NEWS IN FOCUS

PHYSICS Photons in light can behave like electrons in superconductors **p.438**

GENETICS Two new techniques provide precision editing of DNA and RNA **p.439**

INDIA Moon mission packs ambitious set of instruments **p.440**

GERONTOLOGY A frightful approach to fight ageing **p.448**

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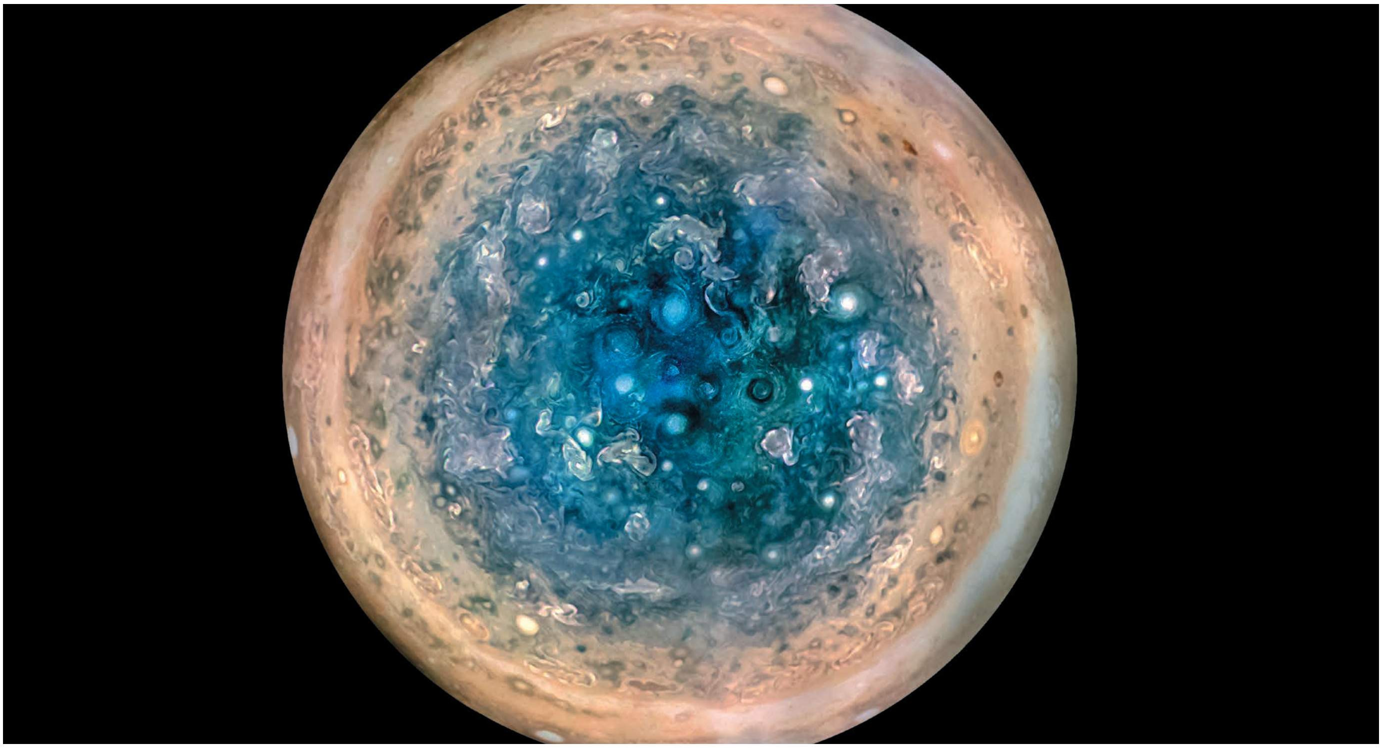


Five cyclones swirl around Jupiter's south pole.

PLANETARY SCIENCE

Jupiter's stormy winds churn deep into the planet

Juno probe discovers surprising activity in the giant planet's interior.

BY ALEXANDRA WITZE

NASA's Juno spacecraft has plumbed the depths of Jupiter, revealing that the planet's famous bands of swirling winds extend thousands of kilometres down. The work is the sharpest glimpse yet into the interior of the Solar System's largest planet.

