Planetary Science

NEW WORLDS, NEW DISCOVERIES

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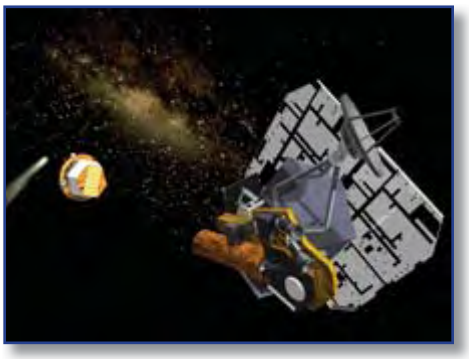
Planetary Science: New Worlds, New Discoveries

By Dr. James L. Green, Director, Planetary Science Division, NASA Headquarters

On September 10, 2010, at the Newseum in Washington, DC, NASA hosted a fabulous event commemorating the 25th anniversary of the nation's first comet encounter: The International Cometary Explorer (ICE) passed through the tail of Comet Giacobini-Zinner on September 11, 1985. That encounter marked the only time (then or since) that a comet's tail was fully traversed, and the resulting discoveries regarding the properties of the induced magnetotail advanced cometary science for years to come. It also provided insights into the origins of our solar system. Over the past 25 years, only five comet encounters have been accomplished by the U.S. In the next six months we will have two more: Comet Hartley 2 on November 4, and Comet Tempel 1 on February 14, 2011. Both of those encounters are due to the creative trajectories of the extended missions of EPOXI and Stardust-NExT.

On September 10, NASA celebrated the 25th anniversary of the nation's first comet encounter.



Deep Impact is en route to study its second comet — Hartley 2.

ICE (originally known as ISEE-3) worked in concert with ISEE-1 and -2, which measured the response of Earth's magnetosphere to the solar wind input as measured by ISEE-3. EPOXI was the Deep Impact satellite and Stardust NExT was Stardust. The anniversary celebration served to raise awareness of the upcoming comet encounters, and to make the public aware of the return on its investment that is provided by planetary science. The Comet Event also marked the unofficial start to our new initiative, Year of the Solar System (YSS) (*solarsystem.nasa.gov/yss*).

Year of the Solar System — It's A Martian Year!

The year's Division of Planetary Science (DPS) meeting in Pasadena, California, will mark the official kick-off of the YSS initiative. Its goals are to (1) raise awareness; (2) build excitement, and (3) make connections with target audiences regarding planetary science activities from October 2010 until September 2011. Over the next 687 days (one martian year), the planetary science community will be embarking on a set of missions and events that are truly historical in nature.

During YSS, besides the comet encounters, several other missions will achieve important milestones — exploring asteroids, and investigating our near and distant neighbors, including the Sun, Mercury, and Saturn. For the first time in history we will launch three planetary missions in four months: Juno to Jupiter, GRAIL to Earth's Moon, and the Mars Science Laboratory to Mars. The YSS presents a unique opportunity for NASA to raise awareness in a way that allows everyone to better understand our solar system, and consequently planet Earth.

It's a New Moon

September 2010 also marks several "firsts" for our community. After stunning successes, the Lunar Reconnaissance Orbiter

Upcoming Planetary Science Mission Events *(as of 09/27/10)*

September 16 – LRO transfer to SMD
September 18 – International Observe the Moon night
November 4 - EPOXI encounters Comet Hartley 2
November 19 - Launch of O/OREOS
December 7- Venus Climate Orbiter (JAXA) arrives at Venus

2011
February 14 - Stardust NExT encounters comet Tempel 1
February 25 – Planetary Decadal Survey (Released to NASA)
March 18 - MESSENGER orbit insertion at Mercury
July - Dawn orbit insertion at asteroid Vesta
August - Juno launch to Jupiter
September - GRAIL launch to the Moon
November - MSL launch to Mars

2012
Mid 2012 -- Mars Opportunity Rover gets to Endeavour Crater
Mid-year -- Dawn leaves Vesta starts on its journey to Ceres
August - MSL lands on Mars

NASA's Solar System Exploration website provides accurate and timely information about planetary science.

The *Beyond: Visions of Planetary Landscapes* exhibition gallery at New Jersey's Monmouth Museum. Courtesy Michael Benson.

(LRO) program management has transferred from NASA's Exploration Science Mission Directorate (ESMD) to the Planetary Science Division (PSD) in the Science Mission Directorate (SMD). This represents a new management paradigm where those organizations with particular expertise lead the respective phase of a program's life cycle. At SMD, we are looking forward to future collaborations with our sister directorate.

On September 18, 2010, the first International Observe the Moon Night (InOMN) took place. This global celebration built on the success of last year's collaborative observation in the U.S. as part of the International Year of Astronomy. More information is available at *http://observethemoonnight.org/*.

As a response to feedback that there were too many sites with incorrect or misleading information regarding planetary science activities, PSD has recently upgraded its *solarsystem.nasa.gov* website. This site is where the general public can go — either as a portal or as a source of content — for accurate, timely information on planetary science. By October, new interactive features will be housed on the site.

I encourage members of the planetary science community to work with the Outreach Manager, Alice Wessen of the Jet Propulsion Laboratory, to link to your sites or host your content.
Finally, an exhibition of planetary imagery will be showcased at Dulles Airport's Gateway Gallery. About 50 images located in the area from the Terminal D to the new train station will be on display for six months beginning September 30. Approximately 13,000 people traverse that tunnel every day, and will get to experience the grandeur of the solar system that we often take for granted. For those who can't make it to Dulles, a snapshot of the images can be found at *http://www.beyondexhibition.net*.

Challenge

Over the past decade, planetary scientists have explored a number of bodies in our solar system, some in great detail, in search of water — so essential for life. We have found many signatures of past or present water at nearly every destination we have looked! Now it's time for planetary science to take the next step and explore these and other new worlds in search of new discoveries such as signs of life beyond Earth. I challenge the planetary science community to plan and implement the final step of the scientific process: communicating your discoveries. During YSS, I challenge you to be proactive and share the excitement of our solar system worlds and your discoveries in new and innovative ways. Let your friends, family, and community groups know what you are doing and why they should care. After all, science is not done — until it's shared!

Year of the Solar System: Efforts of the Planetary Science Education and Public Outreach Community

By Dr. Stephanie Shipp, Lunar and Planetary Institute

The planetary science education and public outreach (E/PO) community is highly engaged in YSS (*solarsystem.nasa.gov/yss*).While YSS offers the opportunity to raise awareness, build excitement, and make connections with educators, students, and the public about planetary science activities, it also provides a framework that allows existing planetary science E/PO products and activities to be placed in a thematic structure. This will promote more effective and sustained use by our audiences and provides the planetary science E/PO community with a construct that allows more effective and efficient collaboration and offers opportunities for new partnerships.

Prior to designing a YSS E/PO strategy, a needs assessment was conducted among primary points of contact in the K–12 formal and informal science education community. More than 200 individuals responded, including classroom teachers, Girl Scout Trainers, Solar System Ambassadors, and education staff from museums, planetariums, science centers, observatories, libraries, and similar venues. All

Featured products include a solar system lithograph set.

the respondents were interested in participating in YSS and identified numerous pathways for involvement, including night-sky viewings, children's and family programs, educator trainings, lectures, planetarium shows, and open houses.

Based on these responses, a YSS informal team and a YSS K–12 team developed an approach and presented it at the community retreat in May 2010. Similar to the International Year of Astronomy (IYA), YSS will have monthly thematic topics presented as a framework of ideas and products for our informal, K–12, and higher-education audiences. Rather than focus on specific planets or missions, the topics explore unifying themes such as the formation of the solar system, impacts, volcanism across the solar system, and the potential for life to exist — or have existed — beyond Earth. The themes connect to the big questions of planetary science and allow new discoveries to be showcased as they are made. Through this thematic approach, the plethora of mission milestones occurring during YSS can be leveraged, as can the rich array of ongoing educational activities and products developed within the planetary science E/PO community. In addition, the approach provides a resource that has a "shelf-life" that extends beyond individual missions.

YSS will feature a variety of themes, including "Home Sweet Solar System."

Year of the Solar System: Monthly Themes

Oct 2010	The Journey Begins
Nov 2010	Birth of Worlds
Dec 2010/Jan 2011	A Family Affair
Feb 2011	Small Bodies — Big Impacts
Mar 2011	Ancient Astronomers/Modern Tools
April 2011	Water, Water, Everywhere!
May 2011	Volcanism!
June 2011	Impacts!
July 2011	Rocks in Space
August 2011	Windy Worlds
September 2011	Gravity: It's What Keeps Us Together
October 2011	Moons and Rings: Our Favorite Things
November 2011	Magnetospheres: Planetary Shields
Dec 2011/Jan 2012	Evolving Worlds
February 2012	Far-Ranging Robots
March 2012	Shadows of the Sun
April 2012	Ice!
May 2012	New Data, New Ideas
Jun/Jul 2012	Got Life?
August 2012	Discovering New Worlds

During the planetary science E/PO community retreat, community members explored how to share the story of the solar system through the exploration of the big questions, paths to engage the audiences and increase their awareness of the opportunities available, types of events in which the community might participate or develop, E/PO portfolio products and events that could be leveraged, and partners with whom we might collaborate. Specific thematic topics — and related mission milestones, opportunities for involvement, and night-sky viewing events — were identified. Following the retreat, the 23-month YSS calendar was compiled; the month-to-month themes address the big questions in planetary science

One of the many featured events on the YSS website is Astronomy Day, which will be held this fall on October 16, 2010.

The Gainesville Solar Walk, a 4,000,000,000,000:1 scale model of the solar system, is a joint project of the City of Gainesville, Florida, the Alachua Astronomy Club, Inc., Tarpon Springs Artist Elizabeth Indianos, and Graphic Artist Saydi Kaufman. Credit: Alachua Astronomy Club, Inc.

in a logical sequence of deepening learning experiences. This allows participants to develop their understanding if they are undertaking the topics in sequence. The development schedule of providing six months of programming at a time is responsive to informal audiences' need to plan their programs well ahead of implementation. The identified themes correlate to national science education standards, allowing K–12 and higher-education faculty to more easily find activities and resources fitting their curriculum needs and their own schedule.

Beginning this month, program facilitators can identify the thematic topics and find activities and resources for K–12 and informal learning environments, as well as promotional materials such as a logo, fliers, press releases, and a YSS PowerPoint. The site will grow with its audience over the 23 months of YSS; through time, additional features will be released to allow the audience to communicate with each other. Visitors can register their events and share their experiences by uploading pictures, video, artwork, and text. Twitter fans will see cascading tweets about YSS (#nasayss). In an effort to leverage existing Facebook and Twitter communities, YSS will share its information through numerous mission and planetary science Facebook and Twitter friends.

The planetary science E/PO community currently is involved in a three-facet approach to YSS: development of content for the website; advertising to numerous existing and potential partners; and integration of YSS into their own activities, such as professional development for educators, planning events, and issuing invitations to their audiences to participate.

We invite the planetary science community to participate in YSS for the next 23 months! Share the resources with educators in your community; host a viewing event; or join museums, libraries, science centers, schools, planetariums, and others across the nation in making scale models of the solar system between October 2010 and March 2011. What will your audience experience? Tell us about your events through the YSS website!

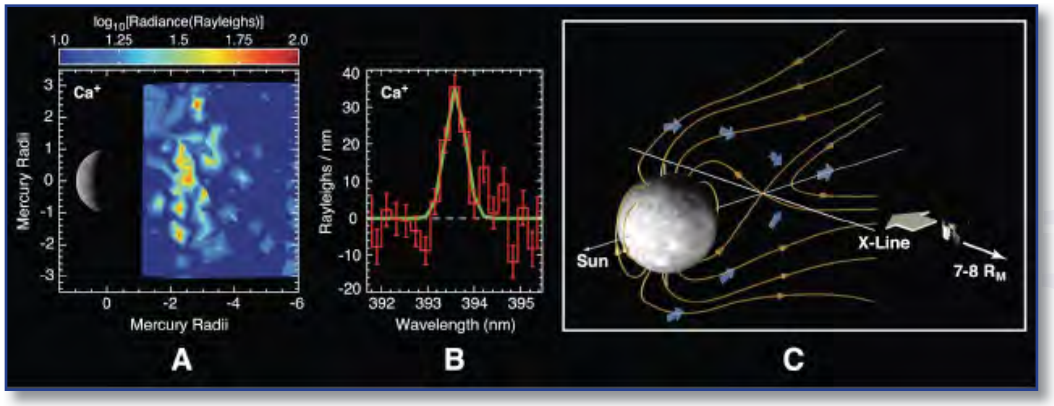
We look forward to celebrating the Year of the Solar System with you as we explore New Worlds and make New Discoveries together!

About the authors

Dr. James Green is the Director of the Planetary Science Division, Science Mission Directorate, NASA Headquarters.

Dr. Stephanie Shipp leads the Education and Public Outreach Department at the Lunar and Planetary Institute, and serves as the Planetary Science Education and Public Outreach Forum Lead for NASA.

MESSENGER Reveals New Information About Mercury's Exosphere, Volcanism, and Magnetic Substorms



Observations of the ionized calcium (Ca+) in Mercury's tail region. (a) Observed column emissions projected onto the plane containing the Sun-Mercury line and Mercury's spin axis, interpolating to fill-in unobserved regions. (b) Red spectrum is an average of the ionized calcium emission-line observations between 1.5 and 3.5 Mercury radii (one-standard-deviation uncertainties are shown); the green line is a Gaussian fit to the average Ca+ line. (c) Schematic illustration of the magnetospheric convection pattern (blue arrows) that concentrates Ca+ in the observed narrow region before the ions are ejected down the tail. Credit: Produced by JHU/APL, reproduced courtesy of Science/AAAS.

Analysis of data from MESSENGER's third and final flyby of Mercury in September 2009 has revealed the first observations of emission from an ionized species in Mercury's exosphere, new information about magnetic substorms, and evidence of younger volcanism on the innermost planet than previously recognized. The results were reported in three papers published online on July 15 in the Science Express section of the website of *Science* magazine.

Mercury's exosphere is a tenuous atmosphere of atoms and ions derived from the planet's surface and from the solar wind. Observations of the exosphere provide a window into the extensive interactions between Mercury's surface and its space environment. The insights such observations provide into surface composition, transport of material about the planet, and loss of material to interplanetary space improve our understanding not only of the current state of Mercury but also of its evolution.

