Many small exoplanets found to be covered in gas

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During its four-year mission, NASA's Kepler space telescope discovered thousands of "planetary candidates" in our Milky Way galaxy—the vast majority of which are almost certainly actual planets. But before scientists can deduce which planets might support life, a fundamental question must be answered: what are the planets made of?

To know this, each planet's mass first must be determined. Northwestern University's Yoram Lithwick now reports having measured the masses of approximately 60 exoplanets larger than Earth and smaller than Neptune. (An exoplanet, or extrasolar planet, is a planet outside our solar system.)

The measurements greatly expand scientists' knowledge of sub-Neptune exoplanets because once the mass and size of a planet are known, the density can be determined and the composition of the planet inferred.

"We were surprised to learn that planets only a few times bigger than Earth are covered by a lot of gas," said Lithwick, an assistant professor of physics and astronomy at Northwestern's Weinberg College of Arts and Sciences.

"This indicates these planets formed very quickly after the birth of their star, while there was still a gaseous disk around the star," he said. "By contrast, Earth is thought to have formed much later, after the gas disk disappeared."

Lithwick presented his findings at a scientific session Jan. 6 at the 223rd

meeting of the American Astronomical Society (AAS) annual meeting in Washington, D.C.

To measure the masses of the planets found by Kepler, Lithwick and his graduate student Sam Hadden used a technique called transit time variation (TTV). They discovered that planets two to three times bigger than Earth have very low density, indicating they are covered in a massive amount of gas. These planets are similar to Neptune, but smaller and fluffier. In contrast, planets that are only slightly smaller than these have much higher density, and are denser than rock. They are similar to Earth or even denser.

The TTV technique used in this work requires two planets that orbit the same star, both of which also transit the star. The planets pull gravitationally on one another and thereby change the time at which each planet transits its star, relative to when it would have transited if it were orbiting the star alone. Therefore, measuring times of transit reveals the planets' masses.

An advantage of the TTV technique over the more common radial velocity (RV) technique is that it requires no extra observations, Lithwick said, beyond what has already been done by the Kepler telescope. But a disadvantage is that it depends on the interaction between planets, which is complicated, making it difficult to infer the planets' masses. As a result, until recently only a handful of sub-Neptune planets have had their masses measured. To overcome that difficulty, Lithwick and his collaborators developed a simple formula for turning observed transit times into masses. Lithwick noted that recent mass measurements with RV are confirming the trends seen with TTV, lending confidence to the conclusions reached by the two independent techniques.

More information: The AAS presentation is based on a paper titled

"Densities and Eccentricities of 163 Kepler Planets from Transit Time Variations" to be published in the *Astrophysical Journal*. Lithwick and Hadden are authors of the paper.

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