MESSENGER Finds New Evidence for Water Ice at Mercury’s Poles

New observations by the MESSENGER spacecraft provide compelling support for the hypothesis that Mercury harbors abundant water ice and other frozen volatile materials in its permanently shadowed polar craters.

Given its proximity to the Sun, Mercury would seem to be an unlikely place to find ice. But the tilt of Mercury’s rotational axis is almost zero—less than 1 degree—so there are pockets at the planet’s poles that never see sunlight. Scientists suggested decades ago that there might be water ice and other frozen volatiles trapped at Mercury’s poles.

Nonetheless, three independent lines of evidence support a water-ice conclusion: the first measurements of excess hydrogen at Mercury’s north pole with MESSENGER’s Neutron Spectrometer, the first measurements of the reflectance of...
Busy 2012 Yields New Challenges for 2013

For APL’s Space Sector, 2012 just kept getting busier and busier. While there were many highlights, one of the most memorable moments was the launch of the RBSP mission on August 30, 2012, at 4:05 a.m. out of Cape Canaveral. This launch required exceptional patience after a 1-day slip for additional testing, two scrubs involving range assets and weather, and another slip due to an impending tropical storm. But the third launch attempt was flawless: the Atlas V rocket, the twin spacecraft, and the teams supporting both elements achieved all their launch goals, and commissioning of the spacecraft and instruments began. RBSP was delivered for 92.5% of the budgeted cost.

By Nov. 9, NASA officially renamed the RBSP mission the Van Allen Probes in honor of the late James Van Allen. This name change had been a long-standing goal of the science teams to honor the fundamental influence of Dr. James Van Allen on the study of the space environment. Before going to the University of Iowa, Van Allen worked at APL during World War II on some of the Laboratory’s original projects, and after the war, he started his high-altitude research program at APL using captured V2 rockets. Two of his daughters attended the renaming ceremony at APL; their parents met when both worked at APL on some of our early research projects as part of the World War II effort.

Science highlights of the year began with Van Allen Probes and ended at the edge of our solar system; many of these highlights were presented at the American Geophysical Union conference in December. From instrument turn-on with the Van Allen Probes, the instrument suites began detecting dramatic changes in the radiation belts in response to solar activity. Initial science results also include the popular sound files of the “chirping” of the radiation belts: the sound files give an indication of the time persistence of waves in the radiation belts. The solar activity at the other end of our solar system was equally intriguing: the APL LECP instrument aboard NASA’s Voyager 1 spacecraft has encountered a new region on the outskirts of our solar system that appears to be a magnetic highway for charged particles. Since December 2004, when Voyager 1 crossed the termination shock, the spacecraft has been exploring our heliosphere’s outer layer, called the heliosheath. Voyager and its science team are literally examining the frontier of interstellar space. Though the spacecraft and instrument are 35 years old, they continue to provide amazing science.

Other news was just as noteworthy. On the national security space front, the SEASONS Conference was held in November, and it is further described in this newsletter. Most recently, NASA held a press conference to announce massive amounts of water ice on Mercury discovered by MESSENGER.

Despite our national budget uncertainty, APL’s spacecraft missions and our grant-based research continue to provide very cost-effective science and operational information to our government sponsors. We pride ourselves in providing our sponsors with affordable and innovative solutions to make the best use of our government resources. We look forward to the coming year.

Best Regards,
John C. Sommerer
Space Sector Head

March 17, 2013
Girl Power Expo
APL campus, Laurel, Md.
www.jhuapl.edu/STEM/docs/GirlPower2013.pdf

March 18–22, 2013
Booth at Lunar and Planetary Science Conference
The Woodlands, Texas

April 8–11, 2013
Booth at National Space Symposium
Colorado Springs, Colo.

April 15, 2013
Abstract Deadline for Pluto Science Conference
Plutoscience.jhuapl.edu

July 22–26, 2013
Pluto Science Conference
APL campus, Laurel, Md.
Plutoscience.jhuapl.edu

Aug. 12–15, 2013
Booth at Small Satellite Conference
Logan, Utah
Voyager Hits “Rumble Strips” at the Edge of Interstellar Space

Voyager 1, the pioneering spacecraft that returned striking photos of Jupiter, Saturn, and their moons more than 30 years ago, has made still another surprising discovery: the existence of an unexpected zone at the very edge of the solar system.

