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Where did I park my spacecraft?

July 5 2012, by Anni Aarinen

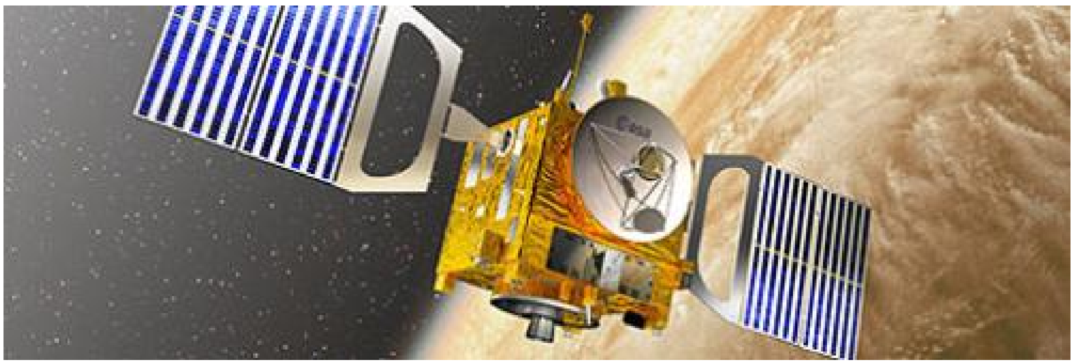

Image: ESA

Researchers have developed a method to determine the location of a spacecraft within one hundred metres, even if the spacecraft is several hundred million kilometres from Earth. In addition to spacecraft-spotting, the same technique can be applied to study the atmosphere of our neighbouring planets or the structure of the planet's interior using radio telescopes. Thus, for example, researchers have discovered water in some of Saturn's moons and have searched for thunderstorms in Mars.

While working on his dissertation, Guifré Molera Calvés wanted to make good use of the state-of-the-art infrastructure available at Metsähovi Radio Observatory. He exploited radio telescopes and VLBI-processing hardware to study a broad variety of space phenomena. During this work, he developed a unique method for processing the data captured by VLBI radio telescopes for radio spectroscopy purposes.

Researchers at Metsähovi, in collaboration with the JIVE Institute in the Netherlands, developed a new method for determining the position and speed of a spacecraft with extreme precision, comparable to GPS accuracy. The researchers can figure out the exact location where a space probe has parked itself on a planet's orbit. To determine this, they only need the signal transmitted by the spacecraft itself and a natural cosmic source, such as a star or a planet, as a reference.

"When tracking the Venus Express satellite with the help of 10 antennas, we managed to estimate its location with the precision of a few hundred metres. And this is for an object that is 200 million kilometres away from the Earth!" Molera enthuses.

The precision of the result is on a scale of about one to a billion. Finding a needle in a haystack is easy in comparison.

Space agencies benefit from the precise determination of the spacecraft's location and speed in the most critical operations in a planetary mission: the approach and insertion into the orbit around the planet, the descent through the atmosphere, and finally the landing.

Another novel approach for this method is the study of the composition of a planet's interior and its gravitational field.

"The rotation of a planet and the orbit of the spacecraft depend on whether the planet's core is solid with hard rock or filled with liquid magma. We could make the analogy with how an egg spins depending whether it's cooked or still raw", Molera explains

Every object, including the planets and moons in our Solar System, emits a unique spectral signature at several radio frequencies. The spectral signature depends on the molecular composition of the object. The radio telescopes can capture these microwave signals for radio spectroscopy purposes. In his dissertation, Molera developed a unique method for processing this data.

Using his method, several events in the atmosphere of our neighbouring planets can be determined, based on telescope observations of the signal.

In 2009, the researchers in Metsähovi discovered signs of water on several of Saturn's moons. In the data captured by the telescope, they noticed strong spectral lines caused by the combination of water molecules in a gaseous state, which resulted in a strong water plume in the rings of Saturn. This phenomenon is known as water maser emission.

Molera also attempted to detect electrical discharges in the atmosphere of Mars. Strong tidal winds in the atmosphere cause so-called dust-devil storms, which can last for several weeks and raise an enormous amount of sand from the planet's surface. These particles may collide and rub each other until they create electrical storms or lightning. Unfortunately, the researchers were not able to confirm that their observations were indeed lightning because the observations did not coincide with strong thunderstorms.

"It is fascinating that Earth antennas can be used to determine the composition of the planetary atmospheres or to search for events such as electrical storms on a planet that are millions of kilometres away!" Molera rejoices.

Provided by Aalto University

Citation: Where did I park my spacecraft? (2012, July 5) retrieved 24 May 2024 from https://phys.org/news/2012-07-spacecraft.html