The spacecraft's observations of Mercury's exosphere indicate remarkably different spatial distributions among the neutral and ionized elements in the exosphere. The third flyby produced the first detailed altitude profiles of exospheric species over the north and south poles of the planet. "These profiles showed considerable variability among the sodium, calcium, and magnesium distributions, indicating that several processes are at work and that a given process may affect each element quite differently," says MESSENGER participating scientist Ron Vervack of the Johns Hopkins University Applied Physics Laboratory (APL).

During its first two flybys of Mercury, MESSENGER captured images confirming that pervasive volcanism occurred early in the planet's history. The spacecraft's third Mercury flyby revealed a 290-kilometer-diameter peak-ring impact basin, among the youngest basins yet seen and recently named Rachmaninoff, having an inner floor filled with spectrally distinct smooth plains.

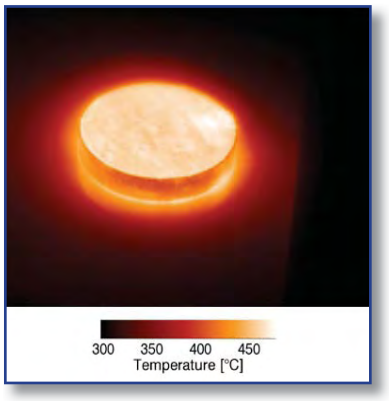
The sparsely cratered Rachmaninoff plains postdate the formation of the basin and apparently formed from material that once flowed across the surface. "We interpret these plains to be the youngest volcanic deposits we have yet found on Mercury," says Louise Prockter, also of APL and one of MESSENGER's deputy project scientists. "Moreover, an irregular depression surrounded by a diffuse halo of bright

material northeast of the basin marks a candidate explosive volcanic vent larger than any previously identified on Mercury. These observations suggest that volcanism on the planet spanned a much greater duration than previously thought, perhaps extending well into the second half of solar system history."

During MESSENGER's third Mercury flyby, the magnetometer documented for the first time the substorm-like build-up, or "loading," of magnetic energy in Mercury's magnetic tail. The increases in energy that MESSENGER measured in Mercury's magnetic tail were very large, by factors of two to three, and they occurred very quickly, lasting only two to three minutes from beginning to end. These increases in tail magnetic energy at Mercury are about 10 times greater than at Earth, and the substorm-like events run their course about 50 times more rapidly.

"The extreme tail loading and unloading observed at Mercury implies that the relative intensity of substorms must be much larger than at Earth," says James A. Slavin, a space physicist at NASA's Goddard Space Flight Center and a member of MESSENGER's Science Team. "However, what is even more exciting is the correspondence between the duration of tail field enhancements and the Dungey cycle time, which describes plasma circulation through a magnetosphere.

For more information, visit *messenger.jhuapl.edu*.



A mineral sample, heated to over 400°C, emits infrared light in the Planetary Emissivity Laboratory at DLR in Berlin. The characteristic spectrum of this infrared emission will be measured, and compared with that observed at Venus, in order to identify minerals on the surface of Venus. Credit: DLR/PEL (J. Helbert).

Recreating Venus in the Lab

Scientists are able to learn about the atmospheres and surfaces of planets by studying their spectra — the different wavelengths of light that they reflect or absorb. However, when researchers study spectra of Venus, the hottest planet in the solar system, they run into a problem. Its high temperatures and pressures seriously affect the data.

Venus and Earth are often described as sister worlds. However, the second planet from the Sun has obviously evolved in a very different manner from our Earth. The surface of Venus is very hot, with temperatures reaching 480°C, and its surface pressure is 90 times greater than on Earth. These extreme conditions cause great difficulties for scientists who are attempting to unveil the mysteries of the venusian lower atmosphere and surface.

In an effort to overcome this problem of interpretation, teams of scientists in several countries are attempting to reproduce the extreme environment of Venus and discover how it affects the data sent back by instruments such as the Visible InfraRed Thermal Imaging Spectrometer (VIRTIS) onboard ESA's Venus Express orbiter.

"High temperatures change the internal structure of minerals, so that some become brighter and others are darker," said Dr. Joern Helbert of the Planetary Emissivity Laboratory in Berlin. "We have been working on this problem for three years, using a unique apparatus in which we heat samples in stainless steel cups with an induction heating system. This enables us to go very quickly to high temperatures and keep the temperature very stable. We are now starting to make real measurements of basalt, haematite, and granite in the lab, so that we can compare them with emissivity data from VIRTIS."

Understanding the properties of the carbon-dioxide-enriched atmosphere presents another major challenge. The lower atmosphere of Venus is like an extreme pressure cooker that is twice as hot as a domestic oven. All light from the surface must pass through this dense, overheated atmosphere before reaching the instruments on Venus Express.

The carbon dioxide blocks most infrared light coming from the surface, but the optical properties of the gas are not fully understood, especially at wavelengths where the gas is almost "transparent." Scientists want to understand how the atmosphere absorbs light from below, and to define accurately the spectral windows that give the clearest views of the lower atmosphere and surface. Only then will they be able to comprehend the finest details of the spectrum and unravel the nature of the planet hidden beneath its blanket of cloud and thick greenhouse gas.

To fill this gap in knowledge, a team led by Giuseppe Piccioni, Principal Investigator for the VIRTIS instrument, is trying to reproduce Venus' atmospheric conditions in the lab. Their research at IASF-Rome of the National Institute for Astrophysics, Italy, involves studying carbon dioxide spectra at temperatures and pressures similar to those on Venus. The painstaking lab work is ongoing, but once the relatively clear spectral windows are clearly defined and recognized, it will be possible to produce accurate, three-dimensional models of the distribution of atmospheric temperatures and gases in the lower atmosphere.

This breakthrough will open the door to detailed analysis of the dynamics and composition of the atmosphere, including the mysterious four-day wind circulation, the polar vortices, and the distribution of water and other minor constituents.

This photograph of the full Moon was taken from Apollo 11 during its trip back to Earth. Credit: NASA.

Research Suggests Water Content of Moon Interior Underestimated

NASA-funded scientists estimate from recent research that the volume of water molecules locked inside minerals in the Moon's interior could exceed the amount of water in the Great Lakes here on Earth. Scientists at the Carnegie Institution's Geophysical Laboratory in Washington, along with other scientists across the nation, determined that the water was likely present very early in the Moon's formation history as hot magma started to cool and crystallize. This finding means water is native to the Moon.

"For over 40 years we thought the Moon was dry," said Francis McCubbin of Carnegie and lead author of a report published on June 14 in Monday's Online Early Edition of the *Proceedings of the National Academy of Sciences.* "In our study we looked at hydroxyl, a compound with an oxygen atom bound with hydrogen, and apatite, a water-bearing mineral in the assemblage of minerals we examined in two Apollo samples and a lunar meteorite."

McCubbin's team utilized tests that detect elements in the parts per billion range. Combining their measurements with models that characterize how the material crystallized as the Moon cooled during formation, they found that the minimum water content ranged from 64 parts per billion to 5 parts per million. The result is at least two orders of magnitude greater than previous results from lunar samples that estimated water content of the Moon to be less than 1 part per billion.

Carnegie researchers looked within crystalline rocks called KREEP (K for potassium; REE, for rare Earth elements; and P for phosphorus). These rocks are a component of some lunar impact melt and basaltic rocks. "Since water is insoluble in the main silicates that crystallized, we believed that it should have concentrated in those rocks," said Andrew Steele of Carnegie, co-author of the report. "That's why we selected KREEP to analyze."

The identification of water from multiple types of lunar rocks that display a range of incompatible trace element signatures indicates that water may be at low concentrations but ubiquitous within the Moon's interior, potentially as early as the time of lunar formation and magma ocean crystallization.

Desert RATS Conduct Field Studies

Space Exploration Vehicle B, one of the technologies that was demonstrated in the 2010 Desert RATS field testing. Credit: James Blair/NASA.

The Desert RATS are at it again. No, they're not striking fear into the hearts of unsuspecting townspeople in some poorly made horror film. Instead, NASA's Desert RATS (Research and Technology Studies) have made their 13th trip to the desert for another round of analog testing.

The Desert RATS tests offer a chance for a NASA-lead team of engineers, astronauts, and scientists from across the country to come together to conduct technology development research in the Arizona desert. The location is a good stand in for destinations for future planetary missions. This year, for the first time, members of the public voted to help NASA decide which location to visit. The winning location, which received a positive vote from 67% of voters from 88 countries around the world, appears to be a place where multiple overlapping lava flows can be examined.

This year's tests took place August 31 through September 15. NASA hardware that was demonstrated includes:

- Space Exploration Vehicles — a pair of rovers that astronauts will live in for seven days at a time
- Habitat Demonstration Unit/Pressurized Excursion Module — a simulated habitat where the rovers can dock to allow the crew room to perform experiments or deal with medical issues
- Tri-ATHLETEs (Terrain Hex-Legged Extra-Terrestrial Explorer) — two heavy-lift rover platforms that allow the habitat, or other large items, to go where the action is
- Portable communications terminals
- Centaur 2 — a possible four-wheeled transportation method for NASA Robonaut 2
- Portable Utility Pallets (PUPs) — mobile charging stations for equipment
- A suite of new geology sample collection tools, including a self-contained GeoLab glove box for conducting in-field analysis of various collected rock samples

For more information, visit *www.nasa.gov/exploration/analogs/desert_rats.html*.

NASA Spacecraft Camera Yields Most Accurate Mars Map Ever

A camera onboard NASA's Mars Odyssey spacecraft has helped develop the most accurate global martian map ever. Researchers and the public can access the map via several websites and explore and survey the entire surface of the Red Planet. The map was constructed using nearly 21,000 images from the Thermal Emission Imaging System (THEMIS), a multiband infrared camera on Odyssey. Researchers at Arizona State University's Mars Space Flight Facility, in collaboration with NASA's Jet Propulsion Laboratory, have been compiling the map since THEMIS observations began eight years ago.

The pictures have been smoothed, matched, blended, and cartographically controlled to make a giant mosaic. Users can pan around images and zoom into them. At full zoom, the smallest surface details are 100 meters (330 feet) wide. While portions of Mars have been mapped at higher resolution, this map provides the most accurate view so far of the entire planet. The new map is available at *www.mars.asu.edu/maps/?layer=thm_dayir_100m_v11*. Advanced users with large bandwidth, powerful computers, and software capable of handling images in the gigabyte range can download the full-resolution map in sections at *www.mars.asu.edu/data/thm_dir_100m*.

Valles Marineris, the "Grand Canyon of Mars," sprawls wide enough to reach from Los Angeles to nearly New York City, if it were located on Earth. The red outline box shows the location of a second, full-resolution image. Credit: NASA/JPL/Arizona State University.

"We've tied the images to the cartographic control grid provided by the U.S. Geological Survey, which also modeled the THEMIS camera's optics," said Philip Christensen, principal investigator for THEMIS and director of the Mars Space Flight Facility. "This approach lets us remove all instrument distortion, so features on the ground are correctly located to within a few pixels, and provide the best global map of Mars to date."

Working with THEMIS images from the new map, the public can contribute to Mars exploration by aligning the images to within a pixel's accuracy at NASA's "Be a Martian" website, which was developed in cooperation with Microsoft Corp. Users can visit the site at *beamartian.jpl.nasa.gov/maproom#/MapMars*.

Other sites build upon the base map. At Mars Image Explorer, which includes images from every Mars orbital mission since the mid-1970s, users can search for images using a map of Mars at *themis.asu.edu/maps*. "The broad purpose underlying all these sites is to make Mars exploration easy and engaging for everyone," Christensen said. "We are trying to create a user-friendly interface between the public and NASA's Planetary Data System, which does a terrific job of collecting, validating, and archiving data."

For more information about NASA's Mars Odyssey spacecraft, visit *mars.jpl.nasa.gov/odyssey/*.

NASA's Hibernating Mars Rover May Not Call Home

NASA mission controllers have not heard from the Mars Exploration Rover Spirit since March 22, and the rover is facing its toughest challenge yet — trying to survive the harsh martian winter. The rover team anticipated Spirit would go into a low-power "hibernation" mode since the rover was not able to get to a favorable slope for its fourth martian winter, which runs from May through November. The low angle of sunlight during these months limits the power generated from the rover's solar panels. During hibernation, the rover suspends communications and other activities so available energy can be used to recharge and heat batteries, and to keep the mission clock running.

Last year, Spirit became partially embedded in the loose sand seen around its left-front wheel in this image. Mobility problems prevented getting the rover to a Sun-facing tilt for the current martian winter. Credit: NASA/JPL-Caltech.

On July 26, mission managers began using a paging technique called "sweep and beep" in an effort to communicate with Spirit. "Instead of just listening, we send commands to the rover to respond back to us with a communications beep," said John Callas, project manager for Spirit and its twin, Opportunity, at NASA's Jet Propulsion Laboratory. "If the rover is awake and hears us, she will send us that beep."

Based on models of Mars' weather and its effect on available power, mission managers believe that if Spirit responds, it most likely will be in the next few months. However, there is a very distinct possibility

Spirit may never respond. Spirit is designed to wake up from its hibernation and communicate with Earth when its battery charge is adequate. But if the batteries have lost too much power, Spirit's clock may stop and lose track of time. The rover could still reawaken, but it would not know the time of day, a situation called a "mission-clock fault." Spirit would start a new timer to wake up every four hours and listen for a signal from Earth for 20 minutes of every hour while the Sun is up.

The earliest date the rover could generate enough power to send a beep to Earth was calculated to be around July 23. However, mission managers don't anticipate the batteries will charge adequately until mid-October. It may be even later if the rover is in a mission-clock fault mode. If Spirit does wake up, mission managers will do a complete health check on the rover's instruments and electronics.

For more information about the rovers, visit *www.nasa.gov/rovers*.

NASA and ESA's First Joint Mission to Mars Selects Instruments

NASA and the European Space Agency (ESA) have embarked on a joint program to explore Mars in the coming decades and selected the five science instruments for the first mission.

NASA and the European Space Agency are jointly developing the ExoMars Trace Gas Orbiter mission for launch in 2016. This is an artist's concept of the planned spacecraft, which will carry five science instruments plus a European entry, descent, and landing demonstrator vehicle. The orbiter will also serve as a communications relay for Mars surface missions. Credit: ESA.

The ExoMars Trace Gas Orbiter, scheduled to launch in 2016, is the first of three joint robotic missions to the Red Planet. It will study the chemical makeup of the martian atmosphere with a 1000-fold increase in sensitivity over previous Mars orbiters. The mission will focus on trace gases, including methane, which could be potentially geochemical or biological in origin and be indicators for the existence of life on Mars. The mission also will serve as an additional communications relay for Mars surface missions beginning in 2018.

