



THE UNIVERSITY OF ARIZONA
COLLEGE OF SCIENCE

LUNAR & PLANETARY LABORATORY

FALL 2021

LPL NEWSLETTER

Comet C/2021 A1 Leonard moves past the Whale and Hockey Stick galaxies. November 25, 2021. Image: Michael Jäger.

Catalina Sky Survey Tops off 2021 with a Rare Bright Comet Discovery

Every night with clear skies, astronomers with LPL's **Catalina Sky Survey** (CSS) scan the sky for near-Earth asteroids – space rocks with the potential of venturing close to Earth at some point. During one such routine observation run on Jan. 3, CSS observer **Gregory Leonard** spotted a fuzzy patch of light tracking across the starfield background in a sequence of four images taken with the 1.5-meter reflector telescope at the summit of **Mount Lemmon, Arizona**. The dot's fuzzy appearance, combined with the fact that it had a tail, was a dead giveaway that he was looking at a comet. This was the first comet discovered in 2021, and it was thus designated **C/2021 A1 (Leonard)**.

At the time of discovery, the comet was 400,000 times dimmer than what the human eye can see and was detected as a fuzzy patch of pixels tracking across the background stars in four telescope images. In the past, comets were discovered visually by very dedicated astronomers who spent countless hours scanning the night skies with a telescope. In recent decades, most comets are discovered incidentally by surveys tasked with finding near-Earth asteroids like the NASA-funded **Catalina Sky Survey**, Pan-STARRS, ATLAS and **NEOWISE** projects.

Most long-period comets such as **Comet Leonard** hail from the **Oort Cloud**, a vast region surrounding our solar system at distances no spacecraft has ever come close to, not even the two Voyager probes, which have officially left the solar system and entered interstellar space. Out there, suspended in the vast interstellar void where temperatures are close to absolute zero, are billions of orbiting comets balanced in a delicate tug-of-war of extremely weak gravitational forces between the distant sun and the rest of the Milky Way. Slight perturbations of this precarious balance of forces may nudge a chunk of ice and dust out of the Oort Cloud and send it onto a trajectory toward the Sun.

Comets are small bodies of the Solar System which are largely comprised of different types of ices and dust. Most comets have undergone very little processing since the beginning of the Solar System since they spend most of their lifetime at large heliocentric distances in the most frigid regions of space. Cometary nuclei therefore contain pristine samples of grains and gas from the protosolar nebula in which they formed; thus studying comets allows us to peek into the early conditions of our Solar System's formation.

The most abundant ice and contributor to cometary activity through sublimation is water-ice, but **C/2021 A1 (Leonard)** was observed to be active beyond the water-ice sublimation zone. This means that other mechanisms different from water-ice sublimation were responsible for the activity, possibly through the sublimation of other icy compounds such as carbon monoxide, carbon dioxide, or different exothermic mechanisms.

Comet Leonard made its closest approach to Earth on Dec. 12, at which point it was still more than 21 million miles away. "This is the last time we are going to see the comet," Leonard says. "It's speeding along at escape velocity, 44 miles per second. After its slingshot around the Sun, it will be ejected from our solar system, and it may stumble into another star system millions of years from now."

Read more: bit.ly/CSSCometDiscoveryC2021A1 **and** bit.ly/CSSResearcherDiscoversComet



WELCOME TO THE LPL NEWSLETTER

Mark S. Marley, Ph.D.
Department Head and Laboratory Director

Welcome to our Fall 2021 newsletter! As you'll read, quite a bit has happened since our last newsletter in the spring. The University of Arizona and LPL fully opened to in person classes and folks have continued a measured return to their offices and labs. Our weekly colloquium series is also up and running in a hybrid mode. After starting my time as Director while still in California, I've fully transitioned to Tucson. In LPL leadership, I've been joined by LPL faculty **Ilaria Pascucci** and **Christopher Hamilton** as Associate Department Heads. Ilaria is focusing on the graduate program and Christopher is focusing initially on steps to improve our undergraduate minor and building more international ties.

This summer, the **NEO Surveyor Mission**, led by **Professor Amy Mainzer**, was approved by NASA to move forward and the mission is included in the NASA budget, pending approval by Congress. Research highlights from the past semester include the work by **Tom Zega's team** to reconstruct in unprecedented detail the history of a dust grain that formed during the birth of the solar system more than 4.5 billion years ago and **Erik Asphaug's** use of machine learning and giant impact simulations to challenge conventional models of planet formation. Images of Bennu taken by the **OSIRIS-REx** spacecraft are teaching us about asteroids and why some have surprisingly craggy surfaces. The productivity of our faculty was recognized in the October 2021 **U.S. News & World Report** list of best global universities for space science, which ranks UArizona, No. 10 overall (No. 7 in the U.S. and No. 2 among public universities) in space science research.

We are excited to welcome our newest Assistant Professor, **Daniella DellaGiustina**, who will be starting in January. Dani is Deputy Principal Investigator of **OSIRIS-REx** and is also interested in pursuing opportunities in planetary seismology. We also currently have an ongoing search for an Assistant Professor working at the exoplanet/solar system interface, particularly in topics relevant to terrestrial planet atmospheres. We hope to welcome a new faculty member in this area by the Fall.

It has been gratifying to see a number of LPL students complete their degrees these past months, including **Laci Brock**, **Teddy Kareta**, **Ben Wei Peng Lew**, **Cassandra Lejoly**, and **Maria Steinrück**. In November, LPL graduate student **Ben Sharkey** made a notable media splash with his discovery that **near Earth asteroid Kamo`oalewa** is likely a collision fragment of the Moon. Meanwhile LPL alumna **Dr. Elizabeth Turtle** was selected as the **College of Science Alum of the Year** and was recognized in a ceremony featuring alums from every college during homecoming week.

You can read about all this and more in this newsletter. For more content and **expanded stories with links**, visit: [LPL.Arizona.edu/news/2021/fall](https://lpl.arizona.edu/news/2021/fall).

