Faint super-planet discovered by radio telescope

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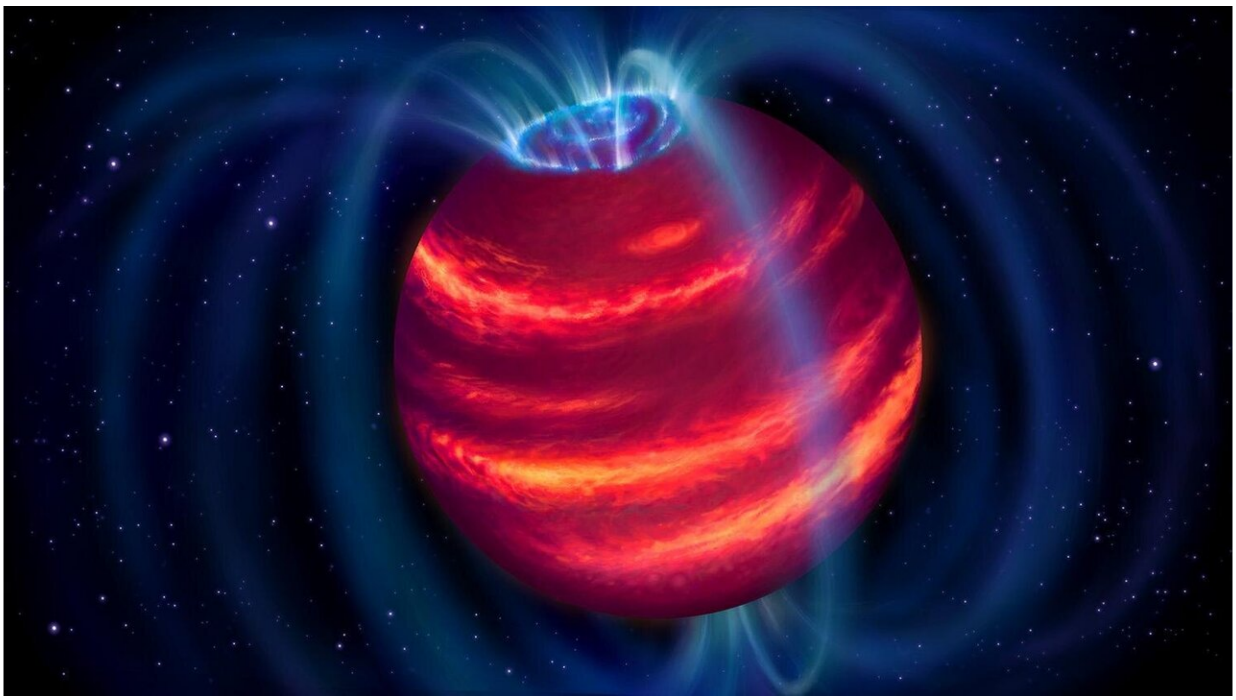

Artist's impression of the discovery dubbed, Elegast. Credit: ASTRON / Danielle Futselaar

For the first time, astronomers have used observations from a radio telescope and a pair of observatories on Maunakea to discover and characterize a cold brown dwarf, also known as a "super planet" or "failed star." The discovery, designated BDR J1750+3809, is the first substellar object detected through radio observations—until now, brown dwarfs have largely been found from infrared sky surveys.

BDR J1750+3809 (dubbed "Elegast" by the discovery team) was first identified using data from the Low-Frequency Array (LOFAR) telescope in Europe, and then confirmed using telescopes on the summit of Maunakea, namely the International Gemini Observatory and the NASA InfraRed Telescope Facility (which is operated by the University of Hawai'i). Directly discovering these objects with sensitive radio telescopes such as LOFAR is a significant breakthrough, because it demonstrates that astronomers can detect objects that are too cold and faint to be found in infrared surveys, and perhaps even detect free-floating gas-giant exoplanets.

The research is published in *The Astrophysical Journal Letters*. Astronomer Michael Liu and graduate student Zhoujian Zhang at the UH Institute for Astronomy (IfA) co-authored the paper. "This work opens a whole new method to finding the coldest objects floating in the Sun's vicinity, which would otherwise be too faint to discover with the methods used for the past 25 years," said Liu.

Brown dwarfs in a new light

Brown dwarfs straddle the boundary between the largest planets and the smallest stars. Occasionally dubbed "failed stars," brown dwarfs lack the mass to trigger hydrogen fusion in their cores, and instead glow at infrared wavelengths with leftover heat from their formation. Also dubbed "super-planets," brown dwarfs possess gaseous atmospheres that resemble the gas-giant planets in our solar system more than they resemble any star.

While brown dwarfs lack the fusion reactions that keep the Sun shining, they can emit light at radio wavelengths. The underlying process powering this radio emission is familiar, as it also occurs in the largest planet in the Solar System. Jupiter's powerful magnetic field accelerates charged particles such as electrons, which in turn produces radiation—in this case radio waves and aurorae.

The fact that brown dwarfs are radio emitters allowed the international collaboration of astronomers behind this result to develop a novel observing strategy. Radio emissions have previously been detected from only a handful of cold brown dwarfs, which were discovered and cataloged by infrared surveys before being observed with radio telescopes. The team decided to flip this strategy, using a sensitive radio telescope to discover cold, faint radio sources and then perform follow-up infrared observations with Maunakea telescopes to categorize them.

"We asked ourselves, 'Why point our radio telescope at cataloged brown dwarfs?'" said Harish Vedantham, lead author of the study and astronomer at ASTRON in the Netherlands. "Let's just make a large image of the sky and discover these objects directly in the radio."

As well as being an exciting result in its own right, the discovery of BDR J1750+3809 could provide a tantalizing glimpse into a future when astronomers can measure the properties of exoplanets' magnetic fields. Cold brown dwarfs are the closest things to exoplanets that astronomers can currently detect with radio telescopes, and this discovery could be used to test theories predicting the magnetic field strength of exoplanets. Magnetic fields are an important factor in determining the atmospheric properties and long-term evolution of exoplanets.

Technique could yield further results

Having found a variety of tell-tale radio signatures in their observations, the team had to distinguish potentially interesting sources from background galaxies. To do so, they searched for a special form of radio waves that were circularly polarized—a feature of light from stars, planets and brown dwarfs, but not from background galaxies. Having found a circularly polarized radio source, the team then turned to archive imagery, the Gemini-North Telescope, and the NASA IRTF to provide the measurements required to identify their discovery.

NASA IRTF is equipped with a sensitive spectrometer, SpeX, which has been a workhorse for studying brown dwarfs for the past 20 years, including an upgrade five years ago funded by the National Science Foundation. The team used SpeX to obtain a spectrum of BDR J1750+3809, which revealed the characteristic signature of methane in the atmosphere. Methane is the hallmark of the coolest brown dwarfs, and also abundant in the atmospheres of our solar system's gas-giant planets.

"These observations really highlight the increased efficiency of SpeX following its NSF-funded upgrade with state-of-the-art infrared arrays and electronics in 2015," said John Rayner, IRTF Director and astronomer at the UH IfA.

More information: H. K. Vedantham et al. Direct Radio Discovery of a Cold Brown Dwarf, *The Astrophysical Journal* (2020). DOI: 10.3847/2041-8213/abc256

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