John Richardson and John Belcher on Voyager 1's crossing and interstellar exploration

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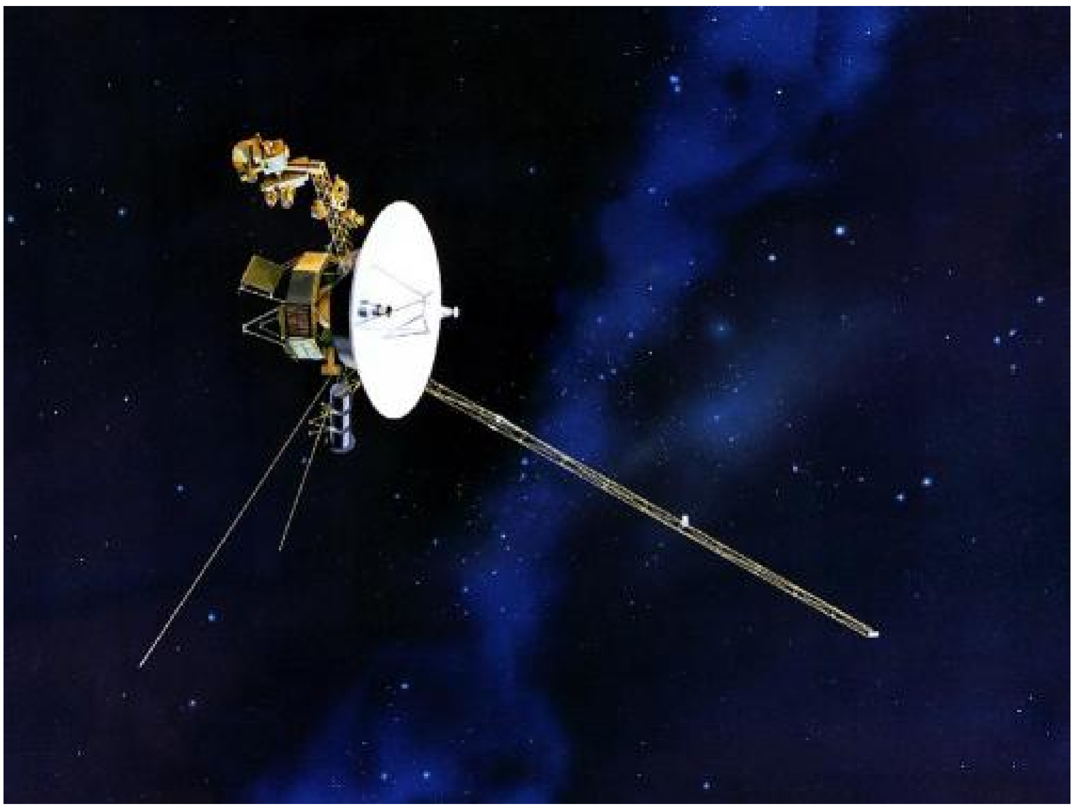

Illustration of the Voyager spacecraft. Credit: NASA

On Sept. 12, scientists announced that NASA's Voyager 1 spacecraft had gone where no man or machine has gone before: beyond the solar system, and into interstellar space. According to data from the probe, Voyager 1 likely broke through the heliosphere—the bubble of charged particles given off by the sun—in August 2012. Its twin, Voyager 2, is not far behind; scientists estimate that it, too, will cross into interstellar space in the near future.

Both spacecraft house plasma sensors developed at MIT. MIT News spoke with MIT's John Richardson, principal investigator of the plasma science instrument and a principal research scientist at the Kavli Institute for Astrophysics and Space Research; and John Belcher, co-investigator of the Voyager mission's Plasma Science Experiment and a professor of physics, about what's in store for both probes as they explore the interstellar medium.

Q: Scientists had been looking for signs of Voyager 1's crossing into interstellar space since 2004, when the spacecraft first detected increased pressure of the interstellar medium on the heliosphere. What finally led scientists to conclude that Voyager 1 had indeed reached interstellar space?

Richardson: In August of 2012, Voyager 1 saw a sharp boundary which had many of the characteristics expected for the heliopause, the boundary of interstellar space. The energetic particles created inside the heliosphere disappeared, and the number of galactic cosmic rays, which come from interstellar space, increased. The magnetic field strength also increased. However, we initially weren't sure this was the heliopause because the magnetic field direction did not change. We did not think the sun's magnetic field and interstellar magnetic field would be in exactly the same direction.

Belcher: One characteristic of the interstellar medium is that the plasma is cold and dense compared to that in the outer heliosphere; unfortunately, the plasma instrument on Voyager 1 does not work and could not measure this plasma. The key data that convinced us Voyager 1 was in the interstellar medium were observations of plasma waves. These waves are produced only when solar disturbances reach the heliopause. When they are observed, their frequency can be used to determine the plasma density. These waves were observed twice since the heliopause crossing, and showed the plasma density was high, confirming that Voyager 1 is in the interstellar medium.

Q: Now that the probe has entered interstellar space, how different is its environment likely to be?

Richardson: The local interstellar medium plasma is colder and denser than that in the solar wind. The cosmic rays dominate the energetic particle population. Now that the heliosphere particles are gone, the lower-energy cosmic rays can be observed for the first time, which should provide clues to their acceleration mechanism.

Belcher: As Voyager 1 moves away from the heliopause, it will observe the magnetic field direction and strength in the undisturbed interstellar medium, and perhaps help explain the puzzling observation of no field-direction change at the heliopause.

Q: According to Voyager 1's data, the probe likely entered interstellar space a little over a year ago. The delay in detection was partly due to the failure of a plasma sensor developed by MIT, which would have detected the crossing immediately. There is a twin instrument currently operating onboard Voyager 2, which has yet to join Voyager 1 in the interstellar

medium. What findings do you hope to obtain from Voyager 2 that were not possible with Voyager 1?

Richardson: The MIT plasma instrument on Voyager 2 will directly measure the plasma flow, density and temperature in the solar wind, at the heliopause, and in the interstellar medium. We will make the direct measurements of the plasma flow and temperature in the interstellar medium, and make continuous density measurements. We will see if the heliopause boundary has a sharp plasma change like the energetic particles, or if the plasma changes more slowly. We will determine how the plasma changes with time in the interstellar medium, and how long the flow in the interstellar medium is affected by the heliosphere.

More information: space.mit.edu/

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