'Temperamental' stars may be distorting exoplanet observations

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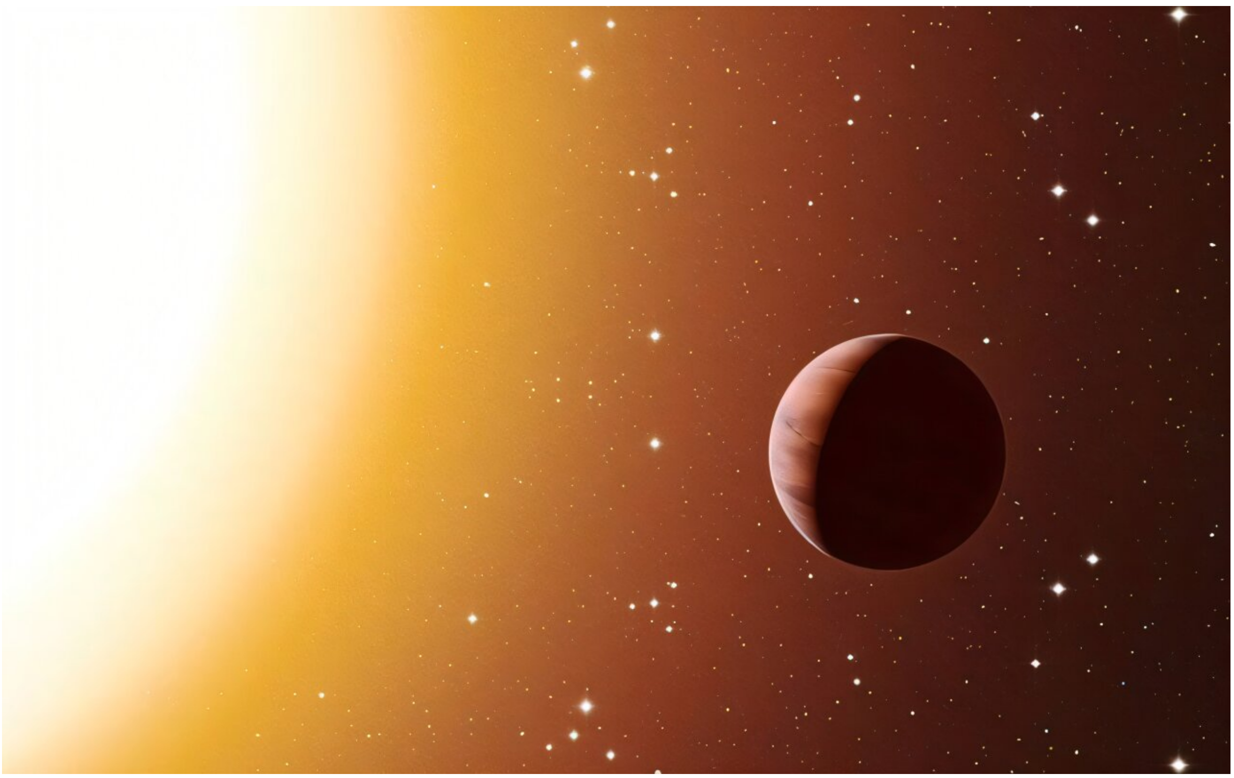

Artist's impression of a hot Jupiter planet orbiting close to one of the stars in the rich old star cluster Messier 67. Credit: ESO/L. Calçada. Source: ESO

"Temperamental" stars that brighten and dim over a matter of hours or days may be distorting our view of thousands of distant planets, suggests a new study led by UCL researchers.

Most of the information we have about planets beyond our solar system (exoplanets) comes from looking at dips in starlight as these planets pass in front of their host star.

This technique can give clues about the planet's size (by looking at how much starlight is blocked) and what its atmosphere is made of (by looking at how the planet changes the pattern of starlight that passes through it).

