

Innovative technique enables scientists to learn more about elusive exoplanet Tau Bootis b

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This artist's impression shows the exoplanet Tau Boötis b. This was one of the first exoplanets to be discovered back in 1996, and it is still one of the closest planetary systems known to date. Astronomers using ESO's Very Large Telescope have now caught and studied the faint light from the planet Tau Boötis b for the first time. By employing a clever observational trick the team find that the planet's atmosphere seems to be cooler higher up, the opposite of what was expected. Credit: ESO/L. Calçada

For the first time a new technique has allowed astronomers to study the atmosphere of an exoplanet in detail -- even though it does not pass in front of its parent star. An international team has used ESO's Very Large Telescope to directly catch the faint glow from the planet Tau Boötis b, solving a 15-year-old problem. The team also finds that the planet's atmosphere seems to be cooler higher up, differently from the expected.

The planet Tau Bootis b was one of the first exoplanets to be discovered back in 1996, and it is still one of the closest exoplanets known.

Although its parent star is easily visible with the naked eye, the planet itself certainly is not, and up to now it could only be detected by its gravitational effects on the star. Tau Bootis b is a large "hot Jupiter" planet orbiting very close to its parent star.

Like most exoplanets, this planet does not transit the disc of its star (like the recent transit of Venus). Up to now such transits were essential to allow the study of hot Jupiter atmospheres: when a planet passes in front of its star it imprints the properties of the atmosphere onto the starlight. As no starlight shines through Tau Bootis b's atmosphere towards us, this means the planet's atmosphere could not be studied before.

But now, after 15 years of attempting to study the faint glow that is emitted from hot Jupiter exoplanets, astronomers have finally succeeded in reliably probing the structure of the atmosphere of Tau Bootis b and deducing its mass accurately for the first time. The team used the CRIRES instrument on the Very Large [Telescope](#) (VLT) at ESO's Paranal Observatory in Chile. They combined high quality infrared observations (at wavelengths around 2.3 microns) with a clever new trick to tease out the weak signal of the planet from the much stronger one from the [parent star](#).

Lead author of the study Matteo Brogi (Leiden Observatory, the Netherlands) explains: "Thanks to the high quality observations provided by the VLT and CRIRES we were able to study the spectrum of the system in much more detail than has been possible before. Only about 0.01% of the light we see comes from the planet, and the rest from the star, so this was not easy".

The majority of [planets](#) around other stars were discovered by their gravitational effects on their parent stars, which limits the information

that can be gleaned about their mass: they only allow a lower limit to be calculated for a planet's mass. The new technique pioneered here is much more powerful. Seeing the planet's light directly has allowed the astronomers to measure the angle of the planet's orbit and hence work out its mass precisely. By tracing the changes in the planet's motion as it orbits its star, the team has determined reliably for the first time that Tau Bootis b orbits its host star at an angle of 44 degrees and has a mass six times that of the planet Jupiter in our own Solar System.

"The new VLT observations solve the 15-year old problem of the mass of Tau Bootis b. And the new technique also means that we can now study the atmospheres of exoplanets that don't transit their stars, as well as measuring their masses accurately, which was impossible before", says Ignas Snellen (Leiden Observatory, the Netherlands), co-author of the paper. "This is a big step forward."

As well as detecting the glow of the atmosphere and measuring Tau Bootis b's mass, the team has probed its atmosphere and measured the amount of carbon monoxide present, as well as the temperature at different altitudes by means of a comparison between the observations and theoretical models. A surprising result from this work was that the new observations indicated an [atmosphere](#) with a temperature that falls higher up. This result is the exact opposite of the temperature inversion -- an increase in temperature with height -- found for other hot Jupiter exoplanets.

The VLT observations show that high resolution spectroscopy from ground-based telescopes is a valuable tool for a detailed analysis of non-transiting exoplanets' atmospheres. The detection of different molecules in future will allow astronomers to learn more about the planet's atmospheric conditions. By making measurements along the planet's orbit, astronomers may even be able to track atmospheric changes between the planet's morning and evening.

"This study shows the enormous potential of current and future ground-based telescopes, such as the E-ELT. Maybe one day we may even find evidence for biological activity on Earth-like planets in this way", concludes Ignas Snellen.

Provided by ESO

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