Jupiter's colourful stripes are atmospheric patterns of winds that flow alternately east and west. Until now, researchers haven't been able to say whether those bands are confined to a shallow layer or reach deeper into the planet. "Determining this is one of the main goals of the Juno mission," said team member Yohai Kaspi, a geophysicist at the Weizmann Institute of Science in Rehovot, Israel, on 18 October at the American Astronomical Society's Division for Planetary Sciences meeting in Provo, Utah.

Juno arrived at Jupiter in July 2016 and has been looping around it once every 53 days. The mission has already revealed several mysterious phenomena, such as Jupiter's patchy magnetic field and sets of cyclones that whirl around the planet's north and south poles like dancers around a maypole.

By studying Jupiter's gravitational field, researchers can probe thousands of kilometres into the planet. On each close fly-by, Juno measures the planet's complex gravitational tug. These observations have already revealed that Jupiter has a small, 'fuzzy', poorly defined core[1].

The latest results show that Jupiter's gravitational field is askew, with different patterns in its northern and southern hemispheres, said Tristan Guillot, a planetary scientist at the Observatory of the Côte d'Azur in Nice, France. That suggests that its hydrogen-rich gas is flowing asymmetrically deep in the planet. "This ▶

is something that was not expected," Guillot said at the meeting. "We were not sure at all whether we would be able to see that."

Another clue to the structure of Jupiter's interior came from how the gravity field varies with depth. Theoretical studies predict that the bigger the gravity signal, the stronger the flow of gas deep down[2,3]. That information is important for teasing out whether all of Jupiter's interior is rotating as a single solid body, or whether different layers spin separately from one another, like a set of nesting Russian dolls moving within each other.

Juno detected a gravity signal powerful enough to indicate that material is flowing as far down as 3,000 kilometres. "We're just taking the clouds and the winds and extending them into the interior," Kaspi said. Future work could help to pinpoint how strong the flow is at various depths, which could resolve whether Jupiter's interior really resembles Russian dolls.

Juno scientists are now looking to see what else the gravity data will tell them, such as how far the famous storm called the Great Red Spot extends into the atmosphere. Another instrument aboard Juno has already hinted that the Great Red Spot's roots may reach hundreds of kilometres down, and it could go even deeper. "It's not yet clear that it is so deep it will show up in gravity data," said David Stevenson, a planetary scientist at the California Institute of Technology in Pasadena. "But we're trying."

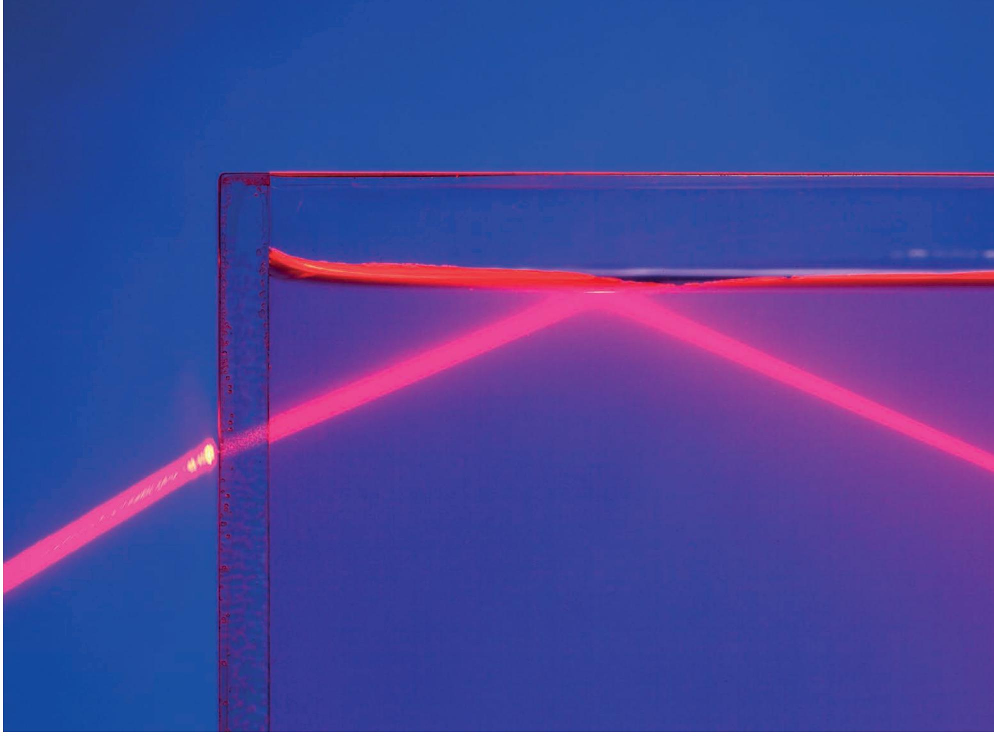
Juno has also been peering into Jupiter's depths in other ways. One big surprise was the clusters of cyclones at each pole, seen by Juno's cameras in visible and infrared wavelengths. Scientists had not spotted the storms before because Juno is the first spacecraft to fly over Jupiter's polar regions. There are eight cyclones around the north pole and five around the south. All are mysterious: computer modelling suggests that such small storms should not be stable in swirling polar winds.