In Dec. 2004, Voyager 1 crossed a shock wave known as the termination shock, and it has been exploring the heliosheath, where charged particles from the Sun—known as the solar wind—abruptly slow from supersonic speeds and become turbulent. Voyager 1’s environment was consistent for about 5.5 years, but just recently the spacecraft detected that the outward speed of the solar wind slowed to zero. The intensity of the magnetic field also began to increase.

On these outskirts of our solar system, scientists deem this region the magnetic highway because our Sun’s magnetic field lines are connected to interstellar magnetic field lines. The connection has allowed lower-energy charged particles that originate from inside our heliosphere—the bubble of charged particles the Sun blows around itself—to zoom out, and higher-energy particles from outside to stream in.

“If we were judging by the charged-particle data alone, I would have thought we were outside the heliosphere,” says Stamatios Krimigis, principal investigator of the APL-built Low-Energy Charged Particle (LECP) instrument. “In fact, our instrument has seen the low-energy particles taking the exit ramp toward interstellar space. But we need

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SEASONS 2012:
Operating Through Solar Max

The Conference on Space Environment Applications, Systems, and Operations for National Security (SEASONS) was held Nov. 14–16 at APL to highlight the effects and impacts of space weather on U.S. operational needs. Operating Through Solar Max was the conference theme: the next 5 years are expected to have higher solar activity than any year since 2003. The conference gave operational users and forecasters a forum to discuss how they may need to adjust their expectations about the influence of solar activity and geomagnetic currents on operations.

More than 150 space-weather practitioners, communications professionals, and members of various military services attended to discuss the current state of art in space-weather modeling and prediction. Conference chair Dr. Erin Taylor was pleased with the turnout. “Even during a time of restricted conference travel, many operators, analysts, and researchers met to discuss continuing efforts to forecast and mitigate space-weather system impacts and fresher topics such as radiation impacts to satellite operations and remote sensing and geomagnetically induced power-grid outages,” she said.

Hurricane Sandy and its effects were still a fresh memory for attendees for a panel discussion on potential cascading effects of prolonged power-grid outages after a geomagnetic storm. Cascading effects, such as the food and water supply disruptions that would occur after a prolonged power outage, can wreak havoc on the quality of life for citizens. Northeastern Canada’s Hydro-Quebec power grid went down during the great geomagnetic storm of March 1989 within 90 seconds of geomagnetic storm commencement, and millions were without electricity for up to 9 hours. Dr. Alenka Brown of the Naval Postgraduate School—National Capital Region led the panel discussion with several of her colleagues.

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Mercury’s polar deposits at near-infrared wavelengths with the Mercury Laser Altimeter (MLA), and the first detailed models of the surface and near-surface temperatures of Mercury’s north polar regions that utilize the actual topography of Mercury’s surface measured by MLA. These findings were presented in three papers published online Nov. 29, 2012, in Science Express.

The idea received a boost in 1991, when the Arecibo radio telescope in Puerto Rico detected unusually radar-bright patches at Mercury’s poles, spots that reflected radio waves in the way one would expect if there were water ice. Many of these patches corresponded to the location of large impact craters mapped by the Mariner 10 spacecraft in the 1970s. But because Mariner saw less than 50 percent of the planet, planetary scientists lacked a complete diagram of the poles to compare with the images.

MESSENGER’s arrival at Mercury in 2011 changed our understanding of the Mercury surface. Images from the spacecraft’s Mercury Dual Imaging System taken during its orbital maneuvers in 2011 and 2012 confirmed that radar-bright features at Mercury’s north and south poles lie within shadowed regions on Mercury’s surface, findings that are consistent with the water-ice hypothesis.

Now the newest data from MESSENGER strongly indicate that water ice is the major constituent of Mercury’s north polar deposits, that ice is exposed at the surface in the coldest of those deposits, and that the ice is buried beneath an unusually dark material across most of the deposits, areas where temperatures are a bit too warm for ice to be stable at the surface itself.

