Galileo's Significance

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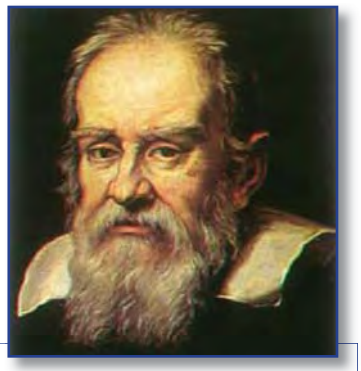
Galileo's Significance

— Guy Consolmagno S.J., Vatican Observatory

This International Year of Astronomy celebrates 400 years since Galileo first pointed his telescope to the heavens and opened up the universe to us all. But in all the celebrations of Galileo's annus mirabilis, I would argue that not nearly enough attention has been given to the traits that actually made Galileo so special.



"Galileo Demonstrates the Telescope," a painting by Justus Sustermans, 1636.

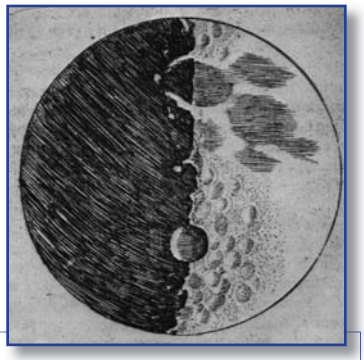
When I joined the Vatican Observatory, I knew that I would be getting lots of questions about Galileo; I made a point of reading much of what he wrote, as well as a lot (but hardly all!) of what has been written about him. And the questions I usually wind up dealing with involve, no surprise, his dealings with the Church. (Turns out, it's a lot more complicated than the typical myth would have you believe. My Church still comes out looking bad, but not necessarily for the reasons usually cited.)

Galileo's telescope.

But what I found most surprising was what I, as an astronomer, could begin to understand about Galileo the scientist. People tend to focus on his string of "firsts" — first to see the craters on the Moon, the phases of Venus, sunspots, etc. But he wasn't the first person to point a telescope at the Moon or discover sunspots; that priority really belongs to Thomas Herriot of England. Instead, Galileo was special because he was the first scientist to understand what he was looking at; to fit it into a larger cosmology; and to bring the attention of the world to what he had discovered.

Persistence and imagination were the root of his genius. Grinding a lens by hand is no trivial task; how many scientists today have ever done that? Getting good, clear, bubble-free glass was itself an expensive proposition. Forming a number of spherical surfaces on this expensive glass took him all of the summer of 1609. And recall, he had no idea whether it would work, or what he would be able to see with it. Hard work made the lenses; imagination inspired him to do so in the first place.

Thinking to point it at the sky — and rigging up a system so that it would hold steady enough for him to see anything when he did, then taking clear notes of what he saw, night after night — again showed this combination of imagination and technical ability.



Galileo's map of the Moon, drawn on December 3, 1609. From the exhibit Face of the Moon: Galileo to Apollo, Linda Hall Library, Kansas City, Missouri.

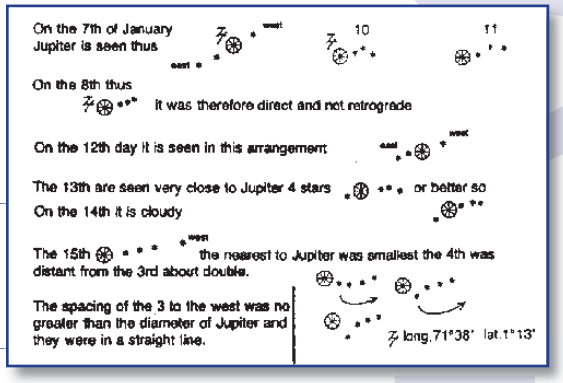
And the things he saw! As art historians have pointed out, Herriot's drawings of the Moon depict it as a flat disk; only Galileo had the artistic skill (and the good fortune of living in Italy, where perspective was well established in the world of painting) to depict it as a globe. More than that, he immediately recognized the rough regions that he saw in his telescopes as mountains. This was no small feat of imagination; at that time, who had ever seen what mountains look like from above, looking down?

Or consider the discovery of Jupiter's moons. An amateur astronomer friend once related to me how he had built his first telescope as a teenager and then pointed it to Jupiter. "The first thing I noticed were these small dots of light on either side of the planet. I was terribly disappointed; I assumed that they were reflections off a crack in my lens!" Galileo had no idea what tricks his telescope might play on him; but he was able to identify, correctly, what he was seeing. What he recorded — what anyone today can see with a small scope —

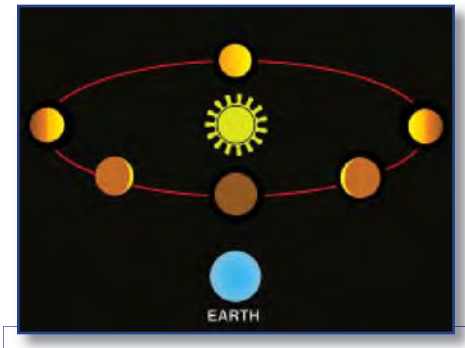
were a collection of dots of light whose position (and number) changed night after night in what might have seemed to be a random or arbitrary manner. It was his persistence and imagination that led him to connect them up not as reflections in the telescope, or a random swarm of objects traveling alongside Jupiter, but as four distinct orbiting satellites.

The four largest moons of Jupiter are known as the Galilean satellites, because they were first seen by Galileo in 1610. Shown from left to right in order of increasing distance from Jupiter, Io is closest, followed by Europa, Ganymede, and Callisto.

A page from Sidereus Nuncius, the most famous publication by Galileo Galilei. Here in his own hand is Galileo's 1610 discovery of Jupiter's four "satellites," a term first used by Kepler later that same year in support of Galileo's discovery.



A translation of the key passages of Galileo Galilei's journal detailing his discovery of four of the moons orbiting Jupiter.



Galileo's discovery that Venus showed phases proved that it orbits the Sun and not Earth.

He also had the imagination to recognize the significance of objects orbiting something other than the Earth. It's a common mistake to think that the geocentric system had Earth in the center, as a place of honor; in fact, it was just the opposite — in that world view, Earth was the bottom of the universe, the next-to-last link on the chain of creation only one step above the Inferno. Copernicus elevated Earth to be as good as all the planets of heaven. And Galileo was a Copernican, even in his youth, judging from his notes written fifteen years before his telescope. What made him so convinced even before he had the data?

As Tycho Brahe and other astronomers had pointed out, there were solid scientific reasons to reject the Copernican view at that time; and Brahe's system (the planets orbit the Sun, but the Sun orbits the Earth) was completely consistent with Galileo's observations. Galileo's championing of heliocentrism was not based on his data, but on his scientific taste. And he was right.

But the most important thing Galileo did was to tell the world about his discoveries. Not just the world of scholarship; Galileo wrote clearly and lucidly, and for the most part in Italian instead of Latin, so that anyone could read of his discoveries. (And buy his books!) Popularizers have never been popular among their fellow scientists; I recall the abuse that Carl Sagan had to endure from his more stuffy contemporaries. Galileo faced that same dilemma; and indeed, his very popularity is no doubt what created the intensely jealous animosity that eventually led to his trial.

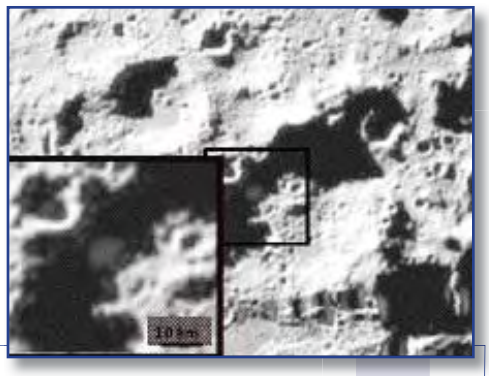
But although the Copernicus idea had been around for nearly 70 years when Galileo wrote his first book of astronomy, and indeed Kepler published his much more accurate description of elliptical orbits at the same time as Galileo, the ideas and significance of the Sun-centered system only penetrated into the popular imagination through Galileo's books. He was not only hard-working and imaginative; he also told a good story.

That is why Galileo is so especially honored during this year. It's not just that he was the first to look, or the first to see. He was the first to get the rest of us to look and see as well.

About the author —

Brother Guy Consolmagno is the curator of the Vatican meteorite collection in Castel Gandolfo, one of the largest in the world. His research explores the connections between meteorites and asteroids, and the origin and evolution of small bodies in the solar system. In 2000 he was honored by the International Astronomical Union for his contributions to the study of meteorites and asteroids with the naming of asteroid 4597 Consolmagno. In addition to his extensive academic background, Consolmagno has written more than 100 scientific publications and has co-authored numerous astronomy books. He took vows as a Jesuit brother in 1991, and was assigned to the Vatican Observatory in 1993.

LCROSS Impacts Confirm Water in Lunar Crater



This visible camera image shows the ejecta plume at about 20 seconds after impact by the LCROSS Centaur upper stage rocket. Credit: NASA.

Preliminary data from NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) indicates the mission successfully uncovered water in a permanently shadowed lunar crater. The discovery opens a new chapter in our understanding of the Moon.

