Astronomers find a planet that shouldn't exist

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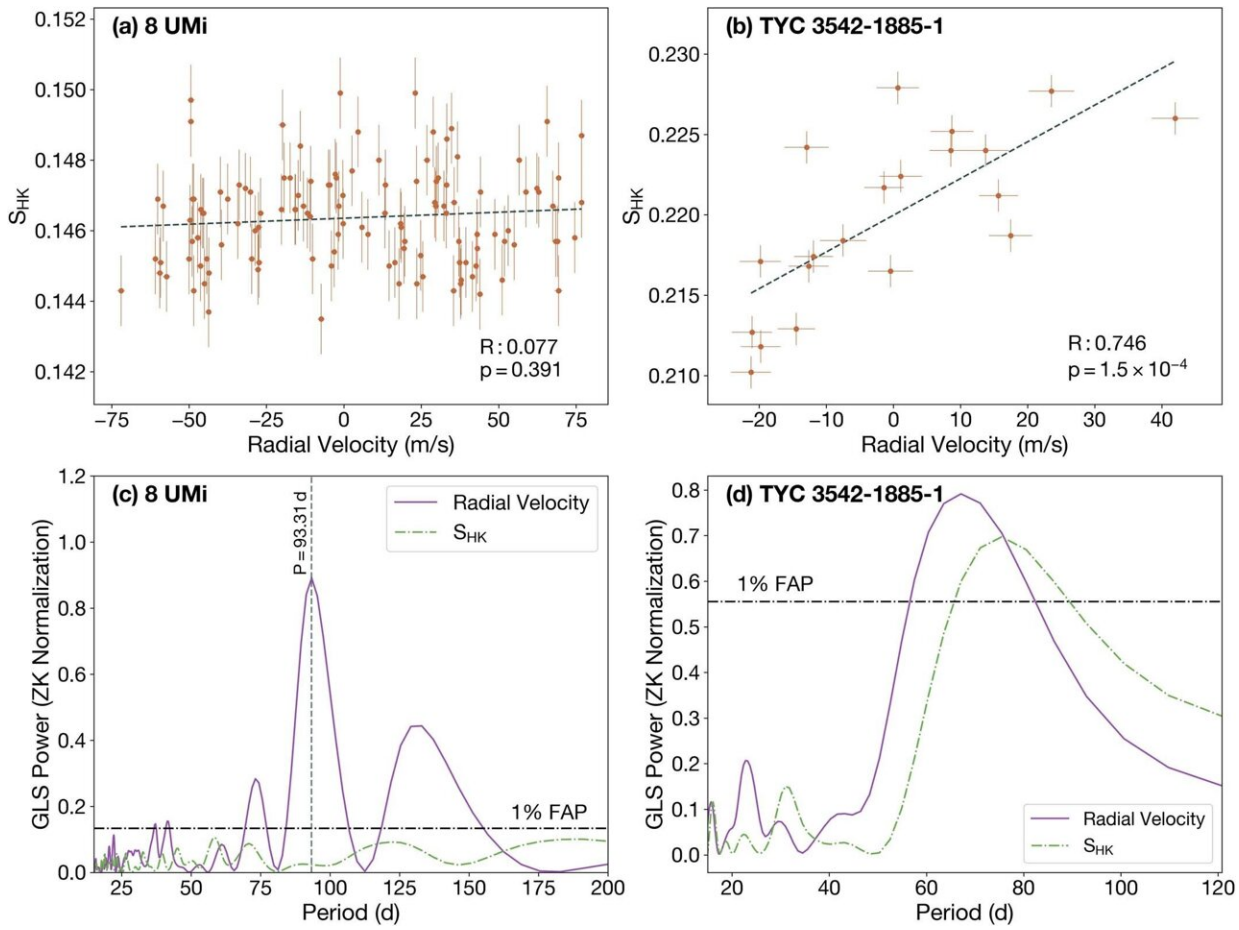

