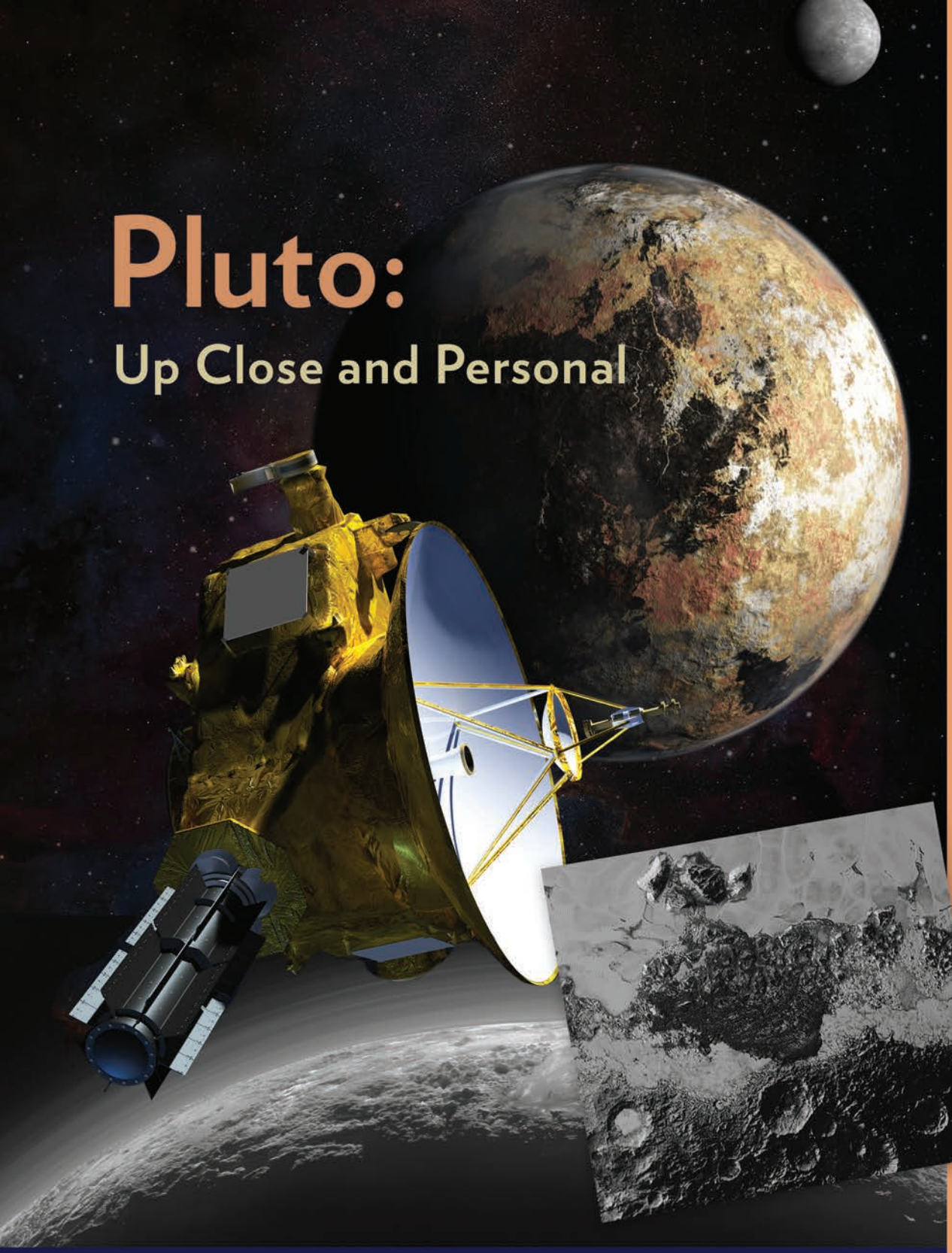

Pluto:
Up Close and Personal

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Lunar and Planetary Information

BULLETIN

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Pluto: Up Close and Personal

— Paul Schenk, Lunar and Planetary Institute

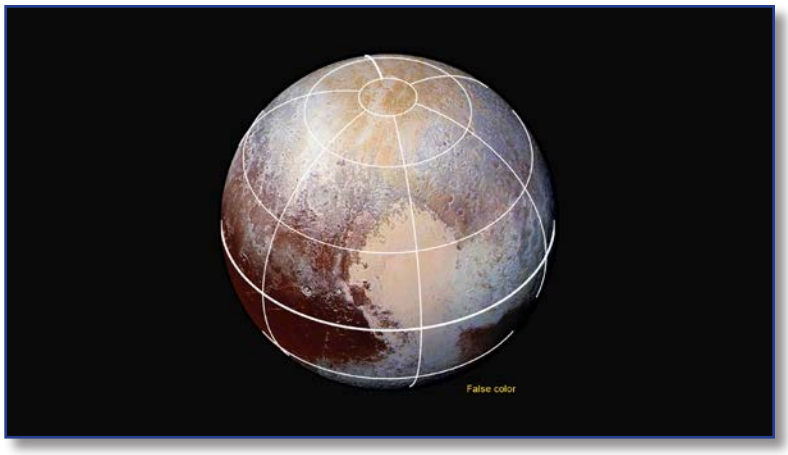
Exploring Pluto has been an humbling experience. As a planetary scientist, I have been fortunate enough to have had the opportunity to participate in some of the grandest adventures mankind has chosen to embark upon in the last century, from Voyager 2 at Jupiter (as a naive 20-something intern), to Magellan at Venus, to Cassini at Saturn, to Dawn at Ceres. But nothing quite prepared any of us for the first spacecraft encounter with Pluto. Even as little as week before the July 14, 2015, encounter with the most distant object yet explored, we had no idea what Pluto was like. Was it old and battered? Hammered by ceaseless impact craters? Or spouting active volcanic plumes like its icy cousin Triton, the large moon of neighboring Neptune? Even its diameter was uncertain; our most accurate information was plus or minus 20 kilometers. As we experienced the visit to Pluto this past summer, I can honestly say that this small bitterly cold icy body changed the worldly perspectives of more than a few of us, and many of us felt forever changed. As a Co-Investigating Scientist on the New Horizons project, I was given the privilege of being with the mission team at the Johns Hopkins University's Applied Physics Laboratory (APL) in Laurel, Maryland, during the Pluto encounter, and wanted to share some of that experience from a personal perspective.

The author posing for a photo at the Applied Physics Laboratory in Laurel, Maryland, a few days before the Pluto encounter. Credit: Paul Schenk.

The road we took to Pluto and its family of moons was onboard the stout vessel New Horizons, an ambassador of sorts, but more of an extension of our imaginations as well as our optics. After a lonely eight-year cruise following the spacecraft's thrilling ride past Jupiter, the Pluto encounter actually began in January with long-range monitoring observations. Approach continued with a breathless routine until the evening of July 4. Many on our team went out for fireworks or just an evening out to relax a bit before the big event. However, most of us returned that evening to find an e-mail notifying us that the spacecraft had entered safing, or safe mode. (Safe mode is an operating mode of modern spacecraft during which all non-essential systems are shut down and only essential functions continue to be active; spacecraft are designed to entered into safe mode automatically upon the detection of a predefined operating condition or event that may indicate conditions that are potentially dangerous and/or out of the normal range.)

Even though the onboard problem turned out to be something that was relatively simple and easy to solve, it still came as quite a blow and let the wind right out of our sails. Anticipation had been replaced by uncertainty and anxiety. The emotions I experienced took me back to the night of August 25, 1981,

as Voyager 2 emerged from behind the vast bulk of Saturn. Joy at the return of the signal quickly became concern and then real anxiety. There were serious problems with Voyager that night. All science had stopped; the camera platform had stopped moving. Even the Uranus and Neptune encounters to follow in 1988 and 1989 seemed at risk. Refusing to panic, Voyager project leaders understood the value of caution and thorough analysis. In three days they had the problems under control, and within weeks Voyager was back in good health and ready for the spectacular performance that was to come. In the same spirit of supreme professionalism, the New Horizons team performed the same feat and prudently returned New Horizons to action. Within three days, just in time to start the final rotation to Pluto, the first new images arrived and we were ecstatic; chastened perhaps in the brief reminder of human and mechanical frailty, but happy nonetheless.



Four images from New Horizons' Long Range Reconnaissance Imager (LORRI) were combined with color data from the Ralph instrument to create this enhanced color global view of Pluto. (The lower right edge of Pluto in this view currently lacks high-resolution color coverage.) The images, taken when the spacecraft was 450,000 kilometers (280,000 miles) away, show features as small as 2.2 kilometers (1.4 miles). Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.

During the final six days of approach, each new image that was returned revealed our best look at that side of Pluto as the planet and its large moon, Charon, lazily turned below us on our high-speed approach. Most of these terrains were puzzling but clearly showed a complex surface that could not be ancient. Still, nothing looked familiar; there were no large impact basins, no giant mountain ranges (at least none that we could see yet). Instead, a large double-lobed heart-shaped enigmatic bright spot and curious bright and dark markings were evident. Speculation was rampant.

During the last three days leading up to the encounter, the atmosphere at the APL facility began to change as media personnel gathered for the main event. Several hundred reporters had gathered, interviewing team members (I'm quoted in the New York Times as admitting "I don't know" to at least one question) and awaiting any news or photos on which they could report.

There were many "big moments" during the encounter, but the first really big one that was planned was the "big reveal"' of the last full-frame image of Pluto. This was the last time we could image Pluto in one single image before going to multiframe mosaics, and provided a nice way to mark our approach. At 4 kilometers resolution, this would also be the first time we could expect to easily resolve major geologic features. On the morning of July 14, encounter day, we arose before dawn and gathered together at the APL facility.

Details of Pluto's largest moon, Charon, are revealed in this image from New Horizons' Long Range Reconnaissance Imager (LORRI), taken July 13, 2015, from a distance of 466,000 kilometers (289,000 miles), combined with color information obtained by New Horizons' Ralph instrument on the same day. The distinctive red marking in Charon's north polar region is currently being studied by scientists. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute).

The full-frame image of Pluto that we saw certainly did not disappoint; the large bright spot was smooth with faint dark markings, there were tall mountains to the south, and there were some impact craters to the north. Obviously, Pluto was a complex geologic world unto itself. This was when we really knew that we were going to be in for a wild ride.

The rest of the day on July 14 was devoted to the technical business of the encounter as well as the opportunity to experience it. As the encounter time passed in the morning, a large crowd gathered to commemorate it. This was the point in real time when we passed by Pluto; at that moment, New Horizons was as close as it would ever be and was busy observing.

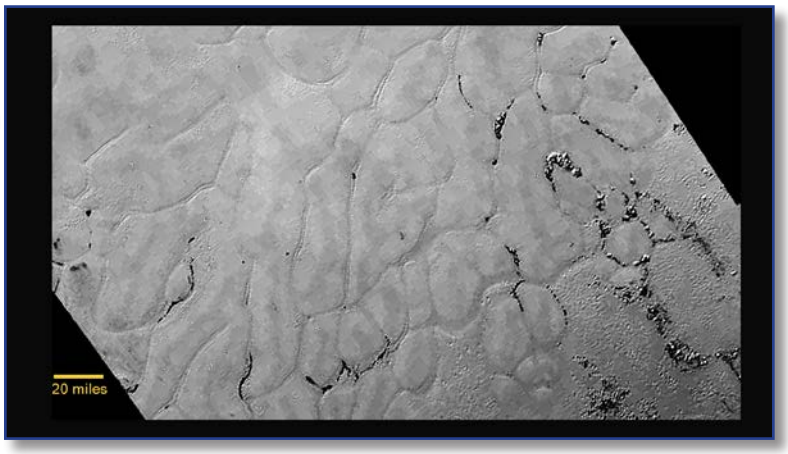
The thrilling moment of signal reception during the successful New Horizons Pluto encounter on July 14, 2015. Credit: Paul Schenk.

By far the most exciting moment to those of us who had worked 10 years (in my case) or much longer (in others) to get to this point was the point at which the spacecraft "phoned home"; at approximately 8:50 p.m. EDT, the first telecommunication was actually received on Earth from the otherwise far too busy New Horizons spacecraft. Almost the entire team (with the exception of those doing the tracking) gathered in the main auditorium, and by video link with mission control, we watched the clock tick down. Alice Bowman, telecommunications chief, was on a headset waiting for the monitors to display evidence of a signal. Finally she announced, "We have carrier." That was the first good sign. If something were amiss, we would have heard either earlier or later (or never). Then we all waited on pins and needles, with our hearts in our throats . . .

We all knew the sequence of calls that had to happen next, and they did. First, the data link was established. Hard data was coming down! Then each system reported whether its data was as expected. Two systems were of tantamount important for the science team: Did the autonomy package run to

completion, indicating that all programmed activities, including imaging, turns, and all other aspects of the science plan, occur? "Autonomy nominal." Yes! The plan worked! Next, the solid-state recorder (SSR) . . . Did it record the information? "SSR full." Yes! We had data. This was when we knew we had a successful encounter. Loud cheers, a few tears, and lots of hugs followed. The relief and joy and sobering realization of accomplishment after more than a decade of planning is difficult to describe and impossible to forget. No one wanted to leave and let go of that feeling. When we heard that the flight team would come over to "take a bow," very few people could bring themselves to leave. An hour later, the flight team entered the room and were greeted with a standing ovation.

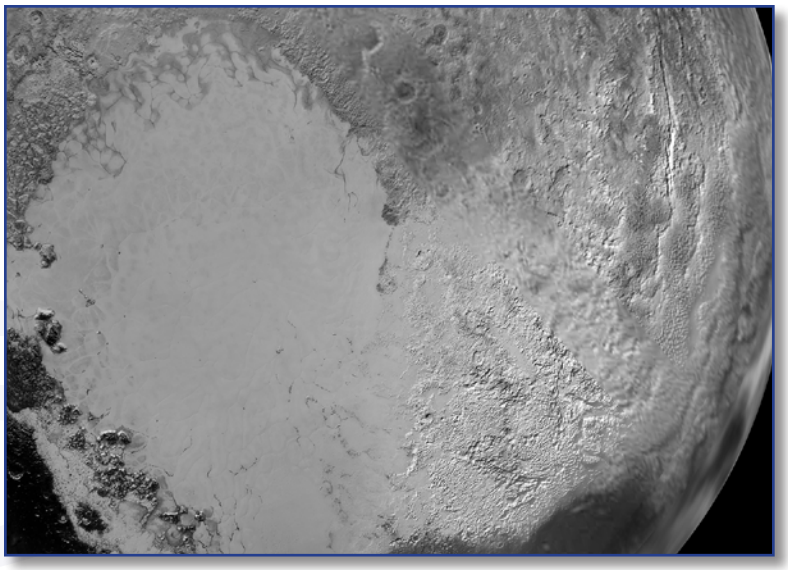
Exhaustion was already evident, and most of us went back to our rooms to get some sleep. Playback of the first images from the encounter would start just after breakfast the next day, and we had to be ready because the world wanted know what Pluto looked like. Nobody would voice it out loud, but there was a final question that could only be answered once we began to see the returned images: Did New Horizons hit the target, so to speak, and point in the right directions? Was the targeting correct?



In the center left of Pluto's vast heart-shaped feature — informally named "Tombaugh Regio" — lies a vast, craterless plain that appears to be no more than 100 million years old, and is possibly still being shaped by geologic processes. This frozen region is north of Pluto's icy mountains and has been informally named Sputnik Planum (Sputnik Plain), after Earth's first artificial satellite. The surface appears to be divided into irregularly shaped segments that are ringed by narrow troughs. Features that appear to be groups of mounds and fields of small pits are also visible. This image was acquired by the Long Range Reconnaissance Imager (LORRI) on July 14, 2015, from a distance of 77,000 kilometers (48,000 miles). Features as small as 1 kilometer (0.5 miles) across are visible. The blocky appearance of some features is due to compression of the image. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.

What followed over the next week can best be described as being in the boxing ring with Muhammad Ali. Beginning the morning of July 15, a small prechosen set of 20 or so images and datasets would be returned for quick analysis and encounter assessment (most of the data are still onboard and will be transmitted over the next year or so). Each new image dealt one blow after another to our simple concepts of what Pluto (or any other planet, for that matter) could be like. After a decade of association with Voyager, my colleagues and I had grown accustomed to surprises in the outer solar system, from volcanos on Io to outgassing on Triton, but even we were completely unprepared for what we saw on Pluto that day.

The race was on to be the first to upload the new images on our screens and catch a glimpse of the furthest planet in our solar system. First and foremost, we knew right away that we were on target! We would indeed be getting images. We quickly forgot that simple fact, because the first image we saw on our monitors that morning set the stage by collectively "blowing our minds." The now-famous image of the seemingly swirling ice fields of (informally named) Sputnik Planum showed us a planetary surface that we had never seen before and did not imagine possible.



Sputnik Planum is the informal name of the smooth, light-bulb shaped region on the left of this composite of several New Horizons images of Pluto. The brilliantly white upland region to the right may be coated by nitrogen ice that has been transported through the atmosphere from the surface of Sputnik Planum, and deposited on these uplands. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.

Image of Pluto's haze layers, taken by New Horizons as it looked back at Pluto's dark side nearly 16 hours after close approach, from a distance of 770,000 kilometers (480,000 miles), at a phase angle of 166°. Pluto's north is at the top, and the Sun illuminates Pluto from the upper right. Faint surface details on the narrow sunlit crescent are seen through the haze in the upper right of Pluto's disk, and subtle parallel streaks in the haze may be crepuscular rays — shadows cast on the haze by topography such as mountain ranges on Pluto, similar to the rays sometimes seen in the sky after the Sun sets behind mountains on Earth. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.

This first image happened to be in the center of the large bright feature we had first detected several weeks before. No impact craters were visible, and this nitrogen and methane ice field had to be very young. The origins of the large ovoid cellular pattern were the source of much conversation.

Each day brought one delightful surprise after another: four-kilometer-high mountains on Pluto, and fractures and smooth plains on unexpectedly complex Charon. Four days after encounter, feeling exhilarated but exhausted from all the new data, came the the first crescent image of Pluto. Sometimes the universe is just too beautiful for words, and when this image arrived, many of us were rendered temporarily speechless. It was enough to just stare at this soft glowing ring in the dark empty sky.

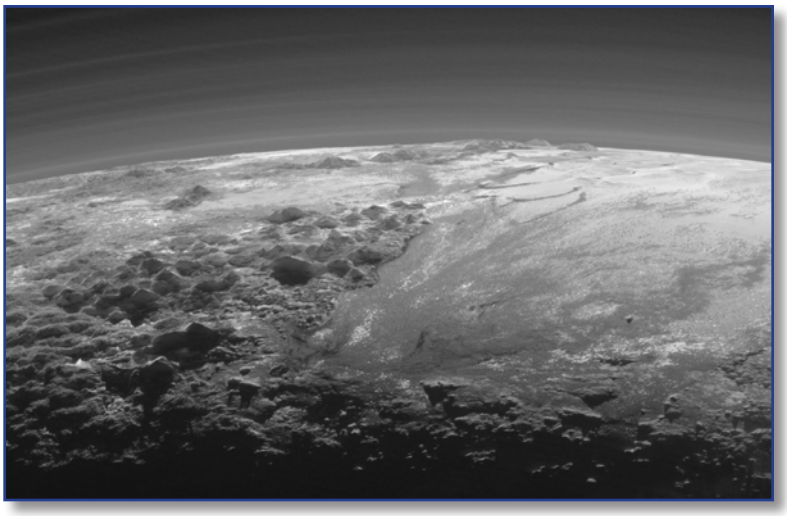
After a month-long gap during which mostly engineering data were returned, playback of uncompressed data began in earnest in early September. Unlike the quick datasets returned in July, which were compressed, these are free of artifacts and reveal just how well the instruments performed.

