VLT makes first detection of titanium oxide in an exoplanet

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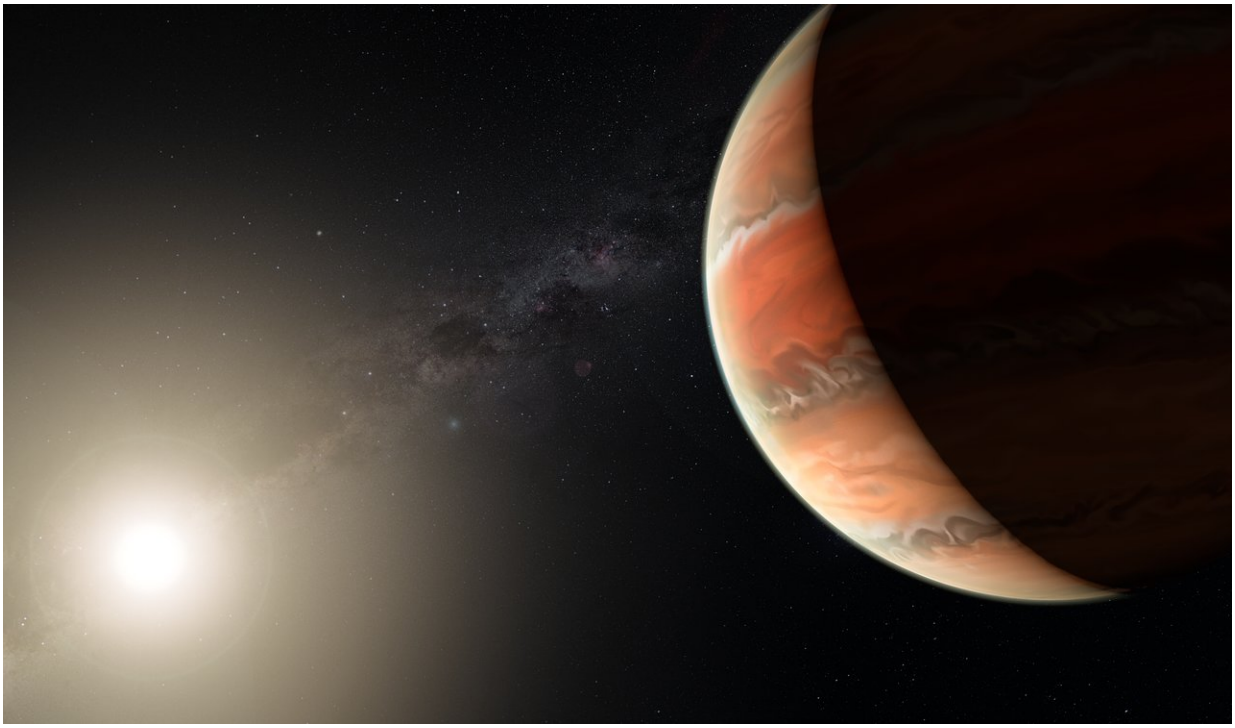

An artist's impression showing the exoplanet WASP-19b, in which atmosphere astronomers detected titanium oxide for the first time. In large enough quantities, titanium oxide can prevent heat from entering or escaping an atmosphere, leading to a thermal inversion -- the temperature is higher in the upper atmosphere and lower further down, the opposite of the normal situation. Credit: ESO/M. Kornmesser

A team of astronomers led by Elyar Sedaghati, an ESO fellow and recent

graduate of TU Berlin, has examined the atmosphere of the exoplanet [WASP-19b] in greater detail than ever before. This remarkable planet has about the same mass as Jupiter, but is so close to its parent star that it completes an orbit in just 19 hours and its atmosphere is estimated to have a temperature of about 2000 degrees Celsius.

As WASP-19b passes in front of its parent star, some of the starlight passes through the planet's atmosphere and leaves subtle fingerprints in the light that eventually reaches Earth. By using the FORS2 instrument on the Very Large Telescope the team was able to carefully analyse this light and deduce that the atmosphere contained small amounts of titanium oxide, water and traces of sodium, alongside a strongly scattering global haze.

"Detecting such molecules is, however, no simple feat," explains Elyar Sedaghati, who spent 2 years as ESO student to work on this project. "Not only do we need data of exceptional quality, but we also need to perform a sophisticated analysis. We used an algorithm that explores many millions of spectra spanning a wide range of chemical compositions, temperatures, and cloud or haze properties in order to draw our conclusions."

Titanium oxide is rarely seen on Earth. It is known to exist in the atmospheres of cool stars. In the atmospheres of hot planets like WASP-19b, it acts as a heat absorber. If present in large enough quantities, these molecules prevent heat from entering or escaping through the atmosphere, leading to a thermal inversion—the temperature is higher in the upper atmosphere and lower further down, the opposite of the normal situation. Ozone plays a similar role in Earth's atmosphere, where it causes inversion in the stratosphere.

"The presence of titanium oxide in the atmosphere of WASP-19b can have substantial effects on the atmospheric temperature structure and

circulation." explains Ryan MacDonald, another team member and an astronomer at Cambridge University, United Kingdom. "To be able to examine exoplanets at this level of detail is promising and very exciting." adds Nikku Madhusudhan from Cambridge University who oversaw the theoretical interpretation of the observations.

The astronomers collected observations of WASP-19b over a period of more than one year. By measuring the relative variations in the planet's radius at different wavelengths of light that passed through the exoplanet's atmosphere and comparing the observations to atmospheric models, they could extrapolate different properties, such as the chemical content, of the exoplanet's atmosphere.

This new information about the presence of metal oxides like titanium oxide and other substances will allow much better modeling of exoplanet atmospheres. Looking to the future, once astronomers are able to observe atmospheres of possibly habitable planets, the improved models will give them a much better idea of how to interpret those observations.

"This important discovery is the outcome of a refurbishment of the FORS2 instrument that was done exactly for this purpose," adds team member Henri Boffin, from ESO, who led the refurbishment project. "Since then, FORS2 has become the best instrument to perform this kind of study from the ground."

This research was presented in the paper entitled "Detection of titanium oxide in the atmosphere of a hot Jupiter" by Elyar Sedaghati et. al. to appear in *Nature*.

More information: Detection of titanium oxide in the atmosphere of a hot Jupiter, *Nature* (2017). nature.com/articles/doi:10.1038/nature23651

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