Voyager 1 Reaches Interstellar Space

The Voyager 1 spacecraft officially is the first human-made object to venture into interstellar space. NASA’s 36-year-old probe is about 12 billion miles (19 billion kilometers) from our Sun.

New data indicate that Voyager 1 has been traveling for about a year through the plasma, or ionized gas, present in the space between the stars. Voyager is in a transitional region immediately outside the solar bubble, where some effects from our Sun are still evident. This data, analyzed by Don Gurnett and the plasma wave science team at the University of Iowa, Iowa City, was published in the Sept. 13, 2013, issue of Science.

“The crossing is like Voyager leaving the hot, million-degree atmosphere of the Sun and entering into a region dominated by the ‘cold,’ 5,000-degree atmosphere of the galaxy,” says APL’s Stamatios (Tom) Krimigis, principal investigator for Voyager’s Low-Energy Charged Particle (LECP) instrument. “It’s like the first time a satellite [Sputnik] went beyond Earth’s atmosphere to an altitude of some 600 miles; Voyager is now leaving the solar bubble at an altitude of 11.3 billion miles. It’s another historic milestone.”

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APL Ventures Into Interstellar Space

The LECP instrument on Voyager has now officially become APL’s first interstellar explorer, and it is now examining what is arguably the most unexplored region of our solar system. Voyager launched in 1977; now, 36 years later, is continuing to provide exciting insights into our understanding the solar system.

On Aug. 30, the Van Allen Probes celebrated the first year of their journey through Earth’s radiation belts, the harshest environment in the solar system. The mission’s two spacecraft, originally named the Radiation Belt Storm Probes (RBSP), were later renamed the Van Allen Probes in honor of Dr. James Van Allen, the discoverer of the radiation belts and a former APL researcher. The Probes have completed 1 year of orbiting the harsh radiation belt environment, where major space-weather activity occurs and many spacecraft operate. Van Allen Probes represents the first Living With a Star mission to be built and operated by the Laboratory under contract to NASA.

Solar Probe Plus, the second APL-led Living With a Star mission for NASA, remains on track for its launch in 2018. The Solar Probe Plus science instruments will survey the most abundant particles in the solar wind—electrons, protons, and helium ions—and measure their properties; image the solar wind; measure the electric and magnetic fields, radio emissions, and shock waves that course through the Sun’s atmospheric plasma; and inventory the elements in the Sun’s atmosphere. If you pass through BWI Airport, a half-sized model of the craft hangs outside the security checkpoint for C gates, in the main concourse.

The MESSENGER spacecraft, still in orbit around Mercury, has completed not only the objectives of its primary mission as of March 17, 2012, but also its 2,000th orbit of Mercury in May 2013 and its 4th Mercury solar day. In the meantime, instruments aboard the spacecraft continue to gather new data on Mercury and its environment, supplying a rich publication record in peer-reviewed journals.

New Horizons is still darting toward Pluto for its historic rendezvous on July 14, 2015. Planning for the mission’s Pluto encounter, less than 2 years away, is in high gear. This newsletter contains some highlights of the science and mission planning that has ramped up to take full advantage of the time we will have to observe Pluto.

The BRRISON payload, a balloon-borne planetary observation platform, is a rapid response to an urgent sponsor need. This mission went from a piece of paper to a full-fledged payload in 7 months.

As summer winds down, our interns start to leave us to return to school. This year we hosted several dozen through a variety of programs. The energy and enthusiasm that they bring to us makes summer a very fun time at the Lab, and this year was no exception.

Thank you for joining us on our journeys, and stay tuned to our website for more on Voyager, the Comet ISON, and all other projects.

Kurt Lindstrom
Civil Space
Mission Area Executive
Laurel Staff Are LA-Bound

Air Force Space Command Draws Local Staff to LA

Did you know?