Thanks to LPL Donors

We would like to thank all those who have donated to LPL in 2021. Thanks for supporting research, education, and outreach at LPL. To give to LPL programs, visit: <https://give.uafoundation.org/science-lpl>.

Individual Donors: Travis Barman, Richard Bruns, Daniel Cavanagh, Laura Dugie, William Hubbard, Brian Jackson, Michael Kaiserman, Norman Komar, Colin Leach, Wei Peng Lew, Renu Malhotra, Kelly Miller, Kelly Kolb Nolan, Alan Rogers, Michelle Rouch, Timothy Swindle, Eric Tilenius

Corporate and Foundation Donors: Brinson Foundation, ExxonMobil, Employees Charity Organization of Northrop Grumman, Hitachi High Technologies U.S.A.



CARSON FELLOWSHIP AWARDED TO MICHAEL DANIEL

FELLOWSHIP PROVIDES ONE ACADEMIC YEAR OF SUPPORT, INCLUDING TUITION, SCHOLARSHIP, AND SUPPLY STIPEND

Michael graduated from **Whitman College** in 2020 with a combined B.A. in physics and astronomy. As an undergrad, he had the opportunity to conduct research during a ten-week REU (Research Experience for Undergraduates) internship at the **MIT Haystack Observatory**, where he tested code for processing supermassive black hole data from the **Event Horizon Telescope**. After completing coursework on planetary science topics during his senior year at Whitman, Michael decided to focus on graduate studies in planetary science. At LPL, Michael plans to study planetary surface processes, with a focus on ices in the solar system. He is also interested in studying climate change through the lens of planetary science.

*The **Lt. Col. Kenneth Rondo Carson and Virginia Bryan Carson Graduate Fellowship** is an endowment established by the estate of Virginia B. Carson, honoring her husband, a former member of the "Flying Tigers," a former member of the Joint Strategic Target Planning Staff Strategic Air Command, retired master navigator and enthusiast of space exploration. Colonel Carson greatly admired the professionalism and accomplishments of NASA's space program. The Carson Fellowship is awarded to students pursuing degrees in the Department of Planetary Sciences, Lunar and Planetary Laboratory, selected on the basis of academic achievement and the promise of further scholarly endeavor.*

DR. HEATHER KNUTSON ADAM P. SHOWMAN DISTINGUISHED LECTURER

APRIL 18-22, 2022

Professor Heather Knutson has been named the inaugural speaker for the **Adam P. Showman Distinguished Visiting Lectureship**. She will spend the week of April 18 at LPL, giving lectures and meeting with faculty, students, postdoctoral associates, and staff members.



Professor Knutson studies the dynamics and chemistry of extrasolar planetary atmospheres, one of the many fields in which Professor Adam Showman conducted pioneering research. Dr. Knutson led a team that confirmed the predicted eastward shift of the substellar hotspot in the atmosphere of the exoplanet HD 189733b, a shift that Dr. Showman and collaborators had predicted on the basis of fundamental atmospheric dynamical principles. This pioneering discovery established the field of observational exoplanet meteorology. Professor Knutson also searches for long-period companions in exoplanetary systems and conducts precision infrared photometry and time series analysis.

Professor Knutson obtained her B.S. in physics from Johns Hopkins University in 2004 and her Ph.D. in astronomy from Harvard University in 2009. She completed her thesis work, *Portraits of Distant Worlds: Characterizing the Atmospheres of Extrasolar Planets*, with Professor David Charbonneau. She has been with Caltech since 2011.

To support the Carson Graduate Fellowship, the Showman Distinguished Lectureship, or other LPL initiatives:

<https://give.uafoundation.org/science-lpl>



DELLAGIUSTINA JOINS FACULTY AS ASSISTANT PROFESSOR

Dr. Daniella DellaGiustina will join LPL as an Assistant Professor this January (2022). Dani is Deputy Principal Investigator for the **OSIRIS-REx** mission, responsible for oversight of extended mission activities. Previous to being named Deputy PI, Dani served as the mission's Image Processing Lead Scientist. Dani is an alumna of the University of Arizona, where she earned a B.S. in Physics and Ph.D. in Geosciences. She also holds an M.S. in Computational Physics from the University of Alaska.

As an undergraduate at UArizona, Dani minored in planetary sciences at LPL and was an **Arizona NASA Space Grant** intern. Her Space Grant project on characterizing mineral phases in meteorites was supervised by **Dante Lauretta**, now Principal Investigator for OSIRIS-REx. Dani continued to work at LPL with Dante Lauretta and **Michael Drake**, leading a student experiment on the Phase A Discovery OSIRIS Mission until the end of her undergraduate career.

In graduate school, she fused remotely-sensed observations of Earth's cryosphere with the numerical modeling techniques to understand the dynamics of the Greenland ice sheet. Her Ph.D. dissertation was on the subject of *Signal Processing of Seismic and Image Data for Planetary Exploration*. In her spare time she is an avid rock-climber and outdoor enthusiast.

NASA HONORS FOR KNUTSON AND POLIT

NASA GODDARD AWARDS RECOGNIZE EXEMPLARY ACHIEVEMENTS IN SPACEFLIGHT

Sara Knutson and **Anjani Polit** were each recognized by NASA for their outstanding work with the **OSIRIS-REx** mission.

Sara received an individual **Robert H. Goddard Award** for her work as Science Operations Lead Engineer at the OSIRIS-REx Science Processing and Operations Center. The citation for Sara's **Exceptional Achievement Award for Engineering** reads, "For systems engineering excellence, teamwork, and leadership of the science implementation activities on the OSIRIS-REx mission."

Anjani and the OSIRIS-REx Planning and Implementation team she leads were honored with the **Robert H. Goddard Award** for their outstanding work in planning the science observations of Bennu. Anjani was previously awarded a **Robert H. Goddard Exceptional Achievement Award for Engineering** by NASA's Goddard Space Flight Center.