Many of these new images have already revealed some stunning surprises. These include the first high-resolution color images, the first of the highest-resolution images (between 100 and 120 meters in

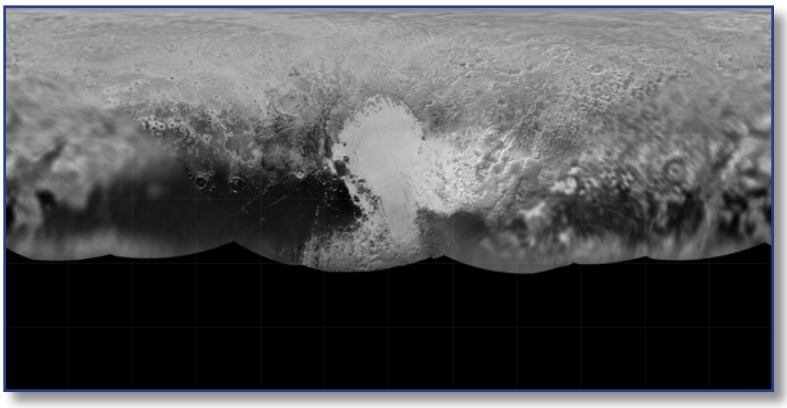
pixel scale), the truly other-worldly high-resolution view of the crescent Pluto, and details in the enormous atmospheric haze layer, as data began to play back in September. Playback of higher-resolution images of Charon and the other small moons will also begin shortly.

Much more can be expected from Pluto and its family of moons as data playback and analysis continue. The Pluto encounter proved to be not only well planned and executed, but also incredibly enriching for many of us. It allowed us as individuals and as a species to look skyward at the heavens for one brief moment, forget our troubles, and marvel at the jewels in our sky.

But perhaps more than that, Pluto was a personal journey for all those involved. We completed our grand adventure with our families and friends, and all of us made many new friends along the way. We shared in something wondrous and profound, and each of us grew a little wiser and better during the journey. And we did our best to share Pluto with the whole planet Earth as well.



Just 15 minutes after its closest approach to Pluto on July 14, 2015, NASA's New Horizons spacecraft looked back toward the Sun and captured a near-sunset view of the rugged, icy mountains and flat ice plains extending to Pluto's horizon. The smooth expanse of the informally named Sputnik Planum (right) is flanked to the west (left) by rugged mountains up to 3500 meters (11,000 feet) high, including the informally named Norgay Montes in the foreground and Hillary Montes on the skyline. The backlighting highlights more than a dozen layers of haze in Pluto's tenuous but distended atmosphere. The image was taken from a distance of 18,000 kilometers (11,000 miles) to Pluto; the scene is 380 kilometers (230 miles) across. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.



This updated global map of the dwarf planet Pluto includes all resolved images of the surface acquired between July 7–14, 2015, at pixel resolutions ranging from 40 kilometers (24 miles) on the Charon-facing hemisphere (left and right sides of the map) to 400 meters (1250 feet) on the anti-Charon facing hemisphere (map center). Many additional images are expected this fall and will be used to complete the global map. Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute.

The author posing for a selfie with Brian May, astrophysicist, stereo imaging aficionado, and member of the rock band Queen, who visited the New Horizons team a few days after the Pluto encounter. Credit: Paul Schenk.

About the Cover:

Main image: Artist's concept of the New Horizons spacecraft as it approaches Pluto and its largest moon, Charon, in July 2015. The spacecraft's most prominent design feature is a nearly 2.1-meter (7-foot) dish antenna, through which it will communicate with Earth from as far as 7.5 billion kilometers (4.7 billion miles) away.

Bottom: Just 15 minutes after its closest approach to Pluto on July 14, 2015, NASA's New Horizons spacecraft looked back toward the Sun and captured this near-sunset view of the rugged, icy mountains and flat ice plains extending to Pluto's horizon. The smooth expanse of the informally named icy plain Sputnik Planum (right) is flanked to the west (left) by rugged mountains up to 3500 meters (11,000 feet) high, including the informally named Norgay Montes in the foreground and Hillary Montes on the skyline.

Inset detail: This 350-kilometer (220-mile)-wide view of Pluto from the New Horizons spacecraft illustrates the incredible diversity of surface reflectivities and geological landforms on the dwarf planet. The image includes dark, ancient heavily cratered terrain; bright, smooth geologically young terrain; assembled masses of mountains; and an enigmatic field of dark, aligned ridges that resemble dunes; its origin is under debate. The smallest visible features are 0.8 kilometers (0.5 miles) in size.

Credit: All cover images courtesy of NASA/Johns Hopkins University Applied Physics Laboratory/ Southwest Research Institute.

About the Author:

Dr. Paul Schenk is a staff scientist at the Lunar and Planetary Institute (LPI) in Houston and serves as the science editor for the Lunar and Planetary Information Bulletin*. His first formal introduction to planetary sciences was as a NASA Planetary Geology summer intern in 1979 at the Jet Propulsion Laboratory during the Voyager 2 Jupiter encounter. After completing his Ph.D. at Washington University in St. Louis under advisor William B. McKinnon, Schenk came to the LPI in 1991. Schenk's research at LPI centers on elucidating the geology and topography of the surfaces of the satellites of the outer planets and Vesta, with a particular interest in the unexpectedly rugged topographic relief on Europa and the shapes of impact craters on Europa, Enceladus, and the icy satellites in general. He currently serves as a Co-Investigating Scientist on the New Horizons mission, and a Participating Scientist on the Dawn (at Vesta and Ceres) and Cassini projects.*

The *Lunar and Planetary Information Bulletin* collects, synthesizes, and disseminates current research and findings in the planetary sciences to the research community, science libraries, educators, students, and the public. The *Bulletin* is dedicated to engaging, exciting, and educating those with a passion for the space sciences while developing future generations of explorers.

The *Bulletin* welcomes articles dealing with issues related to planetary science and exploration. Of special interest are articles describing web-based research and educational tools, meeting highlights and summaries, and descriptions of space missions. Peer-reviewed research articles, however, are not appropriate for publication in the *Bulletin*. Suggested topics can be e-mailed to the editors, who will provide guidelines for formatting and content.

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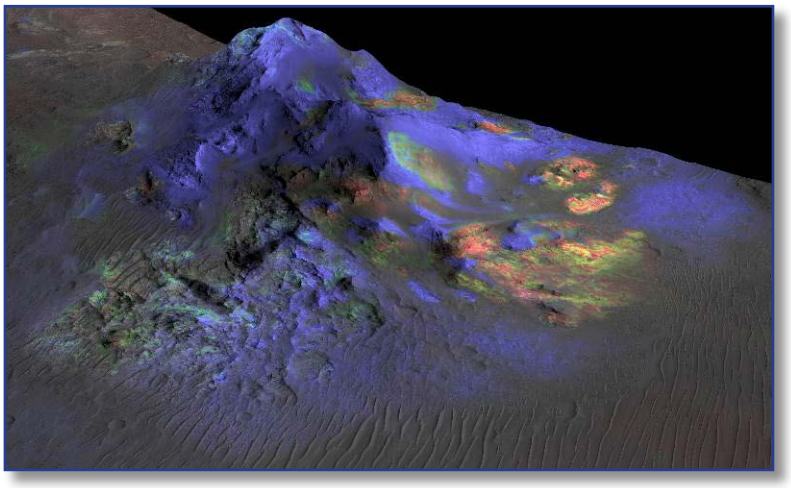
NASA Spacecraft Detects Impact Glass on Surface of Mars

NASA's Mars Reconnaissance Orbiter (MRO) has detected deposits of glass within impact craters on Mars. Although formed in the searing heat of a violent impact, such deposits might provide a delicate window into the possibility of past life on the Red Planet.

During the past few years, research has shown that evidence about past life has been preserved in impact glass here on Earth. A 2014 study led by scientist Peter Schultz of Brown University in Providence, Rhode Island, found organic molecules and plant matter entombed in glass formed by an impact that occurred millions of years ago in Argentina. Schultz suggested that similar processes might preserve signs of life on Mars, if they were present at the time of an impact. Fellow Brown researchers Kevin Cannon and Jack Mustard, building on the previous research, detail their data about martian impact glass in a report now online in the journal *Geology*.



Researchers have found deposits of impact glass (in green) preserved in martian craters, including Alga Crater, shown here. The detection is based on data from the instrument Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on NASA's Mars Reconnaissance Orbiter. Credit: NASA/JPL-Caltech/JHUAPL/Univ. of Arizona.

"The work done by Pete and others showed us that glasses are potentially important for preserving biosignatures," Cannon said. "Knowing that, we wanted to go look for them on Mars and that's what we did here. Before this paper, no one had been able to definitively detect them on the surface."

Cannon and Mustard showed large glass deposits are present in several ancient, yet well-preserved, craters on Mars. Picking out the glassy deposits was no easy task. To identify minerals and rock types remotely, scientists measured the spectra of light reflected off the planet's surface. But impact glass doesn't have a particularly strong spectral signal. "Glasses tend to be spectrally bland or weakly expressive, so signature from the glass tends to be overwhelmed by the chunks of rock mixed in with it," said Mustard. "But Kevin found a way to tease that signal out."

In a laboratory, Cannon mixed together powders with a similar composition of martian rocks and fired them in an oven to form glass. He then measured the spectral signal from that glass. Once Mustard had the signal from the lab glass, he used an algorithm to pick out similar signals in data from MRO's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), for which he is the deputy principal investigator.

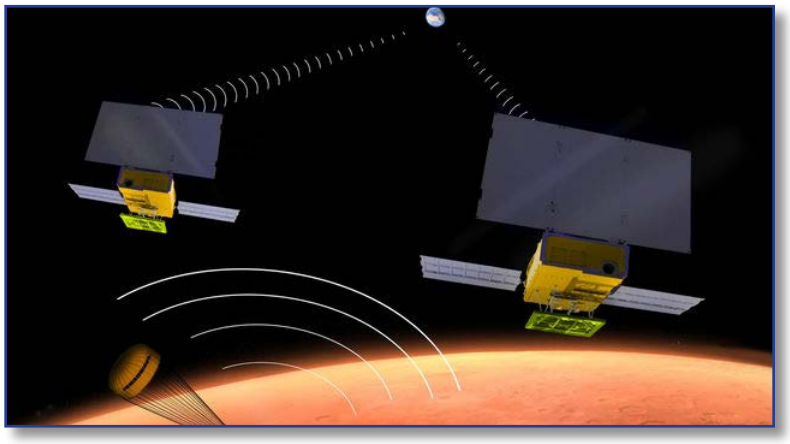
The technique pinpointed deposits in several martian crater central peaks, the craggy mounds that often form in the center of a crater during a large impact. The fact the deposits were found on central peaks is a good indicator that they have an impact origin. Knowing that impact glass can preserve ancient signs of life — and now knowing that such deposits exist on the martian surface today — opens up a potential new strategy in the search for ancient martian life.

"The researchers' analysis suggests glass deposits are relatively common impact features on Mars," said Jim Green, director of NASA's planetary science division at the agency's headquarters in Washington. "These areas could be targets for future exploration as our robotic scientific explorers pave the way on the journey to Mars with humans in the 2030s."

Learn more about the Mars Reconnaissance Orbiter mission at *http://mars.nasa.gov/mro* and *http://www.nasa.gov/mro*.

NASA Prepares for First Interplanetary CubeSats

When NASA launches its next mission on the journey to Mars — a stationary lander in 2016 — the flight will include two CubeSats. This will be the first time CubeSats have flown in deep space. If this flyby demonstration is successful, the technology will provide NASA the ability to quickly transmit status information about the main spacecraft after it lands on Mars.



NASA's two small MarCO CubeSats will be flying past Mars in 2016 just as NASA's next Mars lander, InSight, is descending through the martian atmosphere and landing on the surface. MarCO will provide an experimental communications relay to inform Earth quickly about the landing. Credit: NASA/JPL-Caltech.

The twin communications-relay CubeSats, being built by NASA's Jet Propulsion Laboratory, Pasadena, California, constitute a technology demonstration called Mars Cube One (MarCO). CubeSats are a class of spacecraft based on a standardized small size and modular use of off-the-shelf technologies. Many have been made by university students, and dozens have been launched into Earth orbit using extra payload mass available on launches of larger spacecraft.

The basic CubeSat unit is a box roughly 10 centimeters (4 inches) square. Larger CubeSats are multiples of that unit. MarCO's design is a six-unit CubeSat — about the size of a briefcase — with a stowed size of about 36.6 centimeters (14.4 inches) by 24.3 centimeters (9.5 inches) by 11.8 centimeters (4.6 inches).

MarCO will launch in March 2016 from Vandenberg Air Force Base, California, on the same United Launch Alliance Atlas V rocket as NASA's Interior Exploration using the Seismic Investigations, Geodesy

and Heat Transport (InSight) lander. InSight is NASA's first mission devoted to understanding the interior structure of the Red Planet. MarCO will fly by Mars while InSight is landing, in September 2016.

"MarCO is an experimental capability that has been added to the InSight mission but is not needed for mission success," said Jim Green, director of NASA's planetary science division at the agency's headquarters in Washington. "MarCO will fly independently to Mars."

During InSight's entry, descent, and landing (EDL) operations on September 28, 2016, the lander will transmit information in the UHF radio band to NASA's Mars Reconnaissance Orbiter (MRO) flying overhead. MRO will forward EDL information to Earth using a radio frequency in the X band, but cannot simultaneously receive information over one band while transmitting on another. Confirmation of a successful landing could be received by the orbiter more than an hour before it's relayed to Earth. MarCO's softball-size radio provides both UHF (receive only) and X-band (receive and transmit) functions capable of immediately relaying information received over UHF.

The two CubeSats will separate from the Atlas V booster after launch and travel along their own trajectories to the Red Planet. After release from the launch vehicle, MarCO's first challenges are to deploy two radio antennas and two solar panels. The high-gain, X-band antenna is a flat panel engineered to direct radio waves the way a parabolic dish antenna does. MarCO will be navigated to Mars independently of the InSight spacecraft, with its own course adjustments on the way.

Ultimately, if the MarCO demonstration mission succeeds, it could allow for a "bring-your-own" communications relay option for use by future Mars missions in the critical few minutes between martian atmospheric entry and touchdown.

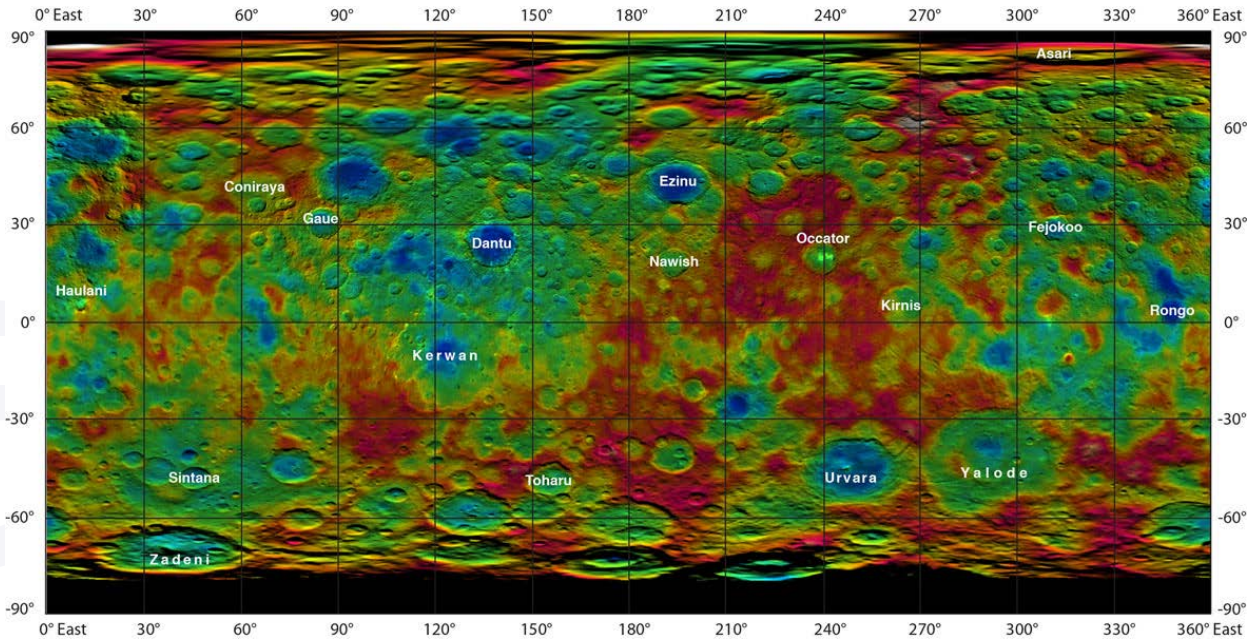
For more information, visit *http://www.jpl.nasa.gov/cubesat/missions/marco.php*, *http://www.nasa.gov/insight*, and *http://www.nasa.gov/content/journey-to-mars-overview*.

New Names and Insights at Ceres

Colorful new maps of Ceres, based on data from NASA's Dawn spacecraft, showcase a diverse topography, with height differences between crater bottoms and mountain peaks as great as 15 kilometers (9 miles). Scientists continue to analyze the latest data from Dawn as the spacecraft makes its way to its third mapping orbit.

"The craters we find on Ceres, in terms of their depth and diameter, are very similar to what we see on Dione and Tethys, two icy satellites of Saturn that are about the same size and density as Ceres. The features are pretty consistent with an ice-rich crust," said Dawn science team member Paul Schenk, a geologist at the Lunar and Planetary Institute in Houston, Texas.

Some of these craters and other features now have official names, inspired by spirits and deities relating to agriculture from a variety of cultures. The International Astronomical Union recently approved a



This color-coded map from NASA's Dawn mission shows the highs and lows of topography on the surface of dwarf planet Ceres. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA.

batch of names for features on Ceres. The newly labeled features include Occator, the mysterious crater containing Ceres' brightest spots, which has a diameter of about 90 kilometers (60 miles) and a depth of about 4 kilometers (2 miles). Occator is the name of the Roman agriculture deity of harrowing, a method of leveling soil. A smaller crater with bright material, previously labeled "Spot 1," is now identified as Haulani, after the Hawaiian plant goddess. Haulani has a diameter of about 30 kilometers (20 miles). Temperature data from Dawn's visible and infrared mapping spectrometer show that this crater seems to be colder than most of the territory around it. Dantu crater, named after the Ghanaian god associated with the planting of corn, is about 120 kilometers (75 miles) across and 3 miles (5 kilometers) deep. A crater called Ezinu, after the Sumerian goddess of grain, is about the same size. Both are less than half the size of Kerwan, named after the Hopi spirit of sprouting maize, and Yalode, a crater named after the African Dahomey goddess worshipped by women at harvest rites.