NASA and ESA invited scientists worldwide to propose the spacecraft's instruments. The five selected were from 19 proposals submitted in January. Both agencies evaluated the submissions and chose those with the best science value and lowest risk. The selection of the instruments begins the first phase of the new NASA-ESA alliance for future ventures to Mars.

The science teams on all the instruments have broad international participation from Europe and the United States, with important hardware contributions from Canada and Switzerland. "To fully explore Mars, we want to marshal all the talents we can on Earth," said David Southwood, ESA director for Science and Robotic Exploration. "Now NASA and ESA are combining forces for the joint ExoMars Trace Gas Orbiter mission. Mapping methane allows us to investigate further that most important of questions: Is Mars a living planet, and if not, can or will it become so in the future?"

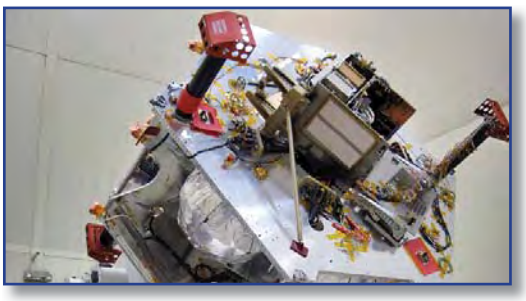
The plan consists of two Mars cooperative missions in 2016 and 2018, and a later joint sample return mission. The 2016 mission features the European-built ExoMars Trace Gas Orbiter, a European-built small lander demonstrator, a primarily-U.S. international science payload, and NASA-provided launch vehicle and communications components. ESA member states will provide additional instrument support.

The 2018 mission consists of a European rover with a drilling capability, a NASA rover capable of caching selected samples for potential future return to Earth, a NASA landing system, and a NASA launch

vehicle. These activities are designed to serve as the foundation of a cooperative program to increase science returns and move the agencies toward a joint Mars sample return mission in the 2020s.

NASA's Mars Exploration Program seeks to characterize and understand Mars as a dynamic system, including its present and past environment, climate cycles, geology, and potential for life. JPL, a division of Caltech, manages the program and development of the NASA-supplied instruments for the 2016 orbiter for NASA's Science Mission Directorate in Washington.

For information about NASA's Mars programs, visit *www.nasa.gov/mars*.



Once the radiation vault was installed on top of the propulsion module, NASA's Juno spacecraft was lifted onto a large rotation fixture to continue with its assembly process. Credit: NASA/JPL-Caltech/LMSS.

Juno Armored Up to Go to Jupiter

NASA's Juno spacecraft will be forging ahead into a treacherous environment at Jupiter with more radiation than any other place NASA has ever sent a spacecraft, except the Sun. In a specially filtered cleanroom in Denver, where Juno is being assembled, engineers recently added a unique protective shield around its sensitive electronics. New pictures of the assembly were released in July.

"Juno is basically an armored tank going to Jupiter," said Scott Bolton, Juno's principal investigator, based at Southwest Research Institute in San Antonio. "Without its protective shield, or radiation vault, Juno's brain would get fried on the very first pass near Jupiter."

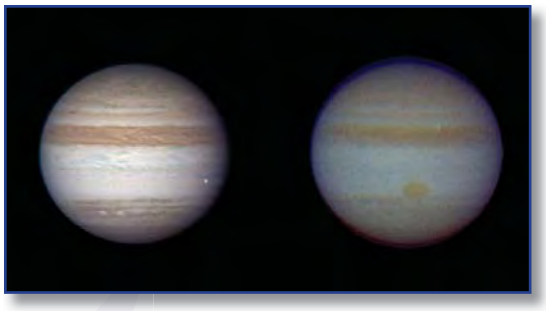
Jupiter's radiation belts are shaped like a huge doughnut around the planet's equatorial region and extend out past the moon Europa, about 650,000 kilometers (400,000 miles) out from the top of Jupiter's clouds. "For the 15 months Juno orbits Jupiter, the spacecraft will have to withstand the equivalent of more than 100 million dental X-rays," said Bill McAlpine, Juno's radiation control manager, based at NASA's Jet Propulsion Laboratory. "In the same way human beings need to protect their organs during an X-ray exam, we have to protect Juno's brain and heart."

The strategy? Give Juno a kind of six-sided lead apron on steroids. With guidance from JPL and the principal investigator, engineers at Lockheed Martin Space Systems designed and built a special radiation vault made of titanium for a centralized electronics hub. While other materials exist that make good radiation blockers, engineers chose titanium because lead is too soft to withstand the vibrations of launch, and some other materials were too difficult to work with.

Each titanium wall measures nearly a square meter (nearly 9 square feet) in area, about 1 centimeter (a third of an inch) in thickness, and 18 kilograms (40 pounds) in mass. This titanium box — about the size of an SUV's trunk — encloses Juno's command and data handling box (the spacecraft's brain), power and data distribution unit (its heart), and about 20 other electronic assemblies. The whole vault weighs about 200 kilograms (500 pounds). The vault is not designed to completely prevent every jovian electron, ion, or proton from hitting the system, but it will dramatically slow down the aging effect radiation has on electronics for the duration of the mission.

The vault will undergo further testing once the whole spacecraft is put together. The assembly and testing process, which also includes installing solar panels for the first-ever solar-powered mission to Jupiter, is expected to last through next spring. Juno is expected to launch in August 2011.

More information about Juno is available at *www.nasa.gov/juno*.



A fleeting bright dot on each of these images of Jupiter marks a small comet or asteroid burning up in the atmosphere. The image on the left was taken on June 3, 2010, by amateur astronomer Anthony Wesley, who was visiting a friend in Broken Hill, Australia, when he obtained the image with a 37-centimeter (14.5-inch) telescope. Wesley's image is a color composite. The fireball appears on the right side of Wesley's image. The color image on the right was taken by amateur astronomer Masayuki Tachikawa, of Kumamoto, Japan, on August 20, 2010. The fireball appears in the upper right of Tachikawa's image. Credit: A. Wesley and M. Tachikawa.

Amateur Astronomers are First to Detect Objects Impacting Jupiter

Amateur astronomers using backyard telescopes were the first to detect two small objects that burned up in Jupiter's atmosphere on June 3 and August 20. Professional astronomers at NASA and other institutions followed up on the discoveries and gathered detailed information on the objects, which produced bright spots on Jupiter. The object that caused the June 3 fireball was estimated to be 8 to 13 meters (30 to 40 feet) in diameter — comparable in size to asteroid 2010 RF12, which flew by Earth on September 8.

The June 3 fireball released 5 to 10 times less energy than the 1908 Tunguska meteoroid, which exploded 6 to 10 kilometers (4 to 6 miles) above Earth's surface with a powerful burst that knocked down millions of trees in a remote part of Russia. Scientists continue to analyze the August 20 fireball, but think it was comparable to the June 3 object.

"Jupiter is a big gravitational vacuum cleaner," said Glenn Orton, an astronomer at NASA's Jet Propulsion Laboratory, and co-author of a paper that appeared online September 9 in *Astrophysical Journal Letters*. "It is clear now that relatively small objects that are remnants from the formation of the solar system 4.5 billion years ago still hit Jupiter frequently. Scientists are trying to figure out just how frequently." The lead author of the paper in *Astrophysical Journal Letters* is Ricardo Hueso of the Universidad del Pais Vasco in Bilbao, Spain.

Before amateurs spotted the June 3 impact, scientists were unaware that collisions that small could be observed. Anthony Wesley, an amateur astronomer from Australia who discovered a dark spot on Jupiter in July 2009, was the first to see the tiny flash on June 3. Amateur astronomers had trained their backyard telescopes on Jupiter that day because the planet was in a particularly good position for viewing. Wesley was watching real-time video from his telescope when he saw a 2.5-second-long flash of light near the edge of the planet. "It was clear to me straight away it had to be an event on Jupiter," Wesley said.

Another amateur astronomer, Christopher Go, of Cebu, Philippines, confirmed the flash also appeared in his recordings. Professional astronomers, alerted by e-mail, looked for signs of the impact in images from larger telescopes, including NASA's Hubble Space Telescope, the European Southern Observatory's Very Large Telescope in Chile, and Gemini Observatory telescopes in Hawaii and Chile. Scientists saw no thermal disruptions or typical chemical signatures of debris, which allowed them to put a limit on the size of the object.

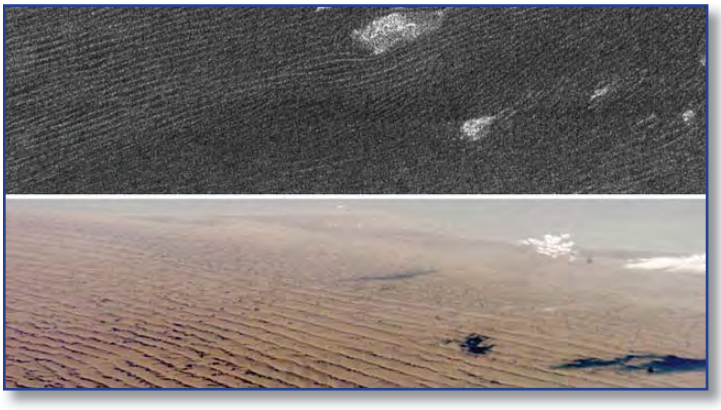
Based on the data, the astronomers deduced the flash came from an object — probably a small comet or asteroid — burning up in Jupiter's atmosphere. The object likely had a mass of about 500 to 2000 metric tons (1 to 4 million pounds), about 100,000 times lighter than that other object that hit Jupiter in July 2009. The second fireball, on August 20, was first detected by Japanese amateur astronomer Masayuki Tachikawa. It flashed for about 1.5 seconds and left no debris observable by a large telescope.

"It is interesting to note that while Earth gets smacked by a 10-meter-sized object about every 10 years on average, it looks as though Jupiter gets hit with the same-sized object a few times each month," said Don Yeomans, manager of the Near-Earth Object Program Office at JPL. "The Jupiter impact rate is still being refined and studies like this one help to do just that."

Previous models of collisions this size on Jupiter had predicted as few as one and as many as 100 such collisions a year. Scientists now believe the frequency must be closer to the high end of the scale.

To see images and video of the two impacts, visit *www.nasa.gov/topics/solarsystem/features/jupiter20100909.html*.

Blowing in the Wind: Cassini Helps with Dune Whodunit



Cassini radar sees sand dunes on Saturn's giant moon Titan (upper photo) that are sculpted like Namibian sand dunes on Earth (lower photo). The bright features in the upper radar photo are not clouds but topographic features among the dunes. Credit: NASA/JPL (upper photo); NASA/JSC (lower photo).

The answer to the mystery of dune patterns on Saturn's moon Titan did turn out to be blowing in the wind. It just wasn't from the direction many scientists expected.

Basic principles describing the rotation of planetary atmospheres and data from the European Space Agency's Huygens probe led to circulation models that showed surface winds streaming generally east-to-west around Titan's equatorial belt. But when NASA's Cassini spacecraft obtained the first images of dunes on Titan in 2005, the dunes' orientation suggested the sands — and therefore the winds — were moving from the opposite direction, or west to east.

A new paper by Tetsuya Tokano, in press with the journal *Aeolian Research*, seeks to explain the paradox. It explains that seasonal changes appear to reverse wind patterns on Titan for a short period. These gusts, which occur intermittently for perhaps two years, sweep west to east and are so strong they do a better job of transporting sand than the usual east-to-west surface winds. Those east-to-west winds do not appear to gather enough strength to move significant amounts of sand. "It was hard to believe that there would be permanent west-to-east winds, as suggested by the dune appearance," said Tokano, of the University of Cologne, Germany. "The dramatic, monsoon-type wind reversal around equinox turns out to be the key."

The dunes track across the vast sand seas of Titan only in latitudes within 30° of the equator. They are about a kilometer (half a mile) wide and tens to hundreds of kilometers (miles) long. They can rise more than 100 meters (300 feet) high. The sands that make up the dunes appear to be made of organic, hydrocarbon particles. The dunes' ridges generally run west-to-east, as wind here generally sheds sand along lines parallel to the equator.

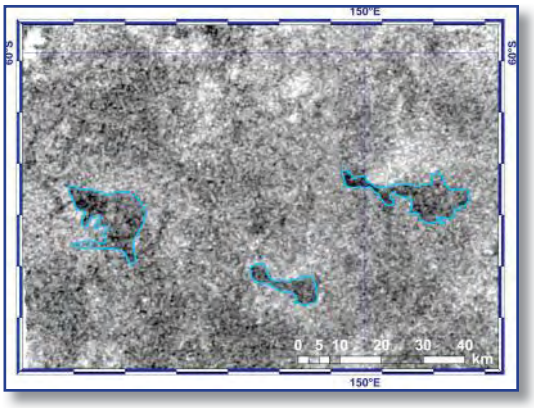
The episodic reverse winds on Titan appear to blow around 1 to 1.8 meters per second (2 to 4 mph). The threshold for sand movement appears to be about 1 meter per second (2 mph), a speed that the typical east-to-west winds never appear to surpass. Dune patterns sculpted by strong, short episodes of wind can be found on Earth in the northern Namib sand seas in Namibia, Africa.

"This is a subtle discovery — only by delving into the statistics of the winds in the model could this rather distressing paradox be resolved," said Ralph Lorenz, a Cassini radar scientist based at the Johns Hopkins University Applied Physics Laboratory. "This work is also reassuring for preparations for proposed future missions to Titan, in that we can become more confident in predicting the winds, which can affect the delivery accuracy of landers or the drift of balloons."

More Cassini information is available at *www.nasa.gov/cassini* and *saturn.jpl.nasa.gov*.

Scientists Measure Changing Lake Depths on Titan

On Earth, lake levels rise and fall with the seasons and with longer-term climate changes, as precipitation, evaporation, and runoff add and remove liquid. Now, for the first time, scientists have found compelling evidence for similar lake-level changes on Saturn's largest moon, Titan — the only other place in the solar system seen to have a hydrological cycle with standing liquid on the surface.



Ephemeral lake observations in Titan's south polar region near 60°S,150°. The image shows partially filled lakes (outlined in cyan) that disappear between images obtained in December 2007 (Cassini pass T39) and May 2009 (T55). Models of the change in radar brightness suggest that the amount of liquid loss is ~1 m/yr, consistent with the analysis of shoreline recession at Ontario Lacus. Credit: Cassini Radar Team, NASA/JPL-Caltech.

