

NASA scientists announce historic leap in human exploration

Voyager 1 spacecraft enters interstellar space

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In a historic scientific and technical accomplishment, NASA astronomers operating the Voyager 1 spacecraft confirmed on September 12 that after 36 years and 19 billion kilometers, humanity's most distant object has entered interstellar space. Moreover, the findings of Voyager 1's research team show that the probe left the solar system more than a year before.

The NASA announcement coincided with the publication in the journal *Science* of a paper on the team's research and findings by Don Gurnett, physicist at the University of Iowa and Voyager 1 specialist in plasma science.

At the hour-long NASA news conference (available here on YouTube), Edward C. Stone of the California Institute of Technology, lead scientist of the Voyager project, explained, "Now that we have new, key data, we believe this is mankind's historic leap into interstellar space ... 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."

Adding some historical perspective, Stone said, "In leaving the heliosphere [the bubble of charged particles around the sun] and setting sail in the cosmic seas between the stars, Voyager has joined the other historic journeys of exploration such as the first circumnavigation of the earth [1519-1522] and the first footprint on the moon [1969]."

Determining what constitutes interstellar space is a complex question, which is why it took nearly thirteen months for the researchers to establish that the probe had passed beyond the edge of the solar system. The key element was understanding the character of the environment that Voyager 1 was traveling through, and whether the charged particles (plasma) around Voyager 1 were primarily from the Sun, or from interstellar space.

Plasma—a state of matter distinct from solids, liquids and gases that is comprised solely of charged particles at extremely high temperatures—dominates the regions between planets in the Solar System and between the stars in the galaxy. It forms an "atmosphere" around the Sun (which is itself a giant ball of plasma) called the heliosphere. Outside the heliosphere, the plasma is referred to as the interstellar medium.

To determine the boundary between the heliosphere and the interstellar medium, the NASA team estimated that the density of the plasma of the interstellar medium is one hundred times greater than that of the solar wind. Starting in December 2004, it appeared that Voyager 1 was nearing the edge of the solar system. The plasma of the heliosphere was becoming less energetic, a predicted consequence of intermingling with the interstellar medium. However, the density of the plasma is the crucial parameter that had to be determined.

Unfortunately, the instrument to measure plasma density aboard Voyager 1 failed nearly twenty-three years ago and therefore the team was unable to precisely determine the probe's environment based exclusively upon plasma density readings.

The first instrument used in an attempt to discover Voyager 1's location was the spacecraft's magnetometer. This system—made of two

instruments mounted on a boom or Astromast that extends 40 feet away from the rest of the equipment on the spacecraft—measures the strength and direction of the surrounding magnetic fields. The NASA scientists thought that crossing the solar system's outer boundary would show both an increase in the strength as well as a change in direction as the magnetic field of the interstellar space began to dominate over the field of the Sun.

In August 2012, it appeared that the probe had left the solar system because the magnetic field strength had increased significantly. However there was no corresponding field rotation, meaning that the scientists could not at that time say definitively that Voyager had left the solar system. This puzzle will likely become the subject of further investigation and exploration by Voyager 1 as it makes its way deeper into interstellar space.

Confirmation of Voyager 1's location came from the instrument supported by Gurnett and his team, which records various properties of waves traveling through plasma, including the velocity of the waves, which is directly dependent on the density. In 1983-84 and 1992-93, the team measured radio waves indicating a collision of solar material with the plasma in interstellar space. They expected that, once in the interstellar medium, they would be able to see this signal directly. Indeed, when the latest eruption of particles from the Sun in the direction of Voyager 1 reached the spacecraft in April-May 2013, the measured velocity of the waves indicated a density 40 times higher than inside the solar system. Voyager 1 officially became an interstellar spacecraft.

One last factor delayed the data analysis. Since the electronic storage equipment on Voyager 1 is an 8-track magnetic tape recorder that is played back and transmitted to NASA once every six months, the information could not be reviewed by the astronomers for many more weeks. However, once Gurnett's team obtained the data and began their analysis, it was determined almost immediately that Voyager 1 had indeed entered the higher plasma densities associated with interstellar space and that this density was increasing over time.

The Voyager mission

The present achievement of NASA's Voyager 1 spacecraft is the latest in a long list of scientific breakthroughs by the agency dating back to the late 1960s and 1970s. The Voyager mission was officially approved in May 1972 and included the launch of twin probes: Voyager 2 on August 20 and Voyager 1 on September 5, 1977. While Voyager 1 would fly by only Jupiter (March 1979) and Saturn (November 1980), Voyager 2 exploited a rare geometric arrangement of the planets to make what came to be known as the "Grand Tour" of the outer planets, observing Jupiter (July 1979), Saturn (August 1981), Uranus (January 1986) and Neptune (August 1989).