"The impact craters Dantu and Ezinu are extremely deep, while the much larger impact basins Kerwan and Yalode exhibit much shallower depth, indicating increasing ice mobility with crater size and age," said Ralf Jaumann, a Dawn science team member at the German Aerospace Center (DLR) in Berlin.

Almost directly south of Occator is Urvara, a crater named for the Indian and Iranian deity of plants and fields. Urvara, about 160 kilometers (100 miles) wide and 6 kilometers (3 miles) deep, has a prominent central peak that is 3 kilometers (2 miles) high.

Dawn is currently spiraling toward its third science orbit, less than 1500 kilometers (900 miles) above the surface, or three times closer to Ceres than its previous orbit. The spacecraft will reach this orbit in mid-August and begin taking images and other data again.

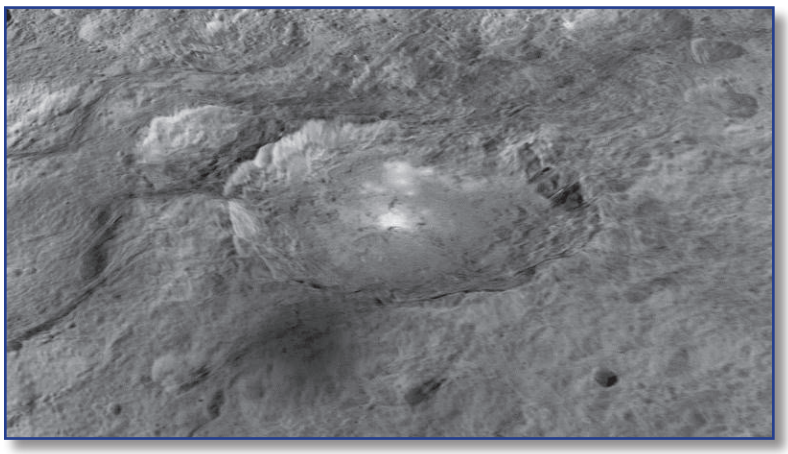
Ceres, with a diameter of 940 kilometers (584 miles), is the largest object in the main asteroid belt, located between Mars and Jupiter. This makes Ceres about 40% the size of Pluto, another dwarf planet, which NASA's New Horizons mission flew by in July of this year (see the related cover story in this issue).

For more information, visit *http://dawn.jpl.nasa.gov* and *http://www.nasa.gov/dawn*.

Cruise Over Ceres in New Video

Striking three-dimensional (3-D) detail highlights a towering mountain, the brightest spots, and other features on dwarf planet Ceres in a new video from NASA's Dawn mission.

A prominent mountain with bright streaks on its steep slopes is especially fascinating to scientists. The peak's shape has been likened to a cone or a pyramid. It appears to be about 6 kilometers (4 miles) high, with respect to the surface around it, according to the latest estimates. This means the mountain has about the same elevation as Mount McKinley in Denali National Park, Alaska, the highest point in North America.



The intriguing brightest spots on Ceres lie in a crater named Occator, which is about 90 kilometers (60 miles) across and 4 kilometers (2 miles) deep. Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA/LPI.

"This mountain is among the tallest features we've seen on Ceres to date," said Dawn science team member Paul Schenk, a geologist at the Lunar and Planetary Institute in Houston. "It's unusual that it's not associated with a crater. Why is it sitting in the middle of nowhere? We don't know yet, but we may find out with closer observations."

Also puzzling is the famous Occator (oh-KAH-tor) crater, home to Ceres' brightest spots. A new animation simulates the experience of a close flyover of this area. The crater takes its name from the Roman agriculture deity of harrowing, a method of pulverizing and smoothing soil.

In examining the way Occator's bright spots reflect light at different wavelengths, the Dawn science team has not found evidence that is consistent with ice. The spots' albedo — a measure of the amount of light reflected — is also lower than predictions for concentrations of ice at the surface.

"The science team is continuing to evaluate the data and discuss theories about these bright spots at Occator," said Chris Russell, Dawn's principal investigator at the University of California, Los Angeles. "We are now comparing the spots with the reflective properties of salt, but we are still puzzled by their source. We look forward to new, higher-resolution data from the mission's next orbital phase."

An animation of Ceres' overall geography, also available in 3-D, shows these features in context. Occator lies in the northern hemisphere, whereas the tall mountain is farther to the southeast (11°S, 316°E).

"There are many other features that we are interested in studying further," said Dawn science team member David O'Brien, with the Planetary Science Institute, Tucson, Arizona. "These include a pair of large impact basins called Urvara and Yalode in the southern hemisphere, which have numerous cracks extending away from them, and the large impact basin Kerwan, whose center is just south of the equator."

Ceres is the largest object in the main asteroid belt between Mars and Jupiter. Thanks to data acquired by Dawn since the spacecraft arrived in orbit at Ceres, scientists have revised their original estimate of Ceres' average diameter to 940 kilometers (584 miles). The previous estimate was 950 kilometers (590 miles).

Dawn resumed its observations of Ceres in mid-August from an altitude of less than 1500 kilometers (900 miles), or three times closer to Ceres than its previous orbit.

For more information, visit *http://www.jpl.nasa.gov/video/details.php?id=1392*, *http://dawn.jpl.nasa.gov*, and *http://www.nasa.gov/dawn*.

Tracking a Mysterious Group of Asteroid Outcasts

High above the plane of our solar system, near the asteroid-rich abyss between Mars and Jupiter, scientists have found a unique family of space rocks. These interplanetary oddballs are the Euphrosyne (pronounced you-FROH-seh-nee) asteroids, and by any measure they have been distant, dark, and mysterious — until now. Distributed at the outer edge of the asteroid belt, the Euphrosynes have an unusual orbital path that juts well above the ecliptic, the equator of the solar system. The asteroid after which they are named, Euphrosyne — for an ancient Greek goddess of mirth — is about 260 kilometers (156 miles) across and is one of the 10 largest asteroids in the main belt. Current-day Euphrosyne is thought to be a remnant of a massive collision about 700 million years ago that formed the family of smaller asteroids bearing its name. Scientists think this event was one of the last great collisions in the solar system.

The asteroid Euphrosyne glides across a field of background stars in this time-lapse view from NASA's WISE spacecraft. Credit: NASA/JPL-Caltech.

A new study conducted by scientists at NASA's Jet Propulsion Laboratory in Pasadena, California, used the agency's orbiting Near-Earth Object Wide-field Infrared Survey Explorer (NEOWISE) telescope to look at these unusual asteroids to learn more about near-Earth objects (NEOs) and their potential threat to

Earth. NEOs are bodies whose orbits around the Sun approach the orbit of Earth; this population is short-lived on astronomical timescales and is fed by other reservoirs of bodies in our solar system. As they orbit the Sun, NEOs can occasionally have close approaches to Earth. For this reason alone — the safety of our home planet — the study of such objects is important.

As a result of their study, the JPL researchers believe the Euphrosynes may be the source of some of the dark NEOs found to be on long, highly inclined orbits. They found that, through gravitational interactions with Saturn, Euphrosyne asteroids can evolve into NEOs over timescales of millions of years. NEOs can originate in either the asteroid belt or the more distant outer reaches of the solar system. Those from the asteroid belt are thought to evolve toward Earth's orbit through collisions and the gravitational influence of the planets. Originating well above the ecliptic and near the far edge of the asteroid belt, the forces that shape their trajectories toward Earth are far more moderate.

"The Euphrosynes have a gentle resonance with the orbit of Saturn that slowly moves these objects, eventually turning some of them into NEOs," said Joseph Masiero, JPL's lead scientist on the Euphrosynes study. "This particular gravitational resonance tends to push some of the larger fragments of the Euphrosyne family into near-Earth space."

By studying the Euphrosyne family asteroids with NEOWISE, JPL scientists have been able to measure their sizes and the amount of solar energy they reflect. Since NEOWISE operates in the infrared portion of the spectrum, it detects heat. Therefore, it can see dark objects far better than telescopes operating at visible wavelengths, which sense reflected sunlight. Its heat-sensing capability also allows it to measure sizes more accurately.

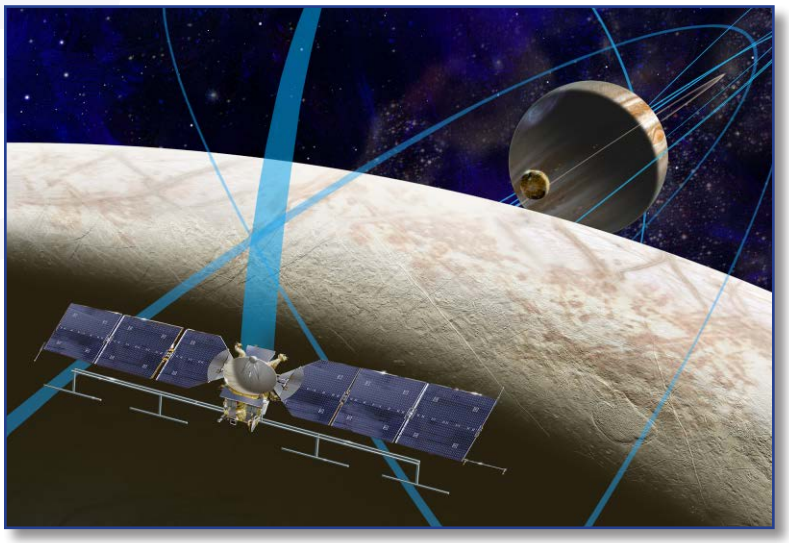
There are over 700,000 asteroidal bodies currently known in the main belt that range in size from large boulders to about 60% of the diameter of Earth's Moon, with many yet to be discovered. This makes finding the specific point of origin of most NEOs extremely difficult. With the Euphrosynes it's different. "Most near-Earth objects come from a number of sources in the inner region of the main belt, and they are quickly mixed around," Masiero said. "But with objects coming from this family, in such a unique region, we are able to draw a likely path for some of the unusual, dark NEOs we find back to the collision in which they were born."

A better understanding of the origins and behaviors of these mysterious objects will give researchers a clearer picture of asteroids in general, and in particular the NEOs that skirt our home planet's neighborhood. Such studies are important, and potentially critical, to the future of humanity, which is a primary reason JPL and its partners continue to relentlessly track these wanderers within our solar system. To date, U.S. assets have discovered more than 98% of the known NEOs.

For more information, visit *http://www.nasa.gov/neowise*, *http://neo.jpl.nasa.gov*, and *http://www.jpl.nasa.gov/asteroidwatch*.

NASA's Europa Mission Team Joins Forces for the First Time

They're united by a lofty goal — to investigate whether Jupiter's moon Europa could harbor primitive life under its icy shell. During the first week of August, a team of scientists and engineers for NASA's planned mission to Europa met for the first time at NASA's Jet Propulsion Laboratory in Pasadena, California, to begin turning that goal into reality. After years of planning and hoping, the premier gathering was the final page of the team's origin story and the beginning of a new chapter that could last as long as two decades.



Artist's rendering of NASA's Europa mission spacecraft. Credit: NASA/ JPL-Caltech.

"We have a rare and wonderful opportunity with this mission to investigate whether Europa could be an abode for life," said Curt Niebur, Europa mission program scientist at NASA Headquarters in Washington, at the meeting's opening. "We're in the service of our colleagues, our scientific community, our country, and our fellow human beings. It's a responsibility we take very seriously."

The mission plan calls for a spacecraft to be launched to Jupiter in the 2020s, arriving in the distant planet's orbit after a journey of several years. The spacecraft would orbit the gas giant planet about every two weeks, providing many opportunities for close flybys of Europa. The mission plan includes 45 flybys, during which the spacecraft would image the moon's icy surface at high resolution and investigate its composition and the structure of its interior and icy shell. In late May, NASA announced the selection of instruments for the mission's scientific payload, while in June the mission formally entered the development phase known as formulation.

Thought to contain an ocean of liquid water beneath its icy surface, Europa is considered one of the most promising places in the solar system beyond Earth to search for signs of present-day life, in the form of simple organisms.

At the introductory meeting, players in the room included many stars in the field of planetary exploration. Some came fresh from leading roles in the recent successful flyby of Pluto by NASA's New Horizons mission. Several have worked together for decades, exploring Europa and other icy moons with NASA's Cassini, Galileo, and Voyager missions.

In addition to its veteran explorers, the Europa mission also includes younger team members who have begun making their contributions to the field more recently. Together, the assembled team of scientists and spacecraft engineers made for a group filled with possibilities for collaboration.

"That's why we're here, in one room, at the very start of the project," said Robert Pappalardo, Europa project scientist at JPL. "So we can begin to function as one team, to understand the cross-cutting science issues we all face, and so we can use all of our tools together to understand Europa."

Mission engineers had already been hard at work for the past couple of years, developing the overall concept that eventually became NASA's mission to Europa. They are charged with designing the spacecraft and choreographing its flight plan, and — of course — building the complex robotic space probe. Their initial briefing to the scientists included information on how to design the mission for Jupiter's hazardous radiation environment and plans for integrating the recently selected science instruments into the probe's overall architecture. "The engineering team has already made great progress, and we're in excellent shape for this phase of the mission," Barry Goldstein, Europa project manager at JPL, reported to the team. "I couldn't be more excited about the work we've done and the road ahead."

The top priority for the mission's first meeting was to begin the work of refining the mission's science, especially with regard to how the instruments can best work together to achieve NASA's main objective for Europa. "Your instruments were each selected separately," said Pappalardo, "But now we want to understand how they can best work together to achieve the overarching goal, which is to investigate the habitability of this icy ocean moon."

For more information, visit *http://www.nasa.gov/europa*.

With One Year to Jupiter, NASA's Juno Team Prepares

With just one year remaining in a five-year trek to Jupiter, the team of NASA's Juno mission is hard at work preparing for the spacecraft's expedition to the solar system's largest planet. The mission aims to reveal the story of Jupiter's formation and details of its interior structure. Data from Juno will provide insights about our solar system's beginnings, and what we learn from the mission will also enrich scientists' understanding of giant planets around other stars.

This artist's rendering shows NASA's Juno spacecraft making one of its close passes over Jupiter. Credit: NASA/JPL-Caltech.

Juno is scheduled to arrive at Jupiter on July 4, 2016 (Pacific Daylight Time). Once it settles into orbit, the spacecraft will brave the hazards of Jupiter's intense radiation when it repeatedly approaches within a few thousand kilometers, or miles, of the cloud tops to collect its data. Juno is the first mission dedicated to the study of a giant planet's interior, which it will do by mapping the planet's magnetic and gravity

fields. The mission will also map the abundance of water vapor in the planet's atmosphere, providing the key to understanding which of several theories about the planet's formation is likely the correct one. In addition, Juno will travel through the previously unexplored region above the planet's poles, collecting the first images from there, along with data about electromagnetic forces and high-energy particles in the environment.

Although other spacecraft have previously visited Jupiter, the space around the planet is full of unknowns, especially the regions above the poles. With these challenges in mind, the Juno team has been busy fine-tuning their flight plan. "We're already more than 90% of the way to Jupiter, in terms of total distance traveled," said Scott Bolton, Juno principal investigator at Southwest Research Institute, San Antonio. "With a year to go, we're looking carefully at our plans to make sure we're ready to make the most of our time once we arrive."

Following a detailed analysis by the Juno team, NASA recently approved changes to the mission's flight plan at Jupiter. Instead of taking 11 days to orbit the planet, Juno will now complete one revolution every 14 days. The difference in orbit period will be accomplished by having Juno execute a slightly shorter engine burn than originally planned.

The revised cadence will allow Juno to build maps of the planet's magnetic and gravity fields in a way that will provide a global look at the planet earlier in the mission than the original plan. Over successive orbits, Juno will build a virtual web around Jupiter, making its gravity and magnetic field maps as it passes over different longitudes from north to south. The original plan would have required 15 orbits to map these forces globally, with 15 more orbits filling in gaps to make the map complete. In the revised plan, Juno will get very basic mapping coverage in just eight orbits. A new level of detail will be added with each successive doubling of the number, at 16 and 32 orbits.

"We have models that tell us what to expect, but the fact is that Juno is going to be immersed in a strong and variable magnetic field and hazardous radiation, and it will get closer to the planet than any previous orbiting spacecraft," said Bolton. "Juno's experience could be different than what our models predict — that's part of what makes space exploration so exciting."

The revised plan lengthens Juno's mission at Jupiter to 20 months instead of the original 15, and the spacecraft will now complete 32 orbits instead of 30. But the extra time doesn't represent bonus science for the mission — rather, it's an effect of the longer orbital period and the change in the way Juno builds its web around Jupiter. Basically, it will take Juno a bit longer to collect the full data set the mission is after, but it will get a low-resolution version of its final products earlier in the mission than originally planned.

NASA also recently approved a change to the spacecraft's initial orbit after Jupiter arrival, called the capture orbit. The revised plan splits the originally planned, 107-day-long capture orbit into two. The new approach will provide the Juno team a sneak preview of their science activities, affording them an opportunity to test the spacecraft's science instruments during a close approach to Jupiter before

beginning the actual science phase of the mission. The original scenario called for an engine burn to ease Juno into Jupiter orbit, followed by a second burn 107 days later, putting the spacecraft into an 11-day science orbit. In the updated mission design, the orbit-insertion burn is followed 53.5 days later by a practice run at Jupiter with science instruments turned on, followed by another 53.5-day orbit before the final engine burn that places Juno into its new, 14-day science orbit.

In addition to myriad preparations being made on the engineering side, Juno's science team is also busy preparing to collect valuable data about the giant planet's inner workings. One piece of this science groundwork is a collection of images and spectra being obtained by powerful groundbased telescopes and NASA's Hubble Space Telescope (spectra are like chemical fingerprints of gases in the atmosphere). These data are intended to provide big-picture context for Juno's up-close observations of Jupiter, which is important for interpreting what the spacecraft's instruments will see.

With the countdown clock ticking — this time, not toward launch, but toward arrival at their destination — the Juno team is acutely aware of how quickly they're sneaking up on the giant planet. And their excitement is building. "It's been a busy cruise, but the journey has provided our team with valuable experience flying the spacecraft and enhanced our confidence in Juno's design," said Rick Nybakken, Juno project manager at NASA's Jet Propulsion Laboratory, Pasadena, California. "Now it's time to gear up for Jupiter."