APL currently has six field offices to support our various sponsors. Several are in proximity to the home campus in Laurel, but the Los Angeles office is the most distant.
“Now that we have new, key data, we believe this is humankind’s historic leap into interstellar space,” adds Ed Stone, Voyager project scientist based at the California Institute of Technology, Pasadena. “The Voyager team needed time to analyze those observations and make sense of them. But we can now answer the question we’ve all been asking: ‘Are we there yet?’ Yes, we are.”

Data from APL’s LECP instrument indicated that Voyager 1 detected the pressure of interstellar space on the heliosphere, the bubble of charged particles surrounding the Sun that reaches far beyond the outer planets, as early as 2004. Scientists then ramped up their search for evidence of the spacecraft’s interstellar arrival. Until mid-2010, the intensity of particles originating from inside our solar system had been holding steady. In 2011, the intensity of those energetic particles (measured by the LECP instrument) began declining, as though they were leaking into interstellar space, and the radial expansion velocity of the solar wind went to zero.

Readings over the 2012 timeframe showed that solar particles had essentially all left and galactic particle intensities increased dramatically, says Matthew Hill, an LECP team member and space physicist at APL. “I remember saying then that if we had to decide based only on our LECP observations, we would say we crossed the heliopause last summer.”

But without a plasma sensor that could regularly measure the density, temperature and speed of plasma, Voyager scientists looked to the magnetic field, which didn’t change direction at all, seemingly indicating that the intrepid probe remained in the solar magnetic field. That changed when a coronal mass ejection from the Sun allowed Voyager 1 to make measurements of its plasma environment. The eruption in March 2012 provided scientists with the data they needed. When the ejecta eventually arrived at Voyager 1’s location 13 months later, in April 2013, the plasma around the spacecraft began to vibrate like a violin string.

On April 9, 2013, Voyager 1’s plasma wave instrument detected the movement. These particular oscillations indicated the spacecraft was bathed in plasma more than 40 times denser than what they had encountered in the outer layer of the heliosphere. Density of this sort is to be expected in interstellar space. The plasma wave science team went back through its recent data and found an earlier, fainter set of oscillations in October–November 2012. Through extrapolation of measured plasma densities from both events, the team determined that Voyager 1 first entered interstellar space in August 2012. This fit with data from other instruments—including APL’s LECP—showing the spacecraft had crossed into a new region.

“We literally jumped out of our seats when we saw these oscillations in our data—they showed us that the spacecraft was in an entirely new region, comparable to what was expected in interstellar space, and totally different than in the solar bubble,” says University of Iowa’s Gurnett. “Clearly we had passed through the heliopause, which is the long-hypothesized boundary between the solar plasma and the interstellar plasma.”

The new interstellar plasma measurements led investigators to reconsider that Voyager 1 might actually have crossed the heliopause back in August 2012. By combining data from Voyager in 2010 and energetic neutral atom images of the heliosphere taken by NASA’s Cassini spacecraft, Krimigis says, the LECP team estimated the location of the heliopause as being at 121 astronomical units, very similar to the boundary measured by Voyager 1 last summer at 121.6 AU. (An AU is the distance between the Sun and Earth, about 93 million miles.)

The scant evidence of solar influence that remains in Voyager’s path just adds to the appeal of this mysterious region. “While our data have been consistent with a clear separation of solar and galactic plasmas, we are not in pristine interstellar space as long as the cosmic rays are not equally distributed around the sky,” Krimigis says. “Perhaps we may arrive in the undisturbed galactic medium in the future, but we are not there yet. That’s why Voyager observations are so exciting; we are in uncharted territory and we continue to be surprised every day.”

Indeed, the Voyager mission isn’t over. “The team’s hard work to build durable spacecraft and carefully manage the Voyager spacecraft’s limited resources paid off in another first for NASA and humanity,” says Suzanne Dodd, Voyager project manager, based at NASA’s Jet Propulsion Laboratory (JPL), Pasadena, Calif. “We can’t wait to see what the Voyager instruments show us next about deep space.”
ISON Approaches and Astronomers Prepare

As Comet ISON approaches, there will be many assets training their scopes on it. Comet lovers, astronomers, and many others are getting prepared. A Comet ISON Observer’s Workshop was held at APL in August to kick off a campaign of observation coordination in earnest.