Using data gathered by NASA's Cassini spacecraft over a span of four years, a team of researchers — led by graduate student Alexander G. Hayes of the California Institute of Technology (Caltech) and Oded Aharonson, associate professor of planetary science at Caltech — have obtained two separate lines of evidence showing roughly a 1 meter per year drop in the levels of lakes in Titan's southern hemisphere. The decrease is the result of the seasonal evaporation of liquid methane from the lakes — which, because of Titan's frigid temperatures (roughly –300°F at the poles), are composed largely of liquid methane, ethane, and propane.

One of the lakes — Ontario Lacus (named after Earth's Lake Ontario, which is of comparable size) — is the southern hemisphere's largest lake, and was the first lake to be observed on the moon. In a paper submitted to the journal *Icarus*, Hayes, Aharonson, and their colleagues report that the shoreline of Ontario Lacus receded by about 10 kilometers (6 miles) from June 2005 to July 2009, a period of time that represents mid-summer to fall in Titan's southern hemisphere. (One Titan year lasts 29.5 Earth years.)

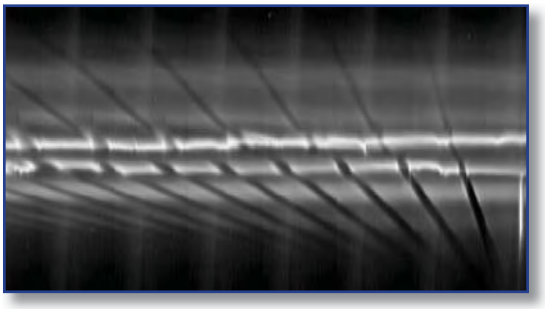
The team was able to determine the bathymetry of the lake out to a depth of about 8 meters. The lake is shallowest and most gently sloped along its southern edge, in areas where sediment is accumulating. Along its eastern shore, the slope of the lake is somewhat steeper. "This is what we are calling the 'beachhead,' " said Hayes. The slope is very steep along the lake's northern boundary, where it butts up against a range of mountains.

The slope changes they saw were consistent with the geology around the lake. The bathymetry measurements and their geologic correlations are discussed in a separate paper by Hayes, Aharonson, and colleagues, which has been accepted for publication in the *Journal of Geophysical Research* (JGR).

The researchers compared lake images obtained four years apart, and found that Ontario had shrunk. "The extent to which the lake has receded is related to the slope — i.e., where the lake is shallow, the liquid will have receded more," Hayes says. "This allows us to deduce the vertical height by which the lake depth has dropped, which is about 1 meter per year."

The researchers also analyzed the evaporation of methane from nearby lakes by comparing the radar signatures of these lakes as measured in December 2007 with data obtained in May 2009. Over that period, the "apparent darkness" of the lakes — indicating the presence of a radar-attenuating liquid — either decreased or disappeared entirely, which means that their liquid levels had been reduced. The researchers were able to calculate the drop in lake depth, "and we got the same result: 1 meter per year of liquid loss," Aharonson says.

Lakes in Titan's northern hemisphere — which is now entering spring — have also been covered multiple times by radar instruments, but so far no analogous changes have been conclusively detected.



This mosaic of images from NASA's Cassini spacecraft shows three fan-like structures in Saturn's tenuous F ring. Such "fans" suggest the existence of additional objects in the F ring. Credit: NASA/JPL/SSI.

Cassini Sees Moon Building Giant Snowballs in Saturn Ring

While orbiting Saturn for the last six years, NASA's Cassini spacecraft has kept a close eye on the collisions and disturbances in the gas giant's rings. They provide the only nearby natural laboratory for scientists to see the processes that must have occurred in our early solar system, as planets and moons coalesced out of disks of debris.

New images from Cassini show icy particles in Saturn's F ring clumping into giant snowballs as the moon Prometheus makes multiple swings by the ring. The gravitational pull of the moon sloshes ring material around, creating wake channels that trigger the formation of objects as large as 20 kilometers (12 miles) in diameter. "Scientists have never seen objects actually form before," said Carl Murray, a Cassini imaging team member based at Queen Mary, University of London. "We now have direct evidence of that process and the rowdy dance between the moons and bits of space debris."

Saturn's thin, kinky F ring was discovered by NASA's Pioneer 11 spacecraft in 1979. Prometheus and Pandora, the small "shepherding" moons on either side of the F ring, were discovered a year later by NASA's Voyager 1. In the years since, the F ring has rarely looked the same twice, and scientists have been watching the impish behavior of the two shepherding moons for clues.

Prometheus, the larger and closer to Saturn of the two moons, appears to be the primary source of the disturbances. At its longest, the potato-shaped moon is 148 kilometers (92 miles) across. It cruises around Saturn at a speed slightly greater than the speed of the much smaller F-ring particles, but in an orbit that is just offset. As a result of its faster motion, Prometheus laps the F-ring particles and stirs up particles in the same segment once in about every 68 days.

"Some of these objects will get ripped apart the next time Prometheus whips around," Murray said. "But some escape. Every time they survive an encounter, they can grow and become more and more stable."

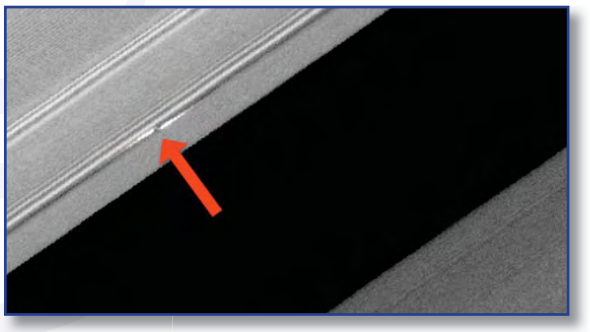
The newly found F-ring objects appear dense enough to have what scientists call "self-gravity." That means they can attract more particles to themselves and snowball in size as ring particles bounce around in Prometheus's wake, Murray said. The objects could be about as dense as Prometheus, although only about one-fourteenth as dense as Earth.

What gives the F-ring snowballs a particularly good chance of survival is their special location in the Saturn system. The F ring resides at a balancing point between the tidal force of Saturn trying to break objects apart and self-gravity pulling objects together. One current theory suggests that the F ring may be only a million years old, but gets replenished every few million years by moonlets drifting outward from the main rings. However, the giant snowballs that form and break up probably have lifetimes of only a few months.

The new findings could also help explain the origin of a mysterious object about 5 to 10 kilometers (3 to 6 miles) in diameter that Cassini scientists spotted in 2004 and have provisionally dubbed S/2004 S 6. This object occasionally bumps into the F ring and produces jets of debris.

Saturn Propellers Reflect Solar System Origins

Scientists using the Cassini spacecraft at Saturn have stalked a new class of moons in the rings of Saturn that create distinctive propeller-shaped gaps in ring material. It marks the first time scientists have been able to track the orbits of individual objects in a debris disk. The research gives scientists an opportunity to time-travel back into the history of our solar system to reveal clues about disks around other stars in our universe that are too far away to observe directly.



A propeller-shaped structure created by an unseen moon is brightly illuminated on the sunlit side of Saturn's rings in this image obtained by the Cassini spacecraft. Credit: NASA/JPL/SSI.

"Observing the motions of these disk-embedded objects provides a rare opportunity to gauge how the planets grew from, and interacted with, the disk of material surrounding the early Sun," said Carolyn Porco, Cassini imaging team lead based at the Space Science Institute in Boulder. "It allows us a glimpse into how the solar system ended up looking the way it does." The results are published in a new study in the July 8 issue of the journal *Astrophysical Journal Letters.*

Cassini scientists first discovered double-armed propeller features in 2006 in an area now known as the "propeller belts" in the middle of Saturn's outermost dense ring, known as the A ring. The spaces were created by a new class of moonlets — smaller than known moons, but larger than the particles in the rings — that could clear the space immediately around them. Those moonlets, which were estimated to number in the millions, were not large enough to clear out their entire path around Saturn, as do the moons Pan and Daphnis.

The new paper, led by Matthew Tiscareno, a Cassini imaging team associate based at Cornell University, reports on a new cohort of larger and rarer moons in another part of the A ring farther out from Saturn. With propellers as much as hundreds of times as large as those previously described, these new objects have been tracked for as long as four years. The propeller features are up to several thousand kilometers (miles) long and several kilometers (miles) wide. The moons embedded in the ring appear to kick up ring material as high as 0.5 kilometers (1600 feet) above and below the ring plane, which is well beyond the typical ring thickness of about 10 meters (30 feet). Cassini is too far away to see the moons amid the swirling ring material around them, but scientists estimate that they are about a kilometer (half a mile) in diameter because of the size of the propellers.

Tiscareno and colleagues estimate that there are dozens of these giant propellers, and 11 of them were imaged multiple times between 2005 to 2009. One of them, nicknamed Bleriot after the famous aviator Louis Bleriot, has been a veritable Forrest Gump, showing up in more than 100 separate Cassini images and one ultraviolet imaging spectrograph observation over this time.

Over the four years, the giant propellers have shifted their orbits, but scientists are not yet sure what is causing the disturbances in their travels around Saturn. Their path may be upset by bumping into other smaller ring particles, or responding to their gravity, but the gravitational attraction of large moons outside the rings may also be a factor. Scientists will continue monitoring the moons to see if the disk itself is driving the changes, similar to the interactions that occur in young solar systems. If it is, Tiscareno said, this would be the first time such a measurement has been made directly.

Lutetia as imaged during Rosetta's closest approach. Credit: ESA 2010 MPS for OSIRIS Team MPS/UPD/LAM/IAA/RSSD/INTA/UPM/DASP/IDA.

Rosetta Triumphs at Asteroid Lutetia

Asteroid Lutetia has been revealed as a battered world of many craters. The European Space Agency's Rosetta mission has returned the first close-up images of the asteroid, showing that it is most probably a primitive survivor from the violent birth of the solar system. The flyby was a spectacular success, with Rosetta performing flawlessly. Closest approach took place on July 10, at a distance of 3162 kilometers.

The images show that Lutetia is heavily cratered, having suffered many impacts during its 4.5 billion years of existence. As Rosetta drew close, a giant bowl-shaped depression stretching across much of the asteroid rotated into view. The images confirm that Lutetia is an elongated body, with its longest side around 130 kilometers.

The pictures come from Rosetta's OSIRIS instrument, which combines a wide-angle and narrow-angle camera. At closest approach, details down to a scale of 60 meters can be seen over the entire surface of Lutetia. "I think this is a very old object. Tonight we have seen a remnant of the solar system's creation," said Holger Sierks, OSIRIS principal investigator, Max Planck Institute for Solar System Research, Lindau, Germany.

Rosetta raced past the asteroid at 15 kilometers per second, completing the flyby in just a minute. But the cameras and other instruments had been working for hours and in some cases days beforehand, and will continue afterward. Shortly after closest approach, Rosetta began transmitting data to Earth for processing.

Lutetia has been a mystery for many years. Ground telescopes have shown that it presents confusing characteristics. In some respects it resembles a C-type asteroid, a primitive body left over from the formation of the solar system. In others, it looks like an M-type. These have been associated with iron meteorites, are usually reddish, and are thought to be fragments of the cores of much larger objects.

The flyby marks the attainment of one of Rosetta's main scientific objectives. The spacecraft and its lander, Philae, will now continue to a 2014 rendezvous with its primary target, Comet Churyumov-Gerasimenko. It will then accompany the comet for months, from near the orbit of Jupiter down to its closest approach to the Sun. In November 2014, Rosetta will release Philae to land on the comet nucleus.

For more information on the Rosetta mission, visit *www.esa.int/rosetta*.

Rich Planetary System Discovered

Astronomers using ESO's world-leading HARPS instrument have discovered a planetary system containing at least five planets, orbiting the Sun-like star HD 10180. The researchers also have tantalizing evidence that two other planets may be present, one of which would have the lowest mass ever found. This would make the system similar to our solar system in terms of the number of planets (seven as compared to our solar system's eight planets). Furthermore, the team also found evidence that the distances of the planets from their star follow a regular pattern, as also seen in our solar system.

"We have found what is most likely the system with the most planets yet discovered," says Christophe Lovis, lead author of the paper reporting the result. "This remarkable discovery also highlights the fact that we are now entering a new era in exoplanet research: the study of complex planetary systems and not just of individual planets. Studies of planetary motions in the new system reveal complex gravitational interactions between the planets and give us insights into the long-term evolution of the system."

Artist's impression of the planetary system around the Sun-like star HD 10180. Credit: European Southern Observatory.

The team of astronomers used the HARPS spectrograph, attached to ESO's 3.6-meter telescope at La Silla, Chile, for a six-year-long study of the Sun-like star HD 10180, located 127 light-years away in the southern constellation of Hydrus (the Male Water Snake). HARPS is an instrument with unrivaled measurement stability and great precision and is the world's most successful exoplanet hunter.

Thanks to the 190 individual HARPS measurements, the astronomers detected the tiny back and forth motions of the star caused by the complex gravitational attractions from five or more planets. The five strongest signals correspond to planets with Neptune-like masses — between 13 and 25 Earth masses — which orbit the star with periods ranging from about 6 to 600 days. These planets are located between 0.06 and 1.4 times the Earth-Sun distance from their central star.

"We also have good reasons to believe that two other planets are present," says Lovis. One would be a Saturn-like planet (with a minimum mass of 65 Earth masses) orbiting in 2200 days. The other would be the least-massive exoplanet ever discovered, with a mass of about 1.4 times that of the Earth. It is very close to its host star, at just 2% of the Earth-Sun distance. One "year" on this planet would last only 1.18 Earth days.

The newly discovered system of planets around HD 10180 is unique in several respects. First, with at least five Neptune-like planets lying within a distance equivalent to the orbit of Mars, this system is more populated than our solar system in its inner region, and has many more massive planets there. Furthermore, the system probably has no Jupiter-like gas giant. In addition, all the planets seem to have almost circular orbits.

So far, astronomers know of fifteen systems with at least three planets. The last record-holder was 55 Cancri, which contains five planets, two of them being giant planets. "Systems of low-mass planets like the one around HD 10180 appear to be quite common, but their formation history remains a puzzle," says Lovis.

Another important result found by the astronomers while studying these systems is that there is a relationship between the mass of a planetary system and the mass and chemical content of its host star. All very massive planetary systems are found around massive and metal-rich stars, while the four lowest-mass systems are found around lower-mass and metal-poor stars. Such properties confirm current theoretical models.