The answer may lie in a quirky physics concept known as a vortex crystal, said Fachreddin Tabataba-Vakili, a planetary scientist at NASA's Jet Propulsion Laboratory in Pasadena. Such crystals have been seen in a few Earth-based phenomena such as rotating superfluids; they are born when small vortices form and persist as the material in which they are embedded continues to flow.

Something about the flow around Jupiter's poles may set up the same dynamics, Tabataba-Vakili said. Next up is to work out why there are eight cyclones at one pole and five at the other, he added.

Between Jupiter's polar cyclones and its deep interior flows, Juno continues to tease out new surprises from the Solar System's biggest planet. "It's clear that giant planets have a lot of secrets," Guillot said. ■

1. Wahl, S. M. *et al. Geophys. Res. Lett.* **44,** 4649–4659 (2017).
2. Hubbard, W. B. *Icarus* **137,** 357–359 (1999).
3. Kaspi, Y. *Geophys. Res. Lett.* **40,** 676–680 (2013).



Shining pulses of laser light through water causes some of the photons to form linked pairs.

GIPHOTOSTOCK/SPL

PHYSICS

Light can act like a superconductor

Quantum vibrations cause photons to pair up just like superconducting electrons.

BY ELIZABETH GIBNEY

Superconductivity — a phenomenon in which electrons can travel in certain materials with zero resistance — has revolutionized aspects of medicine, travel and science. Now, an intriguing experiment has seen the same behaviour that underlies superconductivity — in particles of light.

"This is really exciting work," says Nick Vamivakas, a quantum physicist at the University of Rochester, New York, who was not involved with the research. "It's a beautiful connection between light scattering, condensed-matter physics and quantum optics."

Conventional superconductivity relies on the formation of 'Cooper pairs' of electrons, which stabilize each other's path and allow electricity to flow without resistance. Its discovery led to the development of powerful superconducting magnets, which are now used in medical scanners, particle accelerators, wind turbines and magnetically levitated trains.

Physicists in Brazil have now seen evidence of photons of light forming similar pairs. The process occurs at room temperature when light passes through a range of transparent liquids, including water, although it is very difficult to observe. "Not only is this formation of pairs possible, but it is everywhere," says André Saraiva, a theoretical physicist at the Federal University of Rio de Janeiro (UFRJ) and co-author of a paper that has been accepted for publication in *Physical Review Letters*.

The team has yet to explore how far the parallel with superconductivity goes. As photons already interact less with their environment than electrons do, similar pairs in light are unlikely to lead to such dramatic effects as in electric currents. But the work has already triggered speculation about how light 'supercurrents' might behave, and how they might be used.

"Not only is this formation of pairs possible, but it is everywhere."

The discovery stems from work led by Ado Jorio at the Federal University of Minas Gerais (UFMG) in Belo Horizonte, Brazil, which investigated how light scatters within materials. When this happens, photons can lose energy to the atoms in the material, which vibrate. If a second photon immediately absorbs this packet of vibrational energy, the