Stellar activity of the host star 8 UMi and active red giant TYC 3542-1885-1. The chromospheric activity of both stars are estimated using Ca II H and K indices (S_{HK}) computed from Keck/HIRES spectra, with error bars indicating 1σ (standard deviation) uncertainties. (a-b) Variations of S_{HK} with radial velocity from each star. Included for each are the Spearman correlation factors (R) and two-sided p-values (p) for the test whose null hypothesis is that S_{HK} and radial

velocity are uncorrelated. (c-d) Generalized Lomb Scargle (GLS) periodograms of radial velocity measurements and S_{HK}. The vertical dashed line indicates 8 UMi b's orbital period, and the horizontal lines indicate the periodogram's False Alarm Probability (FAP). Credit: *Nature* (2023). DOI: 10.1038/s41586-023-06029-0

When our sun reaches the end of its life, it will expand to 100 times its current size, enveloping the Earth. Many planets in other solar systems face a similar doom as their host stars grow old. But not all hope is lost, as astronomers from the University of Hawai'i Institute for Astronomy (UH IfA) have made the remarkable discovery of a planet's survival after what should have been certain demise at the hands of its sun.

The Jupiter-like planet 8 UMi b, officially named Halla, orbits the red giant star Baekdu (8 UMi) at only half the distance separating the Earth and the sun. Using two Maunakea Observatories on Hawai'i Island—W. M. Keck Observatory and Canada-France-Hawai'i Telescope (CFHT)—a team of astronomers led by Marc Hon, a NASA Hubble Fellow at UH IfA, has discovered that Halla persists despite the normally perilous evolution of Baekdu.

Using observations of Baekdu's stellar oscillations from NASA's Transiting Exoplanet Survey Satellite (TESS), they found that the star is burning helium in its core, signaling that it had already expanded enormously into a red giant star once before. The work is published in the journal *Nature*.

The star would have inflated up to 1.5 times the planet's orbital distance—engulfing the planet in the process—before shrinking to its current size at only one-tenth of that distance.

"Planetary engulfment has catastrophic consequences for either the planet or the star itself—or both. The fact that Halla has managed to persist in the immediate vicinity of a giant star that would have otherwise engulfed it highlights the planet as an extraordinary survivor," said Hon, the lead author of the study.

Maunakea observatories confirm the survivor

The planet Halla was discovered in 2015 by a team of astronomers from Korea using the radial velocity method, which measures the periodic movement of a star due to the gravitational tug of the orbiting planet. Following the discovery that the star must at one time have been larger than the planet's orbit, the IfA team conducted additional observations from 2021–2022 using Keck Observatory's High-Resolution Echelle Spectrometer (HIRES) and CFHT's ESPaDOnS instrument. These new data confirmed the planet's 93-day, nearly circular orbit had remained stable for over a decade and that the radial velocity changes must be due to a planet.

"Together, these observations confirmed the existence of the planet, leaving us with the compelling question of how the planet actually survived," said IfA astronomer Daniel Huber, second author of the study. "The observations from multiple telescopes on Maunakea was critical in this process."

Escaping engulfment

At a distance of 0.46 astronomical units (AU, or the Earth-sun distance) to its star, the planet Halla resembles "warm" or "hot" Jupiter-like planets that are thought to have started on larger orbits before migrating inward close to their stars. However, in the face of a rapidly evolving host star, such an origin becomes an extremely unlikely survival pathway

for planet Halla.

Another theory for the planet's survival is that it never faced the danger of engulfment. Similar to the famous planet Tatooine from Star Wars, which orbits two suns, the team believes the host star Baekdu may have originally been two stars. A merger of these two stars may have prevented any one of them from expanding sufficiently large enough to engulf the planet.

A third possibility is that Halla is a relative newborn—that the violent collision between the two stars produced a gas cloud from which the planet formed. In other words, the planet Halla may be a recently-born "second generation" planet.

"Most stars are in binary systems, but we don't yet fully grasp how planets may form around them. Therefore, it's plausible that more planets may actually exist around highly evolved stars thanks to binary interactions," explained Hon.

More information: Marc Hon, A close-in giant planet escapes engulfment by its star, *Nature* (2023). DOI: 10.1038/s41586-023-06029-0.
www.nature.com/articles/s41586-023-06029-0

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