For more information, visit *www.eso.org/public*.

Artist's rendition of newly discovered gas giant planet HD 209458b. Credit: NASA, ESA, and G. Bacon (STScI).

NASA Finds Super Hot Planet with Unique Comet-Like Tail

Astronomers using NASA's Hubble Space Telescope have confirmed the existence of a baked object that could be called a "cometary planet." The gas giant planet, named HD 209458b, is orbiting so close to its star that its heated atmosphere is escaping into space. Observations taken with Hubble's Cosmic Origins Spectrograph (COS) suggest powerful stellar winds are sweeping the cast-off atmospheric material behind the scorched planet and shaping it into a comet-like tail.

"Since 2003 scientists have theorized the lost mass is being pushed back into a tail, and they have even calculated what it looks like," said astronomer Jeffrey Linsky of the University of Colorado in Boulder, leader of the COS study. "We think we have the best observational evidence to support that theory. We have measured gas coming off the planet at specific speeds, some coming toward Earth. The most likely interpretation is that we have measured the velocity of material in a tail."

The planet, located 153 light years from Earth, weighs slightly less than Jupiter but orbits 100 times closer to its star than the jovian giant. The roasted planet zips around its star in a short 3.5 days. In contrast, our solar system's fastest planet, Mercury, orbits the Sun in 88 days. The extrasolar planet is one of the most intensely scrutinized, because it is the first of the few known alien worlds that can be seen passing in front of, or transiting, its star. Linsky and his team used COS to analyze the planet's atmosphere during transiting events.

During a transit, astronomers study the structure and chemical makeup of a planet's atmosphere by sampling the starlight that passes through it. The dip in starlight because of the planet's passage, excluding the atmosphere, is very small, only about 1.5%. When the atmosphere is added, the dip jumps to 8%, indicating a bloated atmosphere.

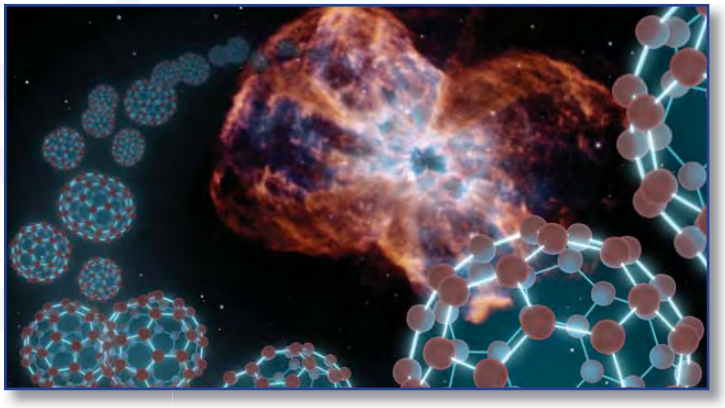
COS detected the heavy elements carbon and silicon in the planet's super-hot 2000°F atmosphere. This detection revealed the parent star is heating the entire atmosphere, dredging up the heavier elements and allowing them to escape the planet. The COS data also showed the material leaving the planet was not all traveling at the same speed. "We found gas escaping at high velocities, with a large amount of this gas flowing toward us at 22,000 miles per hour," Linsky said. "This large gas flow is likely gas swept up by the stellar wind to form the comet-like tail trailing the planet."

Although this extreme planet is being roasted by its star, it won't be destroyed anytime soon. "It will take about a trillion years for the planet to evaporate," Linsky said. The results appeared in the July 10 issue of *The Astrophysical Journal.*

For illustrations and more information about HD 209458b, visit *www.nasa.gov/hubble*.

NASA Telescope Finds Elusive Buckyballs in Space for First Time

Astronomers using NASA's Spitzer Space Telescope have discovered carbon molecules, known as "buckyballs," in space for the first time. Buckyballs are soccer-ball-shaped molecules that were first observed in a laboratory 25 years ago. They are named for their resemblance to architect Buckminster Fuller's geodesic domes, which have interlocking circles on the surface of a partial sphere. Buckyballs were thought to float around in space, but had escaped detection until now.



NASA's Spitzer Space Telescope has at last found buckyballs in space, as illustrated by this artist's conception. Credit: NASA/ JPL-Caltech.

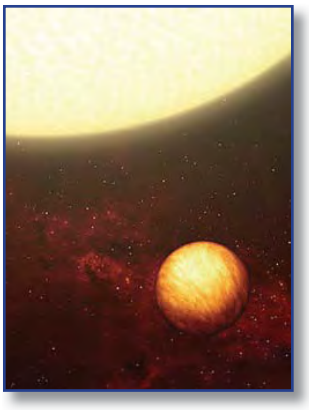
"We found what are now the largest molecules known to exist in space," said astronomer Jan Cami of the University of Western Ontario, Canada, and the SETI Institute in Mountain View, California. "We are particularly excited because they have unique properties that make them important players for all sorts of physical and chemical processes going on in space." Cami has authored a paper about the discovery that appeared online on July 22 in the journal *Science*.

Buckyballs are made of 60 carbon atoms arranged in three-dimensional, spherical structures. Their alternating patterns of hexagons and pentagons match a typical black-and-white soccer ball. The research team also found the more elongated relative of buckyballs, known as C70, for the first time in space. These molecules consist of 70 carbon atoms and are shaped more like an oval rugby ball. Both types of molecules belong to a class known officially as buckminsterfullerenes, or fullerenes.

The Cami team unexpectedly found the carbon balls in a planetary nebula named Tc 1. Planetary nebulas are the remains of stars, like the Sun, that shed their outer layers of gas and dust as they age. A compact, hot star, or white dwarf, at the center of the nebula illuminates and heats these clouds of material that has been shed. The data from Spitzer were compared with data from laboratory measurements of the same molecules and showed a perfect match.

In 1970, Japanese professor Eiji Osawa predicted the existence of buckyballs, but they were not observed until laboratory experiments in 1985. Researchers simulated conditions in the atmospheres of aging, carbon-rich giant stars, in which chains of carbon had been detected. Surprisingly, these experiments resulted in the formation of large quantities of buckminsterfullerenes. The molecules have since been found on Earth in candle soot, layers of rock and meteorites. Sir Harry Kroto, who shared the 1996 Nobel Prize in chemistry with Bob Curl and Rick Smalley for the discovery of buckyballs, said, "This most exciting breakthrough provides convincing evidence that the buckyball has, as I long suspected, existed since time immemorial in the dark recesses of our galaxy."

For more information about Spitzer, visit *www.nasa.gov/spitzer*.



Artist's conception of an extrasolar planet, or exoplanet. Credit: NASA/ JPL-Caltech/R. Hunt.

Astronomer Finds Planets in Unusually Intimate Dance Around Dying Star

Hundreds of extrasolar planets (exoplanets) have been found over the past decade and a half, most of them solitary worlds orbiting their parent star in seeming isolation. With further observation, however, one in three of these systems have been found to have two or more planets. Planets, it appears, come in bunches. Most of these systems contain planets that orbit too far from one another to feel each other's gravity. In just a handful of cases, planets have been found near enough to one another to interact gravitationally. Now, however, John A. Johnson, an assistant professor of astronomy at the California Institute of Technology (Caltech), and his colleagues have found two systems with pairs of gas giant planets locked in an orbital embrace.

In one system — a planetary pair orbiting the massive, dying star HD 200964, located roughly 223 light-years from Earth — the intimate dance is closer and tighter than any previously seen. "This new planet pair came in an unexpected package," says Johnson.

Adds Eric Ford of the University of Florida in Gainsville, "A planetary system with such closely spaced giant planets would be destroyed quickly if the planets weren't doing such a well synchronized dance. This makes it a real puzzle how the planets could have found their rhythm."

A paper by Johnson, Ford, and their collaborators describing the planets and their intriguing orbital dynamics has been accepted for publication in the *Astronomical Journal* (a preprint is available at *arxiv.org/abs/1007.4552*).

All four of the newly discovered exoplanets are gas giants more massive than Jupiter, and like most exoplanets, were discovered by measuring the wobble, or Doppler shift, in the light emitted by their parent stars as the planets orbit around them. Surprisingly, however, the members of each pair are located remarkably close to one another.

For example, the distance between the planets orbiting HD 200964 occasionally is just 0.35 astronomical units (AU) — roughly 33 million miles — comparable to the distance between Earth and Mars. The distance between the planets orbiting the second star, 24 Sextanis (located 244 light-years from Earth) are 0.75 AU, or about 70 million miles. By comparison, Jupiter and Saturn are never less than 330 million miles apart. "There are many locations in a protoplanetary disk where planets can form," says Johnson. "It's very *unlikely*, however, that two planets would just happen to form at locations where they have periods in one of these ratios."

A 2:1 resonance — which is the case for the planets orbiting 24 Sextanis — is the most stable and the most common pattern. "Planets tend to get stuck in the 2:1. It's like a really big pothole," Johnson says. "But if a planet is moving very fast" — racing in from the outer part of the protoplanetary disk, where it formed, toward its parent star — "it can pass over a 2:1. As it moves in closer, the next step is a 5:3, then a 3:2, and then a 4:3."

Johnson and his colleagues have found that the pair of planets orbiting HD 200964 is locked in just such a 4:3 resonance. "The closest analogy in our solar system is Titan and Hyperion, two moons of Saturn that also follow orbits synchronized in a 4:3 pattern," says Ford. "But the planets orbiting HD 200964 interact much more strongly, since each is around 20,000 times more massive than Titan and Hyperion combined."

"This is the tightest system that's ever been discovered, and we're at a loss to explain why this happened," said Johnson. "This is the latest in a long line of strange discoveries about extrasolar planets, and it shows that exoplanets continuously have this ability to surprise us. Each time we think we can explain them, something else comes along."

For more information about exoplanets, visit *nexsci.caltech.edu/*.

"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.

Updated To the Moon and Beyond Activities

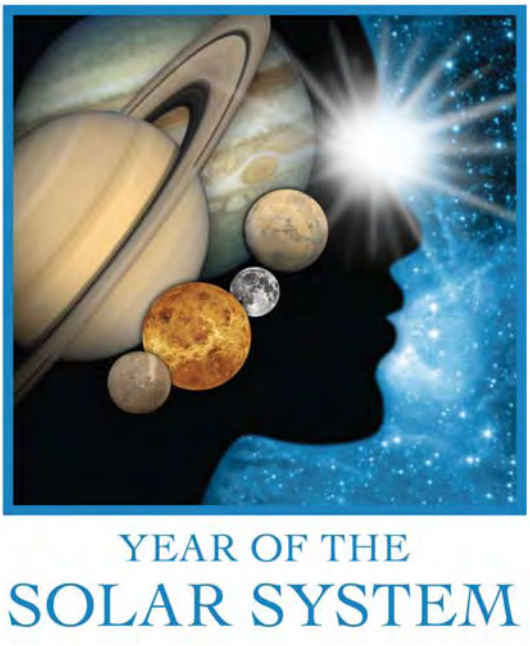
The *Explore! To the Moon and Beyond!* module of activities has been updated. The activity, Mission Moon, includes new data from the Lunar Reconnaissance Orbiter. For more information, visit *www.lpi.usra.edu/education/explore/LRO/*.

Space School Musical

There are a variety of education resources you might want to share with teachers you know. One of these new resources is "Space School Musical," a 30-minute production from KidTribe. The story features Hannah, who is working to finish her science project, a model of the solar system. Download the videos, audio, lyrics, hands-on activities, and more. "Space School Musical" is available at *discovery.nasa.gov/musical/index.html*.

Year of the Solar System Launched!

Spanning a martian year — 23 months —the Year of the Solar System (see cover story in this issue) celebrates the amazing discoveries of numerous NASA missions as they explore our near and distant neighbors and probe the very outer edges of our solar system. New missions will further unveil the secrets of Jupiter, the Moon, and Mars. Other robotic explorers will encounter comets and asteroids, journey to dwarf planets, and continue to unlock the mysteries of our Sun, Mercury, Saturn, and our home planet, Earth.



Each month, from October 2010 to August 2012, audiences explore different aspects or our solar system — its formation, volcanism, ice, and life — weaving together activities, resources, and ideas that teachers, clubs, and organizations can use to engage audiences. Promotional and educational materials, updates, a calendar of activities, and a space to share Year of the Solar System experiences will be available in October at NASA's Solar System website, *solarsystem.nasa.gov/yss*.

Mark your calendars to host an event to kick off the Year of the Solar System in your community. Museums, libraries, science centers, schools, planetariums, and others are invited to create their own scale models of the solar system and share their events and experiences through the Year of the Solar System website!

Registration Open for NASA Explorer School Project

Please share this opportunity with teachers and schools in the United States or U.S. territories: The NASA Explorer Schools (NES) project is NASA's classroom-based gateway for middle-school and high-school classrooms. NES provides resources that promote student engagement in science, technology, engineering, and mathematics. The NES Virtual Campus website will allow students to examine real-world problems and challenges based on NASA research and exploration, and teachers to participate in professional development. All participants must be U.S. citizens. For more information and to schedule an orientation session, visit *www.nasa.gov/offices/education/programs/national/nes2/home/index.html*.

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

AAAS Early Career Award for Public Engagement with Science

Nominate a colleague! The AAAS Early Career Award for Public Engagement with Science, established in 2010, recognizes an early career scientist or engineer (must be an individual actively conducting research, who has been in his of her current field for less than seven years and is pre-tenure) who demonstrates excellence in his or her contribution to public engagement with science activities.

The nominee will have demonstrated excellence in his or her contribution to public engagement with science activities, with a focus on promoting meaningful dialogue with a nonscientific, public audience(s). The nomination deadline is October 15. To nominate a colleague, visit *www.aaas.org/aboutaaas/awards/public_engagement/*.

Cooperative Agreement Notice for the NASA Astrobiology Institute Minority Institution Research Support Program

Proposals Due: October 7, 2010, Identification Number: NNA10339208C

On July 9, 2010, the National Aeronautics and Space Administration Ames Research Center released a Cooperative Agreement Notice for the NASA Astrobiology Institute (NAI) Minority Institution Research Support (MIRS) Program. The full text of the CAN solicitation is available at *nspires.nasaprs.com/*.

The NAI MIRS Program is intended to help train a new generation of researchers in astrobiology and to increase diversity within the astrobiology community. This solicitation seeks proposals to continue the process of recruiting and retaining underrepresented groups in science, technology, engineering, and mathematics careers by involving faculty and students from Minority Serving Institutions (MSIs) in astrobiology research.