MESSENGER uses neutron spectroscopy to measure average hydrogen concentrations within Mercury’s radar-bright regions. Water-ice concentrations are derived from the hydrogen measurements. “The neutron data indicate that Mercury’s radar-bright polar deposits contain, on average, a hydrogen-rich layer more than tens of centimeters thick beneath a surficial layer 10 to 20 centimeters thick that is less rich in hydrogen,” wrote APL’s David Lawrence, a MESSENGER Participating Scientist and the lead author of one of the papers. “The buried layer has a hydrogen content consistent with nearly pure water ice.”
In March 2012, MESSENGER completed 1 Earth-year of observations from orbit around Mercury, successfully accomplishing its primary mission and initiating an extended phase designed to build upon the results of the first year. Having met all full-mission-success criteria for the primary mission, MESSENGER is now addressing a new set of science questions, each of which has arisen only as a result of discoveries made from orbit.

Early in the extended mission, controllers at APL conducted a pair of maneuvers that changed the spacecraft’s orbital period from 12 to 8 hours, enhancing science return by offering more time close to the planet and more frequent passes through the planet’s magnetosphere. The additional time at lower altitudes amplifies the effectiveness of the high-energy spectrometers used to determine the composition of the planet’s surface and increases the number of altitude profiles that the laser altimeter will be able to make in the northern hemisphere, allowing for more detailed topographic maps. Operation at this lower altitude also enables higher-resolution imaging of Mercury’s southern hemisphere.

MESSENGER has resources that can support operations well past the end of the present extended mission, and it is capable of continuing its global characterization of Mercury as solar activity increases toward and past the next maximum in the solar cycle. The planet’s responses to the changes in its environment over that period promise to yield new surprises.

MESSENGER’s location also offers unique observation opportunities not directly related to the study of Mercury. In November 2013, comet 2P/Encke will approach within 0.025 AU (only 10 times the Earth–Moon distance) of Mercury, close enough to allow MESSENGER’s science payload to make unprecedented observations, providing composition and structural information about its nucleus, coma, and tail. The spacecraft’s proximity to the Sun also presents unique opportunities for measurements related to solar and heliospheric science. MESSENGER is the first mission to fly a neutron detector so close to the Sun, offering an unparalleled opportunity to characterize particle acceleration processes on the Sun using solar neutrons. Finally, a number of MESSENGER’s instruments are sensitive to energetic charged particles and the space plasma environment within the inner heliosphere, affording critical anchor points for multi-spacecraft observations of space-weather phenomena during the upcoming solar cycle maximum.

MESSENGER’s unprecedented orbital science campaign is providing the first global close-up of Mercury and has already revolutionized scientific perceptions of that planet. As the mission continues to uncover secrets of the innermost planet, the science teams are eager to see what new mysteries await.
RBSP Mission Renamed to Honor James Van Allen

NASA officially renamed the recently launched mission to study Earth’s radiation belts the Van Allen Probes, in honor of the late James Van Allen. The name of the mission, previously called the Radiation Belt Storm Probes (RBSP), was announced during a Nov. 9, 2012, ceremony at APL.

Van Allen was the head of the physics department at the University of Iowa and is recognized for his discovery in 1958 of radiation belts encircling Earth. During his career, Van Allen was the principal investigator for scientific investigations on 24 Earth satellites and planetary missions, beginning with the first successful American satellite, Explorer I, and continuing with Pioneer 10 and Pioneer 11. He helped develop the first plans for an International Geophysical Year, held in 1957, and is credited with discovery of a moon of Saturn in 1979, as well as radiation belts around that planet. Van Allen worked at APL both during and after World War II on some of the Laboratory’s most prominent early research projects, including the variable timing (VT) fuze that helped end the war.

The ceremony’s speakers included Dr. John Grunsfeld, astronaut and associate administrator, Science Mission Directorate, NASA Headquarters, Washington; Dr. Ralph Semmel, director, APL; Dr. Mona Kessel, RBSP program scientist, NASA Headquarters; and Rick Fitzgerald, Space Department program area manager, APL. A small plaque commemorating the renaming was presented by NASA to two of Van Allen’s daughters, who attended the event.

The Van Allen Probes (http://vanallenprobes.jhuapl.edu/) are part of NASA’s Living With a Star (LWS) program to explore aspects of the connected Sun–Earth system that directly affect life and society. LWS is managed by the agency’s Goddard Space Flight Center in Greenbelt, Md. APL built the Van Allen Probes and manages the mission for NASA.

The Pluto Science meeting will feature sessions on all aspects of the Pluto system and its context in the Kuiper Belt. A focus of the program will be to spur interdisciplinary discussion about the Pluto system as a whole, as well as the interrelated aspects of geology, geophysics, atmospheres, and origins. Invited reviews, contributed talks, and posters will form the program.