Sara Knutson



Anjani Polit

NEW GRADUATE STUDENTS

SEVEN INCOMING STUDENTS FOR 2021/2022



Maizey Benner
Purdue University
Cosmochemistry
Advisor: Tom Zega



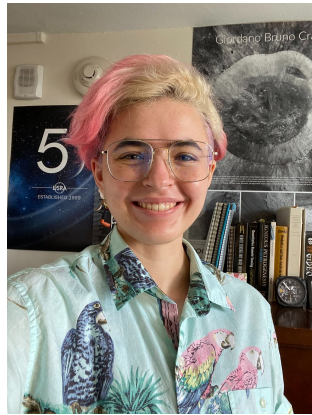
Robert Melikyan
Ithaca College
Small Bodies
Advisor: Erik Asphaug



Rishi Chandra
University of Illinois
(Urbana Champaign)
Cosmochemistry



Michael Daniel
Whitman College
Planetary Surfaces
Advisor: Jack Holt



Orion Hon
University of Hawaii Manoa
Planetary Surfaces
Advisor: Lynn Carter



Rowan Huang
Brigham Young University
Planetary Surfaces
Advisor: Virginia Gulick



Rocio Jacobo Bojorquez
Universidad de Sonora
Planetary Surfaces
Advisor: Jack Holt



LPLC 2021

BY ADAM BATTLE

The **Lunar and Planetary Laboratory Conference (LPLC)** marks the start of the academic year for many planetary scientists in the Tucson area. This year, LPLC 2021 reflected the cautious trend toward normal operations and was hosted in a hybrid format. For one full day, participants—all fully masked—gathered at the **Michael J. Drake Building** to spread out in the massive auditorium and watch presentations given by faculty, staff, and graduate students. The presentations were also live-streamed to a Zoom webinar for people to watch and ask questions virtually. At lunch time, participants enjoyed viewing the expansive meteorite collection housed in the Drake building and the outdoor patio space.

Despite the strange conditions this year, LPLC had the same level of attendance as previous years, with over 70 people participating. Among the invited speakers was **Teddy Kareta**, the winner of the “Best Grad Student Presentation” in 2020, who gave a great talk entitled *No Ice, Please: 46P/Wirtanen in the Near-Infrared*. The winner of this year’s “Best Grad Student Presentation” award was **Galen Bergsten**, who will be invited to give a talk at LPLC in 2022. In addition to the invited speakers, 23 people gave presentations about their current or upcoming research. For a conference largely designed to bring the planetary science community together, LPLC met all of its goals despite the ongoing difficulties of the global pandemic. The conference concluded with LPL director **Mark Marley's keynote** on *Modeling Atmospheres from Giant Planets to Cool Stars*.

ARIZONA RANKED IN TOP 10 FOR SPACE SCIENCE ON U.S. NEWS BEST GLOBAL UNIVERSITIES LIST

LPL IS A LEADER IN SPACE SCIENCE RESEARCH AND PUBLICATION FREQUENCY

The **University of Arizona** has once again been recognized as one of the world's top 100 research institutions by *U.S. News & World Report*.

UArizona ranked No. 99 out of 1,750 higher education institutions across 90 countries in the **2022 Best Global Universities ranking**. The university was No. 42 among universities in the U.S. and No. 22 among public universities.

"It is gratifying to see the University of Arizona listed alongside many of the world's premier academic research institutions," said University of Arizona President Robert C. Robbins. "Our university is home to many breathtaking scientific innovations, and it is upon this foundation that our faculty members seek to make further extraordinary discoveries."

U.S. News & World Report's Best Global Universities ranks colleges and universities in 43 separate subjects – up from 38 the year before. The University of Arizona earned a spot on 32 of the subject rankings lists.

UArizona earned its **top placement in the space science category, placing No. 10 overall, No. 7 in the U.S. and No. 2 among public universities** – all up one spot from last year's rankings. The university earned top marks for its research reputation in space sciences, along with the number of citations and publications by UArizona researchers.

The university's overall research reputation ranked No. 46 in the U.S. and No. 93 globally.

"The resolve and innovative spirit of researchers across campus are at the heart of the university's outstanding research reputation," said Elizabeth "Betsy" Cantwell, senior vice president for research and innovation. "From our commitment to building resilience amid a swiftly changing climate, to our leadership of NASA's groundbreaking **OSIRIS-REx** mission returning an asteroid sample to Earth, to our pioneering work understanding individualized health needs through the NIH-funded All of Us Program, University of Arizona research creates real-world solutions in nearly every scientific discipline."

UArizona earned top-100 global placements for its programs in geosciences (No. 26), arts and humanities (tied for No. 42), environment/ecology (No. 42), plant/animal sciences (No. 53) and biotechnology and applied microbiology (No. 86).

The eighth annual **Best Global Universities** rankings are produced to provide insight into how research institutions compare throughout the world. The rankings focus specifically on schools' academic research and reputation overall. To produce the global rankings, which are based on data and metrics provided by analytics company Clarivate, **U.S. News & World Report** uses a methodology that focuses on 13 indicators to measure research performance.

MARS ICE MAPPER SCIENCE DEFINITION TEAM

IF CONCEPT MOVES FORWARD, THE MISSION COULD BE READY TO LAUNCH AS EARLY AS 2026.

LPL graduate student **Indujaa Ganesh** and Postdoctoral Research Associate **Stefano Nerozzi** have been selected to be part of the Early Career Team for the **Mars Ice Mapper** Reconnaissance/Science Measurement Definition group team. Indujaa's mission expertise is radar, lunar landing site characterization, and imaging. Stefano's expertise is radar, geophysical glacial surveys, geomechanical stability, geomorphology, analogues, and atmosphere.