AGU Sessions of Interest

Numerous education sessions have been proposed for AGU. Two of these will be of particular interest to the planetary science community:

ED25. NASA's Year of the Solar System — Science Isn't Done Until It's Shared!

NASA's Year of the Solar System (YSS) is a celebration of solar system mission milestones that will begin in fall 2010 and continue for one martian year, ending in late summer 2012. The breadth of solar system bodies and missions involved is extensive, including EPOXI, Stardust-NeXT, Dawn, MESSENGER, Juno, MSL, MER, GRAIL, and LADEE; all the major questions uniting solar system investigations are in play. YSS is a rare opportunity to enhance student learning about the solar system, and engage the public in the exploration and excitement that is uniquely NASA. This session will bring together Education and Public Outreach projects and programs that are making a contribution to YSS. Presentations will cover YSS programs, thematic connections, the potential to engage audiences, collaborations, and the science connection. Join the community to discuss possible steps forward to engage a larger audience in YSS.

ED26. It's Not Just a Moon, It's Our Moon!

The past year has seen a plethora of new Lunar Education and Public Outreach programs and resources. From public outreach projects such as the International Observe the Moon Night and MyMoon, citizen science projects such as MoonZoo, formal programs such as a suite of lunar teacher professional development workshops and the revitalized Lunar Sample Education Disk Program, and higher education resources such as Lunar GradCon, the lunar community has been providing education and outreach opportunities for a diverse group of audiences across various platforms. This session will showcase the latest lunar Education and Public Outreach creations. Join the community for a discussion about future directions for lunar education.

Additional Education and Public Outreach sessions explore citizen science, cyber education in the geosciences, using real-time data, attracting and retaining underrepresented racial minorities to research intensive universities, and more! Find sessions at *www.agu.org/meetings/fm10/program/scientific_session_search.php?show=session&section=7&cosection=0&category=&keysearch=&title=1&desc=1&searchBy=sponsor*.

From Earth to the Solar System: Solicitation for Image Contributions

Presented by the NASA Astrobiology Program as part of NASA's Year of the Solar System, From Earth to the Solar System (FETTSS) will be an online collection of images that can be freely downloaded and exhibited by organizations worldwide in whatever manner they choose. A flyer can be downloaded at *nai.arc.nasa.gov/library/uploads/FromEarthToTheSolarSystem-ImageSubmission.pdf*.

We are currently seeking images for the exhibit, whether it be your favorite NASA image (we all have favorites!), or a picture from a research expedition. We're looking for artistic and informative images of astrobiological or planetary science significance that tell a story and showcase views of the planets, moons, and other bodies in our solar system, as well as pictures of field sites here on Earth. Beginning in January 2011, the final collection of images will be made available online for organizations to mount exhibits as they wish.

The concept stems from the success of the International Year of Astronomy initiative From Earth to the Universe, a collection of astronomical images that were exhibited globally in non-traditional venues such as rail stations, public parks, and shopping centers. For more information and guidelines on how to submit an image, visit the FETTSS website at *fettss.arc.nasa.gov/*. Questions can be directed to Daniella Scalice (phone: 650-604-4024; e-mail: *daniella.m.scalice@nasa.gov*).

Barringer Fund Awardees Announced

The Lunar and Planetary Institute (LPI) is pleased to announce the names of the students whose research will be supported by The Barringer Family Fund for Meteorite Impact Research.

The 2010 awardees are Marc Biren (University of New Brunswick, Canada), Marisa Palucis (University of California–Berkeley, United States), Sebastian Sturm (Westfälisches Wilhelms–Universität Münster, Germany), and Marcos Alberto Rodrigues Vasconcelos (University of Campinas, Brazil).

The Barringer Family Fund for Meteorite Impact Research was established to support field work by eligible students interested in the study of impact cratering processes. The Fund provides a small number of competitive grants each year for support of field research at known or suspected impact sites worldwide.

The Fund was established as a memorial to recognize the contributions of Brandon, Moreau, Paul, and Richard Barringer to the field of meteoritics and the Barringer family's strong interest and support over many years in research and student education. In addition to its memorial nature, the Fund also reflects the family's long-standing commitment to responsible stewardship of The Barringer Meteorite Crater and the family's steadfast resolve in maintaining the crater as a unique scientific research and education site.

For more information, visit *www.lpi.usra.edu/science/kring/Awards/Barringer_Fund/index.html*.

NASA Honors Lunar Science Trailblazer Don Edward Wilhelms

Don Edward Wilhelms received the Shoemaker Distinguished Lunar Scientist Award during a ceremony at the annual Lunar Science Forum held in July at NASA Ames Research Center. The award is given annually to a scientist who has significantly contributed to the field of lunar science.

Wilhelms was hired by Gene Shoemaker and worked at the U.S. Geological Survey in Menlo Park, California, as an astrogeologist for 24 years. He retired from the USGS in 1986. His research was very broad, covering nearly all categories of lunar science. According to scientists, no student of the lunar surface, its terrain, and the geologic context of samples can function without the framework developed by Wilhelms.

"Dr. Wilhelms has literally written the book on lunar geology. Both of his books, *To a Rocky Moon* and *The Geologic History of the Moon*, have been required reading for students of lunar science," said David Morrison, retiring director of the NASA Lunar Science Institute. David Kring of the Lunar and Planetary Institute in Houston notes, "Wilhelms' real-time guidance to the Apollo program was extraordinary. Furthermore, his geologic analyses and interpretative maps continued to shape our measure of the Moon for decades after the Apollo era."

The first Distinguished Lunar Scientist Award was given posthumously last year to Gene Shoemaker and presented to his wife, Carolyn, for Shoemaker's many contributions to the lunar geological sciences.

NASA Names New Director for Lunar Science Institute

Yvonne Pendleton has been named director of the NASA Lunar Science Institute (NLSI) headquartered at NASA's Ames Research Center in Moffett Field, California. Pendleton has served as the NASA Ames Deputy Associate Center Director, Chief of the Space Science and Astrobiology Division, and as a research astrophysicist for 31 years, including nearly two years at NASA Headquarters.

Pendleton has a Ph.D. in Astrophysics from the University of California at Santa Cruz, a master's degree in Aeronautics and Astronautics from Stanford University, and a bachelor's degree in Aerospace Engineering from the Georgia Institute of Technology. Pendleton replaces David Morrison, who was acting director for NLSI.

Morrison recently was appointed director for the Carl Sagan Center for Study of Life in the Universe at the SETI Institute and continues part-time as a senior scientist at the NLSI.

"Dr. Pendleton is a natural fit for the Lunar Science Institute director role," said NASA's Planetary Science Division Director Jim Green. "She has an extensive astrophysics background and besides — how many directors have asteroids named after them?"

Asteroid 7165 Pendleton was named in honor of her work in astrophysics and planetary research. She is interested in how interstellar ices and organics are delivered to bodies in the solar system via comets and asteroids. Pendleton is also an elected fellow of the California Academy of Science.

NLSI is a virtual organization that supplements and extends existing NASA lunar science programs. Supported by the NASA Science Mission Directorate and the Exploration Systems Mission Directorate, the NLSI is managed by the NASA Ames Research Center and is modeled on the NASA Astrobiology Institute with dispersed teams across the nation working together to help lead the agency's research activities related to NASA's lunar exploration goals.

For more information about the NASA Lunar Science Institute, visit *lunarscience.nasa.gov/*.

NASA Administrator Bolden Named Champion of Summer Learning

The National Summer Learning Association has recognized NASA Administrator Charles Bolden as a Champion of Summer Learning. The award honors Bolden's dedication to keeping America's middle school students engaged in science, technology, engineering, and mathematics (STEM) through a new initiative called the Summer of Innovation. Five leaders from across the nation who have invested in summer learning programs and helped increase public support for them will receive the award.

"Bolden's leadership on the NASA Summer of Innovation program has resulted in a major step forward on two critical policy challenges facing our nation: summer learning loss and STEM education," said Ron Fairchild, CEO of the association.

Bolden officially kicked off the Summer of Innovation June 10 at NASA's Jet Propulsion Laboratory.

Using content from NASA's missions and research, the program will engage thousands of middle school students in STEM learning during the summer months when many students experience "summer slide," or a loss of skills acquired during the school year. Summer of Innovation is a cornerstone of the Educate to Innovate campaign President Obama announced last November.

"It is such an honor for me personally — and for NASA — to be recognized for our commitment to summer learning," Bolden said. "However, I do want to single out two individuals without whom the Summer of Innovation would not be in place today — Nicole Campbell, a White House Fellow who raised the idea of this program when she joined my staff, and Dovie Lacy, the project manager, who breathed life into the program. Education is a passion of mine, and I have asked that NASA's best and brightest get involved and make this Summer of Innovation a special and meaningful experience for these middle school students. They're our future and I want to ensure it is a bright one."

To learn more about the Summer of Innovation, visit *www.nasa.gov/soi*.

COSPAR Announces 2010 Award Winners

During the 38th COSPAR Scientific Assembly held in July in Bremen, Germany, the 2010 winners of the annual COSPAR awards were announced.

The COSPAR Space Science Award for outstanding contributions to space science was given to Günther Hasinger, Max-Planck Institute for Plasma Physics, Garching, Germany, and Steven W. Squyres, Department of Astronomy, Cornell University, Ithaca, New York.

The COSPAR International Cooperation Medal for distinguished contributions to space science and work that has contributed significantly to the promotion of international scientific cooperation was given to Lee-Lueng Fu, Jet Propulsion Laboratory, Pasadena, California, and Yves Ménard (posthumous), CNES, Paris.

The COSPAR William Nordberg Medal commemorating the late William Nordberg and for distinguished contributions to the application of space science in a field covered by COSPAR was given to Kuo-Nan Liou, Department of Atmospheric and Oceanic Sciences, University of California, Los Angeles, California.

The COSPAR Distinguished Service Medal for extraordinary services rendered to COSPAR over many years was given to Margaret (Peggy) Ann Shea, Air Force Research Laboratory, Hanscom Air Force Base, Massachusetts.

The Committee on Space Research (COSPAR) has both National Scientific Institutions and International Scientific Unions as members. Forty-four National Scientific Institutions engaged in space research and 13 International Scientific Unions adhering to the International Council for Science (ICSU) belong to COSPAR. Moreover, approximately 6500 scientists actively engaged in space research are COSPAR Associates.

COSPAR's objectives are to promote on an international level scientific research in space, with emphasis on the exchange of results, information and opinions, and to provide a forum, open to all scientists, for the discussion of problems that may affect scientific space research. These objectives are achieved through the organization of Scientific Assemblies, publications, and other means. COSPAR is an interdisciplinary entity that ignores political considerations and views all questions solely from the scientific standpoint.

For a complete list of award recipients, visit *cosparhq.cnes.fr/Awards/awards.htm*.

NASA Announces Education Research Program Award Recipients

NASA has awarded $16.8 million to colleges and universities nationwide to conduct research and technology development in areas of importance to the agency's mission. In addition to the research and technology development, the awards enable faculty development and higher education student support.

The selections are part of NASA's Experimental Program to Stimulate Competitive Research (EPSCoR). The program is designed to assist states in establishing an academic research enterprise directed toward a long-term, self-sustaining and competitive capability that will contribute to the states' economic viability and development. EPSCoR assists in developing partnerships between NASA research assets, academic institutions, and industry.

A total of 24 proposals were selected for funding in Puerto Rico and the following states: Alabama, Alaska, Hawaii, Idaho, Iowa, Kentucky, Louisiana, Maine, Mississippi, Montana, Nevada, New Hampshire, Rhode Island, South Carolina, South Dakota, Tennessee, West Virginia, and Wyoming. Winning proposals were selected through a merit-based, peer-reviewed competition.

For additional information about NASA's EPSCoR program, visit *education.nasa.gov/epscor*.

NASA Receives Spirit of Houston Award

In August, NASA Administrator Charles Bolden accepted the Spirit of Houston Award from the city's Mayor Annise Parker. The award was established in 2004 to honor Houstonians who motivated their fellow citizens with their everyday acts of leadership.

NASA Administrator Charles Bolden accepts the Spirit of Houston Award from Mayor Annise Parker and others representing the city at Houston's 174th Birthday Celebration on August 26, 2010. Pictured from left are Council Member Mike Sullivan, JSC Center Director Michael Coats, Mayor Parker, Bolden, Council Member Jolanda "Jo" Jones and Mayor Pro-Tem Anne Clutterbuck. Credit: NASA.

"It is an honor to accept the 2010 Spirit of Houston Award on behalf of all of the men and women of NASA," Bolden said. "Every one of us is absolutely committed to a vibrant future for exploration and improving life on Earth."

Parker recommended the NASA workforce receive the city's annual award for the iconic contributions they have made throughout the agency's history. It was presented at Houston's 174th Birthday Celebration at the George R. Brown Convention Center. The theme for this year's birthday event was "Houston, We Have the Moon and the Stars!" Former astronaut Bernard A. Harris Jr. was inducted into the 2010 Houston Hall of Fame at the event.

Parker proclaimed August 26, 2010, as "The NASA Family Spirit of Houston Day." The proclamation stated the "dedicated workforce reaches beyond the boundaries of the Johnson Space Center campus and makes Houston a better community at large."

For more than 50 years, NASA and its workforce have powered Houston and the nation into the 21st century through accomplishments that are enduring milestones of human achievement. Among those accomplishments are technological innovations and scientific discoveries that have improved lives on Earth.

Vice President Spiro Agnew and former President Lyndon B. Johnson view the liftoff of Apollo 11 from pad 39A at Kennedy Space Center on July 16, 1969. This and other iconic photos are available for the public to tag and comment on The Commons section of the Flickr site.

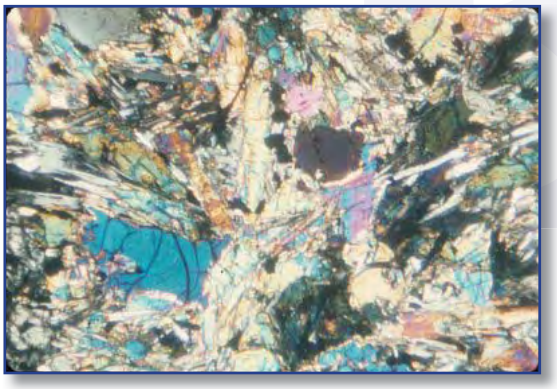
NASA, Internet Archive, and Flickr Launch Historic Image Collection

Three compilations of images from more than half a century of NASA history are available for comment on a section of the photo-sharing site Flickr known as The Commons. Visitors to NASA on The Commons can help tell the photos' story by adding tags, or keywords, to the images to identify objects and people. In addition, viewers can communicate with other visitors by sharing comments. These contributions will help make the images easier to find online and add insight about NASA's history. The capability to interact with these already-public photos is the result of a partnership between NASA, Flickr from Yahoo! in Sunnyvale, California, and Internet Archive, a nonprofit digital library based in San Francisco.