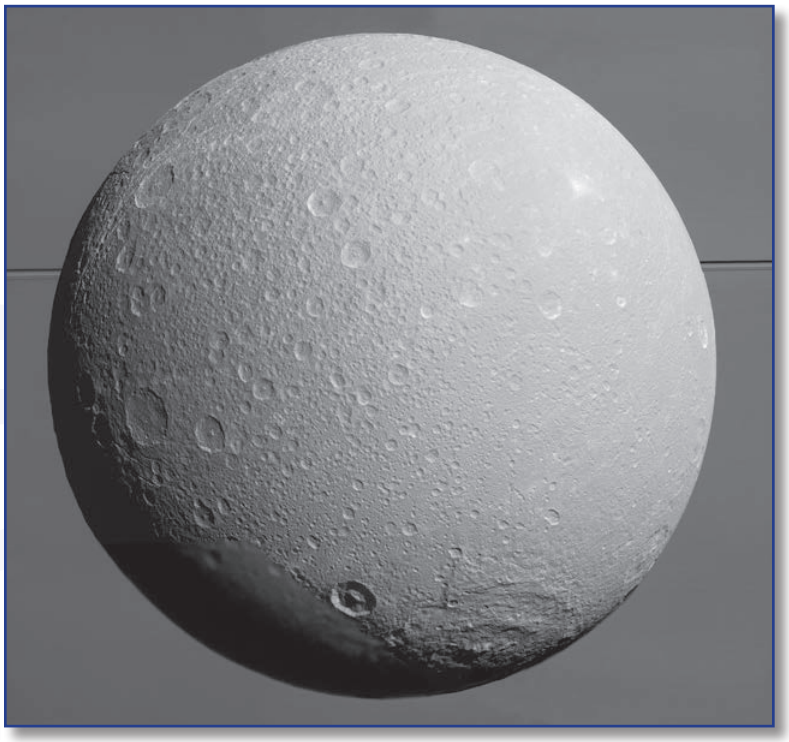
For more information about Juno visit *http://www.nasa.gov/juno* and *http://missionjuno.swri.edu*.

Cassini's Final Breathtaking Close Views of Dione

A pockmarked, icy landscape looms beneath NASA's Cassini spacecraft in new images of Saturn's moon Dione taken during the mission's last close approach to the small, icy world. Two of the new images show the surface of Dione at the best resolution ever. Cassini passed 474 kilometers (295 miles) above Dione's surface at 11:33 a.m. PDT (2:33 p.m. EDT) on August 17. This was the fifth close encounter with Dione during Cassini's long tour at Saturn. The mission's closest-ever flyby of Dione was in December 2011, at a distance of 100 kilometers (60 miles).

"I am moved, as I know everyone else is, looking at these exquisite images of Dione's surface and crescent, and knowing that they are the last we will see of this far-off world for a very long time to come," said Carolyn Porco, Cassini imaging team lead at the Space Science Institute, Boulder, Colorado. "Right down to the last, Cassini has faithfully delivered another extraordinary set of riches. How lucky we have been."

The main scientific focus of this flyby was gravity science, not imaging. This made capturing the images tricky, as Cassini's camera was not controlling where the spacecraft pointed. "We had just enough time to snap a few images, giving us nice, high-resolution looks at the surface," said Tilmann Denk, a Cassini participating scientist at Freie University in Berlin. "We were able to make use of reflected sunlight from Saturn as an additional light source, which revealed details in the shadows of some of the images."



This view from NASA's Cassini spacecraft looks toward Saturn's icy moon Dione, with giant Saturn and its rings in the background, just prior to the mission's final close approach to the moon on August 17, 2015. Credit: NASA/JPL-Caltech/Space Science Institute.

Cassini scientists will study data from the gravity science experiment and magnetosphere and plasma science instruments over the next few months as they look for clues about Dione's interior structure and processes affecting its surface.

Only a handful of close flybys of Saturn's large, icy moons remain for Cassini. The spacecraft is scheduled to make three approaches to the geologically active moon Enceladus on October 14 and 28 and December 19. During the October 28 flyby, the spacecraft will come dizzyingly close to Enceladus, passing a mere 49 kilometers (30 miles) from the surface. Cassini will make its deepest-ever dive through the moon's plume of icy spray at this time, collecting valuable data about what's going on beneath the surface. The December Enceladus encounter will be Cassini's final close pass by that moon, at an altitude of 4999 kilometers (3106 miles).

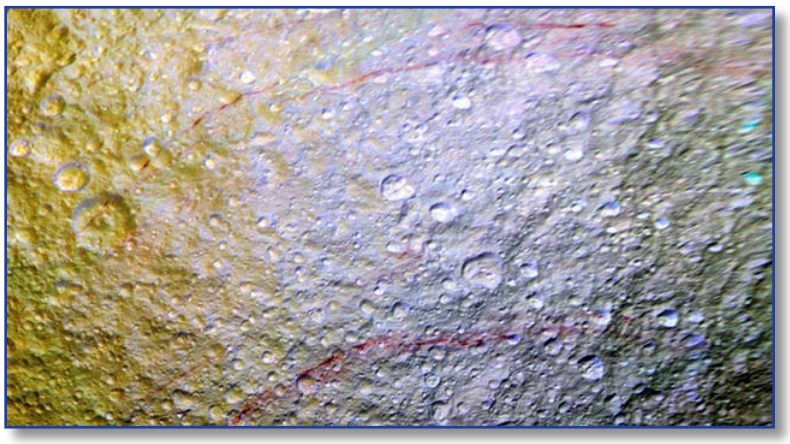
After December, and through the mission's conclusion in late 2017, there are a handful of distant flybys planned for Saturn's large, icy moons at ranges of less than about 50,000 kilometers (30,000 miles). Cassini will, however, make nearly two dozen passes by a menagerie of Saturn's small, irregularly shaped moons — including Daphnis, Telesto, Epimetheus and Aegaeon — at similar distances during this time. These passes will provide some of Cassini's best-ever views of the little moons. During the mission's final year — called its Grand Finale — Cassini will repeatedly dive through the space between Saturn and its rings.

For more information, visit *http://www.nasa.gov/mission_pages/cassini/main/index.html* and *http://saturn.jpl.nasa.gov/*. Raw, unprocessed images from the flyby are available at *http://saturn.jpl.nasa.gov/mission/flybys/dione20150817/*.

Unusual Red Arcs Spotted on Icy Saturn Moon

Like graffiti sprayed by an unknown artist, unexplained arc-shaped, reddish streaks are visible on the surface of Saturn's icy moon Tethys in new, enhanced-color images from NASA's Cassini spacecraft. The red arcs are narrow, curved lines on the moon's surface, and are among the most unusual color features on Saturn's moons to be revealed by Cassini's cameras. Images taken using clear, green, infrared, and ultraviolet spectral filters were combined to create the enhanced-color views, which highlight subtle color differences across the icy moon's surface at wavelengths not visible to human eyes.

A few of the red arcs can be seen faintly in observations made earlier in the Cassini mission, which has been in orbit at Saturn since 2004. But the color images for this observation, obtained in April 2015, are the first to show large northern areas of Tethys under the illumination and viewing conditions necessary to see the arcs clearly. As the Saturn system moved into its northern hemisphere summer over the past few years, northern latitudes have become increasingly well illuminated. As a result, the arcs have become clearly visible for the first time.



Unusual arc-shaped, reddish streaks cut across the surface of Saturn's ice-rich moon Tethys in this enhanced-color mosaic. The red streaks are narrow, curved lines on the moon's surface, only a few kilometers (or miles) wide but several hundred kilometers (or miles) long. Credit: NASA/JPL-Caltech/Space Science Institute.

"The red arcs really popped out when we saw the new images," said Cassini participating scientist Paul Schenk of the Lunar and Planetary Institute in Houston. "It's surprising how extensive these features are."

The origin of the features and their reddish color is a mystery to Cassini scientists. Possibilities being studied include ideas that the reddish material is exposed ice with chemical impurities, or the result of outgassing from inside Tethys. They could also be associated with features like fractures that are below the resolution of the available images. Except for a few small craters on Saturn's moon Dione, reddish-tinted features are rare on other moons of Saturn. Many reddish features do occur, however, on the geologically young surface of Jupiter's moon Europa.

"The red arcs must be geologically young because they cut across older features like impact craters, but we don't know their age in years." said Paul Helfenstein, a Cassini imaging scientist at Cornell University, Ithaca, New York, who helped plan the observations. "If the stain is only a thin, colored veneer on the icy soil, exposure to the space environment at Tethys' surface might erase them on relatively short time scales."

"After 11 years in orbit, Cassini continues to make surprising discoveries," said Linda Spilker, Cassini project scientist at NASA's Jet Propulsion Laboratory in Pasadena, California. "We are planning an even closer look at one of the Tethys red arcs in November to see if we can tease out the source and composition of these unusual markings."

For more information, visit *http://www.nasa.gov/mission_pages/cassini/main/index.html* and *http://saturn.jpl.nasa.gov/*.

Rosetta's Big Day in the Sun

This series of images of Comet 67P/Churyumov–Gerasimenko was captured by Rosetta's OSIRIS narrow-angle camera on August 12, 2015, just a few hours before the comet reached the closest point to the Sun (perihelion) along its 6.5-year orbit. Credit: ESA/Rosetta/MPS.

ESA's Rosetta witnessed Comet 67P/Churyumov-Gerasimenko making its closest approach to the Sun on August 13. The exact moment of perihelion occurred at 02:03 Greenwich Mean Time (GMT) when the comet came within 186 million kilometers of the Sun.

In the year that has passed since Rosetta arrived, the comet has traveled some 750 million kilometers along its orbit toward the Sun, the increasing solar radiation heating up the nucleus and causing its frozen ices to escape as gas and stream out into space at an ever greater rate. These gases, and the dust particles that they drag along, build up the comet's atmosphere — coma — and tail. The activity reaches its peak intensity around perihelion and in the weeks that follow — and is clearly visible in the spectacular images returned by the spacecraft in the last months. One image taken by Rosetta's navigation camera was acquired at 01:04 GMT on August 13, just an hour before the moment of perihelion, from a distance of around 327 kilometers.

The scientific camera was also taking images — the most recent available image was taken at 23:31 GMT on August 12, just a few hours before perihelion. The comet's activity is clearly seen in the images, with a multitude of jets stemming from the nucleus, including one outburst captured in an image taken at 17:35 GMT on August 12.

"Activity will remain high like this for many weeks, and we're certainly looking forward to seeing how many more jets and outburst events we catch in the act, as we have already witnessed in the last few weeks," said Nicolas Altobelli, acting Rosetta project scientist.

Rosetta's measurements suggest the comet is spewing up to 300 kilograms of water vapor — roughly the equivalent of two bathtubs — every second. This is a thousand times more than was observed this time last year when Rosetta first approached the comet. Then, it recorded an outflow rate of just 300 grams

per second, equivalent to two small glasses of water. Along with gas, the nucleus is also estimated to be shedding up to 1000 kilograms of dust per second, creating dangerous working conditions for Rosetta.

"In recent days, we have been forced to move even further away from the comet. We're currently at a distance of between 325 kilometers and 340 kilometers this week, in a region where Rosetta's startrackers can operate without being confused by excessive dust levels — without them working properly, Rosetta can't position itself in space," comments Sylvain Lodiot, ESA's spacecraft operations manager. Monitoring the comet's changing environment in the lead up to, during, and after perihelion is one of the primary long-term science goals of the mission.

Over the last few months, seasons on the comet have changed, throwing its southern hemisphere into a short — about 10 months — summer after more than five-and-a-half years in darkness. This has revealed parts of the surface that have previously been cast in shadow during Rosetta's sojourn at the comet, allowing scientists to fill in some of the missing pieces of its regional map. They have now identified four new geological regions on the southern hemisphere, which includes parts of both comet lobes, bringing the total number of regions to 23. The names of the new regions follow the naming convention of Egyptian gods and goddesses adopted for the comet: Anhur, Khonsu, Sobek, and Wosret.

The comet's average temperature has also been on the increase. Not long after arriving, surface temperatures of around –70°C were recorded. By April–May 2015, this had risen to only a few degrees below 0°C, and now highs of a few tens of degrees above zero are forecast for the next month.

Meanwhile, astronomers back on Earth have been following the comet's evolution from afar. Rosetta is far too close to the comet to see its growing tail, but images collected over the past few months with telescopes across the world show that it already extends more than 120,000 kilometers.

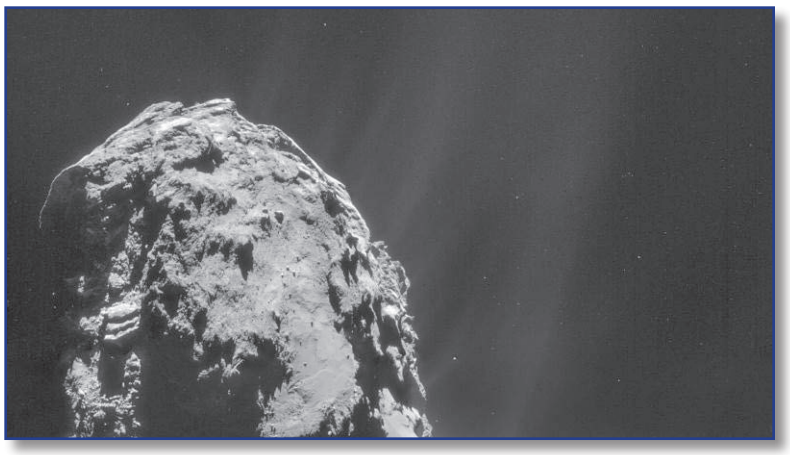
A lop-sided coma, with a notable high-density region away from the main tail, was revealed in various images, including some taken earlier in August from the Gemini-North telescope on Mauna Kea, Hawaii. "Combining these big-picture views from groundbased telescopes with Rosetta's close-up study of individual jets and outbursts will help us to understand the processes at work on the comet's surface as it approaches the Sun," adds Nicolas. "We aim to go back in much closer again after the activity subsides and make a survey of how the comet has changed. We also continue to hope that Philae will be able to resume its scientific operations on the surface and give us a detailed look at changes which may be occurring immediately surrounding its landing site."

For more information, visit *http://www.esa.int/Our_Activities/Space_Science/Rosetta* and *http://rosetta.jpl.nasa.gov/*.

NASA Instrument on Rosetta Makes Comet Atmosphere Discovery

Data collected by NASA's Alice instrument onboard the European Space Agency's Rosetta spacecraft reveal that electrons close to the surface of Comet 67P/Churyumov-Gerasimenko — not photons from the Sun, as had been believed — cause the rapid breakup of water and carbon dioxide molecules spewing from the comet's surface.

"The discovery we're reporting is quite unexpected," said Alan Stern, principal investigator for the Alice instrument at the Southwest Research Institute (SwRI) in Boulder, Colorado. "It shows us the value of going to comets to observe them up close, since this discovery simply could not have been made from Earth or Earth orbit with any existing or planned observatory. And, it is fundamentally transforming our knowledge of comets."



This composite is a mosaic comprising four individual NAVCAM images taken from 31 kilometers (19 miles) from the center of Comet 67P/Churyumov-Gerasimenko on November 20, 2014. Credit: ESA/ Rosetta/NAVCAM.

A report of the findings has been accepted for publication by the journal *Astronomy and Astrophysics*.

Analysis of the relative intensities of observed atomic emissions allowed the Alice science team to determine the instrument was directly observing the "parent" molecules of water and carbon dioxide that were being broken up by electrons in the immediate vicinity, about 1 kilometer (0.6 miles) from the comet's nucleus. The carbon dioxide and water are being released from the comet's nucleus and affected by electrons near the nucleus.

Since last August, Rosetta has orbited within 160 kilometers (100 miles) of Comet 67P. The Alice spectrograph onboard Rosetta specializes in sensing the far-ultraviolet wavelength band. Alice examines light the comet is emitting to understand the chemistry of the comet's atmosphere, or coma. A spectrograph is a tool astronomers use to split light into its various colors. Scientists can identify the chemical composition of gases by examining their light spectrum. Alice is the first such far-ultraviolet spectrograph to operate at a comet. Alice data indicate much of the water and carbon dioxide in the comet's coma originate from plumes erupting from its surface.

"It is similar to those that the Hubble Space Telescope discovered on Jupiter's moon Europa, with the exception that the electrons at the comet are produced by solar radiation, while the electrons at Europa come from Jupiter's magnetosphere," said Paul Feldman, an Alice co-investigator from the Johns Hopkins University in Baltimore, Maryland.

By looking at the emission from hydrogen and oxygen atoms broken from the water molecules, Alice scientists can actually trace the location and structure of water plumes from the surface of the comet. The far-ultraviolet region of the spectrum allows scientists to detect the most abundant elements in the universe: hydrogen, oxygen, carbon and nitrogen. However, such measurements must be made from outside Earth's atmosphere, either from orbiting observatories such as the Hubble Space Telescope, or from planetary missions such as Rosetta. From Earth orbit, the atomic constituents can only be seen after their parent molecules, such as water and carbon dioxide, have been broken up by sunlight, hundreds to thousands of kilometers, or miles, away from the nucleus of the comet.

The Alice spectrograph has also studied the surface of Comet 67P and was used in further studies of its atmosphere as the comet approached the Sun and its plumes became more active due to solar heating. The comet observations will help scientists learn more about the origin and evolution of our solar system and the role comets may have played in providing Earth with water, and perhaps even life.

The Alice instrument is one of two ultraviolet spectrometers named Alice currently flying in space. The other is onboard NASA's New Horizons spacecraft. The Alice onboard Rosetta is probing the origin, composition, and workings of Comet 67P to gather sensitive, high-resolution insights that cannot be obtained by either groundbased or Earth-orbiting observation. It has more than 1000 times the data-gathering capability of instruments flown a generation ago, yet it weighs less than 4 kilograms (9 pounds) and draws just 4 watts of power.

Other U.S. contributions onboard the Rosetta spacecraft are the Microwave Instrument for Rosetta Orbiter (MIRO); the Ion and Electron Sensor (IES), part of the Rosetta Plasma Consortium Suite; and the Double Focusing Mass Spectrometer (DFMS) electronics package for the Rosetta Orbiter Spectrometer for Ion Neutral Analysis (ROSINA). They are part of a suite of 11 total science instruments onboard Rosetta.

For more information, visit *http://www.esa.int/Our_Activities/Space_Science/Rosetta* and *http://rosetta.jpl.nasa.gov/*.

NASA's Kepler Mission Discovers Bigger, Older Cousin to Earth

NASA's Kepler mission has confirmed the first near-Earth-sized planet in the "habitable zone" around a Sun-like star. This discovery and the introduction of 11 other new small habitable-zone candidate planets mark another milestone in the journey to finding another "Earth."

The newly discovered Kepler-452b is the smallest planet to date discovered orbiting in the habitable zone — the area around a star where liquid water could pool on the surface of an orbiting planet — of a G2-type star, like our Sun. The confirmation of Kepler-452b brings the total number of confirmed planets to 1030.

"On the 20th anniversary year of the discovery that proved other suns host planets, the Kepler exoplanet explorer has discovered a planet and star which most closely resemble the Earth and our Sun," said John Grunsfeld, associate administrator of NASA's Science Mission Directorate at the agency's headquarters

This artist's concept compares Earth (left) to the new planet, called Kepler-452b, which is about 60% larger in diameter. Credit: NASA/JPL-Caltech/T. Pyle.

in Washington. "This exciting result brings us one step closer to finding an Earth 2.0." Kepler-452b is 60% larger in diameter than Earth and is considered a super-Earth-sized planet. While its mass and composition are not yet determined, previous research suggests that planets the size of Kepler-452b have a good chance of being rocky.

While Kepler-452b is larger than Earth, its 385-day orbit is only 5% longer. The planet is 5% farther from its parent star Kepler-452 than Earth is from the Sun. Kepler-452 is 6 billion years old, 1.5 billion years older than our Sun, has the same temperature, is 20% brighter, and has a diameter 10% larger.