In late November, ISON will pass within 684,000 miles of the Sun, categorizing it as a sungrazer comet. “This is an extraordinary event,” says APL’s Carey Lisse, head of NASA’s Comet ISON Observation Campaign (CIOC) and organizer of the workshop. “Comet ISON will help show us what the recipe for building the solar system was. Comets like ISON are the dinosaur bones of solar system formation.”

Comet ISON is believed to come from the distant Oort Cloud, a roughly spherical collection of comets and comet-like structures about 1 light-year away from the Sun. ISON may contain the same fundamental building blocks that led to the formation of life on Earth some 3.5 billion years ago, so scientists are keen to study it by using modern instruments and observatories located around Earth and the solar system. NASA is leading an effort to observe and study this comet, providing the use of its available resources, including currently operating spacecraft, ground-based telescopes, and the Balloon Rapid Response for Comet ISON (BRRISON) project, launching this fall.

This visit is likely ISON’s first to our solar system, which makes predictions of its travels somewhat uncertain. “It remains difficult to predict exactly how bright the comet will become in November,” says Lisse. “However, the potential exists for this to be one of the brightest comets of the past century. We encourage observers from around the world to study this fascinating comet.”

Thanks to an active outreach and social media team, many geographically dispersed astronomers, from amateur to professional, were tied in via webcast, chat, and Twitter.

ISON Tools

Workshop archive: http://www.livestream.com/cometison
BRRISON webpage: brrison.jhuapl.edu
NASA’s Comet ISON-Observing Campaign: http://www.isoncampaign.org
Twitter: @BRRISON, @CIOCISON, @SungrazerComets
APL Smallsats Seek a Larger Trade Space

With APL’s first 3U cubesat, scheduled to launch on Nov. 4 from NASA’s Wallops Flight Facility, the smallsat initiative at the Laboratory has emerged as a robust program of small satellite development and execution. Smallsat, or cubesats, have been considered “experimental” or not robust enough for operational needs. However, there is a growing demand in the user community for spacecraft that are quicker to execute and cheaper to launch. With budget pressures on virtually every government agency, smallsats have become even more appealing.

Inspired by this experience, where small teams and short development cycles provide both high autonomy and quick turnaround, APL’s engineering and science teams have joined up to propose other applications and improvements to this architecture. For technology demonstrations or small instruments, smallsats can be a viable option.

One such program was recently awarded by the In-Space Validation of Earth Science Technologies (InVEST) program at NASA. For the Radiometer Assessment using Vertically Aligned Nanotubes (RAVAN), a NASA-funded investigation, APL will build an instrument to study the Earth’s energy imbalance. The RAVAN instrument is composed of carbon nanotubes, the blackest known substance, which makes them an ideal choice to study the energy absorption of Earth’s atmosphere. By using RAVAN to measure the Earth’s energy absorption, we can gain a better understanding of how the solar input influences our climate.

A wide range of investigations can be efficiently accomplished with smallsats. The RAVAN instrument is the first APL-built flight-ready science payload. The primary objective is to perform a technology demonstration to determine whether carbon nanotubes can be flight-qualified to help us understand the Earth’s radiation budget. RAVAN may even pave the way for a smallsat constellation to monitor the solar input.

APL has also been funded under an Office of Naval Research program, NANOBridge, to improve smallsat design by improving the area available to the payload as well as making it easier to manufacture. The NANOBridge effort will improve on the Multimission Bus Demonstration (MBD) design by reducing the production time cycles as well as improving the manufacturability.

A variety of sponsors are interested in how they can use this technology and are starting to develop other applications. APL is committed to use this experience to improve the state of the art for smallsats, where they are appropriate.
Education and Public Outreach

Space Department Provides Professional Development and Classroom Resources for Teachers

During the spring and summer months, the Space Department’s Education and Public Outreach (E/PO) Office provided a variety of professional development workshops for educators aimed at increasing STEM (science, technology, engineering, and mathematics) literacy in U.S. classrooms. NASA missions and research were highlighted in these workshops, and resources were given to the teachers so they could return to their classrooms and engage their students with the exciting work that is being done at APL.