Three sets of photos share a common theme of NASA beginnings. The "Launch and Takeoff" set captures iconic spacecraft and aircraft taking flight. "Building NASA" spotlights groundbreaking events and the construction of some of NASA's one-of-a-kind facilities. The "Center Namesakes" set features photos of the founders and figureheads of NASA's 10 field centers. The Commons was launched with the Library of Congress to increase access to publicly held photography collections and provide a way for the public to contribute information and knowledge. To view NASA on The Commons images, visit *www.flickr.com/photos/nasacommons*.

Through a competitive process, NASA selected the Internet Archive in 2007 to organize a comprehensive online compilation of the agency's vast collection of photographs, historic film, and video on the NASA Images website. Launched in 2008, *NASAimages.org* provides hundreds of thousands of images and thousands of hours of video, HD video, and audio content available free to the public for download. "Sharing important assets like NASA photography is the core mission of the Internet Archive. Through this partnership with NASA and Flickr, NASA on The Commons is bringing these images to a vast audience and providing an opportunity for the public to give fresh insight and increase our shared knowledge of NASA in all its varied activities," said Jon Hornstein, director of the NASA Images Project at the Internet Archive in San Francisco. For more information and to see the image collection, visit *www.nasaimages.org*.

LPI Expands Lunar Sample Atlas, Receives Award for Digital Library of the Week



The Lunar and Planetary Institute (LPI) is pleased to announce the expansion of its digital lunar sample image collection.

More than 8000 new images have been added to the Lunar Sample Atlas. This library of images provides pictures of the Apollo samples taken in the Lunar Sample Laboratory, full-color views of the samples in microscopic thin sections, cutting views and diagrams that illustrate how the samples were subdivided for scientific analyses, and *in situ* views of the samples on the lunar surface. The atlas contains information

about the type of sample (e.g., rock, soil), the lithology (e.g., basalt, norite), and a description of the sample. Links to additional information about each sample are provided for those that have been previously described in The Lunar Sample Compendium and Lunar Sample Catalogs.

This expansion was made possible through the efforts of a collaborative team, including Rice University student Rob Hoffmann, who produced an immense number of new thin-section views. Access to the lunar samples was provided by the staff of the Lunar Curatorial Facility at the NASA Johnson Space Center. Also contributing to the project were colleagues Clive Neal, Katie O'Sullivan, Amy Fagan, and Pat Donohue of Notre Dame University. Partial funding for this project was provided by the NASA Lunar Science Institute.

Version 1 of the atlas was released in August 2009, and version 2 was released in July 2010. The process of scanning lunar sample images continues, and the atlas will grow in the future. A subset of this collection, the Apollo Thin Sections catalog, includes all samples for which thin-section views are available. Another subset, the Virtual Microscope catalog, provides interactive views of selected thin sections as they would be seen through a microscope.

The American Library Association recently listed the Lunar Sample Atlas as the "Digital Library of the Week." The atlas illustrates both the scientific value and the artistic beauty of lunar samples, and users will revel in the stained-glass appearance of these treasures from the Moon.

To view the Lunar Sample Atlas, visit *www.lpi.usra.edu/lunar/samples/atlas/*.

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.

Dr. Paul Schenk,
Scientific Editor (*schenk@lpi.usra.edu*)

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Copy deadline for the next issue: November 15, 2010

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Frank J. Stadermann

Frank Stadermann passed away on October 4, 2010, at age 48, after suffering a cerebral hemorrhage. A senior research scientist in physics, member of the Laboratory for Space Sciences, and director of the NanoSIMS and Auger laboratories at Washington University in St. Louis, Stadermann received an undergraduate degree in physics from the University of Heidelberg for his work on ^{40}Ar–^{39}Ar dating of lunar rocks from the Fra Mauro region. After a two-year research visit to Washington University, he obtained a Ph.D. from the University of Heidelberg in 1991 with a dissertation on SIMS isotopic and trace element measurements of interplanetary dust particles (IDPs), which included the discovery of widespread nitrogen isotopic variations in IDPs. As a post-doc at the Max-Planck-Institut für Kernphysik in Heidelberg he studied micrometeoroid impacts on satellite surfaces to evaluate the relative contributions of cosmic particles and man-made debris in low-Earth orbit. He re-joined Washington University in 1996 to participate in development, fund-raising, and the eventual purchase of the very first NanoSIMS, a newly designed high-resolution and high-sensitivity type of ion microprobe.

Stadermann developed techniques for NanoSIMS measurements in TEM sections, which allowed for the first time correlated mineralogical and isotopic studies on a submicrometer scale. He also discovered the first presolar corundum and SiC grains in IDPs. He served as a sample advisor for the Stardust mission, and the analysis of cometary particles was an important focus of his research. His analyses during the preliminary examination of dust particles from Comet Wild-2 returned by the Stardust space probe led to the discovery of a presolar grain among the returned cometary samples. Stadermann's wife, Christine Floss, a research associate professor of physics at Washington University, often collaborated with him.

Audouin Charles Dollfus

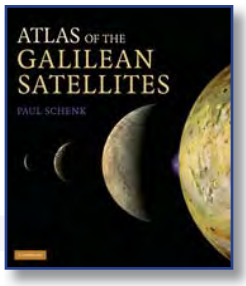
French astronomer Audouin Dollfus passed away on October 1, 2010 in Versailles, France, at the age of 85. Born in Paris and son of an aeronaut, he built his first refracting telescope at the age of 14. With a degree in mathematical sciences and physics, he began his career at the Observatory of Paris-Meudon as a student of astronomer Bernard Lyot. At a time when astronomy was focusing on the deep sky, Dollfus turned to the study of the solar system, and became a worldwide expert on the subject. He created the Laboratory of Solar System Physics at Meudon, focusing on Mars, Venus, Mercury, Saturn, and Jupiter. He also contributed to the study of the Sun by creating a coronograph used by many spacecraft missions. Dollfus led astronomical campaigns both at the Observatory of Meudon and the Pic-du-Midi Observatory. In 1966 he discovered Janus, the tenth satellite of Saturn, and asteroid 2451 bears his name.

In 1955, Dollfus' analysis of lunar dust using polarimetry allowed him to deduce the basaltic nature of the lunar soil. As a result, NASA invited him to collaborate on the study of the Apollo 11 landing site. He contributed to the analysis of the lunar samples returned by the Apollo program and to studies of the martian soil in preparation for the 1976 Viking mission.

Dollfus was a pioneer of space exploration through his practice of astronomy using balloons. He designed prototypes that allowed him to take a telescope up to 6000 meters (19,700 feet) in the air. His most famous flight was on April 24, 1959, when he reached a height of 14,000 meters (45,920 feet), which remains the French record to this day. That day, he opened the door to the study of astronomy from space, and the data he collected during that flight allowed him to infer the existence of water on Mars.

Dollfus was also dedicated to passing on his passion for astronomy and never refused an opportunity to share his enthusiasm through lectures, debates, and talks to astronomy clubs. He mentored students in astronomy and planetary sciences, and many of these students are directly involved in planetary and space exploration today.

Books



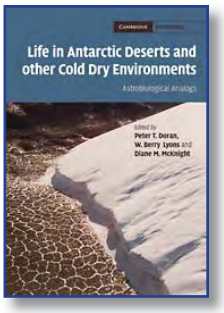
Atlas of the Galilean Satellites.

By Paul Schenk. Cambridge University Press, 2010. 406 pp., Hardcover, $160.00. *www.cambridge.org*

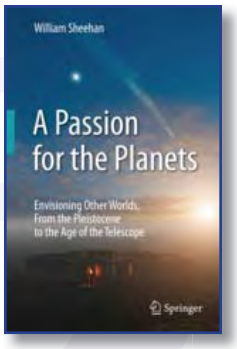
Complete color global maps and high-resolution mosaics of Jupiter's four large moons — Io, Europa, Ganymede, and Callisto — are compiled for the first time in this important atlas. The satellites are revealed as four visually striking and geologically diverse planetary bodies: Io's volcanic lavas and plumes and towering mountains; Europa's fissured ice surface; the craters, fractures, and polar caps of Ganymede; and the giant impact basins, desiccated plains, and icy pinnacles of Callisto. Featuring images taken from the recent Galileo mission, this atlas is a comprehensive mapping reference guide for researchers. It contains 65 global and regional maps, nearly 250 high-resolution mosaics, and images taken at resolutions from 500 meters to as high as 6 meters.

Life in Antarctic Deserts and Other Cold Dry Environments: Astrobiological Analogs.

Edited by Peter T. Doran, W. Berry Lyons, and Diane M. McKnight. Cambridge University Press, 2010. 320 pp., Hardcover, $110.00. *www.cambridge.org*



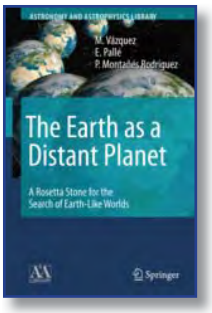
The McMurdo Dry Valleys form the largest relatively ice-free area on the Antarctic continent. The perennially ice-covered lakes, ephemeral streams, and extensive areas of exposed soil are subject to low temperatures, limited precipitation, and salt accumulation. The dry valleys thus represent a region where life approaches its environmental limits. This unique ecosystem has been studied for several decades as an analog to environments on other planets, particularly Mars. For the first time, the detailed terrestrial research of the dry valleys is brought together here, presented from an astrobiological perspective. Chapters include a discussion on the history of research in the valleys, a geological background of the valleys, setting them up as analogs for Mars, followed by chapters on the various subenvironments in the valleys such as lakes, glaciers, and soils. Includes concluding chapters on biodiversity and other analog environments on Earth.



A Passion for the Planets: Envisioning Other Worlds, From the Pleistocene to the Age of the Telescope.

By William Sheehan. Springer, 2010. 194 pp., Paperback, $34.95. *www.springer.com*

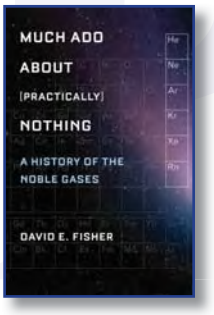
In this lively and compelling account, William Sheehan — professional psychiatrist, noted historian of astronomy, and incurable observer — explores the nature of that allure through the story of man's visual exploration of the planets. In this first volume of a trilogy, Sheehan starts with observational astronomy's profound and lasting effect on his own life, setting the points of embarkation for the journey to come. He travels across the historical landscape seeking the earliest origins of man's compulsion to observe the planets among the hunter gatherers of the upper Palaeolithic, and traces the evolving story from the planetary records of the earliest cities, to Pharonic Egypt through to Hellenistic Greek astronomy culminating in Ptolemy. The necessity to observe played its part in the perceptual changes wrought by the Copernican revolution, as well as the observational advances achieved by such extraordinary characters as Tycho with his sharpest of eyes, and his luxurious practice of total astronomy. The two epochal advances published in 1609, both born through planetary observation, namely Kepler's discovery of the true nature of the orbit of Mars and Harriot and Galileo's observations of the Moon, have a pivotal place in this account. This book will be of interest to amateur astronomers, active planetary observers, armchair astronomers, and those interested in the history of astronomy, the cultural history of science, and astronomical art.



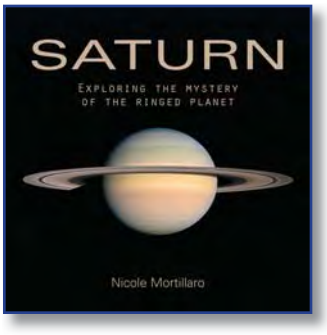
The Earth as a Distant Planet: A Rosetta Stone for the Search of Earth-Like Worlds.
By M. Vázquez, E. Pallé, and P. Montañés Rodríguez. Springer, 2010. 422 pp., Hardcover, $119.00. *www.springer.com*

Since the discovery in 1992 of the first exoplanet, or planet outside our solar system, the number of known planets has increased exponentially. Ambitious space missions are already being designed for the characterization of their atmospheres and to explore the possibility that they host life. The exploration of Earth and the rest of the rocky planets in our solar system will help us in classifying and understanding the multiplicity of planetary systems that exist in our galaxy. In time, statistics on the formation and evolution of exoplanets will be available and will provide vital information for solving some of the unanswered questions about the formation, as well as the evolution, of our own world.

Much Ado About (Practically) Nothing: A History of the Noble Gases.
By David Fisher. Oxford University Press, 2010. 288 pp., Hardcover, $24.95. *www.oup.com*



Noble gases are colorless, odorless, invisible gases that do not react with anything, and were thought to be unimportant until the early 1960s. Author David Fisher has spent roughly 50 years doing research on these gases, publishing nearly 100 papers in the scientific journals, applying them to problems in geophysics and cosmochemistry, and learning how other scientists have utilized them to change our ideas about the universe, the Sun, and our own planet. This book covers this spectrum of ideas, interspersed with the author's own work, and serves to introduce each gas and the important work others have done with them. The rare gases have participated in a wide range of scientific advances — even revolutions — but no book has ever recorded the entire story. Topics include the intricacies of the atomic nucleus and the tiniest of elementary particles, the neutrino, to the energy source of the stars; the age of Earth to its future energies; and life on Mars to cancer here on Earth.



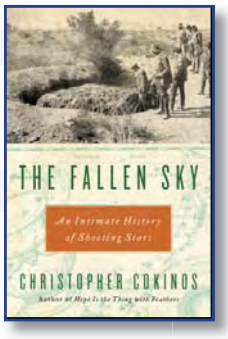
Saturn: Exploring the Mystery of the Ringed Planet.
By Nicole Mortillaro. Firefly Books, 2010. 96 pp., Hardcover, $29.95.
www.fireflybooks.com

Saturn is one of the five planets that stargazers can see with the naked eye. In 1997 the satellite Cassini-Huygens was launched with the sole purpose of studying Saturn and its moons and rings. Cassini is still in orbit, and in 2009 it witnessed Saturn's equinox firsthand, providing an entirely new perspective of the planet and a basis for amazing discoveries. Its accomplishments so far include landing on Saturn's moon Titan, recording images of a storm raging across Saturn that has lightning 10,000 times more powerful than any lightning on Earth, discovering there may be as many as 10 million tiny moonlets in Saturn's rings, and finding that a newly discovered moon embedded in the planet's G ring may actually be responsible for that ring. Featuring extraordinary photos selected from NASA resources on almost every page, this book examines the planet and its place in our universe with a special emphasis on the most recent discoveries of the Cassini probe.

