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Astronomers Could Soon Find Moons Outside the Solar System--Even Habitable Ones

Ewoks and the Na'vi may be pure fiction, but Endor and Pandora, the moons they inhabit, appear closer to reality

By John Matson

In the past two decades, the roster of known planets in the galaxy has mushroomed. Astronomers have added to the handful in our own solar system roughly 450 so-called exoplanets orbiting other stars. Most of those planets are more massive than Saturn, which makes them unpromising from a habitability standpoint—such giants tend to be gaseous bodies without a surface to walk on.

But the giant planets in our solar system—Jupiter, Saturn, Neptune and Uranus—all have moons, some with planetlike features such as atmospheres, magnetic fields or active volcanoes. And although the giant planets roam the cold outer regions of our solar system, other planetary systems feature massive planets in closer, more temperate orbits where life-enabling liquid water could persist. If those planets have satellites, as would be expected, they could provide a real-life counterpart to the Endors and Pandoras of science fiction—livable worlds that are not planets but moons.

No one has yet discovered any extrasolar moons, but some researchers think the capacity to detect them—and even analyze them for habitability—may be just over the horizon. "It's going to happen," says astrophysicist Sara Seager of the Massachusetts Institute of Technology. "It's just a matter of time."

Exoplanets in the habitable zone

Already researchers are locating giant planets far enough from the gravitational pull of their host star to potentially harbor stable satellites. In the May 20 issue of *The Astrophysical Journal,* a group will report locating a Saturn-mass planet in its star's so-called habitable zone—the temperate ring around a star within which orbiting bodies could harbor liquid water. "It's more than likely the planet has moons," says the study's lead author Nader Haghighipour, a planetary astronomer with the Institute for Astronomy and the NASA Astrobiology Institute at the University of Hawaii–Manoa.

But because the newfound planet, HIP 57050 b, is only Saturn-size rather than, say, the size of Jupiter or larger, any moons it may have are probably rather small and not especially planetlike. "All the things that you need to have a habitable world are not likely" to be found on satellites of HIP 57050 b, Haghighipour says.

Although some moons in our own solar system have been flagged as possible havens for extraterrestrial life, none is as plainly habitable as Earth. That is in part because they orbit on the outskirts of the solar system, making surface temperatures colder, and in part because they are too small to maintain sufficient shielding, in the form of robust atmospheres and magnetic fields, to fend off the charged particles of the solar wind.

But in other planetary systems, moons Earth-size or larger are not out of the question, says astronomer Darren Williams of Penn State Erie. Such large moons could form on their own and later be captured by a more massive planet's gravity to become a satellite. He points to a proposed mechanism by which Neptune may have snagged its moon Triton, in the process ejecting a third object that had been in a binary pairing with Triton. "I've scaled that type of event to something up to a terrestrial mass, and what I've been able to show is you can form something as large as the Earth around a Jupiter by losing a secondary object that is as small as Mars," Williams says.

Exomoon diversity

The incredible menagerie of extrasolar planets already discovered is filled with worlds that look nothing like the denizens of our own solar system. Some are several times the mass of Jupiter; some hug their host stars so tightly that a year on those planets—a full orbital revolution around the star—is shorter than a single day on Earth. So it is not unreasonable to think that extrasolar moons will be a diverse group as well, boasting members that would not fit into the limited sample of solar system satellites. "The possibilities are endless," Seager says. "So far, with exoplanets, nature has been more creative than we are."

Astronomers may soon have observations to back up their hypotheses about lunar companions to extrasolar worlds. In March

a team of researchers reported the discovery of COROT 9 b, a planet of about the same mass and size of Jupiter that orbits its star, known as COROT 9, at about the distance Mercury circles the sun. (The names come from the French COROT spacecraft, which spotted the planet.) At that distance the host star's gravitational influence should be sufficiently weak that COROT 9 b could retain stably orbiting moons millions of kilometers from the planet.

On June 17, COROT 9 b will pass in front of its host star from the vantage point of Earth, an event known as a transit, and the hunt will be on for satellites encircling the planet. A mostly France-based team has secured discretionary time on the Spitzer Space Telescope to look for rings and moons around COROT 9 b during the transit. "If they get really lucky this [discovery of extrasolar moons] could happen this year," Seager says. Others have calculated that NASA's Kepler spacecraft, which has been in the exoplanet hunt since 2009, should be able to identify the presence of large lunar companions orbiting the planets it locates.

Whatever the outcome of those campaigns, NASA's massive successor to the Hubble Space Telescope should open up the field of exomoons, assuming they are as abundant as theory predicts. The James Webb Space Telescope (JWST), currently scheduled to launch in 2014, may even be able to resolve atmospheric constituents of those moons, according to a recent analysis by astrophysicist Lisa Kaltenegger of Harvard University. And Williams's research shows that under certain conditions exomoons may be far brighter than their host planets in near infrared wavelengths, to which JWST should be exquisitely sensitive.

But if astronomers manage to turn up an extrasolar moon in the coming years, even a habitable one like those of sci-fi lore, some aspects of Pandora will remain firmly fictional. "What's interesting is *Avatar* is out of date by about seven years," Seager says. Astronomers have looked for the presence of giant planets in the habitable zone of Alpha Centauri, the nearby star system that is home to Pandora in the film, and have not found one. That's not to say that Alpha Centauri doesn't have a habitable world of some kind—it would just have to be a planet like our own, rather than a moon. "If they had called me or someone else in exoplanet astronomy," Seager says, "we would have advised them to just put an Earth there."

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