But a new study, published in *The Astrophysical Journal Supplement*, concluded that fluctuations in the starlight due to hotter and colder regions on a star's surface may be distorting our interpretations of planets more than we previously thought.

The researchers looked at the atmospheres of 20 Jupiter- and Neptune-sized planets and found that the host stars' changeability distorted the data for about half of them.

If researchers did not properly account for these variations, the team said, they could misinterpret a range of features such as the planets' size, temperature and the composition of their atmospheres. The team added that the risk of misinterpretation was manageable if researchers looked at a range of wavelengths of light, including in the optical region where effects of stellar contamination are most apparent.

Lead author Dr. Arianna Saba (UCL Physics & Astronomy), who did the work as part of her Ph.D. at UCL, said, "These results were a surprise—we found more stellar contamination of our data than we were expecting. This is important for us to know. By refining our understanding of how stars' variability might affect our interpretations of exoplanets, we can improve our models and make smarter use of the much bigger datasets to come from missions including James Webb, Ariel and Twinkle."

Second author Alexandra (Alex) Thompson, a current Ph.D. student at UCL Physics & Astronomy whose research focuses on exoplanet host stars, said, "We learn about exoplanets from the light of their host stars and it is sometimes hard to disentangle what is a signal from the star and what is coming from the planet.

"Some stars might be described as 'patchy'—they have a greater proportion of colder regions, which are darker, and hotter regions, which are brighter, on their surface. This is due to stronger magnetic activity.

"Hotter, brighter regions (faculae) emit more light and so, for instance, if a planet passes in front of the hottest part of the star, this might lead researchers to over-estimate how large the planet is, as it will seem to block out more of the star's light, or they might infer the planet is hotter than it is or has a denser atmosphere. The reverse is true if the planet passes in front of a cold starspot, making the planet appear 'smaller."

"On the other hand, the reduction in emitted light from a starspot could even mimic the effect of a planet passing in front of a star, leading you to think there might be a planet when there is none. This is why follow up observations are so important to confirm exoplanet detections.

"These variations from the star can also distort estimates of how much water vapor, for instance, is in a planet's atmosphere. That is because the variations can mimic or obscure the signature of water vapor in the pattern of light at different wavelengths that reaches our telescopes."

For the study, researchers used 20 years of observations from the Hubble Space Telescope, combining data from two of the telescope's instruments, the Space Telescope Imaging Spectrograph (STIS) and the Wide Field Camera 3 (WFC3).

They processed and analyzed the data for each planet in an identical way, to ensure they were comparing like with like, minimizing the biases that occur when datasets are processed using different methods.

The team then looked at which combination of atmospheric and stellar models fit their data the best, comparing models that accounted for stellar variability with simpler models that did not. They found that data for six planets out of the 20 analyzed had a better fit with models adjusted for stars' variability and six other planets may have experienced minor contamination from their host star.

They analyzed light at visible, near-infrared and near-ultraviolet wavelengths, using the fact that distortions from stellar activity are much more apparent in the near-UV and visible (optical) region than at longer wavelengths in the infrared.

The team described two ways to judge if stellar variability might be affecting planetary data.

Dr. Saba explained, "One is to look at the overall shape of the spectrum—that is, the pattern of light at different wavelengths that has passed through the planet from the star—to see if this can be explained by the planet alone or if stellar activity is needed. The other is to have two observations of the same planet in the optical region of the spectrum that are taken at different times. If these observations are very different, the likely explanation is variable stellar activity."

Alex Thompson added, "The risk of misinterpretation is manageable with the right wavelength coverage. Shorter wavelength, optical observations such as those used in this study are particularly helpful, as this is where stellar contamination effects are most apparent."

More information: Arianna Saba et al, A Population Analysis of 20 Exoplanets Observed from Optical to Near-infrared Wavelengths with

the Hubble Space Telescope: Evidence for Widespread Stellar Contamination, *The Astrophysical Journal Supplement Series* (2025).
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