Finding Earthlike planets in other solar systems by looking for moons

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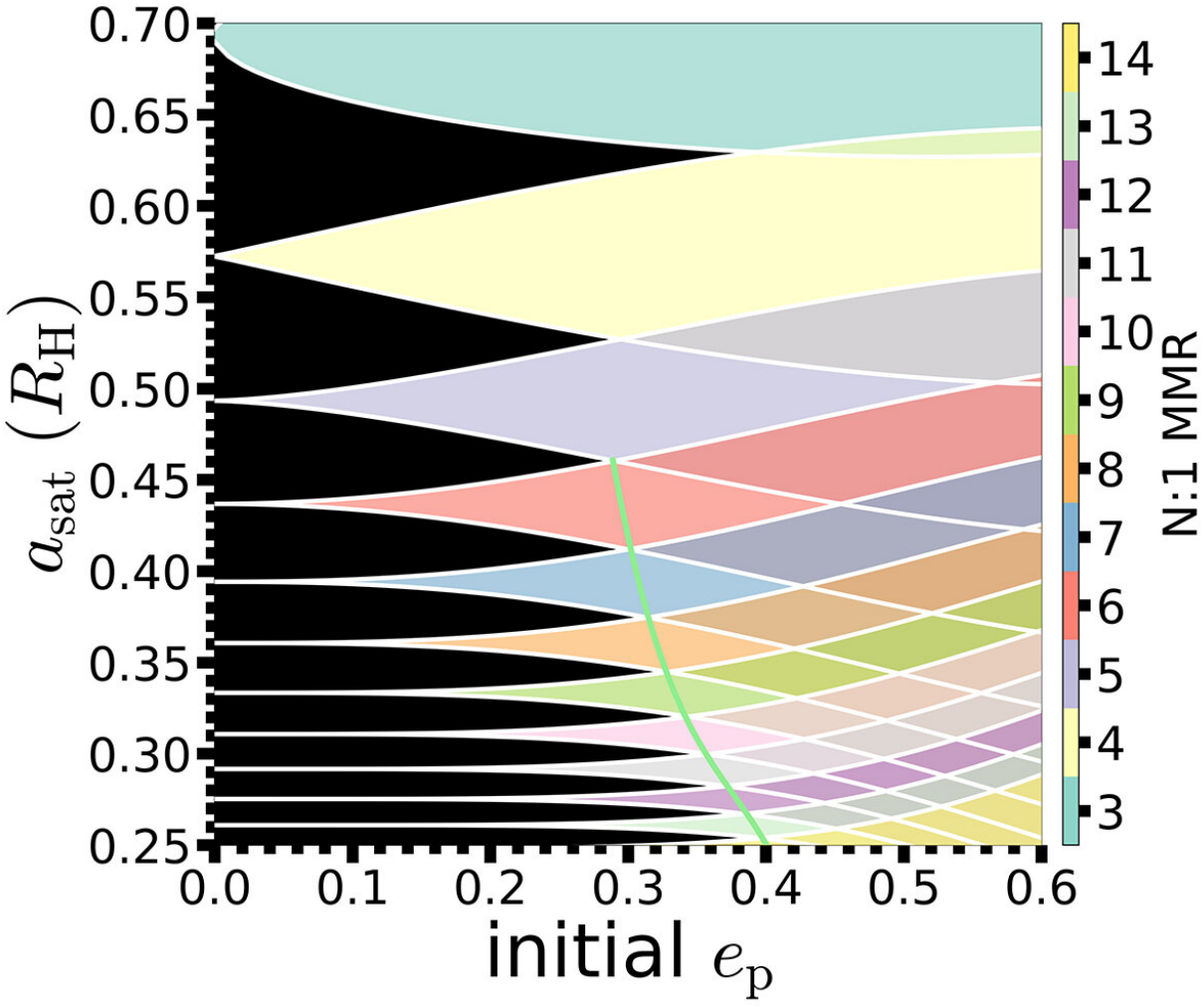

Credit: University of Illinois at Urbana-Champaign

Finding an exact copy of the Earth somewhere in the universe sounds like a far-fetched notion, but scientists believe that because Earth happened in our solar system, something similar is bound to exist someplace else. University of Illinois Urbana-Champaign researcher Siegfried Eggl and his colleagues say orbiting moons may play a key role in keeping planets habitable over long periods and identified a method to find them.

"In our solar system, we have an average of 20 moons orbiting around each planet. So, we suspected there are moons around planets in other systems, too. There is really no reason why there shouldn't be any," said Eggl, a professor in the Department of Aerospace Engineering at UIUC.

Eggl said astronomers using the Atacama Large Millimeter Array have recently observed what they believe is evidence of a moon forming around the extrasolar planet PDS 70c. The next step is finding moons around planets that have two stars.

Some planets in other solar systems can be seen using very large telescopes like ALMA, the W.M. Keck observatory in Hawaii or the European Southern Observatory in Chile, but fully formed moons are still too tiny to spot.

"We know they are there. We just need to look harder. But because it is so difficult to see them, we identified a way to detect them through the effect they have on a planet using transit timing variations."

Eggl said they can observe how planets behave in orbit and compare those observations to models with and without moons. "We know the planets, stars, and moons in our solar system interact gravitationally like a giant boardgame," Eggl said. "The moon is tidally interacting with the Earth and slowing its own rotation, but the Sun is also there, tugging on both. A second star would act as another external perturber to the

system."

Eggl explained, when a planet passes in front of a star the star dims a little. A moon tugging on the planet is causing the planet to wobble slightly on its orbit. This wobble makes the darkening of the star occur sometimes earlier and other times later. In a double star system, additional variations in the time of transit are due to the forced, elliptical orbits of the planet and its moon. If detected, those variations can lead to additional insights into the properties of the system.

Much like proving there is wind by observing tree branches bending, Eggl said "This is an indirect proof of a moon because there's nothing else that could tug on the planet in that kind of fashion."

Of course, this assumes that planets did not lose their moons along the way.

"We first had to determine the orbital resonances in the systems we looked at," Eggl said. "When moons and planets have slightly elliptical orbits, they don't always move at the same speed. The more eccentric an orbit, the more frequencies can be excited, and we see these resonances become more and more important. At some point there will be overlapping resonances that can lead to chaos in the system. In our study we have shown, however, that there is enough stable 'real estate' to merit a thorough search for moons around planets in double star systems."

Billy Quarles, lead author of the study, said, "The major difference with binary systems is the companion star acts like the tide at the beach, where it periodically comes in and etches away the beachfront. With a more eccentric binary orbit, a larger portion of the stable 'real estate' is removed. This can help out a lot in our search for moons in other star systems."

The bottom line for Eggl is that our solar system is probably not as special as we'd like to think it is.

"If we can use this method to show there are other moons out there, then there are probably other systems similar to ours," he said. "The moon is also likely critical for the evolution of life on our planet, because without the moon the axis tilt of the Earth wouldn't be as stable, the results of which would be detrimental to climate stability. Other peer-reviewed studies have shown the relationship between moons and the possibility of complex life."

The study, "Exomoons in Systems with a Strong Perturber: Applications to α Cen AB," by Billy Quarles and Gongjie Li from Georgia Tech, Siegfried Eggl from UIUC, and Marialis Rosario-Franco from the National Radio Astronomy Observatory and the University of Texas at Arlington, appears in *The Astronomical Journal*.

More information: Billy Quarles et al, Exomoons in Systems with a Strong Perturber: Applications to α Cen AB, *The Astronomical Journal* (2021). DOI: 10.3847/1538-3881/ac042a

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