On October 9, the LCROSS spacecraft and a companion rocket stage made twin impacts in the Cabeus crater that created a plume of material from the bottom of a crater that has not seen sunlight in billions of years. The plume traveled at a high angle beyond the rim of Cabeus and into sunlight, while an additional curtain of debris was ejected more laterally. "We're unlocking the mysteries of our nearest neighbor and, by extension, the solar system," said Michael Wargo, chief lunar scientist at NASA Headquarters in Washington. "The Moon harbors many secrets, and LCROSS has added a new layer to our understanding."

Scientists have long speculated about the source of significant quantities of hydrogen that have been observed at the lunar poles. The LCROSS findings are shedding new light on the question with the discovery of water, which could be more widespread and in greater quantity than previously suspected. If the water that was formed or deposited is billions of years old, these polar cold traps could hold a key to the history and evolution of the solar system, much as an ice core sample taken on Earth reveals ancient data. In addition, water and other compounds represent potential resources that could sustain future lunar exploration.

Since the impacts, the LCROSS science team has been analyzing the huge amount of data the spacecraft collected. The team concentrated on data from the satellite's spectrometers, which provide the most definitive information about the presence of water. A spectrometer helps identify the composition of materials by examining light they emit or absorb.

"We are ecstatic," said Anthony Colaprete, LCROSS project scientist and principal investigator at NASA's Ames Research Center. "Multiple lines of evidence show water was present in both the high angle vapor plume and the ejecta curtain created by the LCROSS Centaur impact. The concentration and distribution of water and other substances requires further analysis, but it is safe to say Cabeus holds water." Colaprete added, "We were able to match the spectra from LCROSS data only when we inserted the spectra for water. No other reasonable combination of other compounds that we tried matched the observations. The possibility of contamination from the Centaur also was ruled out."

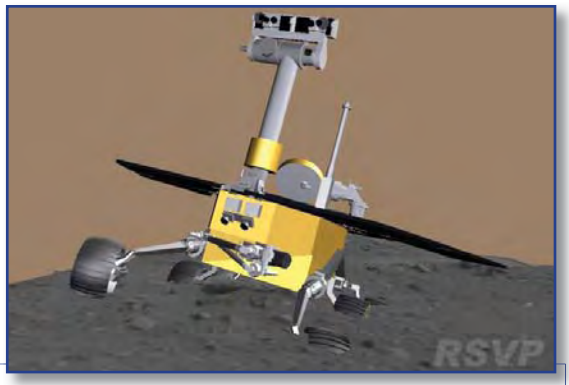
Additional confirmation came from an emission in the ultraviolet spectrum that was attributed to hydroxyl, one product from the breakup of water by sunlight. When atoms and molecules are excited, they release energy at specific wavelengths that can be detected by the spectrometers. A similar process is used in neon signs. When electrified, a specific gas will produce a distinct color. Just after impact, the LCROSS ultraviolet visible spectrometer detected hydroxyl signatures that are consistent with a water vapor cloud in sunlight.

LCROSS was launched June 18 from NASA's Kennedy Space Center in Florida as a companion mission to the Lunar Reconnaissance Orbiter (LRO). Moving at a speed of more than 1.5 miles per second, the spent upper stage of its launch vehicle hit the lunar surface shortly after 4:31 a.m. PDT on October 9, creating an impact that instruments onboard LCROSS observed for approximately four minutes. LCROSS then impacted the surface at approximately 4:36 a.m.

LRO observed the impact and continues to pass over the site to give the LCROSS team additional insight into the mechanics of the impact and its resulting craters. The LCROSS science team is working closely with scientists from LRO and other observatories that viewed the impact to analyze and understand the full scope of the LCROSS data.

For information about LCROSS, visit *www.nasa.gov/lcross*.

NASA to Begin Attempts to Free Sand-Trapped Mars Rover



A screen shot from software used by the Mars Exploration Rover team for assessing movements by Spirit and Opportunity illustrates the degree to which Spirit's wheels have become embedded in soft material at the location called "Troy." The image simulates Spirit's position on May 8, 2009, during the 1900th martian day, or sol, of what was originally planned as a 90-sol mission on Mars. Credit: NASA/JPL-Caltech.

NASA began transmitting commands to its Mars exploration rover Spirit on November 9 as part of an escape plan to free the venerable robot from its martian sand trap. Spirit has been lodged at a site scientists call "Troy" since April 23. Researchers expect the extraction process to be long and the outcome uncertain based on tests here on Earth this spring that simulated conditions at the martian site. "This is going to be a lengthy process, and there's a high probability attempts to free Spirit will not be successful," said Doug McCuistion, director of the Mars Exploration Program at NASA Headquarters in Washington. "After the first few weeks of attempts, we're not likely to know whether Spirit will be able to free itself."

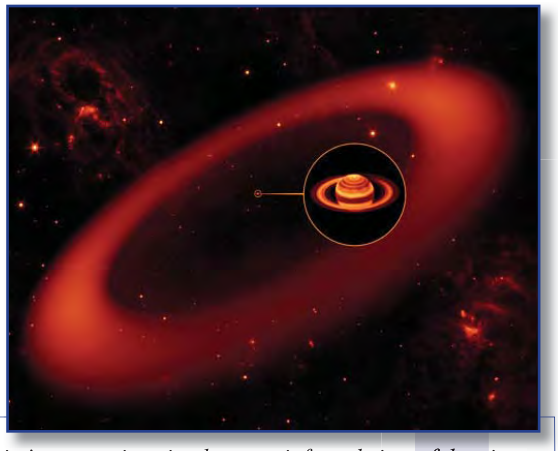
Spirit has six wheels for roving the Red Planet. The first commands will tell the rover to rotate its five working wheels forward approximately six turns. Engineers anticipate severe wheel slippage, with barely perceptible forward progress in this initial attempt. Since 2006, Spirit's right-front wheel has been inoperable, possibly because of wear and tear on a motor as a result of the rover's longevity. "Mobility on Mars is challenging, and whatever the outcome, lessons from the work to free Spirit will enhance our knowledge about how to analyze martian terrain and drive future Mars rovers," McCuisition said. "Spirit has provided outstanding scientific discoveries and shown us astounding vistas during its long life on Mars, which is more than 22 times longer than its designed life."

In the spring, Spirit was driving backward and dragging the inoperable right front wheel. While driving in April, the rover's other wheels broke through a crust on the surface that was covering a bright-toned, slippery sand underneath. After a few drive attempts to get Spirit out in the subsequent days, it began sinking deeper in the sand trap. Driving was suspended to allow time for tests and reviews of possible escape strategies. Data show Spirit is straddling the edge of a 26-foot-wide crater that had been filled long ago with sulfate-bearing sands produced in a hot water or steam environment. The deposits in the crater formed distinct layers with different compositions and tints, and they are capped by a crusty soil. It is that soil that Spirit's wheels broke through. The buried crater lies mainly to Spirit's left. Engineers have plotted an escape route from Troy that heads up a mild slope away from the crater.

"The soft materials churned up by Spirit's wheels have the highest sulfur content measured on Mars," said Ray Arvidson, a scientist at Washington University in St. Louis and deputy principal investigator for the science payloads on Spirit and Opportunity. "We're taking advantage of its fixed location to conduct detailed measurements of these interesting materials." Spirit and its twin rover landed on Mars in January 2004. They have explored Mars for five years, far surpassing their original 90-day mission. Opportunity currently is driving toward a large crater called Endeavor.

For updates about Spirit's progress, visit *marsrovers.jpl.nasa.gov/home/index.html*.

NASA Space Telescope Discovers Largest Ring Around Saturn



This artist's conception simulates an infrared view of the giant ring that has just been discovered around Saturn. Saturn appears as just a small dot from outside the band of ice and dust. The inset shows an enlarged image of Saturn, as seen by the W. M. Keck Observatory at Mauna Kea, Hawaii, in infrared light. The ring, stars, and wispy clouds are an artist's representation. Credit: NASA/JPL-Caltech/Keck.

NASA's Spitzer Space Telescope has discovered an enormous ring around Saturn — by far the largest of the giant planet's many rings. The new belt lies at the far reaches of the saturnian system, with an orbit tilted 27° from the main ring plane. The bulk of its material starts about 6 million kilometers (3.7 million miles) away from the planet and extends outward roughly another 12 million kilometers (7.4 million miles). One of Saturn's farthest moons, Phoebe, circles within the newfound ring, and is likely the source of its material. Saturn's newest halo is thick, too — its vertical height is about 20 times the diameter of the planet. It would take about one billion Earths stacked together to fill the ring.

"This is one supersized ring," said Anne Verbiscer, an astronomer at the University of Virginia, Charlottesville. "If you could see the ring, it would span the width of two full moons' worth of sky, one on either side of Saturn." Verbiscer; Douglas Hamilton of the University of Maryland, College Park; and Michael Skrutskie, of the University of Virginia, Charlottesville, are authors of a paper about the discovery published online in the October 8 issue of the journal *Nature*.

The discovery may help solve an age-old riddle of one of Saturn's moons. Iapetus has a strange appearance — one side is bright and the other is really dark, in a pattern that resembles the yin-yang symbol. The astronomer Giovanni Cassini first spotted the moon in 1671, and years later figured out it has a dark side, now named Cassini Regio in his honor. A stunning picture of Iapetus taken by NASA's Cassini spacecraft is online at *photojournal.jpl.nasa.gov/catalog/PIA08384*. Saturn's newest addition could explain how Cassini Regio came to be.

