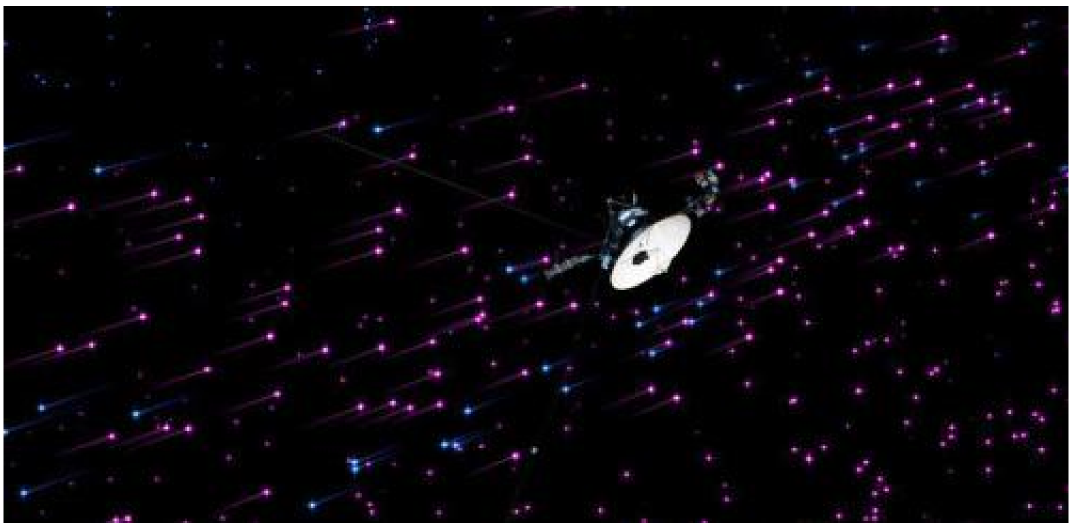
Voyager 1 is leaving the solar system, but the journey continues

December 14 2012, by Kevin Orrman-Rossiter



Voyager 1 has come across an unexpected region of the solar system – a “magnetic superhighway”. Credit: NASA

At 18.5 billion kilometres from Earth, the Voyager 1 space probe is the most distant human-made object ever to leave our planet.

And now the spacecraft, which was launched in September 1977, has discovered a new region at the edge of our solar system.

Voyager 1 is now entering what space scientists think is the final region of the "heliosphere" – the bubble of charged particles the sun blows around itself – before it reaches interstellar space.

For a spacecraft that's now in the darkest reaches of the solar system, it's easy to forget its mission is really all about the sun.

On Earth, we are at the mercy of solar flares, coronal mass ejections, and the vast amounts of electromagnetic energy and particles those phenomena fling our way. We can't see these particles, but they can take out power grids and exposed satellites.

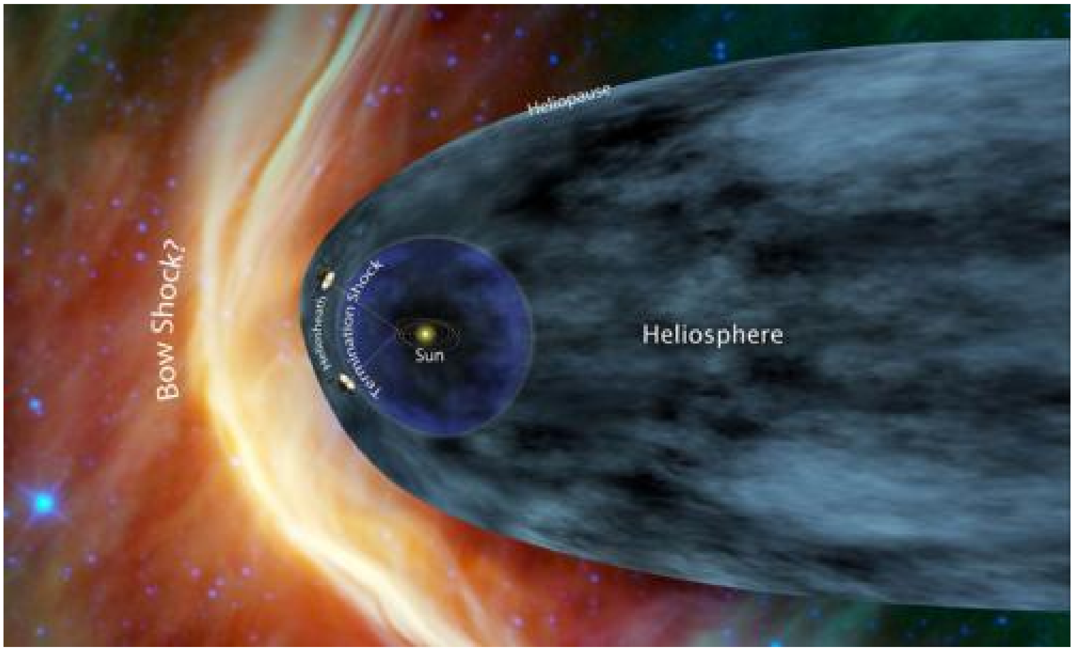
There are several missions close to the sun, including NASA's Solar Dynamics Observatory, which is studying the dynamics of the sun, 36,000km from Earth. Questions of interest include: where does the sun's energy come from? And how is it stored and released in the sun's atmosphere?

