At the solar system's edge, more surprises from Voyager

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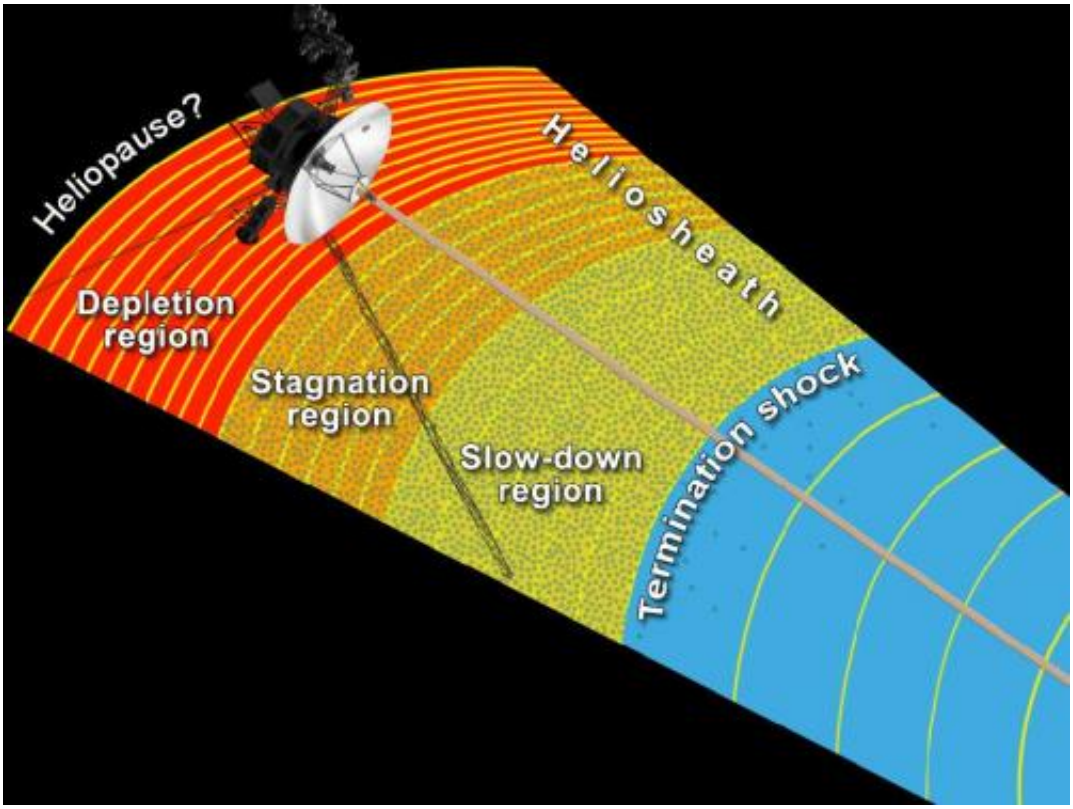
Artist's concept of NASA's Voyager spacecraft. Credit: NASA/JPL-Caltech

(Phys.org) —Data from NASA's Voyager 1 spacecraft continues to provide new insight on the outskirts of our solar system, a frontier thought to be the last that Voyager will cross before becoming the first man-made object to reach interstellar space.

In papers published this week in the journal *Science*, scientists from the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Md., and other Voyager partner institutions provide more clarity on the region they named the "magnetic highway" in December 2012. Cruising

through what scientists describe as a curious, unexpected charged-particle environment, Voyager has detected, for the first time, low-energy galactic cosmic rays, now that particles of the same energy from inside the bubble around our Sun disappeared. As a result, Voyager now sees the highest level so far of particles from outside our solar bubble that originate from the death of other nearby stars.

"Voyager 1 may be months or years from leaving the solar system—we just don't know," says APL's Stamatios Krimigis, principal investigator for Voyager's Low-Energy Charged Particle (LECP) instrument. "But the wait itself is incredibly exciting, since Voyager continues to defy predictions and change the way we think about this mysterious and wonderful gateway region to the galaxy."