In April, the Van Allen Probes team hosted 35 pre-service teachers from the education departments of Howard University and University of Maryland Eastern Shore (UMES) as part of a partnership with Historically Black Colleges and Universities. The theme of this 1-day workshop was “NASA Science Across Disciplines.” Resources provided at the workshop included a variety of heliophysics classroom activities that could be taught in STEM as well as art and history disciplines, and included information for teaching heliophysics concepts to special needs students. Dr. Dan Smith gave an overview of the Van Allen Probes mission, and APL’s STEM Program Manager Dwight Carr gave opening remarks on the importance of connecting STEM concepts to all classroom subjects.

In June, The Unknown Moon Institute, a weeklong educator workshop sponsored by the NASA Lunar Science Institute, hosted 18 high school educators at APL and provided information about APL’s role in studying the scientific and exploration potential of the lunar poles. High school science teachers from around the country participated in hands-on activities focusing on lunar science and Earth–Moon basics, heard from Dr. Ben Bussey and his team of lunar scientists, and participated in tours that took them to the Planetary Impact Lab and Building 30 to view the BRRISON mission gondola. Daily lunch sessions with the scientists gave teachers the opportunity to ask both follow-up questions generated during hands-on activities and broader solar system exploration questions.

In July, Van Allen Probes E/PO specialists traveled to UMES to participate in an in-service educator workshop hosted by the UMES Education Department. For 1 day, Van Allen Probes and other NASA resources were highlighted to show the teachers how easy it is to access these resources and how to integrate NASA science activities into regular classroom curricula.

Teacher workshops at APL provide opportunities for collaborative input and sharing of best practices for STEM education. JHUAPL
New Horizons Team Has Eyes on Pluto

Summer wasn’t much of a vacation for the New Horizons mission team. There was usual work—tasks the team has performed annually since the APL-built spacecraft launched toward Pluto in January 2006—like onboard system and instrument checkouts and flight software updates. But a few activities offered big hints that the spacecraft’s historic July 2015 encounter with the distant, icy world is fast approaching.

From July 5 to 14, the team conducted its only planned full-blown Pluto-encounter dress rehearsal. The actual encounter commands were loaded aboard New Horizons’ computers and carried out in real time, with the spacecraft operating exactly as it will during the 9 days it flies toward and passes Pluto, and with members of the mission’s operations, science, navigation, design, and management teams all manning their stations at APL. “We accomplished everything we set out to do during the rehearsal, and then some,” says APL’s Mark Holdridge, the New Horizons mission manager. “Everything was very much as it will be in 2015, and it showed us that the close-encounter sequence and spacecraft will perform as designed.”

Later in July, planetary scientists from around the world converged on the Kossiakoff Center for a weeklong conference, organized by the New Horizons team, covering nearly every imaginable aspect of the Pluto system. Among the 103 talks, 30 poster presentations, and 13 topical sessions were many educated predictions on what New Horizons will reveal about the Pluto system. “The conference exceeded our expectations,” says New Horizons Project Scientist Hal Weaver, of APL, “with a lot of brainstorming by planetary experts about what we might see when the New Horizons spacecraft flies by Pluto in 2015.”

The team did offer its own glimpse of things to come, using New Horizons’ cameras to snap distant pictures of Pluto and its largest moon, Charon, in early July—detecting them separately for the first time. “Seeing these images...viscerally signaled to me that we’re nearing our destination and the end of the long, 3-billion-plus-mile cruise we set out on back in January 2006,” says Alan Stern, New Horizons principal investigator from the Southwest Research Institute in Boulder, Colo.

New Horizons has cruised more than 2 billion miles from home, where it’s currently racing to Pluto at nearly 1 million miles a day. Follow along at pluto.jhuapl.edu.