Explained: Transiting exoplanets

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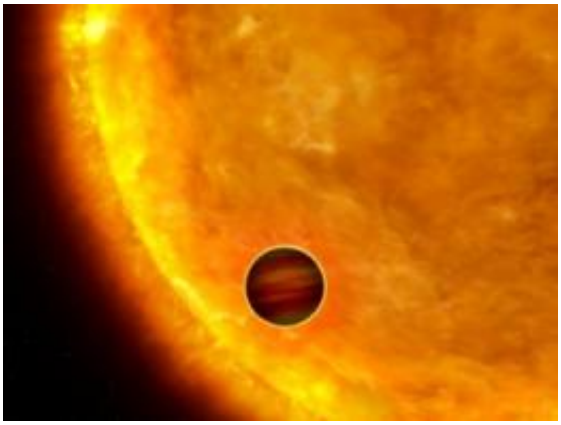

A transiting planet obscures just a tiny fraction of the light from its parent star, allowing astronomers to detect its presence. Credit: NASA/ESA/G. Bacon

In the quest to find life elsewhere in the universe, planetary scientists have detected more than 500 planets outside the solar system, or exoplanets, over the past 15 years. About one-fifth of those were discovered by scanning the sky for any change in a star's brightness that might be caused by a planet passing in front of that star as seen from Earth.

Known as a transit, this event is essentially an eclipse, but instead of blocking an entire celestial body from view, as the Moon does to the sun during a solar eclipse, a transiting planet obscures just a tiny fraction of the light from its parent star. Astronomers use ground-based telescopes to detect these tiny fractions — changes as small as 0.25 percent. Then

they try to confirm a planet's existence through careful follow-up observations.

The discovery of the first transiting exoplanet in 1999 provided a way to study exoplanets in considerable detail. By measuring the change in starlight during a transit, scientists can learn a great deal about a planet in addition to its existence, including its precise mass and the types of molecules in its atmosphere. Such details are critical for confirming whether a planet is small, rocky and cool enough for liquid water to exist on its surface although no such discovery has occurred yet.

Of the 519 exoplanets that have been discovered since 1995, 114 happen to orbit their stars at an angle that makes it possible to observe their transits from Earth. But that doesn't mean that 20 percent of all exoplanets can be seen transiting their stars from Earth, according to Joshua Winn, an assistant professor in MIT's Department of Physics and a researcher for the MIT Kavli Institute for Astrophysics and Space Research. "The reason why we know of about 100 or so is because people have tried their hardest to find them," says Winn, who has studied exoplanets for six years.

Astronomers have detected the majority of exoplanets by analyzing the spectrum of wavelengths emitted in a star's light that are caused by the Doppler shift phenomenon; any subtle change in that pattern is likely caused by the gravitational tug of a planet on the star. But this technique, known as the radial-velocity method, only provides a few details about a planet, such as its minimum mass.

Transits can reveal significantly more. By comparing the fraction of light that disappears during a transit to the total amount of light that typically emanates from a star, researchers can figure out the precise size of a planet. For example, if the starlight dims by 1 percent, this indicates that the planet is 1 percent the size of its star. Researchers estimate a star's

size by studying the overall spectrum of light produced by the star.

Astronomers hope to one day rely on transits to probe a planet's atmosphere for molecules like water and oxygen that are essential for most life as we know it. When a planet transits its star, the molecules in its atmosphere absorb some of the starlight that filters through it. Because lab experiments have determined what kinds of molecules are absorbed at different wavelengths, researchers can identify the molecules in a planet's atmosphere by analyzing changes in the wavelengths of light. So far, the only molecules that have been detected in exoplanetary atmospheres are methane, carbon dioxide and water vapor.

Despite the level of detail produced by observations of transiting exoplanets, Winn concedes there is one downside to studying transiting exoplanets. "They are intrinsically rare, so finding them is exceptionally difficult because you have to search a larger portion of the galaxy and look far away from Earth," he explains. That means studying slight changes in light from very faint stars, a task that will become increasingly difficult as researchers look for smaller exoplanets. But there is some hope for finding these planets thanks to Kepler, a NASA satellite based in space that is observing 150,000 stars with the goal of detecting slight changes in light that could be caused by transiting Earthlike planets.

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