The ring is circling in the same direction as Phoebe, while Iapetus, the other rings, and most of Saturn's moons are all going the opposite way. According to the scientists, some of the dark and dusty material from the outer ring moves inward toward Iapetus, slamming the icy moon like bugs on a windshield.

Verbiscer and her colleagues used Spitzer's longer-wavelength infrared camera, called the multiband imaging photometer, to scan through a patch of sky far from Saturn and a bit inside Phoebe's orbit. The astronomers had a hunch that Phoebe might be circling around in a belt of dust kicked up from its minor collisions with comets — a process similar to that around stars with dusty disks of planetary debris. Sure enough, when the scientists took a first look at their Spitzer data, a band of dust jumped out.

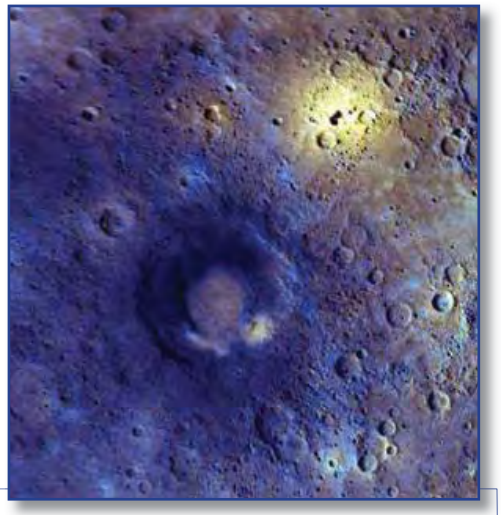
The ring would be difficult to see with visible-light telescopes. Its particles are diffuse and may even extend beyond the bulk of the ring material all the way in to Saturn and all the way out to interplanetary space. The relatively small numbers of particles in the ring wouldn't reflect much visible light, especially out at Saturn where sunlight is weak. "The particles are so far apart that if you were to stand in the ring, you wouldn't even know it," said Verbiscer.

Spitzer was able to sense the glow of the cool dust, which is only about 80 Kelvin (–316°F). Cool objects shine with infrared, or thermal radiation; for example, even a cup of ice cream is blazing with infrared light. "By focusing on the glow of the ring's cool dust, Spitzer made it easy to find," said Verbiscer.

These observations were made before Spitzer ran out of coolant in May and began its "warm" mission.

For additional images relating to the ring discovery and more information about Spitzer, visit *www.spitzer.caltech.edu* or *www.nasa.gov/spitzer*.

MESSENGER Spacecraft Reveals More Hidden Territory On Mercury



This enhanced-color view was created with a statistical technique that highlights subtle color variations seen in the 11 filters of MESSENGER's wide-angle camera that are often related to composition. Merged with images from the higher-resolution narrow-angle camera, the two sets of observations tell the story of the geology of the area and the compositional differences of the features observed. This region, viewed in detail for the first time during the third flyby, appears to have experienced a high level of volcanic activity. Credit: NASA.

A NASA spacecraft's third and final flyby of Mercury gives scientists, for the first time, an almost complete view of the planet's surface and provides new scientific findings about this relatively unknown world. The Mercury Surface, Space Environment, Geochemistry and Ranging spacecraft, known as MESSENGER, flew by Mercury on September 29. The probe completed a critical gravity assist to remain on course to enter into orbit around Mercury in 2011. Despite shutting down temporarily because of a power system switchover during a solar eclipse, the spacecraft's cameras and instruments collected high-resolution and color images unveiling another 6% of the planet's surface never before seen at close range.

Approximately 98% of Mercury's surface now has been imaged by NASA spacecraft. After MESSENGER goes into orbit around Mercury, it will see the polar regions, which are the only unobserved areas of the planet. "Although the area viewed for the first time by spacecraft was less than 350 miles across at the equator, the new images reminded us that Mercury continues to hold surprises," said Sean Solomon, principal investigator for the mission and director of the Department of Terrestrial Magnetism at the Carnegie Institution of Washington.

Many new features were revealed during the third flyby, including a region with a bright area surrounding an irregular depression, suspected to be volcanic in origin. Other images revealed a double-ring impact basin approximately 180 miles across. The basin is similar to a feature scientists call the Raditladi basin, which was viewed during the probe's first flyby of Mercury in January 2008.

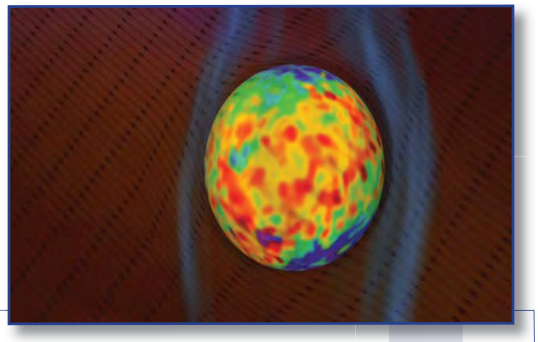
One of the spacecraft's instruments conducted its most extensive observations to date of Mercury's exosphere, or thin atmosphere, during this encounter. The flyby allowed for the first detailed scans over Mercury's north and south poles. The probe also has begun to reveal how Mercury's atmosphere varies with its distance from the Sun. "A striking illustration of what we call 'seasonal' effects in Mercury's exosphere is that the neutral sodium tail, so prominent in the first two flybys, is 10 to 20 times less intense in emission and significantly reduced in extent," says participating scientist Ron Vervack, of the Johns Hopkins University Applied Physics Laboratory (APL). "This difference is related to expected variations in solar radiation pressure as Mercury moves in its orbit and demonstrates why Mercury's exosphere is one of the most dynamic in the solar system."

The third flyby also revealed new information on the abundances of iron and titanium in Mercury's surface materials. Earlier Earth and spacecraft-based observations showed that Mercury's surface has a very low concentration of iron in silicate minerals, a result that led to the view that the planet's crust is generally low in iron. "Now we know Mercury's surface has an average iron and titanium abundance that is higher than most of us expected, similar to some lunar mare basalts," says David Lawrence, an APL participating mission scientist.

The spacecraft has completed nearly three-quarters of its 4.9-billion-mile journey to enter orbit around Mercury. The full trip will include more than 15 trips around the Sun. In addition to flying by Mercury, the spacecraft flew past Earth in August 2005 and Venus in October 2006 and June 2007.

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

Cassini Data Help Redraw Shape of Solar System



This image shows an artist's conception of the bubble around our solar system moving through the interstellar medium, the matter that fills the local region of our galaxy. New observations from the Cassini spacecraft orbiting Saturn suggest the shape resembles something like a slippery ball moving through smoke. Credit: NASA/JPL-Caltech/JHUAPL.

Images from the Ion and Neutral Camera on NASA's Cassini spacecraft suggest that the heliosphere, the region of the Sun's influence, may not have the comet-like shape predicted by existing models. In a paper published October 15 in *Science Express*, researchers from the Johns Hopkins Applied Physics Laboratory (APL) present a new view of the heliosphere, and the forces that shape it. "These images have revolutionized what we thought we knew for the past 50 years; the Sun travels through the galaxy not like a comet but more like a big, round bubble," said Stamatios Krimigis of APL, principal investigator for Cassini's Magnetospheric Imaging Instrument, which carries the Ion and Neutral Camera. "It's amazing how a single new observation can change an entire concept that most scientists had taken as true for nearly 50 years."

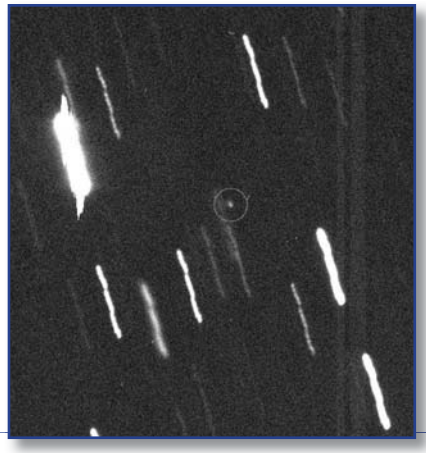
As the solar wind flows from the Sun, it carves out a bubble in the interstellar medium. Models of the boundary region between the heliosphere and interstellar medium have been based on the assumption that the relative flow of the interstellar medium and its collision with the solar wind dominate the interaction. This would create a foreshortened "nose" in the direction of the solar system's motion, and an elongated "tail" in the opposite direction. The Ion and Neutral Camera images suggest that the solar wind's interaction with the interstellar medium is instead more significantly controlled by particle pressure and magnetic field energy density. "The map we've created from the images suggests that pressure from a hot population of charged particles and interaction with the interstellar medium's magnetic field strongly influence the shape of the heliosphere," says Don Mitchell, Magnetospheric Imaging Instrument/Ion and Neutral Camera co-investigator at APL.

Since entering into orbit around Saturn in July of 2004, the Ion and Neutral Camera has been mapping energetic neutral atoms near the planet, as well as their dispersal across the entire sky. The energetic neutral atoms are produced by energetic protons, which are responsible for the outward pressure of the heliosphere beyond the interface where the solar wind collides with the interstellar medium, and which interact with the magnetic field of the interstellar medium. "Energetic neutral atom imaging has demonstrated its power to reveal the distribution of energetic ions, first in Earth's own magnetosphere, next in the giant magnetosphere of Saturn, and now throughout vast structures in space — out to the very edge of our Sun's interaction with the interstellar medium," says Edmond C. Roelof, Magnetospheric Imaging Instrument co-investigator at APL.