Presenting Science: A Practical Guide to Giving a Good Talk.

By Cigdem Issever and Ken Peach. Oxford University Press, 2010. 136 pp., Paperback, $35.00. *www.oup.com*

"Giving a talk" is one of the most important ways in which we communicate research. The "talk" covers everything from a 10-minute briefing on progress to a handful of colleagues, to a keynote address to a major international conference with more than 1000 delegates. Whatever the occasion, the aim is the same — to get the message across clearly and effectively. At the same time, presentational skills are becoming more important in all walks of life — and presenting science has particular issues. This book will help equip the reader with the basic skills needed to make a good presentation.



The Fallen Sky: An Intimate History of Shooting Stars.

By Christopher Cokinos. Tarcher Books, 2010. 528 pp., Paperback, $16.95. *us.penguingroup.com*

Weaving natural history, memoir, and the stories of maverick scientists, daring adventurers, and stargazing dreamers, this book takes us from Antarctica to outer space to tell the tale of how the study of meteorites became a scientific passion. Long sought as trophies of exploratory success, scientific specimens, or even space-age novelties, meteorites have a long and complex hold on the human psyche. Their allure endures from tribal altars to high-tech labs, and author Christopher Cokinos explores the drama and history of our pursuit of the fallen sky. Over the course of more than seven years, he crisscrossed the globe from Greenland to the American Southwest, from Australia to Antarctica, following in the footsteps of explorers, collectors, and scientists, gaining access to their personal papers and documents, to try to understand the obsession that draws so many people to these fragments of iron and stone, these pieces of the universe that we can hold in our hands. This is an adventure story, a compelling work of first-person literary journalism, and a scientific history, all told through the lives of its remarkable characters — the eccentrics and geniuses who have committed themselves to understanding the stuff of life and death that comes from the sky.

DVDs

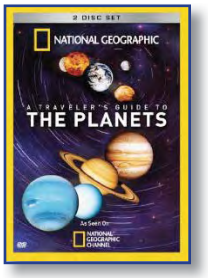
Phoenix Mars Mission: Onto the Ice.

Produced by PBS, 2010, one disc. $24.99. *www.shoppbs.org*

Following on from the 2007 DVD *Phoenix Mars Mission: Ashes to Ice*, this documentary tells the story of the Phoenix Lander from its arrival on the martian surface through the completion of its mission.

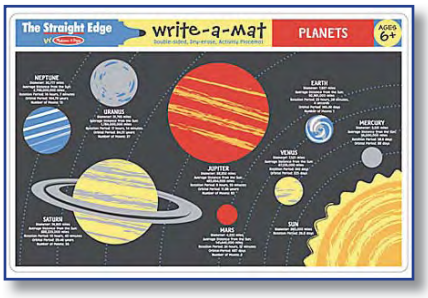
A Traveler's Guide to the Planets.

Produced by National Geographic, 2010, two discs. $34.95. *www.shopnationalgeographic.com*



Take a trip of a lifetime to visit our neighboring planets with *A Traveler's Guide to the Planets.* National Geographic takes off beyond Earth's boundaries for the ultimate tour of our solar system. From Mars' monstrous mountains to Saturn's glittering rings, the sights are out of this world. Each of six episodes offers breathtaking tours of the planets using modern-day high-tech telescopes and stunning CGI. Programs include Saturn, *Jupiter, Neptune and Uranus, Pluto and Beyond, Mars*, and *Venus and Mercury*. Includes bonus programs *The Sun* and *The Moon*.

For Kids!



Solar System Write-a-Mat Placemat.

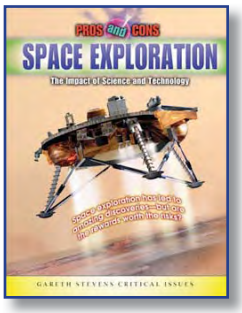
By Melissa & Doug, LLC. $12.99. *www.melissaanddoug.com*

This double-sided placemat encourages learning through visual aid and fun facts. On one side are full-color images of the planets with their names and interesting facts about each. Flip over the mat, and it's your turn! See if you can remember the names of each of the planets, fill in their labels, and color them in! This mat is to be used with write-on, wipe-off crayons and measures approximately 17.25" × 11.25".

3-in-1 Space Explorer Telescope.

By Uncle Milton. $24.95. *www.unclemilton.com*

Explore the final frontier with this real working telescope. Point it at space and see the stars and planets up close. This telescope also has 10 backlit NASA images and synchronized audio narration with facts about the universe, and features a focus and image selector dials. This telescope requires three AAA batteries, not included. For ages 6 and up.



Space Exploration: The Impact of Science and Technology.

By Joseph Harris. Gareth Stevens Publishing, 2010. 64 pp., Hardcover, $35.00. *www.garethstevens.com*

Humans have explored Earth, its Moon, and its atmosphere, but people have traveled hardly any distance into space. The vast distances between stars and galaxies mean that scientists on Earth study most of the universe from far away. Exploring space offers its own unique challenges and rewards. This book examines the politics of space — the space race, weapons in space, and international cooperation, the realities of living in space, the uses of satellites and space probes, space age technologies that changed life on Earth, and the future of space exploration, from space tourism to space elevators. This book goes beyond the science to explore the pros and cons of each new development, and examines the ways in which space exploration has changed our society and the world. For grades 5–8.

Space Exploration Experiment Kit.

By Thames & Kosmos, LLC. $34.95. *www.thamesandkosmos.com*

Blast off on a mission to explore outer space and the objects in it. Learn about rocket propulsion with balloons and chemically powered rockets. Build a telescope and star map to investigate the stars and constellations. Assemble a model of the solar system and learn about the planets that share it. Find out how Earth's rotation creates day and night, how Earth's axis and revolution around the Sun causes the seasons, and how the Moon's rotation around Earth gives us the phases of the Moon. See for yourself how meteorites formed the craters on the Moon. Make a Moon flipbook and a Moon calendar. Build a sundial and a solar collector to experiment with the Sun. Grasp a comet's tail and learn about how meteoroids become falling stars. A full-color, 32-page experiment book guides your space exploration. For ages 8 and up.

October 2010

4–6 **GMT2010: Opening New Frontiers with the Giant Magellan Telescope,** Seoul, Korea. *http://astro1.snu.ac.kr/gmt2010/*

4–8 **42nd Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society (DPS 2010),** Pasadena, California. *http://dps.aas.org/meetings/2010/*

4–8 **5th Alfvén Conference on Plasma Interaction with Non-Magnetized Planets/ Moons and Its Influence on Planetary Evolution,** Sapporo, Japan. *http://www.ep.sci.hokudai.ac.jp/~alfven5/*

4–9 **Comprehensive Characterization of Astronomical Sites,** Kislovodsk, Russia. *http://site2010.sai.msu.ru/description*

5–6 **Robotic Science from the Moon: Gravitational Physics, Heliophysics and Cosmology,** Boulder, Colorado. *http://lunar.colorado.edu/workshop.php*

10–12 **WittFest: Origins and Evolution of Dust,** Toledo, Ohio. *http://wittfest.net/Welcome.html*

11–14 **Science with the Hubble Space Telescope — III,** Venice, Italy. *http://www.stecf.org/conferences/HST3/*

11–15 **First Moscow Solar System Symposium (1M-S3),** Moscow, Russia. *http://ms2010.cosmos.ru/*

11–15 **IAU Symposium 276: The Astrophysics of Planetary Systems: Formation, Structure, and Dynamical Evolution,** Torino, Italy. *http://iaus276.oato.inaf.it/IAUS_276/index.htm*

16–18 **The 3rd International Congress on Image and Signal Processing (CISP'10) and the 3rd International Conference on BioMedical Engineering and Informatics (BMEI'10),** Yantai, China. *http://cisp-bmei2010.ytu.edu.cn/*

18–22 **Graduate School in Astronomy XV Special Advanced Courses,** Rio de Janeiro, Brazil. *http://www.on.br/cce/2010/english.html*

19–22 **Big Science with Small Telescopes: The Role of 2–4 m Telescopes in the Era of the Large and Extremely Large Telescopes,** Dornburg, Germany. *http://www.tls-tautenburg.de/tls50/tls50.php*

24–27 **First Puerto Rico Space Congress: Space Is the Answer,** San Juan, Puerto Rico. *http://leeward.crowdvine.com/*

25–29 **In the Spirit of Lyot 2010: Direct Detection of Exoplanets and Circumstellar Disks,** Paris, France. *http://lyot2010.lesia.obspm.fr/*

25–29 **7th International Conference on the Inspiration of Astronomical Phenomena,** Bath, United Kingdom. *http://www.insapvii.org/*

27–30 **Joint Meeting of the "Paneth Kolloquium" and Workshop of the DFG Special Program "The First 10 Million Years of the Solar System — A Planetary Materials Approach,"** Nördlingen, Germany. *http://www.cosmochemistry.org/*

31–Nov 3 **Geological Society of American Annual Meeting,** Denver, Colorado. *http://www.geosociety.org/meetings/2010/*

November

1–5 **International Young Astronomer School on High Angular Resolution Techniques (2010),** Paris, France. *http://ufe.obspm.fr/rubrique256.html*

10–11 **Synchrotron Radiation in Earth, Space and Planetary Science — Exploiting the UK's Newest Facility, Didot,** Oxfordshire, UK. *http://www.diamond.ac.uk/Home/Events/EE_village_workshop.html*

15–19 **ISPRS Symposium/Planetary Mapping Workshop,** Orlando, Florida. *http://www.asprs.org/orlando2010/index.html*

16–18 **9th Triennial Canada-France-Hawaii Telescope Users' Meeting,** Taipei, Taiwan. *http://www.cfht.hawaii.edu/en/news/UM2010/*

December

6–8 **Carbon in the Solar System,** Brussels, Belgium. *http://www.busoc.eu/cost/*

13–17 **Fall Meeting of the American Geophysical Union,** San Francisco, California. *http://www.agu.org/meetings/fm10/*

January 2011

5–9 **Archaeoastronomy and Ethnoastronomy: Building Bridges Between Cultures,** Lima, Peru. *http://www1.archaeoastronomy.org/index.php?option=com_content&view=article&id=13&Itemid=15&lang=en*

8–14 **Colloquium of African Geology,** Johannesburg, South Africa. *http://www.cag23.co.za/*

10–14 **The Millimeter and Submillimeter Sky in the Planck Mission Era,** Paris, France. *http://www.planck2011.fr/*

10–15 **CPS 7th International School of Planetary Sciences: Theory of Stellar Evolution and Its Applications,** Kobe, Japan. *https://www.cps-jp.org/~pschool/pub/2011-01-10/index.html*

17–21 **Landing Site Characterization and Selection for Future Exploration Missions (A Europlanet JRA1 Workshop),** Leiden/Noordwijk, The Netherlands. *http://www.planetarygis.org/wiki/Workshop2011*

18–22 **The 15th International Conference on Gravitational Microlensing and School on Planetary Microlensing Events Modeling,** Salerno, Italy. *http://smc2011.physics.unisa.it/*

25–26 **4th Meeting of the Small Bodies Assessment Group,** Washington, DC. *http://www.lpi.usra.edu/sbag/meetings/*

29–Feb 8 **International Workshop on Extrasolar Planets,** Kish Island, Iran. *http://www.astro.ipm.ir/conferences/ESPW/*

February

7–14 **Geobiology in Space Exploration (with Field Trip),** Marrakech, Morocco. *http://www.irsps.unich.it/education/geoexp2011/*

18–22 **IAG/AIG Regional Conference on Geomorphology,** Addis Ababa, Ethiopia. *http://www.geomorph.org/main.html*

28–Mar 2 **Next-Generation Suborbital Researchers Conference,** Orlando, Florida. *http://nrsc.swri.org*

March

1–3 **Astronomy with Radioactivities VII,** Phillip Island, Victoria, Australia. *http://cspa.monash.edu.au/awr7/*

7–11 **42nd Lunar and Planetary Science Conference (LPSC 2011),** The Woodlands, Texas. *http://www.lpi.usra.edu/meetings/lpsc2011/*

20–25 **Twelfth International Conference on Accelerator Mass Spectrometry,** Wellington, New Zealand. *http://www.gns.cri.nz/ams12/index.html*

April

3–8 **European Geosciences Union General Assembly,** Vienna, Austria. *http://meetings.copernicus.org/egu2011/*

3–9 **From Planets to Life,** Villars-sur-Ollon, Switzerland. *http://www.isdc.unige.ch/sf2011/*

11–15 **18th IAA Humans in Space Symposium,** Houston, Texas. *http://www.dsls.usra.edu/meetings/IAA/*

May

2–7 **18th Young Scientists' Conference on Astronomy and Space Physics,** Kiev, Ukraine. *http://ysc.kiev.ua/*

18–20 **Conference on Micro-Raman Spectroscopy and Luminescence Studies in the Earth and Planetary Sciences (CORALS II),** Madrid, Spain. *http://www.lpi.usra.edu/meetings/corals2011/*

22–26 **20th ESA Symposium on European Rocket and Balloon Programmes and Related Research,** Hyeres, France. *http://spaceflight.esa.int/pac-symposium2011/*

June

5–8 **Astrobiology Graduate Student Conference (AbGradCon 2011),** Bozeman, Montana. *http://abgradcon2011.org/*

5–10 **Second Workshop on Robotic Autonomous Observatories,** Malaga, Spain. *http://arae.iaa.es:8000/malaga-2011/index.php*

13–15 **A Wet vs. Dry Moon: Exploring Volatile Reservoirs and Implications for the Evolution of the Moon and Future Exploration,** Houston, Texas. *http://www.lpi.usra.edu/meetings/volatiles2011/*

July

3–8 **Origins 2011: The International Astrobiology Society and Bioastronomy Joint International Conference,** Montpellier, France. *http://www.origins2011.univ-montp2.fr/*

5–8 **40th Young European Radio Astronomers Conference (YERAC),** Alcala de Henares, Spain. *http://www.yerac.org/*

25–29 **2011 Sagan Exoplanet Summer Workshop: Exploring Exoplanets with Microlensing,** Pasadena, California. *http://nexsci.caltech.edu/workshop/2011/*