The Core Team includes **Professor Shane Byrne** (radar, ice detection, surface roughness, geology, imaging, landing site analysis, atmosphere, GIS) and LPL alumni **Ali Bramson** (radar, midlatitude ice distribution, polar studies, landing site analysis, analogues, ice coring) and **Catherine Neish** (radar, ice detection, surface roughness, analogues, imaging, astrobiology).

NASA and three international partners have signed a statement of intent to advance **Mars Ice Mapper**, a possible robotic Mars ice mapping mission, which could help identify abundant, accessible ice for future candidate landing sites on Mars.

ELIZABETH TURTLE

2020-2021 ALUMNA OF THE YEAR

For her outstanding contributions to planetary science, LPL alumna **Dr. Elizabeth "Zibi" Turtle** was named the **2020-2021 Alumna of the Year for the College of Science** by the **Arizona Alumni Association**. Zibi was recognized at the November 4th, 2021, Alumni of the Year Awards Ceremony.

Zibi earned her doctorate from LPL in 1998. Her dissertation research combined remote sensing observations and geophysical modeling of impact craters to understand the cratering process and what craters can tell us about the surfaces and interiors of the planets and moons on which they are formed.

After working on the **Galileo**, **Cassini**, and **Lunar Reconnaissance Orbiter** missions while at UA, she led a team that successfully proposed the **Europa Imaging System** (known as EIS) for NASA's Europa Clipper mission, which is scheduled to launch in 2024 to explore the habitability of this ice-covered, ocean world moon of Jupiter.

In 2019, NASA selected **Dragonfly**, led by Zibi as Principal Investigator, as its next New Frontiers mission. Dragonfly, which is scheduled to launch in 2027, is a robotic rotorcraft lander that will spend ~3 years exploring Saturn's largest moon, **Titan**. Taking advantage of Titan's low gravity and dense atmosphere, Dragonfly will fly from place to place to make measurements that will help us to understand the chemistry of this organic-rich, ocean world. Titan's chemical processes may be similar to what occurred on the early Earth before life developed here. Dragonfly is the first **NASA New Frontiers** mission led by a woman.

In addition to her project leadership, Zibi has held several important and influential roles in the planetary science community. She has served on the leadership committee for the American Astronomical Society's Division of Planetary Sciences, the steering committee of NASA's Outer Planets Assessment Group, and the National Research Council's Committee on Astrobiology and Planetary Science—the highest-level advisory group for NASA planetary science. Dr. Turtle is a Scientist at the **Johns Hopkins University Applied Physics Laboratory**.

CHABOT AND RIVKIN

NASA DART MISSION TEAM

Congratulations to LPL alums **Nancy Chabot** (1999), DART Coordination Lead, and **Andy Rivkin** (1997), DART Co-Investigation Team Lead.

On November 24, NASA launched its **Double Asteroid Redirection Test (DART) Mission** to the near-Earth binary asteroid **Didymos**. In September 2022, it will smash into Didymos' moonlet, **Dimorphos**, to test if the technique, which will alter Dimorphos' speed and orbit around Didymos, could be used to defend the Earth from potential impactors.

Read more about DART: nasa.gov/planetarydefense/dart



JONATHAN FORTNEY

SIMONS INVESTIGATOR IN ASTROPHYSICS

LPL alumnus (2004) **Jonathan Fortney** has been appointed a **Simons Investigator in Astrophysics** by the Simons Foundation. The award provides \$500,000 over five years to support his research on planetary atmospheres.

The Simons Investigator program supports outstanding theoretical scientists most productive years, when they are establishing creative new research directions, providing leadership to the field and effectively mentoring junior scientists. Fortney studies the atmospheres, interiors, and thermal evolution of planets, including exoplanets, and develops numerical models to explore many aspects of the physics of planets.

Dr. Fortney is a professor of astronomy and astrophysics at **U.C. Santa Cruz**.

MILAZZO SELECTED BY NASA

NAMED FIRST CHIEF SCIENTIST FOR PDE

NASA has named LPL alumnus (2005) **Moses Milazzo** as the first Chief Scientist for the **Planetary Data Ecosystem** (PDE). The PDE examines the data collected and analyzed by the science community.

Moses is a planetary scientist and educator specializing in visible and near-infrared **remote sensing**, as well as **planetary data processing**. He has been involved with eight NASA spacecraft missions and has contributed significantly to the development of planetary remote sensing, image processing, **cartographic mapping and calibration** techniques for a variety of missions and data types.

In this new role, Moses will represent the **PDE** to **NASA** and serve as a link between the PDE community and the **Planetary Data System**.

EMILEIGH SHOEMAKER AND THE NASA GIFT TEAM IN ICELAND

EMILEIGH IS A FOURTH-YEAR PH.D. STUDENT WHOSE RESEARCH INTERESTS INCLUDE PLANETARY SURFACES AND ANALOGS, RADAR REMOTE SENSING, AND VOLCANOLOGY.

by Emileigh Shoemaker

In August 2021, the **NASA Goddard Instrument Field Team (GIFT)** led a group of scientists, engineers, and astronauts from various NASA centers and universities, including the University of Arizona, to conduct a variety of field investigations of a planetary analog site in the **Icelandic highlands**. GIFT traveled to **Askja volcano** in the Northern Volcanic Zone (NVZ) of Iceland. The Askja caldera and the surrounding region share a striking similarity to Mars and the Moon with its volcanic and largely unvegetated landscape. This site also serves as an excellent test bed for geophysical methods and tools that could be used by astronauts in the future on the surfaces of the Moon or Mars.

Four science and operations teams conducted a variety of scientific investigations and field equipment tests at sites in and around the Askja caldera. I had the opportunity to join the the **ground-penetrating radar (GPR)** team. The team has been mapping the extent and thickness of ice deposits buried beneath pumice, ash, and other tephra from eruptions of Askja in 1875 and 1961. These ice deposits are potentially analogous to those found on Mars or the Moon. Combining the confirmed GPR observations of subsurface ice with airborne synthetic aperture radar (SAR) observations over the Askja caldera allows the team to simulate what future orbital radar systems could observe on Mars. This will be used to determine what a signal from ice would look like from orbital SAR systems in the future. The GPR team has also been monitoring these ice deposits over two field seasons to track any changes between 2019 and 2021 as the long-term stability of this ice is threatened by the warming climate. The ice deposits have been found to be as thin as 10 centimeters and thicker than 2.5 meters in some regions buried beneath up to 40 centimeters of tephra.

