Voyager 1 Hasn't Really Left The Solar System, But That's OK

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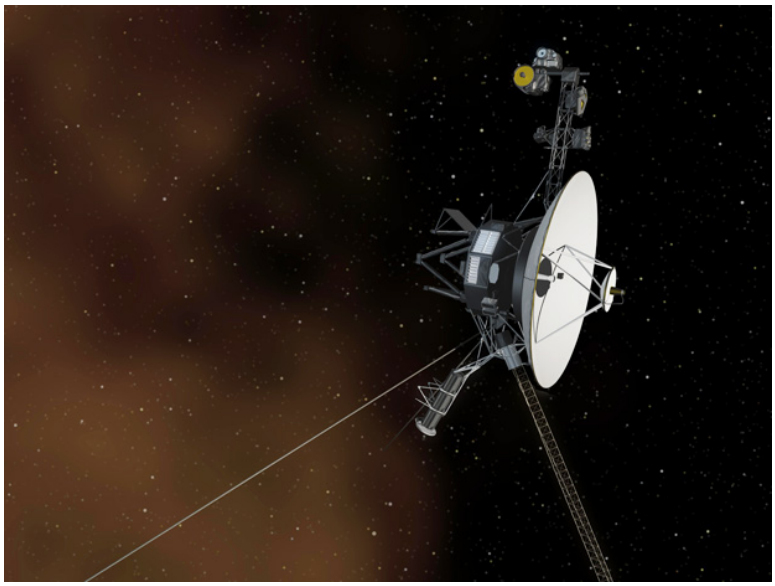
Posted 13 Sep 2013 | 19:49 GMT



In August of last year, NASA's Voyager 1 crossed over. That was the point, scientists say, when the spacecraft left the plasma-filled bubble that surrounds the sun and all the planets and entered the vast sea of high-energy particles that suffuses the galaxy. And in doing so, the spacecraft managed a singular feat: it entered interstellar space without ever leaving the solar system (http://www.jpl.nasa.gov/news/news.php?release=2013-278).

This might seem like a complete contradiction, but it comes about because we have to be careful in how we define our edges. Most astronomers peg the solar system's boundary to the outermost gravitational reach of the sun, the distance at which the strength of the sun's gravity is overcome by that of other stars. By that measure, our solar system goes out to the very outer edge of the Oort Cloud (http://www.nasa.gov/mission_pages/voyager/multimedia/pia17046.html), an enormous but sparse reservoir of icy bodies that extends out to perhaps 100 000 AU from the Sun (1 AU is the distance from the Earth to the Sun). Voyager 1 is currently just 125 AU from Earth, and is expected to take roughly 300 years to reach the inner edge of the Oort Cloud and some 30 000 years to escape it entirely.

That is the edge of the solar system, and the Voyager team, based at NASA's Jet Propulsion Laboratory, has been very careful not to claim the spacecraft has gotten anywhere near it. Various (http://www.theguardian.com/science/2013/sep/12/voyager-1-leaves-solar-system) news (http://www.nytimes.com/2013/09/13/science/in-a-breathtaking-first-nasa-craft-exits-the-solar-system.html) stories (http://www.sciencemag.org/content/341/6151/1158.full) and even this Science@NASA post (http://science.nasa.gov/science-news/science-at-nasa/2013/12sep_voyager1/) have not observed the same convention.

This isn't the first time that Voyager 1 has left the solar system this year. You might remember a flurry of news stories in March, when a press release from the American Geophysical Union (http://http://www.nytimes.com/2013/03/21/science/space/nasas-voyager-1-not-yet-out-of-the-solar-system.html?ref=science&_r=0) (AGU), on a paper set to be published in *Geophysical Research Letters (http://onlinelibrary.wiley.com/doi/10.1002/grl.50383/abstract)*, carried a headline that touted that new data showed the spacecraft had left the solar system.

The press release was amended just a few hours later. But the claim turned out to be a bit prescient, at least if you conflate "solar system" with "interstellar space". The paper in question, authored by two astronomers outside the mission, looked at data collected by the spacecraft's Cosmic Ray Subsystem (http://voyager.jpl.nasa.gov/spacecraft/instruments_crs.html), which showed a "sudden and unprecedented" jump in the intensity of galactic cosmic rays passing through Voyager 1 on August 25, 2012. The paper's lead author, Bill Webber, an emeritus astronomy professor at New Mexico State University in Las Cruces, said the data was an indication that the spacecraft had exited the heliosphere, where charged particles from the sun dominate, and entered a new region of space, which Webber called the "heliocliff".

Webber did not claim the probe had yet made it to interstellar space. But in response to the AGU press release and its "solar system" headline, Voyager project scientist, Edward Stone, issued a demurral (http://www.nasa.gov/centers/jpl/news/voyager20130320.html), arguing that the spacecraft had only entered a region called the "magnetic highway" and that, the "last critical indicator" that Voyager 1 had reached interstellar space – a change in the direction magnetic field – had still not been observed.

Indeed that crucial piece of data has *still* not been observed. The detector capable of directly measuring a jump in plasma density failed just a few years after Voyager 1's 1977 launch. To compensate, Voyager scientists hoped to use magnetic field direction as a proxy for the source of the plasma. Inside the heliosphere, as Glenn Fleishman wrote (http://www.economist.com/blogs/babbage/2013/03/economist-explains-voyager-left-solar-system) in *The Economist*, the magnetic field lines should keep an east-west orientation. Outside, they should switch to a north-south orientation.

The heliosphere boundary hasn't played along. The magnetic field hasn't changed. But, as other researchers report in *Science* (http://www.sciencemag.org/content/early/2013/09/11/science.1241681.abstract) this week, the plasma environment has. Using a plasma wave detector on the spacecraft capable of picking up oscillations when the plasma is hit by a burst of solar energy, a team has been able to infer plasma density. Backing out from data collected from events in April this year and October last year, the team came to the same conclusion as Webber's paper did: the spacecraft seemed to have exited the heliosphere on 25 August 2012. "Plasma trumped magnetic field in this case," Donald Gurnett, principal investigator of the plasma wave detector, told *Science* reporter Richard Kerr (http://www.sciencemag.org/content/341/6151/1158.full).

Stone, who is not an author on the paper, concurs with the findings. But not everyone does. Kerr's story, which is behind a paywall, says there are still researchers who say the boundary to interstellar space has not been crossed. One says that "the jump in plasma density is merely the solar wind piling up just inside the heliopause", the edge of the heliosphere. "The unchanging direction of the magnetic field is still a puzzle", Stone told *Nature News* (http://www.nature.com/news/voyager-1-has-reached-interstellar-space-1.13735), adding that it might be just a chance alignment between the magnetic fields inside and outside of the heliosphere.

Given all of this, perhaps it's just best to say that Voyager 1 is somewhere new. With enough power to last until 2025 or so, we may still have some time to settle the question.

(Image: JPL-Caltech/NASA)