Study helps unravel mysteries of the venusian atmosphere (w/ Video)

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Venus. Photo courtesy of NASA

(Phys.org) —Underscoring the vast differences between Earth and its neighbor Venus, new research shows a glimpse of giant holes in the electrically charged layer of the Venusian atmosphere, called the ionosphere. The observations point to a more complicated magnetic environment than previously thought – which in turn helps us better understand this neighboring, rocky planet.

Planet Venus, with its thick atmosphere made of carbon dioxide, its parched surface, and pressures so high that landers are crushed within a few hours, offers scientists a chance to study a planet very foreign to our own. These mysterious holes provide additional clues to understanding Venus's atmosphere, how the planet interacts with the constant onslaught of solar wind from the sun, and perhaps even what's lurking deep in its core.

"This work all started with a mystery from 1978," said Glyn Collinson, a space scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, who is first author of a paper on this work in the *Journal of Geophysical Research*. "When Pioneer Venus Orbiter moved into orbit around Venus, it noticed something very, very weird – a hole in the planet's ionosphere. It was a region where the density just dropped out, and no one has seen another one of these things for 30 years."

Until now.

Collinson set out to search for signatures of these holes in data from the European Space Agency's Venus Express. Venus Express, launched in 2006, is currently in a 24-hour orbit around the poles of Venus. This orbit places it in much higher altitudes than that of the Pioneer Venus Orbiter, so Collinson wasn't sure whether he'd spot any markers of these mysterious holes. But even at those heights the same holes were spotted, thus showing that the holes extended much further into the atmosphere than had been previously known.

The observations also suggested the holes are more common than realized. Pioneer Venus Orbiter only saw the holes at a time of great solar activity, known as solar maximum. The Venus Express data, however, shows the holes can form during solar minimum as well.

Interpreting what is happening in Venus's ionosphere requires understanding how Venus interacts with its environment in space. This environment is dominated by a stream of electrons and protons – a charged, heated gas called plasma—which zoom out from the sun. As this solar wind travels it carries along embedded magnetic fields, which can affect charged particles and other magnetic fields they encounter along the way. Earth is largely protected from this radiation by its own strong magnetic field, but Venus has no such protection.

What Venus does have, however, is an ionosphere, a layer of the atmosphere filled with charged particles. The Venusian ionosphere is bombarded on the sun-side of the planet by the solar wind. Consequently, the ionosphere, like air flowing past a golf ball in flight, is shaped to be a thin boundary in front of the planet and to extend into a long comet-like tail behind. As the solar wind plows into the ionosphere, it piles up like a big plasma traffic jam, creating a thin magnetosphere around Venus – a much smaller magnetic environment than the one around Earth.

Venus Express is equipped to measure this slight magnetic field. As it flew through the ionospheric holes it recorded a jump in the field strength, while also spotting very cold particles flowing in and out of the holes, though at a much lower density than generally seen in the ionosphere. The Venus Express observations suggest that instead of two holes behind Venus, there are in fact two long, fat cylinders of lower density material stretching from the planet's surface to way out in space. Collinson said that some magnetic structure probably causes the charged particles to be squeezed out of these areas, like toothpaste squeezed out of a tube.

The next question is what magnetic structure can create this effect? Imagine Venus standing in the middle of the constant solar wind like a lighthouse erected in the water just off shore. Magnetic field lines from the sun move toward Venus like waves of water approaching the lighthouse. The far sides of these lines then wrap around the planet leading to two long straight magnetic field lines trailing out directly behind Venus. These lines could create the magnetic forces to squeeze the plasma out of the holes.

But such a scenario would place the bottom of these tubes on the sides of the planet, not as if they were coming straight up out of the surface. What could cause magnetic fields to go directly in and out of the planet? Without additional data, it's hard to know for sure, but Collinson's team devised two possible models that can match these observations.

In one scenario, the magnetic fields do not stop at the edge of the ionosphere to wrap around the outside of the planet, but instead continue further.

"We think some of these field lines can sink right through the ionosphere, cutting through it like cheese wire," said Collinson. "The ionosphere can conduct electricity, which makes it basically transparent to the field lines. The lines go right through down to the planet's surface and some ways into the planet."

In this scenario, the magnetic field travels unhindered directly into the upper layers of Venus. Eventually, the magnetic field hits Venus' rocky mantle – assuming, of course, that the inside of Venus is like the inside of Earth. A reasonable assumption given that the two planets are the same mass, size and density, but by no means a proven fact.

A similar phenomenon does happen on the moon, said Collinson. The moon is mostly made up of mantle and has little to no atmosphere. The magnetic field lines from the sun go through the moon's mantle and then hit what is thought to be an iron core.

In the second scenario, the magnetic fields from the solar system do drape themselves around the ionosphere, but they collide with a pile up of plasma already at the back of the planet. As the two sets of charged material jostle for place, it causes the required magnetic squeeze in the perfect spot.

Either way, areas of increased magnetism would stream out on either side of the tail, pointing directly in and out of the sides of the planet. Those areas of increased magnetic force could be what squeezes out the plasma and creates these long ionospheric holes.

Scientists will continue to explore just what causes these holes. Confirming one theory or the other will, in turn, help us understand this planet, so similar and yet so different from our own.

Provided by NASA's Goddard Space Flight Center