"We can think of Kepler-452b as an older, bigger cousin to Earth, providing an opportunity to understand and reflect upon Earth's evolving environment," said Jon Jenkins, Kepler data analysis lead at NASA's Ames Research Center in Moffett Field, California, who led the team that discovered Kepler-452b. "It's awe-inspiring to consider that this planet has spent 6 billion years in the habitable zone of its star; longer than Earth. That's substantial opportunity for life to arise, should all the necessary ingredients and conditions for life exist on this planet."

To help confirm the finding and better determine the properties of the Kepler-452 system, the team conducted groundbased observations at the University of Texas at Austin's McDonald Observatory; the Fred Lawrence Whipple Observatory on Mt. Hopkins, Arizona; and the W. M. Keck Observatory atop Mauna Kea in Hawaii. These measurements were key for the researchers to confirm the planetary nature of Kepler-452b, to refine the size and brightness of its host star, and to better pin down the size of the planet and its orbit.

The Kepler-452 system is located 1400 light-years away in the constellation Cygnus. The research paper reporting this finding has been accepted for publication in the *Astronomical Journal*.

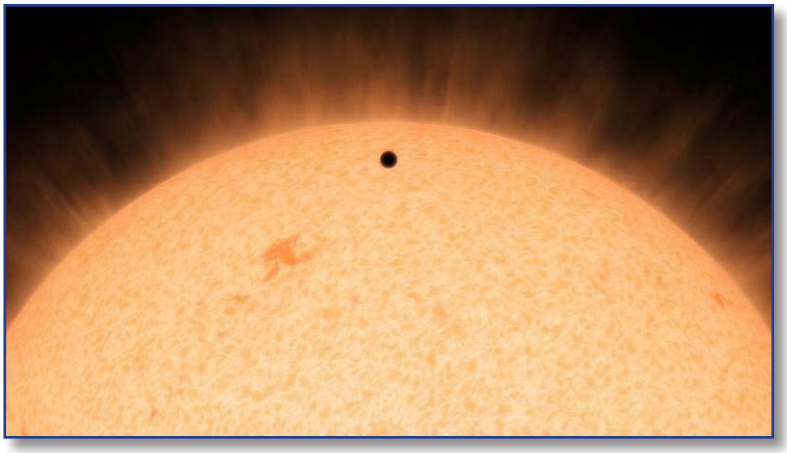
In addition to confirming Kepler-452b, the Kepler team has increased the number of new exoplanet candidates by 521 from their analysis of observations conducted from May 2009 to May 2013, raising the number of planet candidates detected by the Kepler mission to 4696. Candidates require follow-up observations and analysis to verify they are actual planets. Twelve of the new planet candidates have diameters between one to two times that of Earth and orbit in their star's habitable zone. Of these, nine orbit stars that are similar to our Sun in size and temperature.

"We've been able to fully automate our process of identifying planet candidates, which means we can finally assess every transit signal in the entire Kepler dataset quickly and uniformly," said Jeff Coughlin, Kepler scientist at the SETI Institute in Mountain View, California, who led the analysis of a new candidate catalog. "This gives astronomers a statistically sound population of planet candidates to accurately determine the number of small, possibly rocky planets like Earth in our Milky Way galaxy."

For more information, visit *http://www.nasa.gov/kepler* and *http://exoplanetarchive.ipac.caltech.edu/index.html*.

NASA's Spitzer Confirms Closest Rocky Exoplanet

Using NASA's Spitzer Space Telescope, astronomers have confirmed the discovery of the nearest rocky planet outside our solar system, larger than Earth and a potential gold mine of science data. Dubbed HD 219134b, this exoplanet, which orbits too close to its star to sustain life, is a mere 21 light-years away. While the planet itself can't be seen directly, even by telescopes, the star it orbits is visible to the naked eye in dark skies in the Cassiopeia constellation, near the North Star. HD 219134b is also the closest exoplanet to Earth to be detected transiting, or crossing in front of, its star and, therefore, perfect for extensive research.



This artist's conception shows the silhouette of a rocky planet, dubbed HD 219134b, as it passes in front of its star. Credit: NASA/JPL-Caltech.

"Transiting exoplanets are worth their weight in gold because they can be extensively characterized," said Michael Werner, the project scientist for the Spitzer mission at NASA's Jet Propulsion Laboratory in Pasadena, California. "This exoplanet will be one of the most studied for decades to come."

The planet, initially discovered using the HARPS-North instrument on the Italian 3.6-meter Galileo National Telescope in the Canary Islands, is the subject of a study accepted for publication in the journal *Astronomy and Astrophysics*.

Study lead author Ati Motalebi of the Geneva Observatory in Switzerland said she believes the planet is the ideal target for NASA's James Webb Space Telescope in 2018. "Webb and future large, ground-based observatories are sure to point at it and examine it in detail," Motalebi said.

Only a small fraction of exoplanets can be detected transiting their stars due to their relative orientation to Earth. When the orientation is just right, the planet's orbit places it between its star and Earth, dimming the detectable light of its star. It's this dimming of the star that is actually captured by observatories such as Spitzer and can reveal not only the size of the planet but also clues about its composition.

"Most of the known planets are hundreds of light-years away. This one is practically a next-door neighbor," said astronomer and study co-author Lars A. Buchhave of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. For reference, the closest known planet is GJ674b at 14.8 light-years away; its composition is unknown.

HD 219134b was first sighted by the HARPS-North instrument and a method called the radial velocity technique, in which a planet's mass and orbit can be measured by the tug it exerts on its host star. The planet was determined to have a mass 4.5 times that of Earth, and a speedy three-day orbit around its star. Spitzer followed up on the finding, discovering the planet transits its star. Infrared measurements from Spitzer revealed the planet's size, about 1.6 times that of Earth. Combining the size and mass gives it a density of 6 grams per cubic centimeter (3.5 ounces per cubic inch) — confirming HD 219134b is a rocky planet.

Now that astronomers know HD 219134b transits its star, scientists will be scrambling to observe it from the ground and space. The goal is to tease chemical information out of the dimming starlight as the planet passes before it. If the planet has an atmosphere, chemicals in it can imprint patterns in the observed starlight. Rocky planets such as this one, with bigger-than-Earth proportions, belong to a growing class of planets termed super-Earths.

"Thanks to NASA's Kepler mission, we know super-Earths are ubiquitous in our galaxy, but we still know very little about them," said co-author Michael Gillon of the University of Liege in Belgium, lead scientist for the Spitzer detection of the transit. "Now we have a local specimen to study in greater detail. It can be considered a kind of Rosetta Stone for the study of super-Earths."

Further observations with HARPS-North also revealed three more planets in the same star system, farther than HD 219134b. Two are relatively small and not too far from the star. Small, tightly packed multi-planet systems are completely different from our own solar system, but, like super-Earths, are being found in increasing numbers.

For more information, visit *http://www.nasa.gov/spitzer*.

46th Lunar and Planetary Science Conference

March 16–20, 2015,
The Woodlands, Texas

The 46th Lunar and Planetary Science Conference (LPSC), held in March at The Woodlands Waterway Marriott Hotel and Convention Center in The Woodlands, Texas, was a huge success. Following the slight drop in numbers in 2014, abstract submissions were back up to the normal growth pattern, with 2024 abstracts being submitted from 42 countries. Attendance was up as well, with 1766 attendees from 34 countries. LPSC is clearly a meeting that is both accessible and important to young scientists, as reflected by the fact that student participation made up 29% of the overall number of participants.

LPSC, co-chaired by Stephen Mackwell of the Lunar and Planetary Institute and Eileen Stansberry of the NASA Johnson Space Center, began with the usual Sunday evening registration and welcome event. The welcome event was held in the Waterway Ballrooms, giving participants an opportunity to meet and greet more of their friends and colleagues. Many participants have said that one of the appealing qualities of the meeting is that it feels as much like a homecoming or reunion event as a scientific conference, and this was in evidence on Sunday night from the smiles, hugs, and earnest conversations held among attendees.

On Monday morning, the oral sessions began. The conference featured five full (very full!) days of sessions, featuring such topics as impacts; planetary dynamics/tectonics, differentiation, atmospheres, aeolian processes, fluvial processes, polar processes and/or cryospheres, and volcanism and igneous processes; early solar system chronology; small bodies; outer planets/satellites/rings; differentiated meteorites and bodies; chondrites and their components; martian geomorphology, geochemistry, and petrology; the Moon, Venus, and Mercury; and much, much more. Special sessions included MAVEN First Results, The Rosetta Mission So Far, How Young is Young?, and Tracing the Evolution of the Ancient Martian Atmosphere and Climate. The complete program and abstracts are available at *http://www.hou.usra.edu/meetings/lpsc2015*.

The plenary session on Monday afternoon featured the Masursky Lecture, “Insights into the Evolution of the Solar System from Isotopic Investigations of Samples,” by Dr. Lars Borg of Lawrence Livermore National Laboratory. The winners of the 2014 Dwornik Awards, the 2015 Pierazzo International Student Travel Award, and the 2015 LPI Career Development Awards were also recognized. During the Monday evening NASA Headquarters Briefing, representatives from the Planetary Sciences Division of NASA’s Science Mission Directorate addressed meeting attendees.

Poster sessions held on Tuesday and Thursday evening included the same topics covered in the oral sessions, as well as topics such as education and public outreach, material and environmental analogs, planetary mission concepts, and instrument and payload concepts. A number of exhibitors were also on hand, featuring everything from virtual reality demonstrations, to 3-D printing technology and its application for planetary missions, commercial space endeavors, the latest planetary science publications, and information about student opportunities in planetary science.

In addition to the oral sessions, there were many peripheral meetings and activities held during the week, including a workshop on tips for successful paper writing and the publication process; an iSALE user group meeting; an E/PO Help desk for scientists interested in increasing their impact; Town Halls for the various NASA Analysis Groups; a review of the 2014–2015 Antarctic Search for Meteorites field season; and a session on conducting planetary science from stratospheric balloon platforms.

For the third year in a row, the conference utilized LPSC Microbloggers to use social media to provide real-time coverage of the science presented during the sessions. Combined with a Twitter feed on the meeting website, this coverage not only allowed participants to know what was going on in the sessions they were unable to attend, but also provided information for those in other parts of the world who were not able to make it to the meeting. The popularity of the constant Twitter feeds was evidenced by the fact that the hashtag #LPSC2015 trended on Twitter several days during the week of the meeting. This was also the third year that the conference allowed poster presenters to submit e-posters, which not only gave more visibility to those posters whose authors chose to upload them, but provided yet another way for non-attendees to have more access to the science presented at the meeting.

Plans are already underway for the 47th LPSC, which is scheduled for March 21–25, 2016. Mark your calendars! For more details, visit *http://www.hou.usra.edu/meetings/lpsc2016*.

Workshop on Planetary Protection Knowledge Gaps for Human Extraterrestrial Missions

March 24–26, 2015
Moffett Field, California

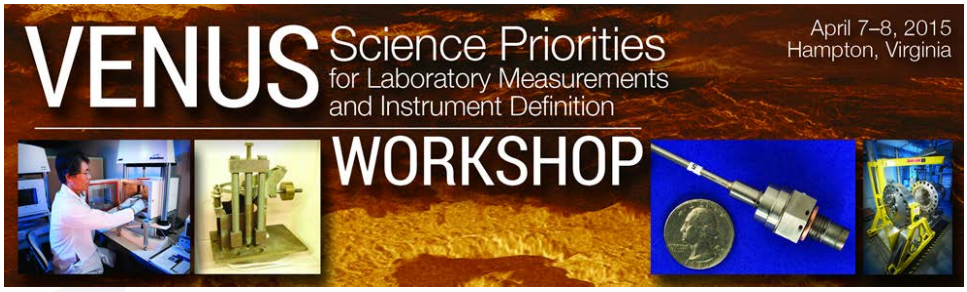
NASA's Office of Planetary Protection (OPP) and Human Exploration and Operations Directorate (HEOMD) co-sponsored the Workshop on Planetary Protection Knowledge Gaps for Human Extraterrestrial Missions at NASA Ames Research Center in Moffett Field, California, on March 24–26, 2015. The workshop was planned as part of an incremental process outlined in NASA's Policy on Planetary Protection Requirements for Human Extraterrestrial Missions (NPI 8020.7), which aims to iteratively facilitate generating information in three key areas: (1) developing capabilities to comprehensively monitor the microbial communities associated with human systems and their changes over time; (2) developing technologies for minimizing/mitigating contamination release, including but not limited to closed-loop systems, cleaning/recleaning capabilities, and support systems that minimize contact of humans with the martian environment (or other solar system destinations); and (3) understanding environmental processes on Mars and other destinations that would contribute to transport and sterilization or organisms released by human activities. The workshop was attended by 105 participants from 10 countries.

The goal of the workshop was to capture the current state of scientific and technological knowledge and to identify gaps where additional research is needed in order to help define the initial set of planetary protection requirements for future human spaceflight missions in compliance with the Outer Space Treaty and current Committee on Space Research (COSPAR) principles and guidelines.

The 2.5-day workshop centered around plenary oral presentations of accepted abstracts that were organized into the three thematic areas with the intention of collectively reviewing the state of knowledge and gaps in each of the areas. Subsequently, subgroup deliberations by participants analyzed each of the three specific study areas using a set of five guiding questions: What planetary protection and research and technology development areas are critical for your subgroup theme? What research is already underway? Are there special needs for nominal vs. off-nominal situations? Are existing options for mitigating contaminants adaptable for the martian surface? Are there any significant stumbling blocks of note? All groups were also asked to assess how their list of particular research and technology development needs would help in addressing specific COSPAR principles and guidelines.

Discussions in the first study area focused on monitoring growth and survivability of human and habitat associated microbes in space, techniques for assaying consumables and waste products, microbiome research to detect extraterrestrial perturbations, and crew quarantine measures and potential impacts from martian materials. The second area of focus reviewed technologies needed for cleaning, sterilization, and prevention of recontamination; mitigation of spacecraft and system effluents; contamination control associated with surface mobility systems and spacesuits; contamination avoidance in "special regions" and *in situ* resource utilization (ISRU) areas; operational strategies to mitigate contamination; and sample-containment technologies. Finally, the third study area examined transport mechanisms on the Mars surface; potential natural sterilization by martian conditions; and environmental clean-up of inadvertent releases of terrestrial materials.

Information on overall workshop deliberations and subgroup findings are being compiled and summarized for an upcoming NASA Technical Report about the workshop, anticipated for publication in fall 2015. In addition, workshop information will also be summarized in journal articles for an upcoming special issue of *Advances in Space Research*, which will focus on planetary protection. Information about the workshop report and publications will also be posted on the NASA Planetary Protection website at *http://planetaryprotection.nasa.gov*.



Workshop on Venus Science Priorities of Laboratory Measurements and Instrument Definition

April 7–9, 2015
Hampton, Virginia

More than 70 people, including several international attendees, with ties and interests in Venus science met on April 7–8, 2015, at the National Institute for Aerospace near NASA's Langely Research Center to discuss two important elements of Venus exploration: instruments and laboratory experiments.

The objectives of this two-day event were to (1) present, discuss, and document the status of the instrument technologies and the definition of new instruments for future Venus missions; and (2) present, discuss, and document the status and needs of laboratory experiments in support of fundamental science as well as future mission preparation.

The workshop was structured to be an interactive event where foundational information, such as the key aspects of the Venus Exploration Goals and Objectives, Roadmap, and Technology documents, were briefed, and then participants broke off into smaller groups to spend the majority of the time discussing and collectively addressing the objectives. Three breakout groups were formed based on potential vantage point: orbit, surface, and atmosphere. The natural world is highly interconnected and therefore the breakout groups joined forces at times and combined sessions were scheduled to foster cross-group interaction and identify common needs.

An important goal of the workshop was also to engage and excite students, and the planning committee strongly emphasized getting students involved and sponsoring their participation with resources, which were generously provided by Northrop Grumman. The efforts paid off and students, both domestic and international, played active roles in workshop. For example, each breakout group had one and sometimes two students assigned as lead note takers. They were often called upon to summarize discussions and capture results of the groups' work.

Other highlights of the workshop included a poster session, scheduled the first morning, where participants had the opportunity to browse dozens of posters and discuss specific technologies or recent experiment results with peers. The posters were then left up for the duration of the workshop as well as for the 12th meeting of the Venus Exploration Analysis Group (VEXAG), which was held in the same location on April 9.

A public lecture was organized and two internationally known speakers were invited to make presentations at the Virginia Air and Space Museum in Norfolk, Virginia. Dr. Jim Green, Director of Planetary Science at NASA Headquarters, and Dr. Hakan Svedham, Principle Investigator of the European Space Agency's Venus Express mission, offered free lectures on searching for life in the solar system and the achievements of the Venus Express mission, respectively.

The last item on the workshop agenda was a high level summary, where overarching or common themes were presented and representatives from each breakout group were given the opportunity to share their specific results with the larger audience.

Some of the notable findings were recognition of the gap in our understanding of the effects of the harsh temperature and pressure environment on the atmosphere and surface and the interactions of the two. At the surface pressures and temperatures on Venus, carbon dioxide is in supercritical phase and we don't really understand its behavior, let alone what to expect when other elements are mixed in. Experiments to understand the physical properties of supercritical phase are important to gain insight into the processes that may be occurring and to be able to develop the sensors and instruments to take reliable measurements that we than can interpret. Another high-priority set of experiments is to characterize the thermal and spectral properties of the atmosphere and the emissivity of the materials that may make up the Venus surface.

In addition to a better understanding of the fundamental properties, experiments are also needed to understand the effects of the harsh environment on the instruments we may send to Venus, the measurements they will take, and our ability to interpret the resulting data. The workshop also pointed out the need for more modeling, again to help understand what may be occurring and to prepare for observations and missions in the future.

Additional information about the workshop is available at *http://www.hou.usra.edu/meetings/venustech2015*. A report is being developed that details the results of the workshop. The report and other referenceable documents are being prepared so scientists, technologists, engineers, and mission planners can access and leverage the great work done by the participants.

Many thanks go out to the Lunar and Planetary Institute for their invaluable contributions in organization, planning, implementation, and general support; the workshop steering committee; Northrop Grumman; VEXAG; and of course the students and other participants.

Astrobiology Science Conference 2015

June 15–19, 2015
Chicago, Illinois

The Astrobiology Science Conference 2015 (AbSciCon) was held June 15–19, 2015, in Chicago, Illinios. Researchers from various disciplines representing institutions from around the world used the conference as a forum to report new discoveries, share data, initiate and advance collaborative efforts, plan new projects, and educate the next generation of astrobiologists. "AbSciCon reflects the importance of astrobiology in supporting NASA's current and ongoing missions," said Mary Voytek, Program Scientist for Astrobiology at NASA.

Peter Doran, the John Franks Endowed Chair at Louisiana State University, served as the Conference Chair for AbSciCon 2015. Doran led a team of more than 20 science organizing committee members to create a diverse and comprehensive program for the four-and-a-half-day conference. "We put a lot of effort into the program, making sure as many people who wanted to talk could," said Doran. "The trade-off was short talks, but I think it was worth it. We also put a lot of time into keeping overlap to a minimum so that everyone could see what they wanted to see." Talks at this year's AbSciCon were framed around the theme "Habitability, Habitable Worlds, and Life."

