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Detecting Life-Friendly Moons

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Artist impression of the view from a hypothetical habitable moon in orbit around a Jupiter-like planet. Image credit: Dan Durda

The search for life-friendly real estate around distant stars doesn't have to be limited to planets. New research shows that habitable exomoons can be detected with a new method using current technology.

Forty years ago, the Apollo astronauts traipsed across our Moon, making it "inhabited" for the first time - albeit for only two and half hours. A bona-fide habitable moon has never been found, but astronomers are considering how we might find one around distant stars.

"I think exomoons are just as interesting as exoplanets," says David Kipping of University College London.

In our own solar system, moons are becoming the main targets of future space missions. But when we look beyond our local conclave, it is only the exoplanets that astronomers have so far been able to detect.

Kipping says this situation may be changing. He and his colleagues have developed a new method to search for exomoons which takes advantage of current technology - specifically the recently launched Kepler spacecraft.

The team's calculations - which appear in the September issue of the Monthly Notices of the Royal Astronomical Society - show that NASA's Kepler could detect a moon in the habitable region (where liquid water could exist) around a star within about 500 light-years of our Sun.

When the moon hits your eye

Our solar system has eight planets (sorry, Pluto), and 170 moons, according to the Planetary Society. Of course, many of these moons are cold, lifeless rocks, but some scientists consider Jupiter's Europa and Saturn's Enceladus as possible havens for some sort of biology.

Other stellar systems may have similar numbers of planets and moons, and some fraction of these will be at the right distance from their star to have liquid water.

"There may be just as many habitable moons as habitable planets in our galaxy," Kipping says.

Astronomers have previously considered how one might detect a far-off moon, but many of these techniques require a lucky alignment of star, planet and satellite. Kipping and his colleagues are proposing an alternative that should increase the chances of spotting an exomoon.

Their method requires close observation of a transiting planet, which is a planet that passes in front of its parent star. Over 50 transits have been detected so far, with many more expected from Kepler and the French-led COROT mission.

"If a transiting planet has a moon, it will cause a wobble in the planet's orbit," Kipping says.

Such a wobble shows up as a change in the time between two transits, which is how long it takes the planet to make one orbit. Astronomers have previously looked for transit timing variations, but so far no evidence for a moon has been seen.

One difficulty is that several things can cause the transit timing to vary. Other planets in the system, perihelion precession, star irregularities -- all these can mimic the signal of an exomoon.

Kipping's group has a way to avoid any confusion. They have shown that by measuring variations in the speed at which a planet passes in front of its star (i.e., the transit duration), one can unambiguously identify a moon. This is because the variations in transit timing and duration occur separately when due to a moon.

There's also an added perk in measuring the two effects: by combining the variations one can estimate the moon's mass and its orbital period.

Artist impression of an Earth-like moon orbiting a Jupiter-like planet in another solar system. Image credit: Dan Durda

Kepler on the job

Kepler is currently staring at about 100,000 target stars, waiting to catch one of them blink as a planet goes by in front of them.

"Kepler will give us the best targets for exomoon searches," Kipping says.

In their latest work, Kipping's team has run simulations of Kepler data to see what their method could detect. In the best case scenario - with a Saturn-sized planet in the habitable zone of a small M dwarf star - Kepler could spot an orbiting moon down to a fifth of an Earth mass.

This might seem odd, considering the fact that Kepler is not likely to detect planets that small. Kipping explains that planets show up in transit surveys because the size of their shadow, but his technique does not require seeing the moon's shadow. It indirectly detects moons by their gravitational effect on the planet.

Hunting for moons wouldn't require any change in observational strategy, but it will take some work to tease out the exomoon signal from the data. So is anyone at Kepler looking?

"At the moment they are focused on their primary goal of looking for planets," Kipping says. But further down the road, he and his colleagues estimate that 25,000 stars in Kepler's field could be surveyed for exomoons.

Tim Brown of the Las Cumbres Observatory Global Telescope in California, who looked for an exomoon signal around the first discovered transiting planet (HD 209458b), says the actual number of candidate stars will be much less.

"In order to measure transit timing or speed variations one must first have a transiting planet, but the fraction of stars that display such is quite small," he says.

Brown also questions whether other search methods might be easier, such as trying to detect the dip in brightness as an exomoon passes in front of its host star.

Kipping responds by saying that the most effective detection technique will vary from case to case.

Lunar living

If exomoons are eventually detected in the habitable zone, one might wonder if they truly deserve the moniker of "habitable," since moons can have peculiarities that might snuff out life.

For instance, a moon may become tidally locked by its planet, resulting in uncomfortably long day-night cycles. Also, the planet's radiation belts can strip away the moon's atmosphere.

Kipping and his colleagues do not address the details of moon habitability, but they cite others who have shown that a moon of at least a third of an Earth mass should be able to hold onto a magnetic field, which could protect its atmosphere long enough to give life a fighting chance to develop.

In certain favorable cases, astronomers may be able to do better than just guess if a moon has an atmosphere.

"If we have the period, we might be able to predict when a lunar eclipse will occur," Kipping says. A spectroscopy study of such an event could reveal the signal from atmospheric gases on the moon's surface.

However, it should be noted that all the moons in our solar system are too small to be detected by Kipping's method (the largest moon is Ganymede with less than 3 percent of the Earth's mass). Kipping says this shouldn't discourage astronomers from looking.

"We have had so many surprises from exoplanets that it would be audacious to assume that no moons would be this big," Kipping says.

Source: by Michael Schirber, Astrobio.net

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