Voyager 1 is at the other end of the solar system, where the solar wind starts to meet with particles and magnetic fields from outside the solar system. And it seems that the interaction is more complex than we could have predicted.

Interstellar turbulence

Since December 2004 Voyager 1 has been travelling in the "heliosheath" where the solar wind has slowed from supersonic speeds and become turbulent.

From August 2012 Voyager 1 has entered a region where these solar winds have sped up and where high-energy particles from outside the solar system are also entering the heliosphere.



Voyager 1 and 2 are now in the "Heliosheath" – the outermost layer of the heliosphere where the solar wind is slowed by the pressure of interstellar gas. Credit: NASA

According to Edward Stone, Voyager project scientist:

"Voyager 1 still is inside the the sun's environment, we can now taste what it is like on the outside because the particles are zipping in and out on this magnetic highway."

It's an intense magnetic region that was not expected from models and will take some time to understand and interpret.

This discovery is remarkable in itself – more remarkable in that it was reported by an instrument designed in the early 1970s.

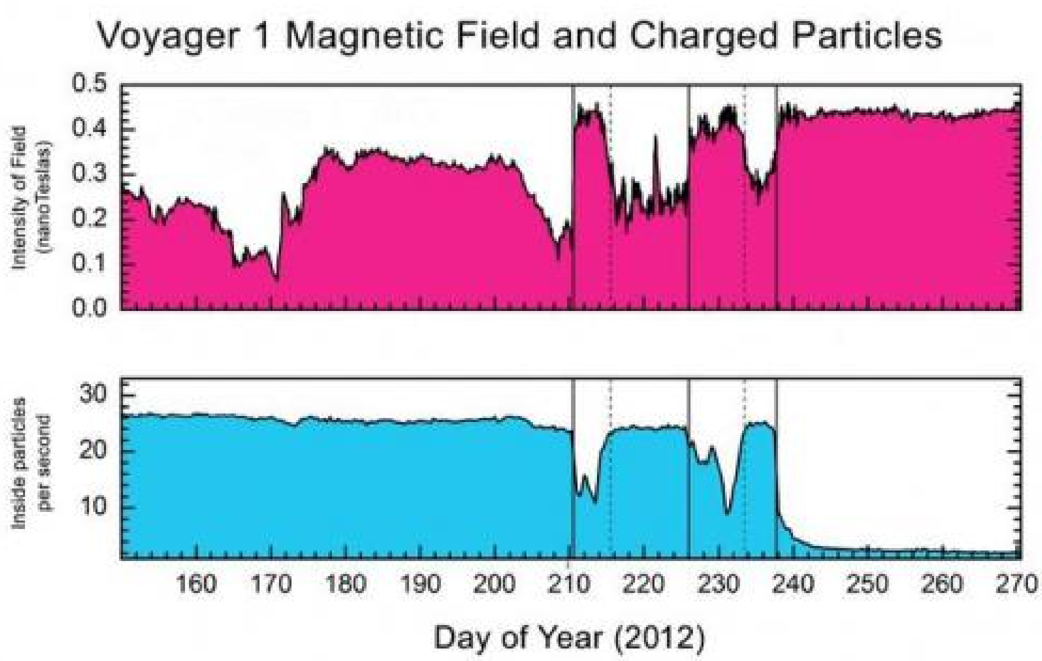
Old-time tech

Data from Voyager 1's ten instruments, including three cameras, are stored on a 500 megabit (62.5MB) tape recorder.