With more than 700 participants, the conference is one of the largest gatherings on the astrobiology calendar. A team of dedicated people is required to ensure its success. "Mary Voytek did a lot behind the scenes," said Doran. "Elizabeth Wagganer and other folks at the Universities Space Research Association (USRA) were also great in handling the logistics. In addition, there was a subset of the organizing committee appointed as 'theme leads' that were instrumental in the conference's success." Theme leads included Shawn Domagal Goldman [NASA Goddard Institute for Space Studies (GISS)], Jim Kasting (Penn State University), Britney Schmidt (Georgia Tech), Frank Rosenzweig (University of Montana), Tim Lyons (University of California, Riverside), Charlie Cockell (University of Edinburgh), and Daniella Scalice (NASA Astrobiology, Paragon Tech). Each lead was in charge of organizing a plenary session on a conference theme, and served as the point person for the sessions that were organized under each category.

The historic Hilton Chicago hotel in downtown Chicago served as the venue for this year's AbSciCon. Part of the regional FameLab competition was held the weekend before AbSciCon at Chicago's world-renowned Field Museum of Natural History. "I think the venue shone," said Doran. "We initially were thinking something more campus-oriented, but I'm glad we went with the Hilton Chicago. The history, location, and efficiency of the staff were all great. Having the Stanley Cup at the same time was a cool addition. Chicago showed well."

Institutional support for AbSciCon came from USRA, the Lunar and Planetary Institute (LPI), and the National Aeronautics and Space Administration (NASA). Sponsors included the Earth-Life Science Institute (ELSI) at the Tokyo Institute of Technology, Smart Sparrow, Blue Marble Space, and the University of Montana.

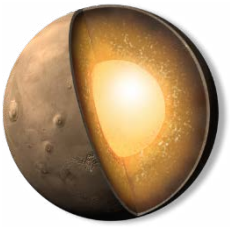
For the benefit of those who missed a talk at AbSciCon 2015, or were unable to attend, all plenary sessions and some afternoon sessions were recorded and are available on demand. Check out all of the archived presentations at *https://astrobiology.nasa.gov/seminars/featured-seminar-channels/conferences-and-workshops/2015/6/15/abscicon-2015/*.

"Spotlight on Education" highlights events and programs that provide opportunities for planetary scientists to become involved in education and public outreach and to engage science educators and the community. If you know of space science educational programs or events that should be included, please contact the Lunar and Planetary Institute's Education Department at shupla@lpi.usra.edu.

Upcoming Public Event Opportunities

Upcoming opportunities exist for educator and public engagement around the broader topics of NASA planetary exploration. Resources for evening observing session events include the Night Sky Network's *Discover the Universe Guides* at *https://nightsky.jpl.nasa.gov/news-display.cfm?News_ID=611* and the Lunar and Planetary Institute's *Look Up* guides at *http://www.lpi.usra.edu/education/look_up/*. Consider getting in touch with local astronomical societies, planetariums and museums, local scientists, and NASA's Solar System Ambassadors (*http://solarsystem.nasa.gov/ssa/directory.cfm*) — ask them to join your events and share their experiences or resources with the children.

InSight Launches for Mars



The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission will land on Mars to study its deep interior; it is scheduled to launch on March 4, 2016. For more information about the mission, visit *http://insight.jpl.nasa.gov/home.cfm*.

Juno Arrives at Jupiter

The Juno mission will improve our understanding of the solar system's beginnings by revealing the origin and evolution of Jupiter. It is scheduled to begin orbiting Jupiter around July 4, 2016. More information is available at *http://www.nasa.gov/mission_pages/juno/main/index.html*.

Lunar and Planetary Science Conference: Education Opportunities

The 47th Lunar and Planetary Science Conference will be held at The Woodlands Waterway Marriott Hotel and Convention Center, The Woodlands, Texas, March 21–25, 2016. There will be a variety of events and opportunities that will be of interest to the E/PO community and scientists who are involved in — or are interested in — education and outreach. Educators and scientists are invited to submit abstracts highlighting their education efforts; the deadline for submission is Tuesday, January 12, 2016. For information, visit *http://www.hou.usra.edu/meetings/lpsc2016/*.

Online Planet Timeline: Year of the Dwarf Planets

View a great online exhibit showing the number of planets through time by NASA/USGS RPIF. Visit *http://astrogeology.usgs.gov/dwarfs/dwarf.html*.

LPI Summer Intern Program

The Lunar and Planetary Institute invites undergraduates with at least 50 semester hours of credit to experience cutting-edge research in the lunar and planetary sciences. As a summer intern, you will work one-on-one with a scientist at the LPI or at the NASA Johnson Space Center on a research project of current interest in lunar and planetary science. Applications will be open beginning October 5, 2015. Information is available at *http://www.lpi.usra.edu/lpiintern/*.

2016 CubeSat Launch Initiative Opportunity

NASA has opened the next round of its CubeSat Launch Initiative to engage the growing community of space enthusiasts that can contribute to NASA's space exploration goals. The CubeSat Launch Initiative gives students, teachers, and faculty a chance to get hands-on flight hardware development experience in the process of designing, building, and operating small research satellites. Applicants must submit their proposals electronically by 4:30 p.m. EST November 24, 2015. For additional information about this opportunity and NASA's CubeSat Launch Initiative, visit *http://www.nasa.gov/press-release/nasa-opens-new-cubesat-opportunities-for-low-cost-space-exploration* and *http://www.nasa.gov/directorates/heo/home/CubeSats_initiative.html*.

NASA Postdoctoral Fellowships

The NASA Postdoctoral Program (NPP) provides opportunities for scientists and engineers to conduct research largely of their own choosing, yet compatible with the research opportunities posted on the NPP website. Selected by a competitive peer-review process, NPP Fellows complete one- to three-year Fellowship appointments that advance NASA's missions in Earth science, heliophysics, astrophysics, planetary science, astrobiology, space bioscience, aeronautics and engineering, human exploration and operations, and space technology. Applicants must have a Ph.D. or equivalent degree in hand before beginning the fellowship, but may apply while completing the degree requirements. U.S. citizens, Lawful Permanent Residents, and foreign nationals eligible for J-1 status as a Research Scholar may apply.

Applications are accepted three times each year: March 1, July 1, and November 1. For further information or to apply, visit *http://nasa.orau.org/postdoc/description/index.htm*.

Mars Resources

There is an opportunity now to leverage audiences' interest in Mars in planetary education. With the upcoming InSight mission and the film *The Martian,* there are a variety of resources that can be used:

The Real Martians

http://www.nasa.gov/realmartians

NASA has assembled images, videos, and resources relating to the real NASA technologies used in the film.

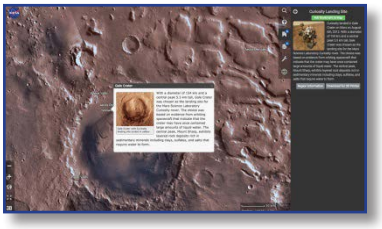
Experience Curiosity

http://eyes.nasa.gov/curiosity/

This program allows viewers to journey along with the rover by simulating Mars in 3-D based on actual data from Curiosity and NASA's Mars Reconnaissance Orbiter (MRO), giving users first-hand experience in a day in the life of a Mars rover.

Mars Trek

http://marstrek.jpl.nasa.gov/



This free online application provides high-quality, detailed visualizations of the planet using real data from 50 years of NASA Mars exploration.

Claudia Alexander, 1959–2015

Pioneering space plasma physicist Dr. Claudia Alexander died on July 11 at the age of 56 from breast cancer. Born in Vancouver, British Columbia, Alexander was raised in the heart of what would become the Silicon Valley in Santa Clara, California, graduating from Buchser High School in 1977, where she was elected student body president and most likely to succeed during her senior year. She then went to the University of California at Berkeley, where she landed an internship at NASA Ames Research Center, igniting her interest in planetary science. She graduated from Berkeley in 1983 with a degree in geophysics, then earned a degree in geophysics and space physics from the University of California at Los Angeles in 1985 and a Ph.D. in space plasma physics from the University of Michigan in 1993. She then immediately joined the Jet Propulsion Laboratory in Pasadena, California, where she remained for the rest of her career.

Alexander became a media darling after she became the project manager on the Galileo mission to Jupiter. She appeared regularly on the Discovery Channel, PBS, and NPR. Last year, she was profiled on the front page of the *Los Angeles Times*. Alexander's work was recognized in other ways as well. Most recently, she was named the 2015 Woman of the Year in the 25th Senate district by State Senator Carol Liu. In 2003, she was awarded the Emerald Honor for Women of Color in Research & Engineering by Career Communications Group, Inc. In 1993, she was named Woman of the Year by the Association for Women Geoscientists.

As project scientist for NASA's Galileo and Rosetta missions, Alexander inspired budding scientists, particularly young African-American women, to pursue careers in science, technology, engineering, and mathematics (STEM). She also wrote a series of fictional children's books in order to inspire young people to pursue science.

"The passing of Claudia Alexander reminds us of how fragile we are as humans but also as scientists how lucky we are to be part of planetary science," James Green, director of NASA's Planetary Science Division, said in a statement. "She and I constantly talked about comets. Comet Churyumov-Gerasimenko in particular. She was an absolute delight to be with and always had a huge engaging smile when I saw her. It was easy to see that she loved what she was doing. We lost a fantastic colleague and great friend. I will miss her."

— Portions of text courtesy of the San Jose Mercury News

Ernst K. Zinner, 1937–2015

Ernst K. Zinner, research professor emeritus of physics and earth and planetary sciences in Arts & Sciences at Washington University in St. Louis, died on July 30 of complications of the mantle cell lymphoma he had battled for more than 19 years. He was 78 years old.

Born in St. Peter in der Au, Austria, a small medieval town about 100 miles west of Vienna, Zinner obtained an undergraduate degree in physics from the Technical University in Vienna, moving to the U.S. in the mid-1960s to attend Washington University. He earned his Ph.D. at Washington University in 1972 in high-energy particle physics, the last person at the university to graduate with a degree in experimental particle physics. The same year, fellow physicist Robert M. Walker invited him to work for the newly established Laboratory for Space Physics (later part of the McDonnell Center for the Space Sciences) as a research associate. In 1989 he was named a research professor in physics and Earth and planetary sciences, a position he held until assuming emeritus status earlier this year.

Among many other accomplishments, in 1987 Zinner identified for the first time material in the laboratory that predated the formation of the solar system 4.6 billion years ago. By analyzing grains they boiled out of primitive meteorites, Zinner and his team proved they were minute amounts of stardust — diamond and silicon carbide — that originated outside our solar system. This work involved a measurement technique called secondary-ion mass spectrometry (SIMS), conducted with an instrument called an ion probe. Zinner dedicated more than a decade to getting reliable results with SIMS and became one of the leading authorities on the instrument, training scientists worldwide in its use.

In 1997, Zinner received the J. Lawrence Smith Medal of the National Academy of Sciences, the top award in this field from that body, and the Leonard Medal from the Meteoritical Society, an international scientific group. He became a fellow of the Meteoritical Society in 1988, a fellow of the American Physical Society in 1990, and a fellow of the American Association for the Advancement of Science in 2011.

A passionate lover of classical music, Zinner was also an accomplished pianist. For many years he met weekly with his friends to play the harpsichord in a baroque music ensemble. And at the age of 55, he took up the cello so that he could play it with his son, who was then learning it himself as a four-year-old.

— Text courtesy of Washington University in St. Louis

Stephen S. Murray, 1944–2015

Prominent astrophysicist Stephen (Steve) S. Murray died on Monday, August 10, 2015, at the age of 70. Murray is widely recognized for advancing the field of high-energy astrophysics through the development of instruments and hardware as well as for his personal research.

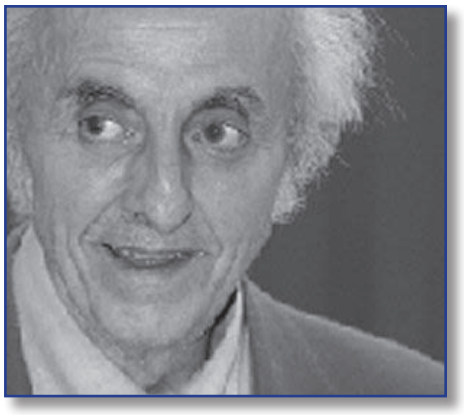
Murray was born in New York City in 1944 and received his undergraduate degree in physics from Columbia University in 1965. In 1971, he was awarded a doctorate in physics from the California Institute of Technology. After beginning his professional career at American Science & Engineering in Cambridge, Massachusetts, Murray joined the newly formed High Energy Division of the Harvard-Smithsonian Center for Astrophysics (CfA) in 1973, where he stayed for more than 40 years.

During his long and distinguished career at CfA, Murray worked on four major high-energy missions, starting with Uhuru. He built instruments for Einstein in the 1970s, the Roentgen Satellite (ROSAT) in the 1980s, and most recently the Chandra X-ray Observatory, for which he was Principal Investigator for the High-Resolution Camera, one of the two imaging detectors that enable spectacular high-resolution images from Chandra. Along with the Hubble Space Telescope, the Spitzer Space Telescope, and the now deorbited Compton Gamma-ray Observatory, Chandra is one of NASA's "Great Observatories" and considered to be the agency's flagship mission for X-ray astronomy.

Murray was also the principal investigator for NASA's Astrophysics Data System, which provides free access to published literature in astronomy and astrophysics and revolutionized the way astronomers conduct their research. Murray took a leadership role in administration as well, serving as the Associate Director of the High-Energy Astrophysics Division, leader of the Center for X-ray Technology, and Deputy Director for Science for the Harvard-Smithsonian Center for Astrophysics. In recent years, he was a senior researcher at the Space Telescope Science Institute and a research professor at the Johns Hopkins University, teaching undergraduates as well as continuing his work on the development of advanced imaging detectors for future high-energy missions. He had recently returned to the CfA as the deputy principal investigator for the Whipple mission, an outer solar system mission that was recently awarded technology funding from NASA.

— Portions of text courtesy of Harvard-Smithsonian Center for Astrophysics and The Boston Globe

Giovanni Picardi, 1936–2015



Professor Giovanni Picardi, principal investigator of the Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) instrument on the European Space Agency's (ESA) Mars Express mission, passed away suddenly on the evening of August 16.

Born in December 1936 in Sarnano, Italy, Picardi earned a Ph.D. in electrical engineering at the University of Rome "La Sapienza" in 1960. In 1961 he joined Selenia SpA (now Alenia SpA) working on radar signal processors. In 1970 he began teaching cybernetics and information theory at the University of Perugia, and in 1975 he joined the University of Bari as a full professor of electrical communications.

With ESA and the Italian Space Agency (ASI), Picardi served as a member of the science teams for the Rosetta, Moon Orbiting Observatory (MORO), and Intermarsnet missions. He was also a member of the Cassini Radar Science Team and the Mars Reconnaissance Orbiter Shallow Radar (SHARAD) Science Team, as well as a co-investigator of the Rosetta Comet Nucleus Sounding Experiment by Radiowave Transmission (CONSERT) experiment.

A brilliant and innovative radar scientist and admired teacher, Picardi's work in radar science provided fundamental contributions to all the radar instruments operating on recent or current planetary missions throughout the solar system, and helped shape the field of planetary radar sounding into what it is today.

— Portions of text courtesy of ESA and Enrico Flamini

Jack Hartung, 1937–2015

Jack Burdair Hartung, a planetary geologist from Iowa, passed away peacefully on August 28 after a long illness from which he suffered gracefully for over more than 30 years.

Hartung attended Iowa State University, where he graduated with a degree in physics in 1959. In that same year he took his first professional job in Langley, Virginia, with NASA, less than a year after it was formed. He worked in the Space Task Group planning the first missions into space, serving in many roles, including a member of the Flight Operations Division for the Mercury program. In 1962, he moved to the new space center in Houston, where he later completed his doctoral degree at Rice University in geophysics in 1968. His main research interest was impact cratering, and the title of his thesis was "Application of the Potassium-Argon Method to the Dating of Shocked Rocks."

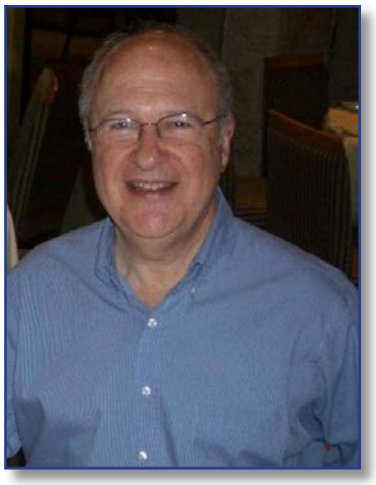
While at NASA, Hartung also studied the first lunar samples, mostly in relation to their microcratering record. His work on microcraters on lunar materials and the related micrometeorite and cosmic dust flux was done in collaboration with Don Brownlee, Don Gault, Fred Hörz, Herb Zook, and others, and led to his most cited research papers. Later he was a visiting scientist at a number of institutions, including the Max Planck Institute in Heidelberg, Germany; the Lunar and Planetary Institute in Houston, Texas (on numerous occasions until the late 1980s); and the Iowa Geological Survey. He was also a visiting professor at the University of Vienna.

Hartung was responsible for the first precise age determinations of a number of impact structures, including the Brent, Tenoumer, and Roter Kamm impact craters. Since 1968 he had pursued the study of the Manson impact structure in Iowa, where he was instrumental in the late 1980s and 1990s for studying the possible relation of Manson to the Cretaceous-Tertiary (K-T) boundary. He also organized a field trip to Cambodia as early as 1992 in search of a possible Australasian tektite source crater.

Throughout his professional career Hartung offered some unique theories for various astronomical and geophysical phenomena. For example, in 1976 he offered a well-publicized proposal that the observation of a strange lunar phenomenon by the medieval monk Gervase of Canterbury on the evening of June 18, 1178, described the formation of the crater Giordano Bruno on the Moon. Even though present data do not support such a recent age for this crater, Hartung's research was always stimulating and scholarly. On a personal note, he was at all times helpful, gentle, in possession of an admirable sense of humor, and did not wear his expertise on his sleeve. He will be missed.

— Text courtesy of Christian Koeberl, University of Vienna, Austria

Joseph I. Goldstein, 1939–2015



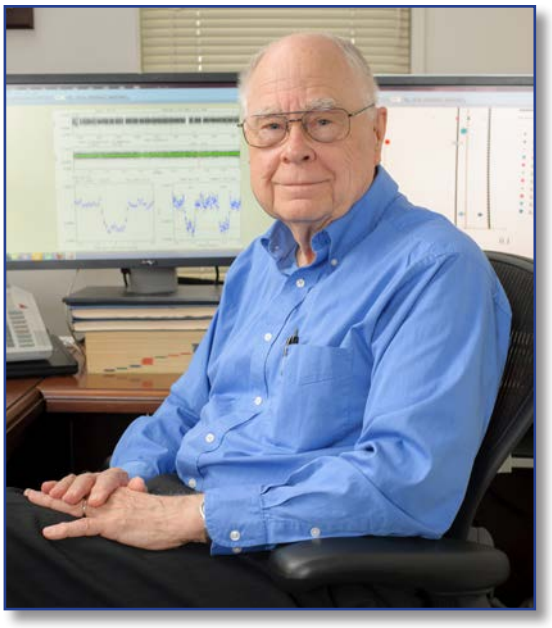
Joseph I. Goldstein, a former Lehigh University vice president and founder of the Microscopy School held annually at Lehigh, died June 27 at his home in Amherst, Massachusetts. He was 76. Goldstein joined the Lehigh faculty in 1964 as a professor of materials science and engineering after earning his Sc.D. from the Massachusetts Institute of Technology. He developed a global reputation for his work in microanalysis and for his study of the materials found in meteorites and lunar rocks. In 1969, Goldstein joined the late Charles B. Sclar, professor of geological sciences, as one of two Lehigh researchers selected by NASA to study materials taken by American astronauts from the surface of the Moon during the Apollo 11 and 12 missions.