I am currently analyzing the collected radar data over the last two field seasons to calculate the thickness and extent of buried ice deposits across the floor of the Askja caldera. I'm also focusing on modifying existing GPR analysis techniques to aid in identifying the signature of buried ice and which radar frequencies are best suited for mapping shallow ice deposits such as these.



Top left: Zach Morse (NASA GSFC), **Emileigh Shoemaker**, and Jacob Richardson (NASA GSFC) take a traverse with the 900 MHz ground-penetrating radar (GPR) antenna over a tephra deposit from 1961 where they suspect buried ice is present. These systems take at least two people to operate with one pushing the antenna across the surface and the other monitoring the data in real-time for quality control.

Top right: GPR team lead David Hollibaugh Baker (NASA GSFC) confirms buried ice beneath pumice erupted in 1875 and takes a sample for later laboratory analysis. These trenches also help determine the depths at which the GPR is detecting ice.

Bottom: A hand sample of ice buried beneath 1875 pumice. This ice is fairly pure and has closed pore spaces, creating the solitary bubbles seen in the sample.

LPL FIELD TRIP FALL 2021

THE CHIRICAHUA MOUNTAINS: IGNEOUS PROCESSES AND PLANETARY ANALOGS

by Christopher Hamilton

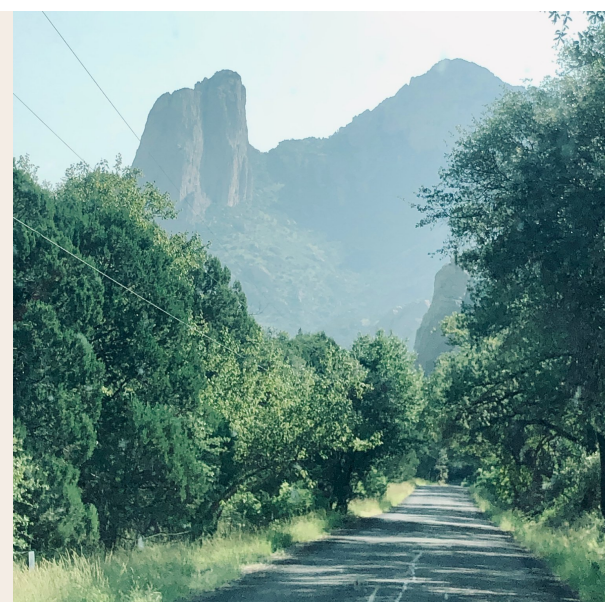
The **LPL Graduate Field Trip (PTYS 590)** resumed this semester with a three-day trip to the **Chiricahua mountains** in southeast Arizona. All participants were vaccinated and—while travelling in vehicles and on trails where social distancing was not possible—students always wore masks.

On the first day of our trip, we travelled to **Texas Canyon**, where we visited the **Triangle T Guest Ranch** and exceptional granite outcrops with spherical weathering. Folks at the ranch kindly let our group explore the rock formations and guided us to see exceptional Native American petroglyphs. We then visited **Willcox Playa** and hiked to Fort Bowie to learn more about the region's cultural history. The next day, we explored **Chiricahua National Monument**, including ancient volcanoes with spectacular hoodoo formations eroded into the 27-million-year-old Turkey Creek ignimbrite deposit. Our group of sixteen visited **Massai Point**, hiked the "Echo Canyon Trail," and climbed to the top of Sugarloaf to see the exceptional geologic history exposed within the walls of the valley.

For the final day of our trip, we crossed into **Cave Creek Canyon**, which is the largest and most biologically diverse canyon in the region. We then visited the **Chiricahua Desert Museum** and explored monogenetic volcanoes in **San Bernardino Volcanic Field**, which include exceptional mantle xenoliths. On the way home to Tucson, we enjoyed the final student presentations with ice cream in Tombstone. After two-years, it was great to explore the beautiful geology and cultural history of the Southwest again, and students are looking forward to exploring the **Mojave Desert** next semester with **Professor Shane Byrne**.

You can support the LPL Graduate Field Trip by donating to the Wilkening-Sill endowment:

<https://give.uafoundation.org/science-lpl>





TEACHING TEAMS PROGRAM

by Hannah Edwards
Instructional Specialist Coordinator

LPL is home to the UArizona Teaching Teams Program, which is led by Associate Professor of Practice Steve Kortenkamp.

In 1998, the **University of Arizona's Teaching Teams Program** was established to create dynamic learning environments for students, teaching assistants, as well as instructors and professors to collaborate in the education of undergraduates. The Teaching Teams Program began promoting **peer learning assistants** for large **General Education** science classes, originally in the area of planetary science and astronomy. Our program quickly expanded to become university-wide, including over 200 learning assistants per semester at its peak. Undergraduate students who enrolled in our Teaching Team classes were recruited to take on added responsibility as so-called "preceptors." **Preceptors** serve as peer guides, mentors, tutors, and teachers for their fellow classmates.

Dr. Steve Kortenkamp uses preceptors every semester for his planetary science **General Education** courses. In the Fall 2021 semester, Steve had the help of four preceptors for his **PTYS/ASTR 206** course. These preceptors assisted with set-up and management of LPL's telescopes for a smartphone astrophotography project, held office hours to help students with writing essays, and worked as peer-graders on the submitted essays.

As other departments began following the Teaching Teams model, our curriculum began evolving away from a preceptor training program and into **professional development** for both preceptors and non-preceptors. Strengthening of interpersonal skills, professional online social media practices, and personal branding preparation for undergraduates is now the core of what Teaching Teams offers to our students.

