Surprises from the Edge of the Solar System

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An artist's concept of Voyager 1.

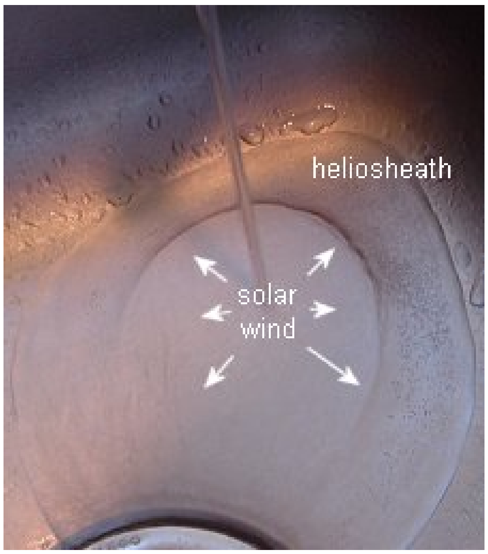
Almost every day, the great antennas of NASA's Deep Space Network turn to a blank patch of sky in the constellation Ophiuchus. Pointing at nothing, or so it seems, they invariably pick up a signal, faint but full of intelligence. The source is beyond Neptune, beyond Pluto, on the verge of the stars themselves.

It's Voyager 1. The spacecraft left Earth in 1977 on a mission to visit Jupiter and Saturn. Almost 30 years later, with the gas giants long ago seen and done, Voyager 1 is still going and encountering some strange things.

"We've entered a totally new region of space," says Ed Stone, Voyager project scientist and the former director of JPL. "And the spacecraft is beaming back surprising new information."

Before we reveal the surprises, let us discuss exactly where Voyager 1 is:

Our entire solar system—planets and all—sits inside a gargantuan bubble of gas about four times wider than the orbit of Neptune. The sun is responsible. It blows the bubble by means of the solar wind. Astronomers call the bubble itself "the heliosphere" and its outer membrane "the heliosheath."



A simulated heliosheath in your kitchen sink. Image credit: Tony Phillips.

Voyager 1 is about 10 billion miles from Earth, inside the heliosheath.

"You can simulate the heliosheath in your kitchen sink," says Stone. "Turn on the faucet so that a thin stream of water pours into the sink. Look down into the basin. Where the stream hits bottom, that's the sun. From there, water flows outward in a thin, perfectly radial sheet. That's the solar wind. As the water (or solar wind) expands, it gets thinner and thinner, and it can't push as hard. Abruptly, a sluggish, turbulent ring forms. That ring is the heliosheath."

"The heliosheath is important to humans," continues Stone. "It helps protect us from galactic cosmic rays." Galactic cosmic rays are subatomic particles accelerated to nearly light speed by supernovas and black holes. Astronauts out in space are exposed to the particles—and that's not a good thing. Cosmic rays can penetrate flesh and damage DNA. Fortunately, the heliosheath deflects many cosmic rays before they ever reach the inner solar system. "Magnetic turbulence in the heliosheath scatters the particles harmlessly away."

Note: We have many shields against cosmic rays from the thin walls of spaceships to massive planetary atmospheres. But the heliosheath is our first line of defense, and that makes it special.

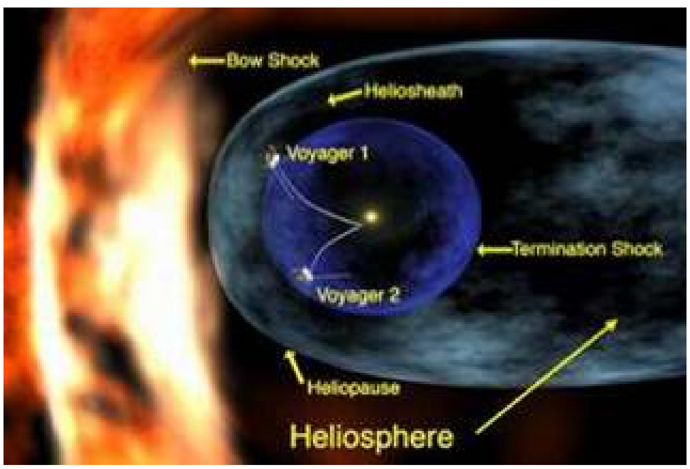
Because of its role as Solar System Protector, "we need to learn as much as we can about the heliosheath," says Stone. "Voyager 1 is giving us our first look inside."

And now for the surprises:

Magnetic Potholes: Every now and then, Voyager 1 sails through a "magnetic pothole" where the magnetic field of the heliosheath almost vanishes, dropping from a typical value of 0.1 nanoTesla (nT) to 0.01 nT or less. There are also "magnetic speed bumps" where the field strength jumps to twice normal, from 0.1 nT to 0.2 nT. These speed bumps and potholes are an unexpected form of turbulence. What role do they play in scattering cosmic rays? "This is under investigation," says Stone.

Sluggish solar wind: The solar wind in the heliosheath is slower than anyone expected. "The solar wind is supposed to slow down out there, just as the water in your sink slowed down to make the 'sluggish ring,'" says Stone, "but not this slow." Before Voyager 1 arrived, computer models predicted a wind speed of 200,000 to 300,000 mph. Voyager 1 measured only about 34,000 mph. "This means our computer models need to be refined."

Anomalous Cosmic Rays: "This one takes a little explaining," he says. "While the heliosheath protects us from deep-space cosmic rays, at the same time it is busy producing some cosmic rays of its own. A shock wave at the inner boundary of the heliosheath imparts energy to subatomic particles which zip, cosmic-ray-like, into the inner solar system. "We call them 'anomalous cosmic rays.' They're not as dangerous as galactic cosmic rays because they are not so energetic."



Researchers expected Voyager 1 to encounter the greatest number of anomalous cosmic rays at the inner boundary of the heliosheath "because that's where we thought anomalous cosmic rays were produced." Surprise: Voyager crossed the boundary in August 2005 and there was no spike in cosmic rays. Only now, 300 million miles later, is the intensity beginning to grow.

"This is really puzzling," says Stone. "Where are these anomalous cosmic rays coming from?"

Voyager 1 may find the source--and who knows what else?--as it continues its journey. The heliosheath is 3 to 4 billion miles in thickness, and Voyager 1 will be inside it for another 10 years or so. That's a lot of new territory to explore and plenty of time for more surprises.

Source: Science@NASA, by Dr. Tony Phillips