In 1970, Goldstein founded the Lehigh Microscopy School, a collection of courses held every summer on various aspects of electron microscopy. The school, in which Goldstein participated actively until June 2014, recently celebrated its 45th year of operation and has trained to date nearly 6000 engineers, scientists, and technicians from around the world. Goldstein served as Lehigh's vice president for graduate studies and research from 1983 to 1990. In 1990, Goldstein left Lehigh to become dean of engineering at the University of Massachusetts in Amherst, a position he held until 2004.

In the field of microanalysis, Goldstein contributed to the development of the electron probe microanalyzer, the scanning electron microscope, and the analytical electron microscope. He published more than 200 technical articles, edited several journals, and wrote and edited several books, most notably the best-selling textbook *Scanning Electron Microscopy and X-Ray Microanalysis*, which was published in 1981 and updated in 1992 and 2003. Goldstein's many awards included the Henry Clifton Sorby Award from the International Metallographic Society for lifetime achievements in metallurgy and the Duncumb Award for Excellence in Microanalysis from the Microanalysis Society. He was elected a Fellow of the American Society of Metals and a Fellow of the Microscopy Society of America, which cited his leadership in quantitative SEM and AEM X-ray microanalysis. Goldstein also received the Leonard Medal, the highest honor given by the Meteoritical Society, for his work with metal, phosphide, carbide, and sulfide in meteorites and lunar rocks; the formation of the Widmanstätten pattern and the determination of cooling rates in irons, stony irons, and chondrites; the nature of plessite and martensite formation; and determination of phase diagrams for the Fe-Ni, Fe-Ni-P, Fe-Ni-Co, Fe-Ni-C, and Fe-Ni-S systems. To honor Goldstein's contributions to the study of meteorites and lunar rocks, the American astronomer Schelte J. Bus named an asteroid for Goldstein in 2000 — 4989 Joegoldstein.

— Text courtesy of Kurt Pfitzer/Lehigh University

Kepler's Borucki Retires After Five Decades at NASA



William Borucki, principal investigator for NASA's Kepler mission, in his office at NASA's Ames Research Center at Moffett Field, California, June 2015. Credit: NASA Ames.

After a career spanning 53 years and championing a mission deemed impossible for decades, William Borucki, the principal investigator of NASA's planet-hunting Kepler mission, retired from the agency on July 3. Borucki's civil service at NASA's Ames Research Center in Moffett Field, California, culminated with the development and launch of NASA's first mission to detect Earth-sized planets around other stars in the habitable zone — the range of distances from the host star where liquid water might exist on the surface of an orbiting planet. Since its launch in March 2009, Kepler has made scientists and enthusiasts alike reimagine the possibilities for life in the galaxy.

Kepler has shown that most stars have planets and that small planets like Earth are common in our Milky Way galaxy. This result has rewritten textbooks and has revised our understanding of our place in the cosmos, and was made possible through the sheer determination of Borucki and fellow team members. In a lesson for science dreamers and future principal investigators, it took five proposals spanning a decade for Borucki and colleagues to prove the efficacy of transit photometry for discovering Earth-size planets around Sun-like stars. The first proposal in 1992 was rejected because suitable detector technology was believed to be unavailable. In 1994, concerns over the cost of the mission resulted in the second proposal rejected.

In 1995, support for Borucki and the team came in the form of the first discovery of an exoplanet around a star like our Sun. This discovery proved the suitability of current detector technology. The third proposal in 1996 was met with rejection as the technique of automatically observing and measuring thousands of stars simultaneously had never been done before, and observations such as Kepler was proposing could be risky. In response to this concern, the team built an observatory at the Crocker Dome at Lick Observatory on Mount Hamilton, east of San Jose, California. Using a specially designed telescope, called Vulcan, the team demonstrated that thousands of stars could be measured simultaneously.

After a rejection in 1998 due to concerns about the instrument's ability to perform in the harsh environment of space, Borucki and colleagues built a test-bed facility to demonstrate Kepler's design stability and sensitivity. With the final concerns addressed, the mission once deemed impossible was accepted in 2000.

During the first 10 years of Borucki's career, he worked on the challenge of getting astronauts to the Moon and safely returning them to Earth. He conducted laboratory and theoretical studies of the radiation

environment of vehicles reentering Earth's atmosphere. The results of the investigations were used in the design of the heat shields for the Apollo program. After the successful Moon landings, Borucki spent the next 12 years studying Earth's atmosphere and lightning activity in planetary atmospheres. He developed models of Earth's atmosphere that estimated the changes in Earth's ozone layer. He also built a lab facility to produce lightning discharges in simulated atmospheres of Jupiter, Venus, and Titan. In 1983, Borucki began working on what would be approved 17 years later as Kepler, with its selection as the 10th Discovery class mission.

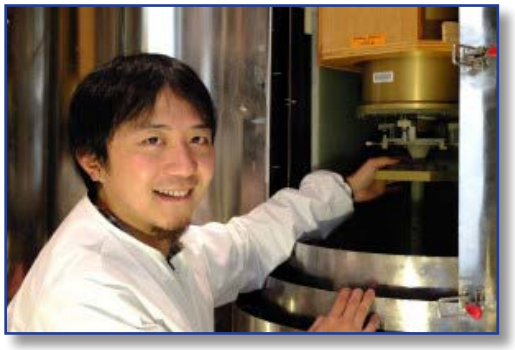
Acknowledging Kepler's achievements, Borucki was recently awarded the esteemed Shaw Prize in Astronomy 2015 for conceiving and leading the Kepler mission, which greatly advanced knowledge of both extrasolar planetary systems and stellar interiors. The $1 million Shaw Prize is just the latest in a long series of acknowledgments that Borucki and the Kepler team have received. Other recent awards include the 2015 Trophy for Current Achievement, National Air and Space Museum; 2015 NASA Ames Fellow; 2014 Robert H. Goddard Memorial Trophy, National Space Club; 2013 Space Award, The World Technology Network; 2013 Career Achievement Award, Samuel J. Heyman Service to America Medals given by U.S. President Obama; 2013 Exceptional Scientific Achievement Medal, NASA Honor Award; and the 2013 Henry Draper Medal, National Academy of Sciences.

"My greatest honor has been the opportunity to develop and lead the Kepler mission. It showed the galaxy is full of Earth-sized planets orbiting in the habitable zone of other stars. New and more powerful missions will tell us if the galaxy teems with life," said Borucki. "I hope that young people the world over will take up the challenge to explore our galaxy and will build missions to continue our search for life and to find our place among the stars."

Borucki rejoined the NASA family in August as a volunteer Ames Associate, where he will continue his personal research studying exoplanets and planetary system formation. For more information about the Kepler mission, visit *http://www.nasa.gov/kepler.*

Nininger Meteorite Award Recipients Announced

The Arizona State University (ASU) Center for Meteorite Studies is pleased to announce that Roger Fu, a graduate student at the Massachusetts Institute of Technology, is the recipient of the 2014 Nininger Meteorite Award, and Adam Sarafian, a graduate student at the Woods Hole Oceanographic Institution, received an Honorable Mention.



Roger Fu.

The Nininger Meteorite Award recognizes outstanding student achievement in the meteoritical sciences as embodied by an original research paper. The paper by Fu, "Nebular magnetic fields recorded by the Semarkona meteorite," describes how a recently developed paleomagnetic technique known as SQUID Microscopy was used to measure the magnetic remanence

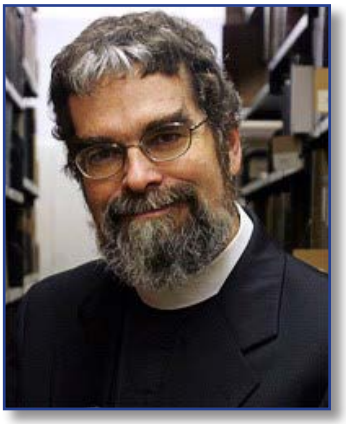
Adam Sarafian.

(the magnetization remaining after removal of an external magnetic field) of eight dusty olivine-bearing chondrules from the Semarkona LL3.0 chondrite.

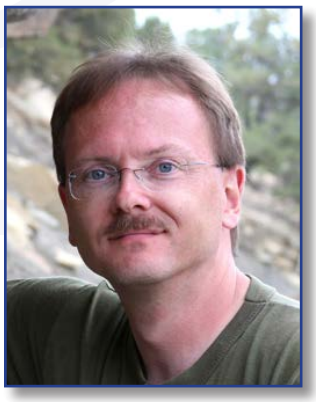
Sarafian's paper, entitled "Early accretion of water in the inner solar system from a carbonaceous-like source," provides evidence that the water accreting in the very early inner solar system had the same source signature as carbonaceous chondrite meteorites and modern-day Earth.

Both papers were published in the journal *Science.* To read more about the award and this year's recipient research, visit *https://meteorites.asu.edu/nininger-2014*.

Consolmagno Appointed Director of Vatican Observatory



On September 18, 2015, Brother Guy Consolmagno SJ was appointed the new director of the Vatican Observatory. Consolmagno is a planetary scientist and educator who has recently been the curator of the Vatican meteorite collection. His Ph.D. is from the planetary science department at the University of Arizona. Last year he won the Carl Sagan medal of the American Astronomical Society for his contributions to public understanding of science. Said Consolmagno, "I am honored and humbled that Pope Francis has appointed me to this position. I can only look in awe at the wonderful things previous directors have accomplished, especially the two Jesuits who have been my directors, Father George Coyne SJ and Father José Funes SJ. I am humbled by the continued support of the Holy See for our work in astronomy, ever since the Observatory was first founded by Pope Leo XIII in 1891. It is important to remember that this Observatory was a Pope's idea, not ours! But we do this work not just because a Pope wants us to do it. All the science we do, and all the outreach we do, reflects a quality that motivates everything we do in astronomy: a sense of joy. The stars are glorious, and it's a treat to be engaged in their study."

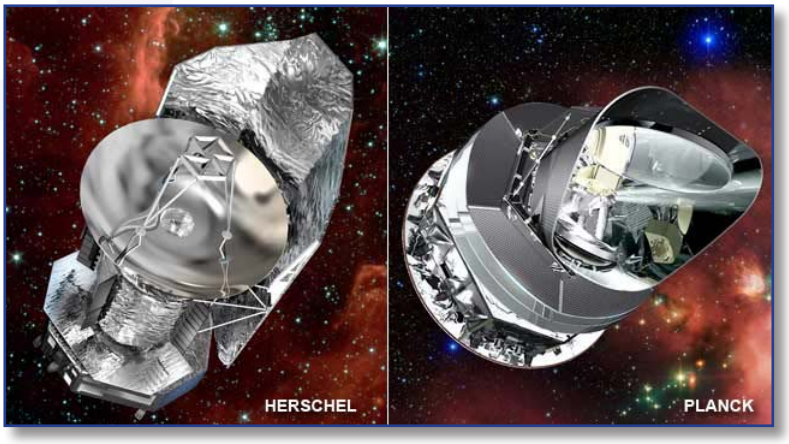


Durda Receives Sagan Medal from AAS Division for Planetary Sciences

Dr. Dan Durda has been awarded the 2015 Carl Sagan Medal for outstanding communication by an active planetary scientist to the general public by the Division for Planetary Sciences of the American Astronomical Society. Durda has consistently communicated with the public about the wonders of exploring new worlds via the written word, the spoken word, and visual artistry. He writes for popular astronomy magazines such as *Sky & Telescope* and *Mercury* and authors columns, articles, and blogs for the public. As a natural extension of his compelling writing, Durda is sought as a planetary science spokesperson, both for lectures and on television. His science addresses impacts and impact processes at many scales, and he

has thus become a requested media commentator on catastrophic asteroid impacts. The artistic dimension of Durda's public outreach, however, sets him in a class apart. His art derives from a healthy dose of scientific knowledge, although, as Durda says, "I'm not afraid to loosen the reins at times." His paintings and digital art present scientifically grounded depictions of solar system objects as well as alien worlds. Durda is currently a planetary scientist at the Southwest Research Institute in Boulder, Colorado. He earned his bachelor's degree in astronomy from the University of Michigan in 1987 and his master's and doctoral degrees in astronomy from the University of Florida in 1989 and 1993 respectively.

Herschel and Planck Honored with Space Systems Award



Artist concepts of Herschel and Planck. Credit: ESA.

The Herschel and Planck project teams are this year's recipients of the American Institute of Aeronautics and Astronautics (AIAA) Space Systems Award. Both space missions were led by the European Space Agency (ESA), with important participation from NASA. This award is presented annually by the AIAA to recognize outstanding achievements in the architecture, analysis, design, and implementation of space systems. This year's award was presented on September 2 during the AIAA Space and Astronautics Forum and Exposition in Pasadena, California. The project teams of the Herschel and Planck missions, which were managed together by ESA, have been cited for "outstanding scientific achievements recognized by the worldwide scientific community and for outstanding technical performances of the two satellites."

The Herschel infrared space observatory, which operated from May 2009 until April 2013, carried the largest telescope ever built for a space observatory. Its 3.5-meter primary mirror collected long-wavelength radiation from some of the coldest and most distant objects in the universe. The observatory made more than 40,000 scientific observations over about 25,000 hours. Herschel's data are publicly available for use by astronomers across the globe.

Planck was launched into space with Herschel in 2009, and also operated until October 2013. It was designed to probe, with the highest accuracy ever achieved, the remnants of the radiation that filled the universe immediately after its explosive birth. Data from Planck, also publicly available, are helping to provide answers to some of the most important questions in modern science: How did the universe begin? How did it evolve to the state we observe today? How will it continue to evolve in the future?

The Jet Propulsion Laboratory (JPL) contributed mission-enabling technology for instruments on both Planck and Herschel. The U.S. data archives for both missions are based at NASA's Infrared Processing and Analysis Center at the California Institute of Technology in Pasadena.

For more information about Herschel, visit *http://www.herschel.caltech.edu* or *http://www.esa.int/SPECIALS/Herschel*. More information about Planck is available at *http://www.nasa.gov/planck* and *http://www.esa.int/planck*.

LightSail™ Test Flight Named Mission of the Year at SmallSat Conference

At the 29th annual American Institute of Aeronautics and Astronautics (AIAA)/Utah State University (USU) Conference on Small Satellites, The Planetary Society's citizen-funded LightSail spacecraft test mission (LightSail-A) was named Mission of the Year by the AIAA Small Satellite Technical Committee. Eleven standout small satellite projects from around the world were nominated by a committee of experts. A voting period during the conference engaged the engineering and scientific community and the public.

The goal of the 29th AIAA/USU Conference on Small Satellites was to explore the current state and future possibilities within the critical systems that support mission success. With the theme, "All Systems Go! Critical Pieces for Mission Success," the Conference on Small Satellites highlighted that effective small satellite missions require success across multiple systems. These systems include launch, satellite, payload, ground network, mission operations, and data analysis. Over the past few decades, satellite mission and systems developers have made critical advancements in each of these areas. These advancements have proven the utility of small satellite missions in military, civilian, and commercial endeavors.

Rex Ridenoure, CEO of Ecliptic Enterprises Corporation, accepted the Mission of the Year Award on behalf of the LightSail-A team, many of whom were also attending the conference. "The small satellite community is one of the most dynamic, innovative and exciting sectors in the global space industry today, and is driving some of the most important changes and trends we see in the news. We are thrilled that LightSail-A has inspired this community and the public to such a degree and are honored to be recognized among such outstanding missions."

For more information about LightSail, visit *http://sail.planetary.org/*.

NASA to Share the Universe with Tumblr Users

NASA is launching an official Tumblr profile that will give Tumblr users a regular dose of space in a blog-like format through text, photos, videos, and more. Tumblr is a social media platform that allows users to connect and follow other content creators in a collaborative microblog format. People are able to discover, share, and create content that expresses their personality, hobbies, and interests. The NASA Tumblr profile will share information, images, and video about the agency's missions of exploration and discovery. To follow NASA's new Tumblr account, visit *http://nasa.tumblr.com*.

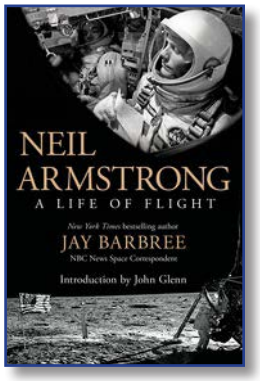
Along with the new official NASA Tumblr account, astronaut Peggy Whitson will offer a behind-the-scenes look at an astronaut's journey as she trains for a six-month mission to the International Space Station. It takes a NASA village to train an astronaut, and Whitson's Tumblr will highlight the many people who make human spaceflight possible. To follow Whitson's Tumblr, visit *http://astropeggy.tumblr.com*.

These two official NASA Tumblr profiles will be joined by two mission accounts. The JunoCam Tumblr (*http://nasajunocam.tumblr.com*) will showcase Jupiter images from amateur astronomers and public-processed images from JunoCam onboard NASA's Juno mission. The Curiosity rover (*http://curiositymarsrover.tumblr.com*) will share engineering, science, and selfies from the surface of Mars.

NASA engages and inspires the public by sharing unique content through social media. The agency continues to add new platforms like Tumblr to offer the public a comprehensive view of NASA's missions, facilities, and people.

Note: Product descriptions are taken from the publisher's website. LPI is not responsible for factual content.

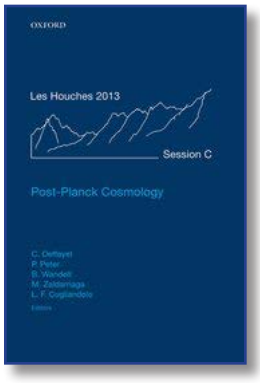
BOOKS



Neil Armstrong: A Life of Flight.

By Jay Barbree. St. Martin's Press. 2015, 384 pp., Paperback. $17.99. *us.macmillan.com*

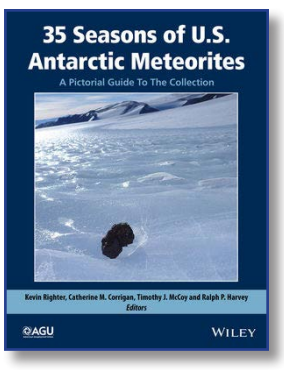
Working from 50 years of conversations he had with Neil Armstrong, from notes, interviews, NASA spaceflight transcripts, and remembrances of those Armstrong trusted, Barbree writes about Armstrong's three passions — flight, family, and friends. This is the inside story of Armstrong from the time he flew combat missions in the Korean War and then flew a rocket plane called the X-15 to the edge of space, to when he saved his Gemini 8 by flying the first emergency return from Earth orbit and then flew Apollo 11 to the Moon's Sea of Tranquility. Together Armstrong and Barbree discussed everything, from Armstrong's love of flying, to the war years, and of course his time in space. The book is full of never-before-seen photos and personal details written down for the first time, including what Armstrong really felt when he took that first step on the Moon, what life with NASA was like, his relationships with the other astronauts, and what he felt the future of space exploration should be.