Teaching Teams workshops provide a format that enables students to experiment with various teaching techniques and communication and internet skills, and outfits them with important interpersonal competencies for a wide variety of careers. Looking towards a globally changing learning and working environment, the overarching goal of the Teaching Teams Program is to instill leadership, teaching, and interpersonal skills as well as personal development for our students to build upon. Using our workshops to reach their desired goals, (i.e., future internships, jobs, graduate schools, etc.), our students will have the knowledge and skills to successfully compete in a changing 21st century world job market.

Today, the Teaching Teams program offers 12 units of course work, enough opportunities to support an undergraduate certificate. The Teaching Teams Program continues to encourage professors to utilize preceptors in conjunction with the program's **PTYS 297A** and **PTYS 397A** workshops for the benefit of students.

***Teaching Teams** preceptors helping Dr. K's class with an astrophotography project.*



RECENT PTYS GRADUATES



Laci Brock

November 8, 2021

Connecting Points in Time: From the Evolution of Clouds in Substellar Atmospheres to Students' Perceptions of Earth's Place in the Universe

Advisors: **Professor Travis Barman & Professor Ed Prather**

New position: Postdoctoral Research Associate, LPL/UArizona



Teddy Kareta

September 24, 2021

Activity and Evolutionary State of Small Bodies

Advisors: **Professor Walt Harris and Associate Professor Vishnu Reddy**

New position: Postdoctoral Research Associate, Lowell Observatory



Cassandra Lejoly

December 3, 2021

The Effect of Dust in Small Bodies: A Sample of Jupiter Family Comets

Advisor: **Professor Walt Harris**

New position: Observer/Data Analyst with LPL Spacewatch



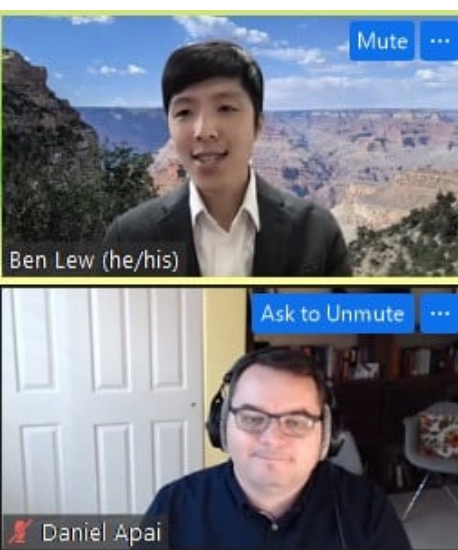
Maria Steinrück

October 26, 2021

Atmospheric Circulation of Hot Jupiters: Implications of Disequilibrium Chemistry and Photochemical Hazes

Advisor: **Assistant Professor Tommi Koskinen**

New position: Postdoctoral Research Associate, Max-Planck-Institut für Astronomie



Ben Wei Peng Lew

August 10, 2021

Self-luminous Worlds with Exotic Clouds: Characterizing Clouds in Brown Dwarf Atmospheres

Advisor: **Professor Daniel Apai**

New position: Research Scientist, Bay Area Environmental Research Institute

RISHI CHANDRA UNIVERSITY FELLOWS AWARD

PRESTIGIOUS AWARD FOR INCOMING GRADUATE STUDENTS PROVIDES ANNUAL STIPEND, TUITION SCHOLARSHIP, AND HEALTH COVERAGE, IN ADDITION TO PROFESSIONAL DEVELOPMENT AND NETWORKING OPPORTUNITIES

by Rishi Chandra

The **University Fellows award** goes to grad students from departments all over campus, and this year's cohort is a tight-knit group. We spent a night at **Biosphere 2** for orientation and team-building, which was an unbelievable welcome to Arizona for me in my second week of classes. Throughout the semester, we have weekly seminars where experts speak with us about practical skills for grad students in any discipline: project management, human-centered design, mentorship and mentee-ship, and more. It's allowed me to connect with students in the humanities, arts, social sciences, and engineering, letting me to explore and present on topics I didn't expect myself to be curious about, such as human-ecosystem coevolution in the Sonoran Desert. It's also given me the opportunity to explore my own interests in new interdisciplinary ways, such as examining ways in which non-Western worldviews can inform Western scientists preparing for human exploration beyond low Earth orbit.

Connecting with scholars from other disciplines has offered me new perspectives on familiar problems, so I'm excited to see where the connections I've made with my peers in the UF program lead me in the coming years.

Rishi's research interests include the analysis of Solar System materials, including meteorites and returned samples.



Nathan Hadland received a **Geological Society of America Graduate Student Research Grant** in support of his work on thermophilic life in hot springs in Iceland. The funding paid for the sequencing of DNA samples to determine the taxonomic diversity of those ecosystems. Nathan explains that it is possible that hot springs similar to those in Iceland may have formed on Mars in the past, and that characterizing the organisms that occupy similar environments on Earth can shed light into the types of life possible on Mars. Nathan is a second-year doctoral student working with associate professors **Solange Duhamel** and **Christopher Hamilton**. His research interests include astrobiology and planetary surfaces.

INDUJAA GANESH EARHART FELLOWSHIP

\$10,000 FELLOWSHIP AWARDED EACH YEAR BY ZONTA INTERNATIONAL TO UP TO 35 WOMEN PURSUING DOCTORAL DEGREES IN AEROSPACE ENGINEERING AND SPACE SCIENCES

Indujaa is a fifth-year student whose research focuses on studies of explosive volcanism on Earth, Mars, and Venus; she uses a combination of radar remote sensing and numerical models in this work. Indujaa also uses radar data to identify buried pyroclastic deposits in the shallow subsurface of Martian shield volcanoes. She also seeks to understand the products of explosive eruptions on Venus by using numerical models to simulate the transport of pyroclastic flows under Venus conditions and comparing them with synthetic aperture radar data to determine eruption parameters that can be used to constrain magma volatile content.