Both Voyager probes revolutionized planetary astronomy. For the first time, a detailed scientific investigation took place on the nature of the four outer planets. To this day, Voyager 2 is the only human craft to visit Uranus and Neptune. Among the most important Voyager findings are the discovery of twenty-three moons of the gas giants, a deeper understanding of planetary rings and magnetic fields, and the existence of active volcanoes on other bodies within the solar system.

Due to budget considerations, the two identical Voyager probes were originally designed and built to last for five years, travel 10 astronomical units (about 1 billion miles) and explore just Jupiter and Saturn. Despite these financial constraints, and knowing that four-planet and interstellar space missions were entirely possible, the Voyager team pushed the project far beyond its initial goals.

The probes were equipped with instruments to conduct ten different scientific investigations and devices to take pictures in the infrared, ultraviolet and visible light, measure magnetic fields, detect plasma and record cosmic rays. The energy of each Voyager probe is maintained by a small block of slowly decaying plutonium whose emitted heat is collected and converted to electrical power to run the instruments, computers, radio and other systems on board the probes.

The 1970s technology means that each Voyager computer has 68 kilobytes of memory, the size of a small digital photograph, or about 240,000 times less than the memory on an average smartphone. Radio communications from the Voyager spacecraft to Earth, traveling at the speed of light, take 17 hours and 22 minutes. Each data burst is sent via a 22.4-watt transmitter (about the energy level of a refrigerator light bulb) to receivers at NASA's Deep Space Network.

Only five of Voyager 1's eleven original instruments are still functioning. According to Suzanne Dodd, Voyager project manager at the Jet Propulsion Laboratory, "We're always one failure away from losing the mission." It is expected that both Voyager probes will continue transmitting data from interstellar space until 2025, when the power source will be dialed down and the instruments are eventually turned off one at a time.

Exploration for all of us

At the September 12 news conference, project manager Dodd pointed out, "The people who created, built and sent Voyager on its way had an extraordinary vision. Voyager was built for scientists, but it's really for all of us." She then explained that both Voyager probes were equipped with a 12-inch gold-plated record designed by astronomer Carl Sagan.

The disk was included because the scientists knew that it was very likely that the probes would eventually travel into interstellar space. The record contains images, sounds, music, greetings (in 55 languages) and other information about the diversity of life and human culture on Earth. It is encased in a protective aluminum jacket. It includes a cartridge and needle and instructions in symbolic language imprinted on the outside that explained the origin of the spacecraft and how the record can be played back. The full contents are listed [here](#).

The scientists who created the Voyager probes and participated in the creation of the golden disks were optimistic about the possibilities that space science opened up for humanity. As Sagan explained at the time, "The spacecraft will be encountered and the record played only if there are advanced space-faring civilizations in interstellar space. But the launching of this 'bottle' into the cosmic 'ocean' says something very hopeful about life on this planet."

Naturally, the crossing of Voyager 1 into interstellar space renews our curiosity about the possibility of other beings existing within the galaxy

and encourages speculative thinking about the fate of humanity outside the solar system. But, above all, it raises important questions about the condition of life on our planet today. When we look back over the past 36 years while Voyager was traveling to the edge of the solar system we should consider the following:

- The science and technology of the space exploration missions of the 1960s and 1970s have been largely displaced by the requirements of the US military-industrial-intelligence apparatus; the unmanned space probe has been replaced by the unmanned drone and the stealth bomber.

- The microcomputer technologies of the post-war era—encouraged by NASA's drive for smaller and lighter electronic components—were commercialized in the form of the PC industry, the World Wide Web and the mobile technologies markets and spawned monopolistic enterprises such as Microsoft, Verizon, Apple, Google and Facebook; the computer and telecom industries have increasingly collaborated with the intelligence-gathering operations of illegal government surveillance and spying on the population.

- The idea of seeking a greater good from scientific investigation and the exploration of the unknown has been undermined; profiteering, personal enrichment, parasitism and financial speculation have become the dominant impulse behind research and development in biology, chemistry, physics and space exploration.

- During the 36 years that the Voyager probes have been speeding out of the solar system, living standards and social conditions have declined dramatically for most members of the society that produced these technological marvels. The wealth of capitalism has expanded, but the conditions of life for working people have grown worse.

- The mainstream media has dropped interest in bringing to the public the importance of major scientific achievements; Voyager 1's entry into interstellar space was barely reported by the major news outlets; the historic achievement was widely presented as being of interest only to specialists and enthusiasts, not as something of importance to everyone.

It is hard to comprehend that the space age started just fifty-five years ago and in that short time humanity's robotic envoys have entered interstellar space. The accomplishment highlights the immense contradiction between the potential of scientific discovery and technological innovation embodied in the productive forces of society and the primitive nature of the organizational forms and class structure of global capitalist society.



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