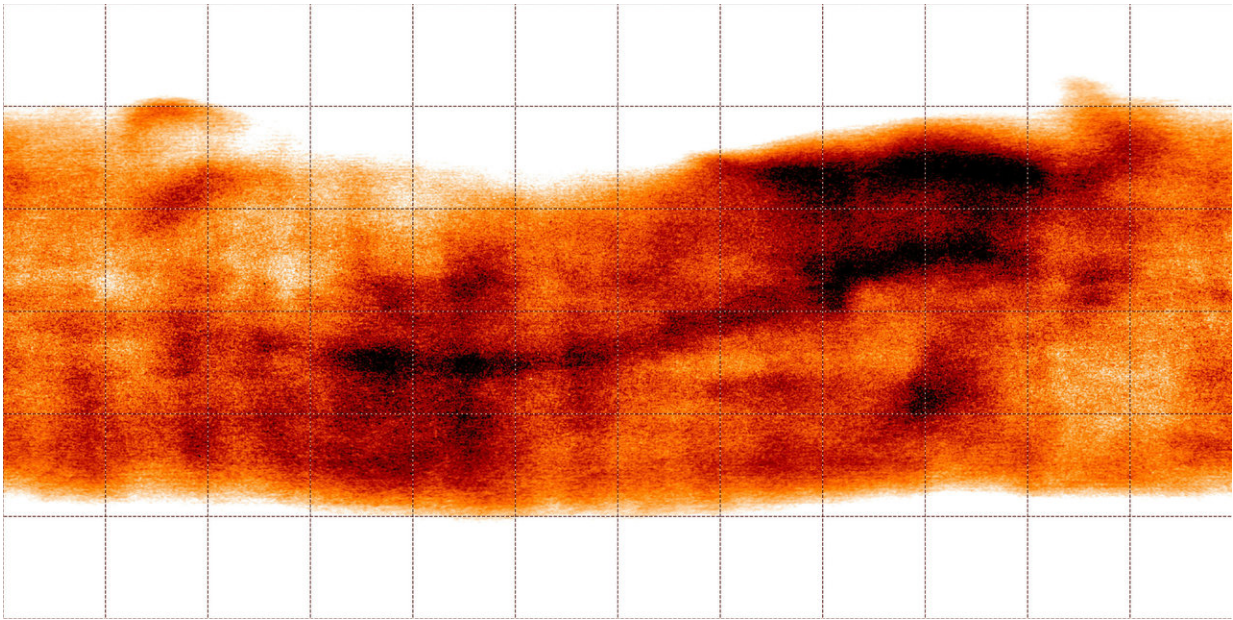


'Ribbon' wraps up mystery of Jupiter's magnetic equator

July 23 2018



This image is a map of the infrared brightness of H_3^+ ions at the top of Jupiter's atmosphere reveals just how complex the ionosphere is. The two white regions at the top and bottom are the planet's brilliant aurora. Glowing vastly brighter than the rest of the planet, they are here so saturated that no details can be seen at all. Instead, the equatorial region can be seen. In the top left of the map, the previously observed darkening associated with the Great Cold Spot can be seen -- the map now shows that this dark feature is only one of many within the ionosphere. The dark ribbon that undulates around the horizontal center of the image, wrapping around the planet from left to right, reveals the location of Jupiter's magnetic equator. To the right of the image, above and below the dark ribbon, there are two very dark regions, a larger one in the north and a small circle in the south. We are not completely sure what these features are, but when

the Juno spacecraft measured the magnetic fields in these regions, they were shown to be highly anomalous -- perhaps these regions are similar to the Southern Atlantic magnetic anomaly on Earth. Credit: University of Leicester

The discovery of a dark ribbon of weak hydrogen ion emissions that encircles Jupiter has overturned previous thinking about the giant planet's magnetic equator.

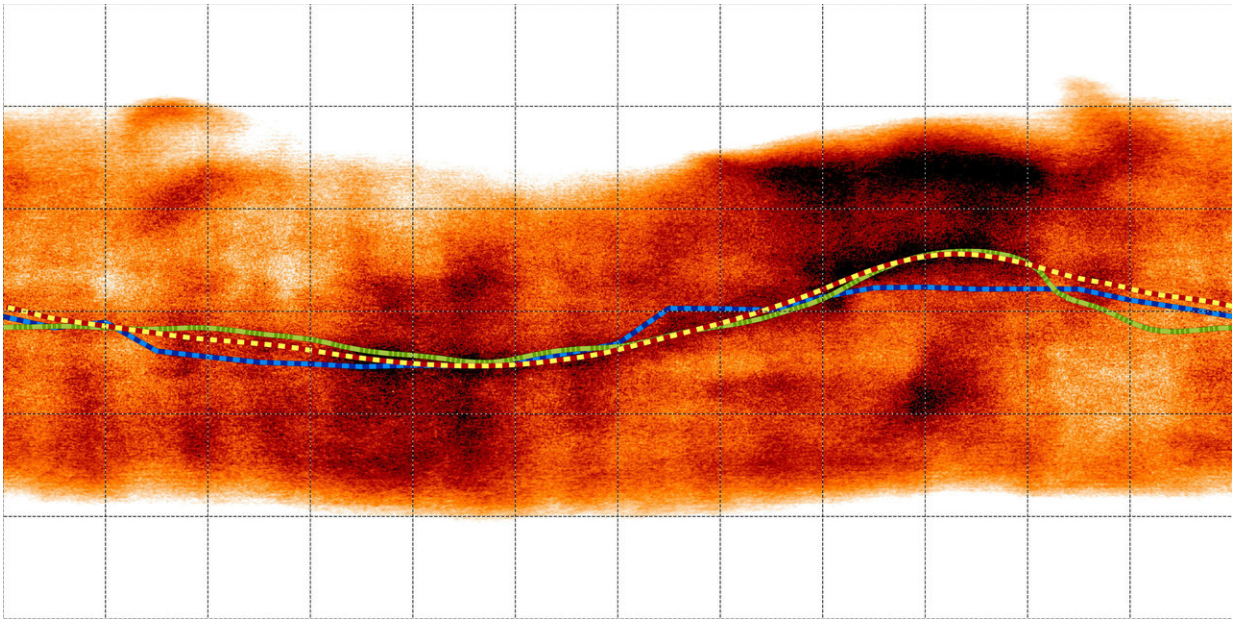
An international team of scientists led by the University of Leicester has identified the weakened [ribbon](#) of H₃⁺ emissions near the jovigraphic equator using the NSFCam instrument at the NASA InfraRed Telescope Facility, the first evidence of a localised ionospheric interaction with Jupiter's magnetic [field](#).