More information on the Cassini mission is available at *www.nasa.gov/cassini*, *saturn.jpl.nasa.gov*, and on the Magnetospheric Imaging Instrument website at *sd-www.jhuapl.edu/CASSINI/*.

NASA Refines Asteroid Apophis' Path Toward Earth

Using updated information, NASA scientists have recalculated the path of a large asteroid. The refined path indicates a significantly reduced likelihood of a hazardous encounter with Earth in 2036. The Apophis asteroid is approximately the size of two-and-a-half football fields. The new data were documented by near-Earth object scientists Steve Chesley and Paul Chodas at NASA's Jet Propulsion Laboratory (JPL). They presented their updated findings at a meeting of the American Astronomical Society's Division for Planetary Sciences in Puerto Rico on October 8. "Apophis has been one of those celestial bodies that has captured the public's interest since it was discovered in 2004," said Chesley. "Updated computational techniques and newly available data indicate the probability of an Earth encounter on April 13, 2036, for Apophis has dropped from one in 45,000 to about four in a million."



Asteroid Apophis was discovered on June 19, 2004. Credit: University of Hawaii Institute for Astronomy.

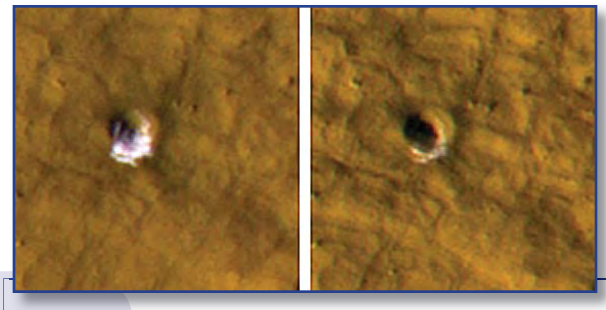
A majority of the data that enabled the updated orbit of Apophis came from observations made by Dave Tholen and collaborators at the University of Hawaii's Institute for Astronomy in Manoa. Tholen pored over hundreds of previously unreleased images of the night sky made with the University of Hawaii's 2.2-meter (88-inch) telescope, located near the summit of Mauna Kea. Tholen made improved measurements of the asteroid's position in the images, enabling him to provide Chesley and Chodas with new datasets more precise than previous measures for Apophis. Measurements from the Steward Observatory's 2.3-meter (90-inch) Bok telescope on Kitt Peak in Arizona and the Arecibo Observatory on the island of Puerto Rico also were used in Chesley's calculations.

Initially, Apophis was thought to have a 2.7% chance of impacting Earth in 2029. Additional observations of the asteriod ruled out any possibility of an impact in 2029. However, the asteroid is expected to make a record-setting — but harmless — close approach to Earth on Friday, April 13, 2029, when it comes no closer than 29,450 kilometers (18,300 miles) above Earth's surface.

"The refined orbital determination further reinforces that Apophis is an asteroid we can look to as an opportunity for exciting science and not something that should be feared," said Don Yeomans, manager of the Near-Earth Object Program Office at JPL. "The public can follow along as we continue to study Apophis and other near-Earth objects by visiting us on our AsteroidWatch website and by following us on the @ AsteroidWatch Twitter feed."

NASA detects and tracks asteroids and comets passing close to Earth using both ground and space-based telescopes. The Near-Earth Object Observations Program, commonly called "Spaceguard," discovers these objects, characterizes a subset of them, and plots their orbits to determine if any could be potentially hazardous to our planet.

For more information about asteroids and near-Earth objects, visit *www.jpl.nasa.gov/asteroidwatch*.



The High Resolution Imaging Science Experiment camera on NASA's Mars Reconnaissance Orbiter took these images of a fresh, 6-meter-wide (20-foot-wide) crater on Mars on October 18, 2008 (left), and on January 14, 2009 (right). When the crater was formed, the impact exposed water ice from below the surface. It is the bright material visible in this pair of images. Credit: NASA/JPL-Caltech/University of Arizona.

NASA Spacecraft Sees Ice On Mars Exposed By Meteor Impacts

NASA's Mars Reconnaissance Orbiter has revealed frozen water hiding just below the surface of midlatitude Mars. The spacecraft's observations were obtained from orbit after meteorites excavated fresh craters on the Red Planet. Scientists controlling instruments on the orbiter found bright ice exposed at five martian sites with new craters that range in depth from approximately 1.5 feet to 8 feet. The craters did not exist in earlier images of the same sites. Some of the craters show a thin layer of bright ice atop darker underlying material. The bright patches darkened in the weeks following initial observations, as the freshly exposed ice vaporized into the thin martian atmosphere. One of the new craters had a bright patch of material large enough for one of the orbiter's instruments to confirm it is water ice.

The finds indicate water ice occurs beneath Mars' surface halfway between the north pole and the equator, a lower latitude than expected in the martian climate. "This ice is a relic of a more humid climate from perhaps just several thousand years ago," said Shane Byrne of the University of Arizona. Byrne is a member of the team operating the orbiter's High Resolution Imaging Science Experiment (HiRISE) camera, which captured

the unprecedented images. Byrne and 17 co-authors reported the findings in the September 25 edition of the journal *Science*. "We now know we can use new impact sites as probes to look for ice in the shallow subsurface," said Megan Kennedy of Malin Space Science Systems in San Diego, a co-author of the paper and member of the team operating the orbiter's Context Camera.

An image from the camera on August 10, 2008, showed apparent cratering that occurred after an image of the same ground was taken 67 days earlier. The opportunity to study such a fresh impact site prompted a look by the orbiter's higher-resolution camera on September 12, 2009, confirming a cluster of small craters. "Something unusual jumped out," Byrne said. "We observed bright material at the bottoms of the craters with a very distinct color. It looked a lot like ice."

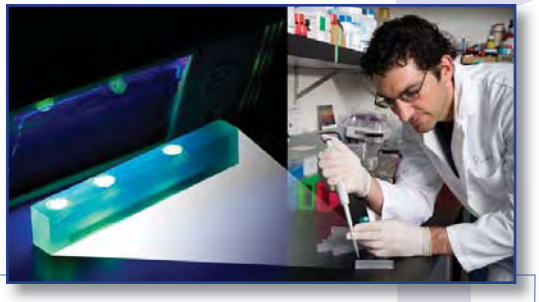
The bright material at that site did not cover enough area for a spectrometer instrument on the orbiter to determine its composition. However, a September 18, 2008, image of a different midlatitude site showed a crater that had not existed eight months earlier. This crater had a larger area of bright material.

The Mars orbiter is designed to facilitate coordination and quick response by the science teams, making it possible to detect and understand rapidly changing features. The ice exposed by fresh impacts suggests that NASA's Viking 2 lander, digging into midlatitude Mars in 1976, might have struck ice if it had dug four inches deeper.

For more about the Mars Reconnaissance Orbiter, visit *www.nasa.gov/mro*.

JPL Develops High-Speed Test to Improve Pathogen Decontamination

A chemist at NASA's Jet Propulsion Laboratory has developed a technology intended to rapidly assess any presence of microbial life on spacecraft. This new method may also help the military test for disease-causing bacteria, such as a causative agent for anthrax, and may also be useful in the medical, pharmaceutical, and other fields. Adrian Ponce, the deputy manager for JPL's planetary science section, devised the new microscope-based method, which has the potential to quickly validate — from days to minutes — a spacecraft's cleanliness.



Chemist Adrian Ponce has devised a new method to quickly validate — from days to minutes — a spacecraft's cleanliness. This sample holder (left) shows samples glowing under ultraviolet light. Credit: NASA/JPL.

NASA adheres to international protocols by striving to ensure that spacecraft don't harbor life from Earth that could contaminate other planets or moons and skew science research. Microbes known as bacterial endospores can withstand extreme temperatures, ultraviolet rays, and chemical treatments, and have been known to survive in space for six years. This resilience makes them important indicators for cleanliness and biodefense. "Bacterial endospores are the toughest form of life on Earth," Ponce explained. "Therefore, if one can show that all spores are killed, then less-resistant, disease-causing organisms will also be dead."

The new technology works by looking for dipicolinic acid — a major component of endospores and evidence of endospore growth — by first applying terbium to a dime-sized area. Terbium is a chemical element used to generate the color green on television screens. That area is then illuminated under an ultraviolet lamp. Within minutes, one can see through a microscope aided by a digital camera whether live endospores are present. That's because they will literally glow: The terbium will show the endospores as bright green spots.

Ponce co-authored a paper on the new technology, called Germinable Endospore Biodosimetry, along with Pun To Young, a postdoctoral student at the California Institute of Technology, in the journal *Applied and Environmental Microbiology*. The research was also highlighted in *Microbe*, a magazine of the American Society for Microbiology.

More information on JPL's planetary science department is available at *science.jpl.nasa.gov/PlanetaryScience*. More information about Ponce and his research is at *science.jpl.nasa.gov/people/Ponce/*.

"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.

New NASA Planetary Science E/PO Forum

The Science Mission Directorate (SMD) has identified four newly-formed Science Education and Public Outreach Forums to increase the overall coherence of the SMD and Public Outreach portfolio of activities and products. Forums support SMD's astrophysics, heliophysics, planetary science, and Earth science divisions in three core areas:

- E/PO Community Engagement and Development
- E/PO Product and Project Activity Analysis
- Cross-Forum Activities

By coordinating and supporting the SMD education community, the Forums will help to achieve more effective, sustainable, and efficient utilization of SMD science discoveries and learning experiences. The Forums will present Poster ED31A-0527 at the Fall AGU Meeting on Wednesday, December 16, *Science Education and Public Outreach Forums (SEPOF): Providing Coordination and Support for NASA's Science Mission Directorate Education and Outreach Programs.* For more information about the Planetary Science Forum, contact Dr. Stephanie Shipp at *shipp@lpi.usra.edu*.