Post-Planck Cosmology: Lecture Notes of the Les Houches Summer School, Volume 100, July 2013.

Edited by Cédric Deffayet, Patrick Peter, Benjamin Wandelt, Matías Zaldarriaga, and Leticia Cugliandolo. Oxford University Press. 2015, 544 pp., Hardcover, $79.95. *global.oup.com*

This book gathers the lecture notes of the 100th Les Houches Summer School, which was held in July 2013. These lectures represent a comprehensive pedagogical survey of the frontier of theoretical and observational cosmology just after the release of the first cosmological results of the Planck mission. The Cosmic Microwave Background is discussed as a possible window on the still unknown laws of physics at very high energy and as a backlight for studying the late-time universe. Other lectures highlight connections of fundamental physics with other areas of cosmology and astrophysics, the successes and fundamental puzzles of the inflationary paradigm of cosmic beginning, the themes of dark energy and dark matter, and the theoretical developments and observational probes that will shed light on these cosmic conundrums in the years to come.

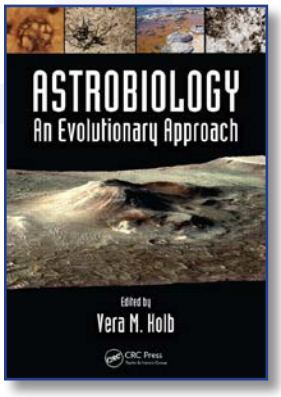


35 Seasons of U.S. Antarctic Meteorites: A Pictorial Guide to the Collection.

Edited by Kevin Righter, Catherine Corrigan, Timothy McCoy, and Ralph Harvey. Wiley, 2014, Hardcover, 320 pp., $99.95. *www.wiley.com*

The U.S. Antarctic meteorite collection exists due to a cooperative program involving the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Smithsonian Institution. Since 1976, meteorites have been collected by an NSF-funded field team; shipped

for curation, characterization, distribution, and storage at NASA; and classified and stored for the long term at the Smithsonian. It is the largest collection in the world with many significant samples, including lunar, martian, fascinating chondrites and achondrites, and even several unusual one-of-a-kind meteorites from as yet unidentified parent bodies. Many Antarctic meteorites have helped to define new meteorite groups. No previous formal publication has covered the entire collection, and an overall summary of its impact and significant samples has been lacking. In addition, available statistics for the collection are out of date and need to be updated for the use of the community. This book is the first comprehensive volume that portrays the most updated key significant meteoritic samples from Antarctica, presenting a broad overview of the program and collection nearly four decades after its beginnings.



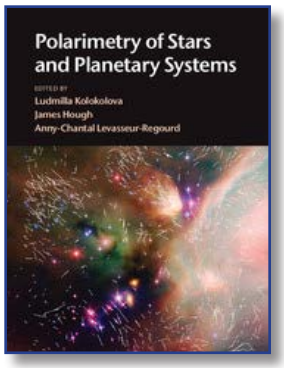
Astrobiology: An Evolutionary Approach.

Edited by Vera M. Kolb. CRC Press, 2014, 504 pp., Paperback, $71.96. *www.crcpress.com*

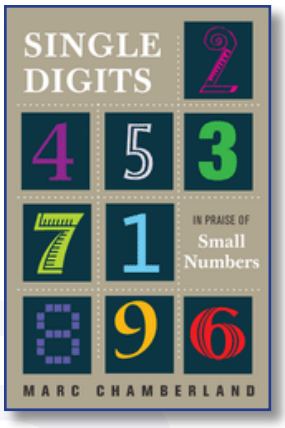
Astrobiology: An Evolutionary Approach provides a full course in astrobiology with an emphasis on abiogenesis and evolution. This textbook presents astrobiology both as a developing science and as the science of the future. The origins of life and the possibility of life elsewhere continue to be subjects of scientific and philosophical examination. These topics evolve with time as our understanding of life itself and the laws of chemical and biological evolution evolve. This book aims both to provide a foundation in astrobiology and to describe the most challenging questions and problems in the field. End-of-chapter questions, a glossary of terms, and recommended references are included.

Polarimetry of Stars and Planetary Systems.

Edited by Ludmilla Kolokolova, James Hough, Anny-Chantal Lavasseur-Regourd. Cambridge University Press, 2015, 503 pp., Hardcover, $150.00. *www.cambridge.org*



Summarizing the striking advances of the last two decades, this reliable introduction to modern astronomical polarimetry provides a comprehensive review of state-of-the-art techniques, models, and research methods. Focusing on optical and near-infrared wavelengths, each detailed, up-to-date chapter addresses a different facet of recent innovations, including new instrumentation, techniques, and theories; new methods based on laboratory studies, enabling the modeling of polarimetric characteristics for a wide variety of astronomical objects; emerging fields of polarimetric exploration, including protoplanetary and debris disks, icy satellites, transneptunian objects, exoplanets, and the search for extraterrestrial life; and unique results produced by space telescopes and polarimeters onboard exploratory spacecraft. With contributions from an international team of accomplished researchers, this is an ideal resource for astronomers and researchers working in astrophysics, Earth sciences, and remote sensing keen to learn more about this valuable diagnostic tool. The book is dedicated to the memory of renowned polarimetrist Tom Gehrels.



Single Digits: In Praise of Small Numbers.

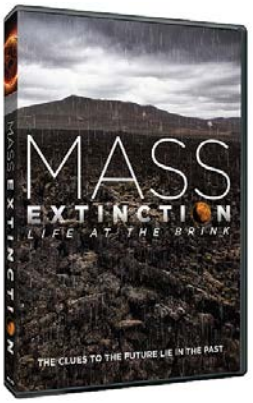
By Marc Chamberland. Princeton University Press, 2015, 240 pp., Hardcover, $26.95. *press.princeton.edu*

The numbers one through nine have remarkable mathematical properties and characteristics. For instance, why do eight perfect card shuffles leave a standard deck of cards unchanged? Are there really "six degrees of separation" between all pairs of people? And how can any map need only four colors to ensure that no regions of the same color touch? In *Single Digits*, Chamberland takes readers on a fascinating exploration of small numbers, from one to nine, looking at their history, applications, and connections to various areas of mathematics, including number theory, geometry, chaos theory, numerical analysis, and mathematical physics. Each chapter focuses on a single digit, beginning with easy concepts that become more advanced as the chapter progresses. Chamberland covers vast numerical territory and introduces readers to an array of puzzles, such as perfect squares, the four-hats problem, Strassen multiplication, Catalan's conjecture, and more. The book's short sections can be read independently and digested in bite-sized chunks — especially good for learning about the Ham Sandwich Theorem and the Pizza Theorem. Appealing to high-school and college students, professional mathematicians, and those mesmerized by patterns, this book shows that single digits offer a plethora of possibilities that readers can count on.

DVD

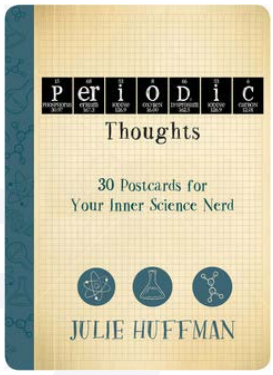
Mass Extinction: Life at the Brink.

Produced by NOVA/PBS, 2015, one disk. $24.99. *www.shoppbs.org*



It's a mystery on a global scale: Five times in Earth's past, life has been nearly extinguished, the vast majority of plants and animals annihilated in a geologic instant. What triggered these dramatic events? And what might they tell us about the fate of our world? *Mass Extinction: Life at the Brink* joins scientists around the globe as they unravel the mysteries of two of the most dramatic mass extinctions — the "K/T Extinction," which wiped out the dinosaurs, and "The Great Dying," which obliterated nearly 90% of all Earth's species. At first glance, these two extinctions couldn't look more different. A six-mile-wide asteroid spelled near-instant doom for the dinosaurs. And as new research covered in the film reveals, massive volcanic eruptions altered the chemistry of the atmosphere and ocean to trigger "The Great Dying." As different as they seem, these two extinctions share uncanny similarities and a message for today. Could the impact of human beings be just as devastating to the planet as a massive asteroid strike or volcanic eruptions?

GIFT IDEA



Periodic Thoughts: 30 Postcards for Your Inner Science Nerd.

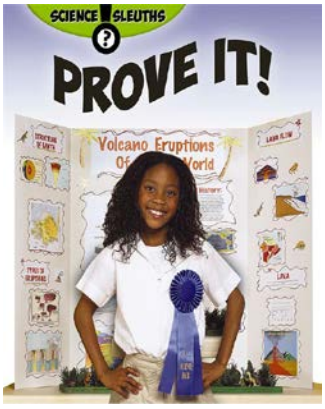
By Julie Huffman. Rock Point, 2015, 30 pp., $10.99. *www.qbookshop.com*

Sometimes you just need to talk science, and what better way to say "hey" to a fellow nerd than with these *Periodic Thoughts* postcards. Imbued with scientific quotes and laws, each card is designed using different letters from the periodic table of elements. A perfect gift for geeks, nerds, and science lovers, these 30 pull-out postcards are held together in perfect binding, so the cards are easy to tear out with no rough edges. Printed on sturdy, heavyweight paper, each card will stand up to the atomic weight of whatever you have to say.

FOR KIDS!!!

Science Sleuths: Prove It!

By Paula Smith. Crabtree Publishing, 2015, 24 pp., Hardcover. $23.60.
www.crabtreebooks.com



Science uses evidence to explain the natural world. Using relatable, real-world examples, this informative book shows readers how to construct an argument with evidence to support a claim. Readers will act and think like scientists as they learn how to distinguish between fact and opinion, and use evidence and reasoning to evaluate the claims of others. For grades K to 3.

Paint Your Own Solar System Mobile Kit.

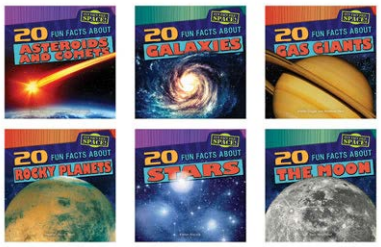
Produced by MasterPieces. 10 wooden pieces with paint, labels, and instructions. $18.99.
www.masterpiecesinc.com

This wooden solar system mobile kit is an out-of-this-world learning experience. This easy-to-use kit is great for the whole family or the classroom. This kit comes with 10 pieces of real wood, labels, and metallic silver and glow-in-the-dark paints for fun learning day or night. Instructions include fun facts about each planet, and included are plenty of inspirational images and drawings to show any painter how to achieve beautiful results. For ages 4 and up.

Reach for the Stars Space Cards.

Produced by Flash of Brilliance. $17.00. *www.flashofbrilliance.com*

This set of space flash cards helps children learn and satisfy their natural curiosity. See planets up close. Look inside a space shuttle. Find out what astronauts eat. And there are many more fun facts children will discover. These thick, durable cards include full-color photographs, many taken from NASA's own spacecraft, and easy-to-understand facts about planets, stars, and spaceships. Children will love to play with these cards again and again, and they will last for years. For ages 3 and up.



Fun Fact File: Space! Book Set.

Gareth Stevens Publishing, 2015, set of six books, 32 pp. each, Hardcover, $151.50. *www.garethstevens.com*

Outer space is full of mysteries. For centuries, stargazers and astronomers have struggled to discover the secrets of the cosmos, and they have made many groundbreaking discoveries. The volumes in this series will amaze and educate young readers with facts about the planets, the stars, moons, and more. Images of cosmic scenes and scientific tools were carefully selected to aid readers in understanding at-level yet potentially difficult science topics. Charts, diagrams, and captions also help readers get the most out of these fascinating tours of the solar system and beyond. Books also sold separately. For grades 2 to 3.

Calendar 2015–2016

For the latest version of the meeting calendar, visit http://www.hou.usra.edu/meetings/calendar.

October

5–8 **From Clouds to Protoplanetary Disks: The Astrochemical Link,** Berlin, Germany. *https://cas-events.mpe.mpg.de/indico/event/0/*

5–9 **Rainbows on the Southern Sky: Science and Legacy Value of the ESO Public Surveys and Large Programmes,** Garching, Germany. *http://www.eso.org/sci/meetings/2015/Rainbows2015.html*

6–9 **15th EANA Astrobiology Conference,** Noordwijk, The Netherlands. *http://www.eana-net.eu/Conferences/EANA2015.html*

9–15 **OHP 2015: Twenty Years of Giant Exoplanets,** Saint-Michel-l'Observatoire, France. *http://ohp2015.sciencesconf.org*

12–16 **Exploring the Universe with JSWT,** Noordwijk, The Netherlands. *http://congrexprojects.com/2015-events/15a02/introduction*

12–16 **Exoplanetary Atmospheres and Habitability,** Nice, France. *http://exoatmo.sciencesconf.org*

12–16 **66th International Astronautical Congress (IAC 2015),** Jerusalem, Israel. *http://iac2015.org/*

20–22 **Annual Meeting of the Lunar Exploration Analysis Group,** Columbia, Maryland. *http://www.hou.usra.edu/meetings/leag2015/*

20–23 **2nd International Planetary Caves Conference,** Flagstaff, Arizona. *http://www.hou.usra.edu/meetings/2ndcaves2015/*

26–Nov 6 **COSPAR Capacity Building Workshop on Planetary Data Mission Analysis,** Guaratingueta, Brazil. *http://cbw.cosparbrazil2015.org/*

27–29 **13th Meeting of the Venus Exploration Analysis Group (VEXAG),** Washington, DC area. *http://www.lpi.usra.edu/vexag/*

27–30 **First Landing Site/Exploration Zone Workshop for Human Missions to the Surface of Mars,** Houston, Texas. *http://www.hou.usra.edu/meetings/explorationzone2015/*

28–29 **Missions to Habitable Worlds,** Budapest, Hungary. *http://life-origins2015.csfk.mta.hu/*

November

1–4 **Geological Society of America Annual Meeting,** Baltimore, Maryland. *http://community.geosociety.org/gsa2015/home*

2–4 **Workshop on Space Weathering of Airless Bodies,** Houston, Texas. *http://www.hou.usra.edu/meetings/airlessbodies2015/*

2–5 **K2 Science Conference (K2SCICON),** Santa Barbara, California. *http://lcogt.net/k2scicon/*

5–6 **Second Off-Earth Mining Forum,** Sydney, Australia. *http://www.futuremining2015.ausimm.com.au/Off_Earth*

8–13 **47th Annual DPS Meeting,** National Harbor, Maryland. *http://dps.aas.org/*

9–13 **Re-Conceptualizing the Origin of Life,** Washington, DC. *https://carnegiescience.edu/events/lectures/re-conceptualizing-origin-life*

9–13 **2nd Symposium of the Committee on Space Research (COSPAR): Water and Life in the Universe (COSPAR 2015),** Foz do Iguacu, Brazil. *http://cosparbrazil2015.org/*

11–13 **Joint Meeting of the Paneth Kolloquium and DFG SPP 1385 "The First 10 Million Years of the Solar System,"** Nördlingen, Germany. *http://www.paneth.eu/PanethKolloquium/Home.html*

16–18 **Enabling Transiting Exoplanet Science with JWST,** Baltimore, Maryland. *http://www.cvent.com/events/enabling-transiting-exoplanet-science-with-jwst/event-summary-122488a7d40e4953adc6dda02f02a643.aspx*

16–20 **International Young Astronomers School on Large Ground-Based 21st Century Radio Instruments: ALMA/NOEMA-SKA/LOFAR/NenuFAR,** Paris, France. *http://ecole-doctorale.obspm.fr/-International-Young-Astronomers-School*

29–Dec 4 **Extreme Solar Systems III,** Waikoloa Beach, Hawaii. *http://ciera.northwestern.edu/Hawaii2015.php*

December

14–18	**AGU Fall Meeting,** San Francisco, California. *http://fallmeeting.agu.org/2015/*
15–16	**International Symposium on Moon 2020–2030: A New Era of Coordinated Human and Robotic Exploration,** ESTEC Noordwijk. *http://spaceflight.esa.int/humanrobotics/*
28–Jan 8	**Exoplanets: 33rd Winter School in Theoretical Physics,** Jerusalem, Israel. *http://www.as.huji.ac.il/content/exoplanets*

January 2016

4–8	**American Astronomical Society 227th Meeting,** Kissimmee, Florida. *http://aas.org/meetings/aas227*
12–15	**4th ELSI Symposium: Three Experiments in Biological Origins,** Tokyo, Japan. *http://www.elsi.jp/en/research/activities/symposium/2016/01/sympo-04.html*
17–22	**Bridging Disciplinary Perspectives to See Further Into Life's Origins,** Galveston, Texas. *http://www.grc.org/programs.aspx?id=14007*
27–29	**14th Meeting of the NASA Small Bodies Assessment Group (SBAG),** Pasadena, California. *http://www.lpi.usra.edu/sbag/*

February

8–12	**The Astrophysics of Planetary Habitability,** Vienna, Austria. *http://habitability.univie.ac.at*
28–Mar 1	**The 2nd Conference on Astrophysics and Space Science (APSS 2016),** Beijing, China. *http://www.engii.org/ws2016/Home.aspx?id=686*

March

7–11	**Protoplanetary Discussions,** Edinburgh, United Kingdom. *http://www-star.st-and.ac.uk/ppdiscs/index.html*
21–25	**47th Lunar and Planetary Science Conference,** The Woodlands, Texas. *http://www.hou.usra.edu/meetings/lpsc2016/*

April

4–8	**International Venus Conference 2016,** Oxford, United Kingdom. *http://venus2016.uk/*
11–15	**15th Biennial ASCE International Conference in Engineering, Science, Construction and Operations in Challenging Environments,** Orlando, Florida. *http://earthspaceconf.mst.edu/*

May

24–25	**5th Interplanetary CubeSat Workshop,** Oxford, United Kingdom. *http://icubesat.org/*
29–Jun 24	**Water in the Solar System and Beyond,** Rome, Italy. *http://www.vaticanobservatory.va/content/specolavaticana/en/summer-schools--voss-/voss2016.html*

June

21–23	**Binaries in the Solar System IV,** Prague, Czech Republic. *http://www.boulder.swri.edu/binaries4-mtg/*
28–30	**15th Meeting of the NASA Small Bodies Assessment Group (SBAG),** Washington, DC. *http://www.lpi.usra.edu/sbag/*

July

3–8	**Exoplanets Conference,** Davos, Switzerland. *http://www.exoplanetscience.org/*
3–8	**International Symposium and Workshop on Astrochemistry,** Campinas, Brazil. *http://www1.univap.br/gaa/iswa/*
10–12	**Astrobiology Australasia Meeting 2016,** Perth, Australia. *http://www.aa-meeting2016.com*
26–29	**Enceladus and the Icy Moons of Saturn,** Boulder, Colorado. *http://www.hou.usra.edu/meetings/enceladus2016/*
30–Aug 7	**41st Scientific Assembly of the Committee on Space Research (COSPAR 2016),** Istanbul, Turkey. *http://www.cospar-assembly.org*