries. Just before the mission ended, UVIS observed the aurora at Saturn's poles with the closest views ever orchestrated.

Mission discoveries include: oxygen, hydrogen, methane, acetylene, and ethane in the Saturn system; Titan's abundance of hydrocarbon lakes; Enceladus's geysers that erupt into space from warm, salty, subsurface water; giant, long-lasting storms in Saturn's atmosphere; and mountain-sized clumps in Saturn's rings.

Cassini sent data throughout its final plunge, while scientists at NASA's Jet Propulsion Laboratory waited for the final signal. In reflection, quoting Goethe's tragedy Faust, where Mephistopheles tells the ever-curious Faust "all that exists is worthy to perish." This fiery, final plunge marks a worthy end for Cassini, one that will allow scientists to take more risks in order to uncover some of Saturn's long-held mysteries.

Dissecting the Butterfly: Dual Outflows in NGC 6240 *by Dr. Francisco Müller-Sánchez*

Nature's most powerful objects are supermassive black holes at the centers of galaxies known as active galactic nuclei (AGN). An active black hole may interact with its host galaxy by means of "feedback" in the form of outflowing winds or jets. At the same time, stellar winds and supernova explosions also influence the evolution of a galaxy. Current theories of galaxy evolution invoke some kind of feedback (from the stars or the supermassive black hole) to explain the properties of galaxies. However, numerical simulations and observations have not been able to evaluate the real impact of feedback in galaxies; largely because most studies have focused on studying stellar feedback or AGN feedback alone, instead of considering the combined effect of both.



Three-color composite image of HST Hα (red), [O III] (blue), and V-band continuum (green) emission in NGC 6240. The inset shows the morphological structures identified in the butterfly-shaped region of NGC 6240 using HST narrow-band filters.

An international team led by CASA's research associate Dr. Francisco Müller-Sánchez, and involving Prof. Julie Comerford and graduate student Rebecca Nevin studied the nearby (about 350 million light-years) star-forming galaxy NGC 6240 and discovered a dual outflow of different species of gas: an AGN-driven outflow of highly-ionized gas to the northeast and a starburst-driven outflow of ionized hydrogen to the northwest. The team used images from the Hubble Space Telescope, optical long-slit spectra from the Dual Imaging Spectrograph at the Apache Point Observatory, and adaptive optics-assisted integral-field spectra from the instrument SINFONI at the Very Large Telescope.

"This is the first time that these two spectacular phenomena are simultaneously observed in a galaxy," says Dr. Müller-Sánchez, who led the investigation. The ionized gas in this region has a peculiar, disturbed morphology, which resembles a butterfly. This morphology is the result of a galactic merger between two massive galaxies. When the two galaxies came together, their supermassive black holes did so too. Furthermore, the merger enhanced the production of stars in the central region. The dual AGN and the nuclear starburst ensure ample activity for driving substantial feedback.

The orientation and position of the outflows in the sky allowed the astronomers to isolate them spatially and study their properties independently. The AGN-driven outflow has a conical geometry and a maximum velocity of 350 km/s. The starburst-driven outflow resembles an expanding bubble with a maximum velocity of 380 km/s. The research team performed detailed data analysis and found that the AGN-driven outflow is approximately four times more powerful than the starburst-driven outflow, which indicates that that the dual AGN contribution to the evolution of the merger remnant and the formation of outflowing winds is significant in the central region of NGC 6240.

These results provide the much-needed guidance to observations and theoretical models on what processes are dictating the co-evolution of black holes and their host galaxies. Specifically, this study provides the first observational constraints on the combined effects of stellar and AGN feedback in galaxies.

APS Members Help Chase Down New Horizons Target *by Dr. Charles Danforth*

After its successful flyby of Pluto in 2015, the New Horizons probe has been directed to fly past another iceball in the outer solar system on January 1st, 2019, known as 2014 MU69. However, little is known about this object besides its orbit (about 45 AU from the Sun) and brightness (which implies a size of 20-40 km). Small KBOs like MU69 are thought to be pristine left-overs from the dawn of the solar system … and have never been observed up-close before!

In preparation for the 2019 encounter, the Southwest Research Institute in Boulder organized a series of astronomical expeditions to several locations in the southern hemisphere to observe MU69 passing in front of a star and, briefly, blocking out the starlight. Shadows like this give information about objects such as physical size, shape, surface reflectivity, and the presence of moons or rings.

Nine APS-affiliated scientists – faculty members Doug Duncan and Charles Danforth, research scientist Brian Keeney (PhD 2007), recent graduates Christian Carter ('17) and R. J. Smith ('16), and current undergraduates Sam Strabala, Alex Rolfsmeier, Sean Moss, and Alison Friedli – joined a team of fifty professional and amateur astronomers for the June 3rd expedition. They were split between two southern hemisphere locations (Mendoza, Argentina, and Clanwilliam, South Africa) where they deployed a set of two dozen large portable telescopes across a few hundred kilometers to catch the fleeting KBO shadow. Despite equipment concerns, wild animals, concern over big game poachers, weather uncertainty, and any number of other unexpected complications, all teams managed to successfully observe during the occultation. Unfortunately, no shadow was detected.

R.J. Smith and his observing team prepare their trusty 16" telescope for a night of observations in South Africa. (Photo credit: R.J. Smith)

Many of the same APS team members traveled to Comodoro Rivadavia, a city in southern Argentina for a second occultation event on July 17th. Using skills honed in the first occultation expedition as well as lots of local support from the Argentinian military and local governmental authorities, teams deployed telescopes in the freezing, windy Patagonian night and managed to capture the shadow of MU69 from five different telescopes.

Observations from both expeditions as well as those from NASA's airborne SOFIA telescope and the Hubble Space Telescope are being analyzed at SWRI and will help in understanding a previously unobserved type of object in our solar system.

You can make a gift to APS easily through the CU Foundation at http://www.colorado.edu/aps/support-us or the APS website at http://www.colorado.edu/aps. If you have questions or need further assistance, please contact the APS office directly at (303) 492-8915 or the Advancement Office for the College of Arts and Sciences at (303) 541-1480.

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