Indujaa is advised by **Associate Professor Lynn Carter**.



DAVID CANTILLO PTYS UNDERGRADUATE MINOR

David Cantillo is a senior majoring in Geosciences with a minor in Math as well as Planetary Sciences (PTYS). Planetary science appeals to him because it combines his interest in astronomy with a more hands-on geological perspective. David has enjoyed all his PTYS courses but notes that the **Observational Campaigns** course taught by **Professor Walt Harris** was most influential: "I quickly learned that comets can be extremely dynamic and complex bodies, and the class was a wonderful introduction to graduate students I'm still in touch with now. The trip up to the **61" telescope** on Mt. Bigelow is also something I'll always remember!"



David's research with **Associate Professor Vishnu Reddy** on the surface composition of asteroid **16 Psyche** resulted in his first lead-author paper. He is currently looking at 16 Psyche in the visible range of light with groundbased telescopes at **Biosphere 2**. The goal is to better constrain the nature of hydration on its surface.

David's future goals include a doctoral degree and a career of research with small bodies, space situational awareness, and astrobiology.

UNDERGRADUATE MINORS

25 students are pursuing a **Planetary Sciences** minor and 20 students are enrolled for the **Astrobiology** minor. We are pleased to feature two students in this newsletter. For the complete Q&A articles, visit

[LPL.Arizona.edu/news/2021/fall](https://lpl.arizona.edu/news/2021/fall)



RUBY FULFORD ASTROBIOLOGY UNDERGRADUATE MINOR

Senior **Ruby Fulford** is majoring in Astronomy with minors in Biology and Physics in addition to Planetary Sciences (PTYS). She wants to pursue a Ph.D. and work on NASA astrobiology missions. Ruby is especially interested in searching for signs of ancient life on Mars and investigating the habitability of outer solar system moons like Titan and Europa.

Ruby notes that her favorite astrobiology class was **Mars (PTYS 442)**, taught by **Regents Professor Alfred McEwen** because she was able to use the **HiRISE** camera to take photos of the red planet. Ruby is currently completing a senior thesis with **Regents Professor Dante Lauretta**: "I am helping to design the spectral imaging system that will be used to study the sample from the near-Earth asteroid Bennu that will be returned by the **OSIRIS-REx** mission. Studying Bennu will hopefully reveal new information about the origins and composition of early Earth."

Ruby notes that the photo above is of her standing on the top platform of the **Green Bank Telescope** in West Virginia. "Working toward this minor has allowed me to take some fascinating classes and has helped me realize how passionate I am about the search for life beyond Earth."

POSTDOCTORAL RESEARCH ASSOCIATES

LPL currently hosts 15 postdocs - meet Dominik and Emily.



EMILY LICHKO

Dr. Emily Lichko is currently a **NSF AGS (Division of Atmospheric and Geospace Sciences) Postdoctoral Research Fellow** at the University of Arizona, working with **Assistant Professor Kristopher Klein** on the effects of linear and nonlinear physics on the onset and evolution of microinstabilities in space-relevant plasmas. Dr. Lichko's research focuses on kinetic plasma physics processes in space and astrophysical plasmas, in particular as they relate to questions of particle heating and nonlinear processes that affect the evolution of collisionless, anisotropic plasmas.

Emily received her B.S. in Physics and Applied Mathematics from the **University of Michigan** in 2013 and her Ph.D. in 2020 from the **University of Wisconsin-Madison**, working under the supervision of Professor Jan Egedal. Outside of her research, she enjoys swimming, biking, running, and failing to replicate recipes from the **Great British Bake Off**.

DOMINIK HINTZ

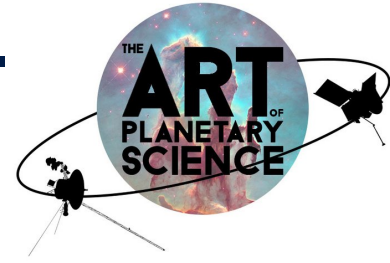
Dr. Dominik Hintz joined LPL in May 2021 as a Postdoctoral Research Associate. Together with **Professor Travis Barman**, he works on stellar atmospheres of the Sun and solar-like low mass stars using the state-of-the-art atmosphere code PHOENIX. The project encompasses improvements of the code in order to gain valuable interpretations of the physics in the atmospheres of these stars when comparing the model spectra to real observations. In particular, the work aims at investigations of ultraviolet radiation of planet-host stars which affect the habitability of exoplanets orbiting them.

Dominik lived in Hamburg, Germany, before moving to Tucson. He earned his B.Sc., M.Sc. and Ph.D. in physics at the **University of Hamburg**. His Ph.D. research dealt with the investigation of stellar activity among M dwarf stars. This work focused on fitting atmosphere models to observed spectral lines from the visible to the near-infrared wavelength range using high-resolution spectra in order to improve the understanding of stellar activity among low mass stars.

During his free time, Dominik is interested in sports such as soccer, cycling, and football. He also likes to travel and to engage in outdoor activities.



THE ART OF PLANETARY SCIENCE



Space Travel

The Art of Planetary Science (TAPS) was proud to hold its 8th annual exhibition this year, with the special theme of *Space Travel*. Like many recent events on the University of Arizona campus, the 2021 show went hybrid, hosting 112 works of art in person and a total of 300 online! The theme was well received by the artists who submitted pieces this year, with 203 of the accepted submissions dedicated to the Space Travel theme; 54 of these were displayed in the Kuiper building for the opening weekend (September 24-26)

After last year's all-virtual show, organizers were excited to offer the in-person component again. With precautions (including a mask requirement and multiple hand sanitizing stations) taken to protect guests, the **Kuiper Space Sciences** building atrium and the fourth-floor atrium balcony were transformed into a public art gallery. The opening weekend was full of special events and talks available to enjoy in-person and online. **TAPS** had a good showing for this year, with 450 in-person visitors!