That is sufficient capacity to store about 100 images or a few graphs worth of data at a time, before it is beamed to Earth as a stream of binary data, with a theoretical upper rate of 14.4 kilobits per second, a rate far slower than a dial-up modem of 56 kilobits per second.

Both Voyager spacecraft – you might remember that Voyager 1 has a twin, Voyager 2 – have three computers. One decodes commands from Earth and issues them to the other two, one handles data from the instruments, and one manages the spacecraft.

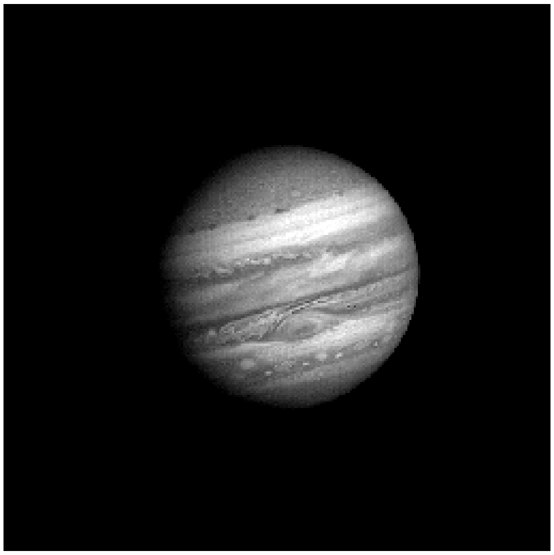
The computers have a tiny amount of memory, with memories ranging from 4 to 8KB, barely enough to run a modern car's trip computer.



This graphic, made from data from Voyager 1, tracks the behaviour of the sun's magnetic field and a population of charged particles as the spacecraft moved in and out of a new region scientists are calling the "magnetic freeway ". The top graphic (magenta) shows the intensity of the magnetic field. The intensity jumped each time Voyager 1 entered the new region. These data come from Voyager's magnetometer. The bottom graphic (blue) shows the prevalence of lower-energy charged particles that originate from inside our heliosphere, which is the bubble of charged particles around our sun. These data come from the cosmic ray instrument. Each time Voyager 1 entered the new region, the population of these inside particles dropped. After Aug. 25, the magnetic field intensity has held steady at the same elevated level and the population of inside particles hit an all-time low and has not changed. Scientists refer to this new region as a "magnetic highway " because here the sun's magnetic field lines are connected to the interstellar magnetic field lines. This connection allows particles from inside the heliosphere to zip away. It also allows particles from interstellar space to zoom in. Credit: NASA/JPL-Caltech/GSFC/University of Delaware

It's not about the destination …

On its journey to the extremities of the sun's influence, Voyager 1 revealed Jupiter's rings and moons to us in May 1979. It flew by Saturn, snapping photos of the planet's rings and the mysterious hazy atmosphere of Saturn's moon Titan.



This time-lapse video records Voyager 1's approach to Jupiter during a period of more than 60 Jupiter days. Credit: NASA

Then it left the ecliptic – the plane in which most of the planets orbit the sun – heading "up", out of the solar system.

During 1998 Voyager 1 overtook the slower Pioneer 10 and 11 crafts – which were launched to investigate Jupiter and more – becoming the furthest human artefact from Earth. It's a record that's likely to stand for some time, given Voyager 1 is travelling at some 520 million kilometres a year.

Its twin, Voyager 2, was actually launched before Voyager 1, on August 20, 1977. Its interplanetary grand tour took it past Jupiter in July 1979, Saturn in August 1981, Uranus in June 1986 and Neptune in August 1989. Now travelling at a mere 470 million kilometres every year it is heading out of the solar system, below the ecliptic plane.

Both Voyagers took advantage of a planetary alignment that only occurs once every 170 years. Their trajectories enabled the Voyagers to receive a gravity-assisted boost to their speed and direction. Without this, the trip to Neptune would have take 30 rather than ten years and they would be far short of their current positions.