2010 LPSC Education Forum: Teaching Planetary Sciences for Undergraduates

It is an exciting time for higher education in the Science Mission Directorate. With the introduction of the new Science Education and Public Outreach Forums, a Higher Education Working Group has been initiated. In an effort to support higher education efforts in the planetary science community, the Planetary Science E/PO Forum is hosting a day-long workshop for undergraduate teaching faculty in planetary sciences on Sunday, February 28, 2010, at the Lunar and Planetary Science Conference. The goals of the workshop are to

- begin to develop a collaborative network of undergraduate teaching faculty in planetary sciences;
- identify learning goals and technical skills that a quality undergraduate should have upon graduation to continue in the discipline;
- understand the challenges institutions face in teaching planetary sciences at the undergraduate level (whether at the introductory or advanced level); and
- identify the kinds of support needed by faculty teaching planetary sciences (e.g., clearinghouse of teaching materials, a virtual community, particular topics of interest for future workshops, etc.).

If you are interested in participating to share your insights and experiences, please contact Emily CoBabe-Ammann at *ecobabe@spaceeducation.org*.

Education and Public Outreach Symposium

The Astronomical Society of the Pacific invites you to "Cosmos in the Classroom 2010: A Hands-on Symposium on Teaching Introductory Astronomy" together with "Making Connections In Education and Public Outreach," the 122nd Annual Meeting of the Astronomical Society of the Pacific, July 31–August 4, 2010, at the University of Colorado at Boulder.

Everyone working in education and public outreach is invited to a meeting to consider how best to share the results of their work and improve their practice, to make connections with each other, across science disciplines, and with the Astro 101 instructors also in attendance. Read more at *www.astrosociety.org/events/meeting.html*.

Resource Guide to the Moon

An annotated list of resources for helping students and the public to understand and appreciate the Moon is now available on the website of the nonprofit Astronomical Society of the Pacific at *www.astrosociety.org/education/family/resources/moonguide.html*.

Doomsday 2012 Resources

A widespread Internet-circulated story claims that December 21, 2012, will be the end for planet Earth because some astronomical event, allegedly predicted by the ending of a Mayan calendar cycle, will destroy or decimate our planet.

- Dr. David Morrison's response has been published by the Astronomical Society of the Pacific at *www.astrosociety.org/2012*.
- *Universe Today* published "No Doomsday in 2012" online at *www.universetoday.com/2008/05/19/no-doomsday-in-2012/*.
- NASA has an article "2012 — A Scientific Reality Check" at *www.nasa.gov/topics/earth/features/yoemans20091110.html*.

A number of student programs are available in the lunar and planetary sciences. Through these programs, students are given the invaluable opportunity to work one-on-one with mentors in their chosen research fields, gaining hands-on experience and enriching their professional experience.

LPI Summer Intern Program in Lunar and Planetary Science

The Lunar and Planetary Institute (LPI) invites undergraduates with at least 50 semester hours of credit to experience cutting-edge research in the lunar and planetary sciences. Summer interns will work one-on-one with a scientist at the LPI or at the NASA Johnson Space Center on a research project of current interest in lunar and planetary science. Furthermore, they will participate in peer-reviewed research, learn from top-notch planetary scientists, and preview various careers in science.

The 10-week program runs from June 7, 2010, through August 13, 2010. Interns will receive a $5000.00 stipend plus travel reimbursement ($1000.00 for U.S. interns, $1500.00 for foreign nationals).

The LPI is located near Johnson Space Center, on the south side of Houston, Texas. The LPI provides, on NASA's behalf, leadership in the scientific community for research in lunar, planetary, and solar system sciences, and linkage with related terrestrial programs.

The deadline for applying for the 2010 program is Friday, January 22, 2010. For more information, including eligibility and selection criteria, areas of research, and an online application form, please visit *www.lpi.usra.edu/lpiintern*.

Lunar Exploration Summer Intern Program

LPI is also hosting a special lunar exploration summer intern program to evaluate possible landing sites for robotic and human exploration missions. Applications are invited from graduate students in geology, planetary science, and related programs. The program is also open to undergraduate students in geology, astronomy, chemistry, and physics with at least 50 semester hours of credit. The goal of this program is to integrate NASA's lunar science priorities with the exploration components of the new Constellation program.

The 10-week program runs from June 1, 2010, through August 9, 2010, and the application deadline is January 22, 2010. For more information, or to access the electronic application form, visit *www.lpi.usra.edu/lunar_intern*.

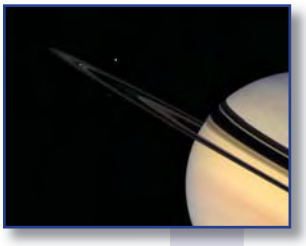
Community College Aerospace Scholars

Community College Aerospace Scholars is a pilot program funded by NASA's Exploration Systems Mission Directorate (ESMD) and administered by NASA Johnson Space Center (JSC). Community college students from across the nation who are interested in the areas of science, technology, engineering, and mathematics will apply to travel to NASA Johnson Space Center (JSC) for a three-day experience. This opportunity will provide a hands-on project featuring engineering career possibilities. Selected students will begin the semester commitment with web-based preparation prior to visiting JSC. The three- day experience at JSC will allow participants to participate in a team project directed by NASA engineers; attend engineer, scientist, and astronaut briefings; tour NASA JSC facilities; and interact with students from across the United States.

Texas residents should apply at *aerospacescholars.jsc.nasa.gov/CAS/*; the application deadline is February 5, 2010. The deadline for the national program is December 5, 2009, and those students should apply at *aerospacescholars.jsc.nasa.gov/NCAS/*.

For additional information about the program, visit the websites listed above. Questions about this opportunity should be directed to *jsc-ae-cas@mail.nasa.gov*.

NASA's Planetary Geology and Geophysics Undergraduate Research Program (PGGURP)



Through the PGGURP program qualified undergraduates are paired with NASA-funded investigators at research locations around the United States for eight weeks during the summer. PGGURP's goals are to provide incentive and development of future planetary geoscientists; broaden the base of students who participate in planetary geoscience; introduce students interested in the traditional sciences to planetary science; and give potential planetary geoscientists a chance to explore the exciting field of planetary research. Students will spend the summer at the NASA scientist's home institution, and the program will pay for housing, travel, and a cost-of-living stipend.

The program consists of an eight-week summer internship, in which qualified students are matched with a NASA-funded planetary scientist. Care is taken to match the skills of the student with the needs of the NASA mentor. Internships take place at the NASA-funded scientist's home institution; in the past, sites have included the NASA Ames Research Center, the Jet Propulsion Laboratory, the U.S.G.S. Astrogeology Branch in Flagstaff, Arizona, and many others.

The application deadline is January 29, 2010. For more information, visit *www.acsu.buffalo.edu/~tgregg/pggurp.html*.

California Institute of Technology Summer Undergraduate Research Fellowships (SURF)

Caltech's Summer Undergraduate Research Fellowships program introduces students to research under the guidance of seasoned research mentors at Caltech and JPL. Students experience the process of research as a creative intellectual activity. SURF is modeled on the grant-seeking process: students collaborate with potential mentors to define and develop a project; applicants write research proposals for their projects; a faculty committee reviews the proposals and recommends awards; students carry out the work over a 10-week period in the summer, mid-June to late August; and at the conclusion of the program, they submit a technical paper and give an oral presentation at SURF Seminar Day, a symposium modeled on a professional technical meeting.

The deadline for all application materials is February 22, 2010. For more information, visit *www.surf.caltech.edu*.

Research Experiences for Undergraduates (REU) Program, American Museum of Natural History

This program, funded by the National Science Foundation, offers the opportunity of a summer internship, complete with stipend, and additional funds for subsistence, for qualified undergraduates to pursue specific projects in conjunction with Museum scientists in the physical sciences. Included in the program are a general orientation to the Museum; a series of weekly meetings at which students will discuss their research, present informal progress reports, and participate in discussions and seminars; as well as graduate and research career opportunities. At the conclusion of the internship, students deliver oral presentations of their work, and prepare publication-quality research papers.

The application deadline is February 1, 2010. For more information, visit *rggs.amnh.org/pages/academics_and_research/fellowship_and_grant_opportunities#reu*.

SAO Summer Intern Program

The Smithsonian Astrophysical Observatory (SAO) Summer Intern Program is a nine- or ten-week-long program, depending on the availability of Harvard housing. In 2010 the program will either begin on Sunday, June 6, or Sunday, June 13. The program is funded by the National Science Foundation and the Smithsonian Institution. Undergraduate students interested in a career in astronomy, astrophysics, physics, or related physical sciences are encouraged to apply.

The application deadline is February 2, 2009. For more information, visit *hea-www.harvard.edu/REU/REU.html*.