The study is published online by *Nature Astronomy* today (23 July).

In the past, studies of Jupiter's ionosphere have almost exclusively focused on the poles of the planet, looking at the aurorae. These observations saw most of Jupiter's ionosphere as relatively smooth and uninteresting.

This latest study has opened up the entire ionosphere for investigation and suggests that Jupiter's ionosphere is as complex as our observations are able to measure with levels of details still yet to be revealed. It also demonstrates that, despite the differences in their size and structure, both Earth and Jupiter have a similar localised ribbon that winds its way around the magnetic equator of the planet.

The ionosphere is the ionized part of Jupiter's upper atmosphere. Here, collisions between photoelectrons and H₂ are a significant source of H₃⁺ ions.



The same map of H₃⁺ brightness as in redmap.jpg. However, here, we have overlain three different measurements of Jupiter's magnetic equator. The first, in blue (with the broadest dashes), is the best past estimate of what was thought to be the equator using ultraviolet light; the second, in red and yellow (with medium dashes) is the location of the dark ribbon seen in this map; the third is the new measurement of the magnetic equator recently measured by the Juno spacecraft. This magnetic measurement shows how closely the dark ribbon follows Jupiter's magnetic equator. Credit: University of Leicester

One explanation for the dark ribbon is that because electrons preferentially travel along magnetic field lines, these photoelectrons are diverted to higher latitudes from the magnetic equator as they move to lower altitudes—leaving behind the ribbon of reduced H₃⁺ production.

Recent data from NASA's Juno spacecraft supports the theory that this ribbon is a signature for Jupiter's magnetic equator.

Lead author Dr. Tom Stallard, Associate Professor in Planetary Astronomy from the University of Leicester, said: "The first time we saw the dark ribbon winding its way around Jupiter in our data, we felt sure we were seeing something special at Jupiter. The result was so startling and yet clear, it took us all by surprise, and we strongly suspected and speculated that the feature was caused by Jupiter's magnetic equator.

"It was a great relief to us that a few months before our paper was published the first magnetic model of Jupiter was released from the Juno spacecraft, providing an unprecedented view of Jupiter's equatorial magnetic field, and the measured magnetic equator lined up almost exactly with our dark ribbon of emission.

"Our observations, along with the recent measurements by Juno spacecraft, have surprised us. Some of Jupiter's auroral regions were highly complex, and so many earlier models predicted a very complex magnetic equator to match with this, but the magnetic equator is actually shaped much more like that of Earth.

"Scientists working with Juno have suggested that this may indicate that the complex distortions in Jupiter's magnetic field may occur at relatively shallow depths in the planet. Our measurements also support that, because even though the equator is surprisingly simple, we see lots of complexity in the ionosphere between the equator and the pole. This suggests Jupiter's magnetic field in these regions is much more complex than that of Earth. It also suggests that as Juno takes higher resolution observations, it will continue to reveal even more fine scale complexity."

The scientists used 13,501 images of H₃⁺ emissions taken over 48 nights between 1995 and 2000. This helps to reveal the rate of change in Jupiter's complex mid-latitude magnetic field and provides insight into what happens deep inside Jupiter. It also suggests that the location of

Jupiter's magnetic [equator](#) has remained stable over the over the 15 years separating these two independent measurements.

The observations identified a number of other localised dark regions, including the area identified last year as the Great Cold Spot by the same team of scientists. The Great Cold Spot is also thought to be caused by the effects of the magnetic field of the planet, with its spectacular polar aurorae driving energy into the atmosphere in the form of heat flowing around the planet and creating a region of cooling in the thermosphere.

More information: Tom S. Stallard et al, Identification of Jupiter's magnetic equator through H3+ ionospheric emission, *Nature Astronomy* (2018). [DOI: 10.1038/s41550-018-0523-z](https://doi.org/10.1038/s41550-018-0523-z)

Provided by University of Leicester

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