This artist's concept shows NASA's Voyager 1 spacecraft exploring a region called the "depletion region" or "magnetic highway" at the outer limits of our

heliosphere, the bubble the sun blows around itself. In this region, the magnetic field lines generated by our sun (yellow arcs) are piling up and intensifying and low-energy charged particles that are accelerated in the heliosphere's turbulent outer later (green dots) have disappeared. Scientists think the depletion region is the last region Voyager 1 has to cross before reaching interstellar space, which is the space between stars, Voyager 1 passed a shockwave known as the termination shock in 2004, where solar wind suddenly slowed down and became turbulent. In 2010, it then passed into an area called the "stagnation region" where the outward velocity of the solar wind slowed to zero and sporadically reversed direction. In the slow-down and stagnation regions, the prevalence of low-energy charged particles from our heliosphere jumped dramatically and is indicated by the green dots. On Aug. 25, 2012. Voyager 1 entered the depletion or magnetic highway region, where the magnetic field acts as a kind of "magnetic highway" allowing energetic ions from inside the heliosphere to escape out, and cosmic rays from interstellar space zoom in. Magnetic field lines form a spiral around the solar system because of the rotation of the sun, and at the edge of the heliosphere they form roughly parallel arcs. Because an interstellar wind outside is pushing back on the heliosphere, magnetic field lines pile up as the solar wind slows, like cars back up at a freeway off-ramp. The compression of field lines increases the strength of the magnetic field as Voyager approaches interstellar space. Since scientists don't know the exact location of the heliopause - which is the border to interstellar space - that area has been labeled with a question mark. Image credit: NASA/JPL-Caltech

Voyager 1 and 2 were launched in 1977 and between them visited Jupiter, Saturn, Uranus and Neptune. Since 1990, the twin spacecraft have been on their Interstellar Mission, on track to leave the heliosphere, which is the bubble of magnetic field and charged particles the Sun blows around itself. On Aug. 25, 2012, when Voyager 1 was about 11 billion miles (18 billion kilometers) from the Sun, the spacecraft reached the so-called magnetic highway where charged particles from inside the heliosphere zoomed out along the magnetic field as cosmic rays from far outside zoomed in. The lack of a detectable change in the direction of

that magnetic field, however, convinced scientists that Voyager remained within the Sun's influence.

The new Science papers focus on observations from the summer and fall of 2012 by LECP as well as Voyager 1's Cosmic Ray and Magnetometer instruments, with additional LECP data through April 2013.

"The most dramatic part was how quickly the solar-originating particles disappeared; they decreased in intensity by more than 1,000 times, as if there was a huge vacuum pump at the entrance ramp onto the magnetic highway," says Krimigis. "We have never witnessed such a decrease before, except when Voyager 1 exited the giant magnetosphere of Jupiter, some 34 years ago."

"Surprisingly, the traveling direction of the 'inside' charged particles in this region made a difference, with those moving straightest along the magnetic field lines decreasing most quickly. Those that moved perpendicular to the magnetic field did not change as quickly," adds LECP Co-investigator Robert Decker, also of APL. The cosmic rays from outside, moving along the field lines, were somewhat more intense than those moving perpendicular to the field, and this imbalance varied significantly with time during the eight months since "It is this time-varying behavior of the cosmic rays that tells us that we're still in a region controlled by our Sun," says APL's Edmond Roelof, also an LECP co-investigator.

The multidimensional measurements speak to the unique abilities of the LECP detector, designed at APL in the 1970s. It includes a stepper motor that rotates the instrument through 45-degree steps every 192 seconds, allowing it to gather data in all directions and pick up something as dynamic as the solar wind and galactic particles. The device, designed and tested to work for 500,000 steps and last four

years, has been working for nearly 36 years and well past 6 million steps.

Voyager 1 is 11.6 billion miles (18.6 billion kilometers) from the Sun, poised to become Earth's first robotic ambassador to the space between the stars. At 9.4 billion miles (15.1 billion kilometers), Voyager 2 has seen some gradual changes in the charged particles, yet scientists do not think Voyager 2 has reached the magnetic highway.

More information: References:

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