NASA Undergraduate Student Research Project Spring and Summer 2010 Sessions

NASA's Undergraduate Student Research Project is currently accepting applications for 15-week spring internships and 10-week summer 2010 internships. These internships offer students the opportunity to work alongside NASA scientists and engineers at NASA's field centers, laboratories, and test facilities. Participants work on practical problems that will be applied in aerospace or on future NASA missions. The deadline for applications for the summer 2010 session is January 22, 2010. For more information and to apply online, visit *usrp.usra.edu*.

Solicitation for Contributions

Contributions to the **Lunar and Planetary Information Bulletin** (LPIB) are solicited from the planetary community and beyond. Articles exploring issues related to planetary science and exploration are welcome. Of special interest are articles describing web-based research and educational tools, meeting highlights and summaries, and descriptions of new space missions that may be of interest to our readers. Peer-reviewed research articles, however, are not appropriate for publication in the LPIB. The LPIB is published quarterly and serves the planetary research community, science libraries, educators, students, and lay readers interested in space-science-related research. 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*)
Renée Dotson,
Production Editor (*dotson@lpi.usra.edu*)

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Production Editor: Renée Dotson
Graphic Design: Leanne Woolley

The Bulletin welcomes articles dealing with issues related to lunar and planetary science and exploration. The copy deadline for the next issue is February 1, 2010. Articles or announcements should be submitted via e-mail to *lpibed@lpi.usra.edu*.

To be added to the list to receive notification by e-mail of future issues, please send your e-mail address to *lpibed@lpi.usra.edu*.

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Eugene M. Shoemaker Impact Cratering Award

Congratulations to Matthew Wielicki of the University of California, Los Angeles, who has been selected as the 2009 winner of the Eugene M. Shoemaker Impact Cratering Award. This award is for undergraduate or graduate students, of any nationality, working in any country, in the disciplines of geology, geophysics, geochemistry, astronomy, or biology. The award, which will include $2500, is to be applied for the study of impact craters, either on Earth or on the other solid bodies in the solar system, which areas of study may include but shall not necessarily be limited to impact cratering processes, the bodies (asteroidal or cometary) that make the impacts, or the geological, chemical or biological results of impact cratering.

This award is managed by the Planetary Geology Division of the Geological Society of America. For more details, along with a list of previous winners, visit *www.lpi.usra.edu/science/kring/Awards/Shoemaker_Award/*.

Gross Receives Prestigious Award

Juliane Gross, a postdoctoral fellow at the Lunar and Planetary Institute, has been selected to receive the prestigious Niedermeyer Award from the Ruhr University in Bochum, Germany. The Niedermeyer Award is given by the Faculty of Geosciences of Ruhr-University Bochum for the most outstanding Ph.D. dissertation.

Gross received her Ph.D. in July 2009. She was selected for the award based on her thesis, entitled "Mineral Solubility Measurements at High Pressures: Redesigning the Hydrothermal Diamond Anvil Cell; Crystal Volume Computations and Birefringence Mapping." The award will be presented, along with a cash prize, at a ceremony at the Ruhr-University Bochum's annual anniversary celebration on December 18. Congratulations, Juliane!

Science Magazines Honor Cutting-Edge NASA Programs

NASA's revolutionary planet-hunting Kepler space telescope has been honored with the 2009 Best of What's New Grand Award from *Popular Science* magazine and a 2009 Breakthrough Award from *Popular Mechanics* magazine. "The Kepler Space Telescope is a stunning new tool that has a very targeted mission: studying planetary systems," the *Popular Mechanics* editors wrote in recognizing Kepler. "It is the first instrument able to detect Earth-like planets, potentially capable of hosting life, as they circle distant suns. About 100,000 stars in our region of the Milky Way will be observed."

Popular Science also honored NASA's new Moon mapping mission, the Lunar Reconnaissance Orbiter, and the Orion Launch Abort System with Best of What's New awards in the aviation and space category. *Popular Science* announced the award winners in its December issue. *Popular Mechanics* made the announcement in its November issue.

"The Lunar Reconnaissance Orbiter, launched in June, will use seven instruments to deliver the most detailed picture of the Moon yet," *Popular Science* editors wrote. "In addition to photographing the lunar surface in high resolution and creating a 3-D topographical map, it will beam back reams of information on surface radiation, surface temperature, soil composition, the presence of water ice and more."

For more information about the Popular Science awards, visit *www.popsci.com*. For information about the Popular Mechanics awards, visit *popularmechanics.com/breakthrough09*.

NASA and X PRIZE Announce Winners of Lunar Lander Challenge

NASA recently awarded $1.65 million in prize money to a pair of innovative aerospace companies that successfully simulated landing a spacecraft on the Moon and lifting off again. NASA's Centennial Challenges program awarded a $1 million first prize to Masten Space Systems of Mojave, California, and a $500,000 second prize to Armadillo Aerospace of Rockwall, Texas, for their Northrop Grumman Lunar Lander Challenge flights. The competition was managed by the X PRIZE Foundation. The Northrop Grumman Corporation is a commercial sponsor that provided operating funds for the contest to the X PRIZE Foundation.

The Northrop Grumman Lunar Lander Challenge involves building and flying a rocket-powered vehicle that simulates the flight of a vehicle on the Moon. The lander must take off vertically then travel horizontally, flying a mission profile designed to demonstrate both power and control before landing accurately at another spot. The same vehicle then must take off again, travel horizontally back to its original takeoff point, and land successfully, all within a time period of 2 hours and 15 minutes.

The challenge requires exacting control and navigation, as well as precise control of engine thrust, all done automatically. The rocket's engine must be started twice in a short time with no ground servicing other than refueling. This represents the technical challenges involved in operating a reusable vehicle that could land on the Moon.

The prize purse is divided into first and second prizes for Level 1 and Level 2. Level 1 requires a flight duration of at least 90 seconds on each flight and Level 2 requires a duration of at least 180 seconds. One of the landings for a Level 2 attempt must be made on a simulated lunar terrain with rocks and craters.

Masten Space Systems met the Level 2 requirements by achieving accurate landings and captured the first place prize during flights of their "Xoie" (pronounced "Zoey") vehicle on October 30 at the Mojave Air and Space Port. Masten also claimed a $150,000 prize as part of the Level 1 competition.

Armadillo Aerospace was the first team to qualify for the Level 2 prize with successful flights of its Scorpius rocket September 12 in Caddo Mills, Texas. Armadillo placed second in the Level 2 competition, earning a $500,000 prize.

"The Northrop Grumman Lunar Lander Challenge has had its intended impact, with impressive performances by multiple teams representing a new generation of aerospace entrepreneurs," said Andrew Petro, NASA's Centennial Challenge program manager at NASA Headquarters. "These companies have demonstrated reusable vehicles with rapid turnaround and a surprising degree of precision in flight, and they have done all this at a much lower cost than many thought possible."

NASA's Centennial Challenges program's goals are to drive progress in aerospace technology that is of value to NASA's missions; encourage participation of independent teams, individual inventors, student groups, and private companies of all sizes in aerospace research and development; and find innovative solutions to technical challenges through competition and cooperation. The Northop Grumman Lunar Lander Challenge is one of six Centennial Challenges managed by NASA's Innovative Partnership Program. The competition was managed for NASA at no cost to the taxpayer by the X PRIZE Foundation under a Space Act Agreement. NASA provided all the prize funds.

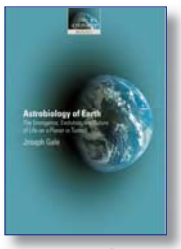
For more information on Centennial Challenges, visit *www.nasa.gov/offices/ipp/innovation_incubator/centennial_challenges/index.html*.

NASA Announces Advisory Council Chairs and Committee Structure

NASA Administrator Charles Bolden held his first meeting with the restructured NASA Advisory Council recently at the agency's Ames Research Center at Moffett Field, California. Bolden has added four new committees to the council in key areas of importance to the agency's future: Commercial Space, Education and Public Outreach, Information Technology Infrastructure, and Technology Innovation. "I consider the NASA Advisory Council to be an extremely important external advisory group, one that is uniquely capable to advise me and the entire NASA senior leadership team on some of the important decisions our agency will face in the coming months and years," Bolden said. "I am confident that this new structure will serve as an effective forum to stimulate meaningful advice to me and the rest of NASA's leadership."

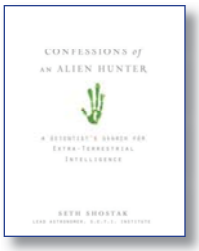
The council's members provide advice and make recommendations to the NASA administrator about agency programs, policies, plans, financial controls, and other matters pertinent to NASA's responsibilities. The chairs for the council and its committees are as follows: NASA Advisory Council: Kenneth M. Ford; Aeronautics Committee: Marion Blakey; Audit, Finance, and Analysis Committee: Robert M. Hanisee; Commercial Space Committee: Brett Alexander; Education and Public Outreach: Miles O'Brien; Exploration Committee: retired Air Force Gen. Lester L. Lyles; Science Committee: Wesley T. Huntress Jr.; Space Operations Committee: former astronaut and retired Air Force Col. Eileen M. Collins; Technology and Innovation Committee: Esther Dyson. An appointment is pending for the Information Technology and Infrastructure Committee.