The hazy atmosphere of Saturn's moon Titan, as seen by Voyager 1 on November 12, 1980. Credit: NASA

Echoes in space

Currently, our sense of the interstellar boundary comes from the merest whisper. Voyager 1 outputs 23W of radio power – barely even a glow by light-bulb standards. We hear this whisper on Earth at the limit of NASA's Deep Space Network, requiring the pooled resources of two antennae at whichever site is in contact, at a ghostly 6x10-18 W – an almost unimaginably small signal.

This remarkable spacecraft represents the extent of our physical senses in the solar system. From the surface of the Earth, our astronomers can remotely sense faraway galaxies and observe intergalactic events far into the distance and deep in time.

But closer to home, there's so much we don't know. And opportunities to continue our exploration outside the bubble are limited.

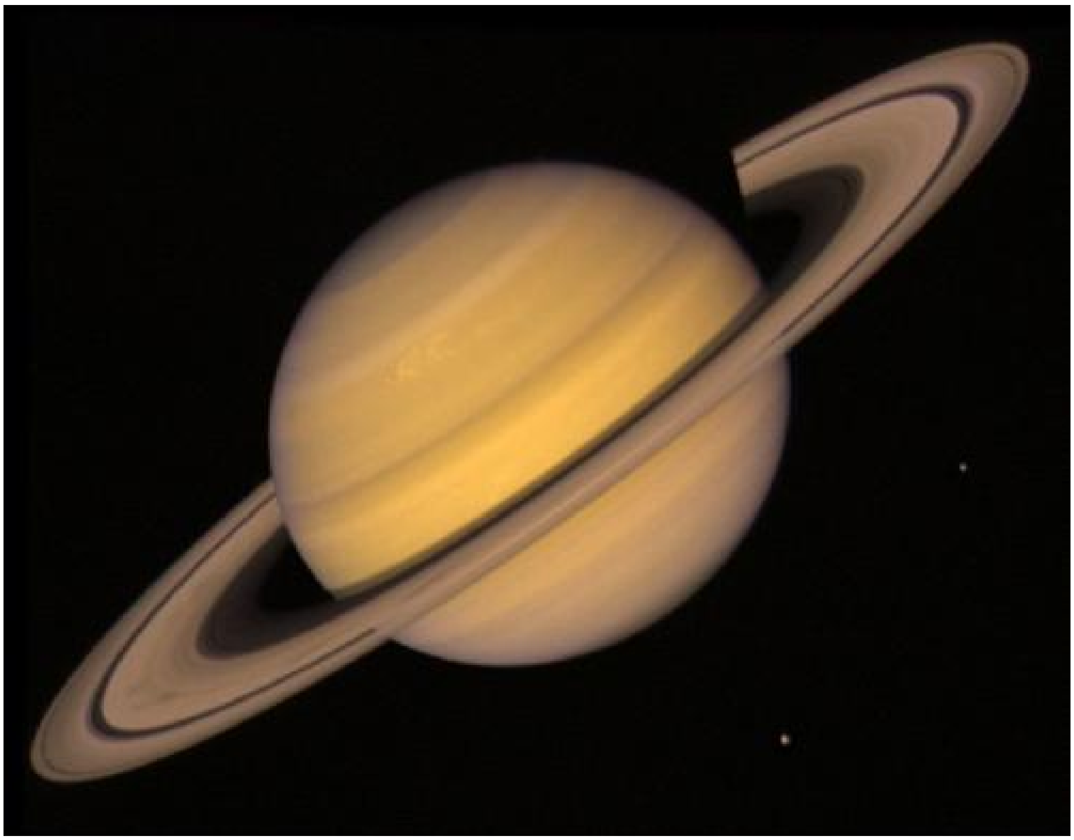


Image of Saturn taken by Voyager 2. Credit: NASA

Powering down

Voyager 1 has only five functioning instruments left from its original ten. As the power in its plutonium-238 batteries runs down towards 2050, the instruments will be turned off one by one, much like house lights winking out in the night.

Voyager 1's whisper will at last fall silent and the same fate awaits Voyager 2.

How will we feel when we can no longer "see" beyond the enigmatic borders of the sun's influence? How will we feel when the solar system appears to contract around us?

Of course, even when the two Voyagers stop communicating with Earth, their journey will continue apace, pushing beyond the confines of our solar system into the unfathomable vastness beyond.

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