Deadlines and Agenda
15 April
Oral Abstract Deadline
31 May
Early Registration Deadline
15 June
Poster Abstract Deadline
21 July
Welcome Reception and Registration
22 July
New Horizons and Kuiper Belt Context
23 July
Atmospheres and Satellites
24 July
Atmospheres and Surfaces
25 July
Interiors and Surfaces
26 July
Origins

Visit the meeting website for more information and abstract submission details:
plutoscience.jhuapl.edu
Education and Public Outreach for the Van Allen mission reached a feverish clip this past August in preparation for launch. One of the many outreach activities was an exhibit at the Kennedy Space Center (KSC) Visitors Complex that described the basic science concepts behind the radiation belts as well as the investigations onboard the Van Allen mission. Multiple hands-on activities provided visitors with opportunities to conduct their own science experiments, using the scientific principles of the Van Allen mission to explain their observations. Van Allen mission scientists and engineers volunteered at the exhibit and answered a variety of questions from the public.

The main exhibit was located in the KSC Visitor Center IMAX Theater, with another non-manned exhibit being located at the LC-39 launch complex, which highlighted the location of the launch and the launch vehicle. This outreach activity was exceptional in its global impact; a significant percentage of KSC visitors came from Europe and Asia. Also, the launch excited many to watch from one of several vantage points in the Florida area.

APL and NASA hosted a 2-day social event for 50 social media followers at KSC. Participants had a unique, backstage experience with mission experts, engineers, and leaders and shared the experience globally through their favorite social networks. With the launch delays, the hardiest of the social participants watched the final launch attempt from the roof of the Vehicle Assembly Building.

radiation at Mercury’s surface, even in permanently shadowed areas.

This dark insulating material is a new wrinkle to the story, said Sean Solomon of the Columbia University’s Lamont-Doherty Earth Observatory, principal investigator of the MESSENGER mission. “For more than 20 years the jury has been deliberating on whether the planet closest to the Sun hosts abundant water ice in its permanently shadowed polar regions. MESSENGER has now supplied a unanimous affirmative verdict.”

“But the new observations have also raised new questions,” added Solomon. “Do the dark materials in the polar deposits consist mostly of organic compounds? What kind of chemical reactions has that material experienced? Are there any regions on or within Mercury that might have both liquid water and organic compounds? Only with the continued exploration of Mercury can we hope to make progress on these new questions.”

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Attendees were curious about what predictability is inherent in our forecasting means and the extent to which the electrical grid can be hardened. According to Dr. Brown, during table-top exercises such as Secure Grid (2011), attendees explored scenarios in which power-grid providers revealed grid vulnerabilities, and some of these vulnerabilities are being addressed as part of larger overall preventative measures. Should a geomagnetic storm occur, power-grid operators currently are able to take defensive measures to protect the grid against geomagnetically induced currents.

Other well-received topics included the radiation belt science conducted by the Van Allen Probes mission since data collection has begun. A complex relationship exists between geomagnetic storms at Earth and changes in the radiation belts. Similar solar inputs can produce different effects on the radiation belts: radiation belts can be enhanced, depressed, or essentially unchanged compared with conditions before the storm. Data from the Probes are being processed at APL and can be viewed on the science gateway website within 15 minutes.

Dr. Joseph Suter, APL’s National Security Space Business Area Executive, was very pleased with the collaboration between scientists and military personnel at the conference. “Space weather is a key research focus at APL, and this conference helps us connect civil research with our other sponsors’ operational needs. For the users, this conference is a great forum to collaborate between what science we understand and what applications are needed,” he stated.

One of the most entertaining points of the conference was the keynote banquet presentation by CAPT Kay Hire, an astronaut and U.S. Navy Reserve Officer, who most recently flew aboard STS-130 in February 2010. The STS-130 crew delivered and outfitted Node 3, also known as Tranquility, and the Cupola, a seven-windowed portal for the space station. Hire entertained the space-weather crowd with fascinating photographs taken from within the space station, giving many an opportunity to visualize how their work can affect actual operations in space.

Stay tuned to this story as Voyager continues to find its way through a truly unexplored region of the solar system. More details are available here: http://www.jhuapl.edu/newscenter/press-releases/2012/121203.asp.