Books



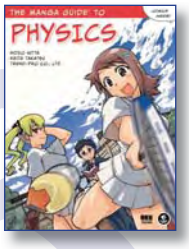
Astrobiology of Earth: The Emergence, Evolution, and Future of Life on a Planet in Turmoil. Joseph Gale. Oxford University Press, 2009. 245 pp., Paperback, $55.00. *www.oup.com*

Astrobiology of Earth adopts a unique approach that differs from most texts in the field of astrobiology, which focus on the possibility of extraterrestrial life. In contrast, the central theme of this book is the fortuitous combination of numerous cosmic factors that together produced the special environment that enabled the emergence, persistence, and evolution of life on our own planet, culminating in humanity. This environment has been subject to constant and chaotic change during life's 3.6-billion-year history. The geologically very recent appearance of humans and their effect on the biosphere is discussed in relation to its deterioration as well as climate change. The search for extraterrestrial life is considered with a view to the suggestion that humans may escape a depleted Earth by colonizing the universe. This book contributes to our understanding of astrobiology from the perspective of life on Earth, particularly human welfare and survival. Astronomical and geological phenomena are related in turn to their biological relevance and impact. This introductory text assumes little or no prior knowledge of more specialized scientific fields and is designed for undergraduate- and graduate-level students taking related courses in departments of biology, Earth science/geology, and environmental science. It will also serve as a useful biology primer for astronomy majors.



Confessions of an Alien Hunter: A Scientist's Search for Extraterrestrial Intelligence. Seth Shostak. National Geographic, 2009. 320 pp., Hardcover, $27.00. *shop.nationalgeographic.com*

Aliens are big in America. Whether they've arrived via rocket, flying saucer, or plain old teleportation, they've been invading, infiltrating, or inspiring us for decades, and they've fascinated moviegoers and television watchers for more than 50 years. About half of us believe that aliens really exist, and millions are convinced they've visited Earth. For 25 years, SETI (Search for Extra Terrestrial Intelligence) has been looking for the proof, and as the program's senior astronomer, Seth Shostak, explains in this engrossing book, it's entirely possible that conclusive evidence will be found before long. His informative, entertaining report offers an insider's view of what we might realistically expect to discover light-years away among the stars. Neither humanoids nor monsters, says Shostak; in fact, biological intelligence is probably just a precursor to machine beings, enormously advanced artificial sentients whose capabilities and accomplishments may have developed over billions of years and far exceed our own. As he explores what, if anything, they would tell us and what their existence would portend for humankind and the cosmos, he introduces a colorful cast of characters and provides a vivid, state-of-the-art account of the past, present, and future of our search for extraterrestrial intelligence.

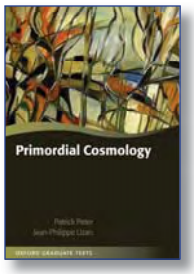


The Manga Guide to Physics. Hideo Nitta, Keita Takatsu, and TREND-PRO Co., Ltd. No Starch Press, 2009. 248 pp., Paperback, $19.95. *www.nostarch.com*

Megumi is an all-star athlete, but she's a failure when it comes to physics class. And she can't concentrate on her tennis matches when she's worried about the questions she missed on the big test! Luckily for her, she befriends Ryota, a patient physics geek who uses real-world examples to help her understand classical mechanics — and improve her tennis game in the process! In *The Manga Guide to Physics*, you'll follow alongside Megumi as she learns about the physics of everyday objects like roller skates, slingshots, braking cars, and tennis serves. In no time, you'll master tough concepts like momentum and impulse, parabolic motion, and the relationship between force, mass, and acceleration. You'll also learn how to apply Newton's three laws of motion to real-life problems, determine how objects will move after a collision, draw vector diagrams and simplify complex problems using trigonometry, and calculate how an object's kinetic energy changes as its potential energy increases. If you're mystified by the basics of physics or you just need a refresher, *The Manga Guide to Physics* will get you up to speed in a lively, quirky, and practical way.

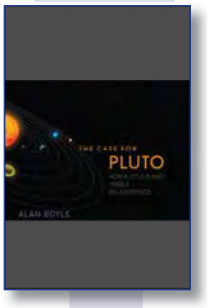
Sites of Impact: Meteorite Craters Around the World. Stan Gaz. Princeton Architectural Press, 2009. 146 pp., Hardcover, $60.00. *www.papress.com*

Sites of Impact features 85 astounding black-and-white photographs of meteor-impact sites, large-scale, aerial landscapes infused with a child's sense of wonder and an adult's preoccupation with the fragility of life. Like the sites themselves — natural monuments to explosive destruction and concomitant creation — the images speak to the vulnerability of the Earth and the significance of our place in the universe. In addition to photographs of the craters and their surrounding landscapes, Stan Gaz includes photographs of actual meteorites and of his own carefully crafted sculptures that recreate their often dynamic form and mimic their specific mineral content. Anecdotal passages about the artist's experiences photographing each crater are interspersed with scientific data regarding the crater's location, age, structure, and condition.



Primordial Cosmology. Patrick Peter and Jean-Phillippe Uzan. Oxford University Press, 2009. 832 pp., Hardcover, $110.00. *www.oup.com*

This book aims at giving the basis of primordial cosmology and is divided into three parts. Part 1 summarizes the fundamentals in theoretical physics needed in cosmology (general relativity, field theory, particle physics). Part 2 describes the standard model of cosmology and includes cosmological solutions of Einstein equations, hot big bang model, cosmological perturbation theory, cosmic microwave background anisotropies, lensing and evidences for dark matter, and inflation. Part 3 describes extensions of this model and opens up to today's research in the field: scalar-tensor theories, supersymmetry, the cosmological constant problem and acceleration of the universe, topology of the universe, grand unification and baryogenesis, topological defects and phase transitions, and string-inspired cosmology including branes and latest developments. This book can be used as a textbook to study cosmology and is self-contained in that all the elements for the derivations of the presented results are given.



The Case for Pluto: How a Little Planet Made a Big Difference. Alan Boyle. Wiley, 2009. 272 pp., Hardcover, $22.95. *www.wiley.com*

Pity poor Pluto: It's a planet that was discovered because of a mistake, a planet that turned out not to be a planet at all, thanks to a still-disputed decision made in 2006. And yet Pluto is the planet best loved by Americans, especially children, one that may have contained the building blocks of life billions of years ago and may well serve as life's last redoubt billions of years from now. In this book, award-winning science writer Alan Boyle traces the tiny planet's ups and downs, its strange appeal, the reasons behind its demotion, and the reasons why it should be set back in the planetary pantheon. He tells the compelling story of Pluto's discovery and how it became a cultural icon and makes the case for Pluto as planet, countering the books that argue against it. The book comes in a small, friendly package — just like Pluto — and features a handsome design, making it a great gift. *The Case for Pluto* is the must-read tale of a cosmic underdog that has captured the hearts of millions: an endearing little planet that is changing the way we see the universe beyond our backyard.

DVDs

Live from the Moon: The Story of Apollo Television. Produced and directed by Mark Gray, 2009, two discs. $39.99. *www.spacecraftfilms.com*

Live from the Moon: The Story of Apollo Television is the story of how the greatest explorations in human history were watched by millions as they happened. This 2-DVD exclusive special edition features the *Live From The Moon* program, in widescreen format, as well as extended bonus features only available from this Spacecraft Films exclusive. This edition features extended interview material not contained in the show from Chris Kraft, Alan Bean, Walt Cunningham, Joe Allen, Ed Fendell, Stan Lebar, Andy Chaikin, and more, along with extended CGI sequences and television sequences not contained in the program. Running time two hours.

Visual Encyclopedia of Space. Produced by Finley-Holiday Films, 2009, two discs. $19.95. *www.finley-holiday.com*

This DVD provides a visual feast of space history. Fully narrated, it is a virtual encyclopedia featuring nearly everything imaginable on space in the last 50 years. Over 60 subjects are covered, including planets, deep space, manned space missions, UFOs, and the space shuttle. Running time is four hours on two discs and includes NASA's historical Apollo 13 film.

For Kids!

***AstroPuppies in Space: An Amazing Adventure for Young Astronauts* DVD.** Produced by Universe Productions, 2009. One disc, $14.95. *astropuppiesinspace.com*

Blast off with the AstroPuppies on an incredible adventure from the Sun to the Moon and out to the planets. Join real astronauts on an exciting space shuttle launch, a visit to the remarkable International Space Station, and an amazing spacewalk. Delightful puppetry, stunning NASA videos, photos from the Hubble Space Telescope, interactive songs and poems, and clever animation are masterfully blended in an entertaining and educational introduction to space exploration. For ages 4–9.

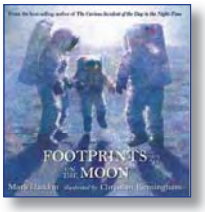
Solar System Backpack. Crocodile Creek. $27.99. *www.crocodilecreek.com*

This backpack is just the right size for younger children and is made of high-quality polyester materials to keep active children organized and ready to go. The front of the backpack features a solar system graphic collage with all the planets. The backpack is 11.5" wide × 14" high and conforms to or exceeds U.S. and European safety standards.

Astronaut Ice Cream. Astronaut Foods/American Outdoor Products, Inc. $2.60. *www.astronautfoods.com*

Freeze-dried Astronaut Ice Cream slices are real ice cream. The freeze-drying technique removes 98% of the original water content, giving the ice cream a three-year shelf life, but once the package is opened, the shelf life diminishes quickly due to absorption of moisture in the air. The ice cream is available in Neapolitan, Chocolate-Chocolate Chip, Mint Chocolate Chip, and of course a Vanilla Ice Cream Sandwich. It's ready to eat and enjoy right from the package. (Please note that this product contains milk and may contain traces of peanuts and tree nuts.)