Last year (2020) was the first for **TAPS** online galleries and organizers decided to make them available again this year, as they allow guests from around the world to participate and access the exhibit. Five virtual art galleries (Data Art, Fine Art, Kids Art, Space Travel Art and Space Shorts) were available to view online through the end of October. The online galleries also include this year's **Art of Planetary Science at DPS** submissions. This tradition was started in 2017 and is typically held at the annual DPS conference, which was online only this year. DPS participants were able to vote for their favorite piece during the conference (Oct. 3-8).

TAPS partnered this year with the **Interstellar Research Group (IRG)** for their 7th Symposium, which was held in Tucson concurrent with the TAPS opening weekend. The **Tucson Amateur Astronomy Association** provided safe solar telescope viewing with hydrogen alpha filters on Sunday afternoon; visitors viewed solar activity through a hydrogen alpha filter. The invited speaker for **SciFi Sunday** was astronaut **Charlie Walker**, who was inspired by science fiction to pursue a career in space. He became the first astronaut with a background in industry and completed three Space Shuttle flights in the 1980s. Mr. Walker helped develop and plan the International Space Station and developed and completed some of the first biological experiments in space. The longstanding partnership between TAPS and the **Flandrau Science Center & Planetarium** continued this year, as they provided the planetarium space for Walker's invited presentation. You can view Walker's recorded presentation on the **TAPS YouTube channel**: www.youtube.com/channel/UCidCIVmrGC8YyLhyptnvvdQ.

This year saw the debut of the **Kids' Art** gallery, which hosted 13 pieces from young artists. This small but mighty aspect of the art show had a big impact for some of the participants, who were invited to the artists' reception. One young artist in particular was especially excited to hear the lecture by **Dr. Christopher Hamilton**, who described his research adventures in Iceland, accompanied by stunning drone footage of active volcanoes. A recording of this lecture, as well as other TAPS events and videos for each art gallery, is on the TAPS YouTube channel.

Another first for 2021 was the special satellite writing project for young humans, titled **Space Shorts**. This call for science fiction short stories expanded the scope of the exhibit beyond visual arts into the written word. To inspire young students to submit their short stories, TAPS partnered with the University of Arizona's **Think Tank**, which chose winner **Henry Payne** for his short story titled *Spacer*.

Other opening weekend events included an album release and musical performance by the local Tucson band, **Daytrails**, fronted by LPL undergraduate minor, **David Cantillo**. Saturday included a visit from Ms. Frizzle of The Magic School Bus, who interacted with guests inside the art gallery and assisted the **Tucson Children's Museum** in some live science demonstrations, including making a cloud in the Kuiper atrium! Guests were invited to wear their favorite space and astronomy-themed clothing on Friday; festive apparel included light-up constellation clothing, tin-foil head pieces, sun and moon masks, nebulae pants, dresses portraying various planets, meteorite petrographic skirts, and alien earrings.

The Art of Planetary Science would like to thank all the collaborators, invited speakers and performers for contributing to this year's show. Many thanks from all the past and current graduate student organizers of The Art of Planetary Science as well to LPL director **Mark Marley** for the continued support.

Travel to space with us again soon!

LPL IN THE NEWS

Complete list of LPL headlines and linked stories available at: [LPL.Arizona.edu/news](https://lpl.arizona.edu/news)

Highly Porous Rocks Responsible for Bennu's Surprisingly Craggy Surface. Using data from NASA's OSIRIS-REx mission, a LP-led team of scientists concluded that asteroids with highly porous rocks, such as Bennu, should lack fine-grain material on their surfaces. (Cambioni, Laretta)

'Mini Psyches' Give Insights into Mysterious Metal-Rich Near-Earth Asteroids. New research into metal-rich asteroids reveals information about the origins and compositions of these rare bodies that could one day be mined. (Reddy, Battle, Sharkey, Kareta, Cantillo)

Earth and Venus Grew up as Rambunctious Planets. What doesn't stick comes around: Using machine learning and simulations of giant impacts, researchers at LPL found that the planets residing in the inner solar system were likely born from repeated hit-and-run collisions, challenging conventional models of planet formation. (Asphaug)

OSIRIS-REx Improves Understanding of Potentially Hazardous Asteroids. NASA and LPL scientists were able to significantly reduce uncertainties about asteroid Bennu's orbit and determine the likelihood of the asteroid impacting Earth between now and the year 2300. (Laretta)

NASA Extends LPL-Led Asteroid Search Mission. For two more years, NASA's Near-Earth Object Wide-field Infrared Survey Explorer, or NEOWISE, will continue its hunt for asteroids and comets – including objects that could pose a hazard to Earth. (Mainzer)

Mars Lake Hypothesis on Ice After Study Offers Different Explanation. Scientists have long debated what's under the surface of Mars' south pole. A new study points to clays being more likely than a subsurface lake. (Nerozzi, Holt)

Researchers Trace Dust Grain's Journey Through Newborn Solar System. Combining atomic-scale sample analysis and models simulating likely conditions in the nascent solar system, a new study reveals clues about the origin of crystals that formed more than 4.5 billion years ago. (Zega, Muralidharan)

Asteroid 16 Psyche Might Not Be What Scientists Expected. New UArizona research finds that the target asteroid of NASA's Psyche mission may not be as metallic or dense as previously predicted. (Cantillo, Reddy, Sharkey, Kareta)

UArizona to Lead Mission to Discover Potentially Dangerous Asteroids. NASA has tasked LPL Professor Amy Mainzer, an expert in infrared astronomy, with leading NEO Surveyor, a mission to find, track and characterize yet unseen asteroids and comets that may pose a threat to Earth.

\$2M Gift Advances UArizona Space Science Initiatives. The gift will enable the purchase of a nanoscale secondary ion mass spectrometer, an instrument the OSIRIS-REx analysis team will use to help find answers to fundamental questions about the origins of the solar system. (Barnes)