Footprints on the Moon. Mark Haddon. Candlewick Press, 2009. 32 pages, Hardcover, $16.95. *www.candlewick.com*



Best-selling author Mark Haddon recalls his boyhood fascination with the Moon and his pure wonder at witnessing the first lunar landing. Years ago, a little boy gazed at the Moon, dizzy with the thought that he was looking at a world 200,000 miles away. As he read atlases and library books and kept clippings on astronauts orbiting the Moon, he hoped and hoped that they would find a way to land there. And one extraordinary day they did, captured on his flickery TV, like giants bouncing in slow motion. When the boy fell asleep, he dreamed that he walked with them too. In this lyrical, transporting tale, Mark Haddon — the boy in the story — conveys the thrill of one moment in history through a child's eyes, aided by Christian Birmingham's evocative illustrations. For ages 4–8.

December

5–15 **Workshop on Asteroid 2008 TC3**, Khartoum, Sudan. *asima.seti.org/2008TC3/workshop2008TC3.html*

7–8 **Geosciences — From Earth to Space: Second International Workshop on Mathematical Geosciences (MatGeoS'09)**, Freiberg, Germany. *www.iamg.tu-freiberg.de/matgeos09*

8–9 **12th MHD Days**, Potsdam, Germany. *www.aip.de/MHD12/*

14–18 **AGU Fall Meeting**, San Francisco, California. *www.agu.org/meetings*

15 **Human-Tended Suborbital Science Workshop**, San Francisco, California. *suborbitalex.arc.nasa.gov/*

15–17 **20th Geological Remote Sensing Group (GRSG) Annual Meeting**, London, United Kingdom. *www.geolsoc.org.uk/gsl/site/GSL/lang/en/GRSG2009*

January 2010

3–7 **American Astronomical Society Meeting #215**, Washington, DC. *aas.org/meetings/aas215/*

4–9 **The Sixth CPS International School of Planetary Sciences: Planetary Atmospheres — Sisters, Relatives and Ancestors of Our Own**, Kobe, Japan. *cps.scitec.kobe-u.ac.jp/~pschool/2010-01-04/*

6–8 **UCF Winter Workshop 2010: Exoplanets for Planetary Scientists**, Orlando, Florida. *planets.ucf.edu/winterworkshop2010*

6–9 **Galileo's Medicean Moons: Their Impact on 400 Years of Discovery (IAU Symposium 269)**, Padua, Italy. *www.astro.unipd.it/galileo/*

9–10 **Origin of Life (Gordon Research Seminar)**, Galveston, Texas. *www.grc.org/programs.aspx?year=2010&program=grs_origin*

13–15 **Astrobio 2010**, Santiago, Chile. *www.astro.puc.cl/astrobio2010/HOME.html*

21–22 **Ground-Based Geophysics on the Moon**, Tempe, Arizona. *www.lpi.usra.edu/meetings/lunargeo2010*

25–26 **The Detection of Extra-Terrestrial Life and the Consequences for Science and Society**, London, United Kingdom. *royalsociety.org/event.asp?id=8602&month=1,2010*

27–29 **Workshop on Lunar Dust, Plasma and Atmosphere: The Next Steps**, Boulder, Colorado. *lpa2010.colorado.edu/*

February

5–10 **2010 NSBE Aerospace Systems Conference**, Los Angeles, California. *www.nsbe-asc.org/*

14–17 **Library and Information Services in Astronomy VI (LISA IV)**, Pune, India. *libibm.iucaa.ernet.in/conf/index.php/LISA/conf*

18–20 **Next-Generation Suborbital Researchers Conference (NSRC2010)**, Boulder, Colorado. *www.lpi.usra.edu/meetings/nsrc2010/*

22–24 **Planetary Decadal Survey Meeting: Steering Group**, Irvine, California. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

27–28 **Brown-Vernadsky Microsymposium 51**, The Woodlands, Texas. *www.planetary.brown.edu/html_pages/micro51.htm*

March

1–5 **41st Lunar and Planetary Science Conference (LPSC 2010)**, The Woodlands, Texas. *www.lpi.usra.edu/meetings/lpsc2010/*

14–17 **From First Light to Newborn Stars: A Science Symposium Celebrating 50 Years of Our National Observatory**, Tucson, Arizona. *www.noao.edu/meetings/first-light/*

14–17 **4th Workshop on Granular Materials in Lunar and Martian Exploration**, Honolulu, Hawaii. *content.asce.org/conferences/earthspace2010/index.html*

14–17 **ASCI Earth and Space 2010 Conference**, Honolulu, Hawaii. *content.asce.org/conferences/earthspace2010/index.html*

14–19 **9th Annual International Astrophysics Conference: Pickup Ions Throughout the Heliosphere and Beyond**, Maui, Hawaii. *icnsmeetings.com/conference/9thannual/index.html*

17–20 **An Eventful Universe: A Science Symposium Celebrating 50 Years of Our National Observatory**, Tucson, Arizona. *www.noao.edu/meetings/eventful-universe/*

28–Apr 2 **Workshop Mars III**, Les Houches, France. *www.rssd.esa.int/index.php?project=MARSEXPRESS&page=planet_mars3*

29–Apr 2 **Exoplanets Rising: Astronomy and Planetary Science at the Crossroads**, Santa Barbara, California. *www.kitp.ucsb.edu/activities/auto/?id=983*

April

12–14 **Planetary Decadal Survey Meeting: Satellites Panel**, Boulder, Colorado. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

12–16 **Royal Astronomical Society National Astronomy Meeting**, Glasgow, United Kingdom. *www.astro.gla.ac.uk/nam2010/*

13–16 **JWST and the ELTs: An Ideal Combination**, Garching, Germany. *www.eso.org/sci/meetings/jwstelt2010/*

14–16 **Planetary Decadal Survey Meeting: Mars Panel**, Boulder, Colorado. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

17–18 **High Spatial Resolution in Astronomy: The VLTI Training School**, Porquerolles Island, France. *www.european-interferometry.eu/training/2010*

19–23 **First International Conference on Mars Sedimentology and Stratigraphy (with accompanying field trip)**, El Paso, Texas. *www.lpi.usra.edu/meetings/marssed2010*

21–23 **Planetary Decadal Survey Meeting: Inner Planets Panel**, Boulder, Colorado. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

25–29 **Annual Meeting of the AAS Division on Dynamical Astronomy (DDA)**, Brookline, Massachusetts. *dda.harvard.edu/*

25–29 **Geospatial Infrastructure Solutions (GIS) Conference**, Phoenix, Arizona. *www.gita.org/gis/*

25–30 **Putting our Solar System in Context: Origin, Dynamical and Physical Evolution of Multiple Planet Systems**, Innsbruck, Austria. *www.esf.org/?id=6420*

26–28 **Planetary Decadal Survey Meeting: Primitive Bodies Panel**, Knoxville, Tennessee. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

26–29 **Astrobiology Science Conference 2010: Evolution and Life: Surviving Catastrophes and Extremes on Earth and Beyond**, League City, Texas. *www.lpi.usra.edu/meetings/abscicon2010/*

26–May 1 **17th Young Scientists' Conference on Astronomy and Space Physics**, Kyiv, Ukraine. *ysc.kiev.ua/*

May

2–7 **European Geosciences Union General Assembly 2010**, Vienna, Austria. *meetings.copernicus.org/egu2010/*

3–6 **Astronomical Data Analysis (ADA6)**, Monastir, Tunisia. *www.aset.org.tn/conf/ADA6/*

5–7 **Planetary Decadal Survey Meeting: Giant Planets Panel**, Boston, Massachusetts. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

24–28 **Meteoroids 2010: An International Conference on Minor Bodies in the Solar System**, Breckenridge, Colorado. *www.cora.nwra.com/Meteoroids2010/*

25–27 **Planetary Decadal Survey Meeting: Steering Group**, Washington, DC. *sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412*

30–Jun 25 **Vatican Observatory Summer School: The Chemistry of the Universe**, Castel Gandolfo, Vatican City State. *www.voss2010.va/*

June

8–12 **International Polar Year Oslo Science Conference**, Oslo, Norway. *www.ipy-osc.no/*

8–15 **Twelfth Synthesis Imaging Workshop**, Socorro, New Mexico. *www.aoc.nrao.edu/events/synthesis/2010/*

12–13 **Short Course on Planetary Protection**, Barcelona, Spain. *www.planetaryprobe.eu/*

13–18 **Goldschmidt 2010 Conference**, Knoxville, Tennessee. *www.goldschmidt2010.org*

14–16 **Faraday Discussion 147: Chemistry of the Planets**, Saint Jacut de la Mer, France. *www.rsc.org/ConferencesAndEvents/RSCConferences/FD147/index.asp*

14–18 **7th International Planetary Probe Workshop (IPPW-7)**, Barcelona, Spain. *www.planetaryprobe.eu/*

22–25 **Western Pacific Geophysics Meeting**, Taipei, Taiwan. *www.agu.org/meetings/wp10/index.php*

27–Jul 1 **TNO 2010: Dynamical and Physical Properties of Trans-Neptunian Objects**, Philadelphia, Pennsylvania. *tno.swri.org/*

27–Jul 2 **SPIE Astronomical Telescopes and Instrumentation 2010**, San Diego, California. *spie.org/astronomical-instrumentation.xml?WT.mc_id=Cal-AS*