Avatar's moon Pandora could be real

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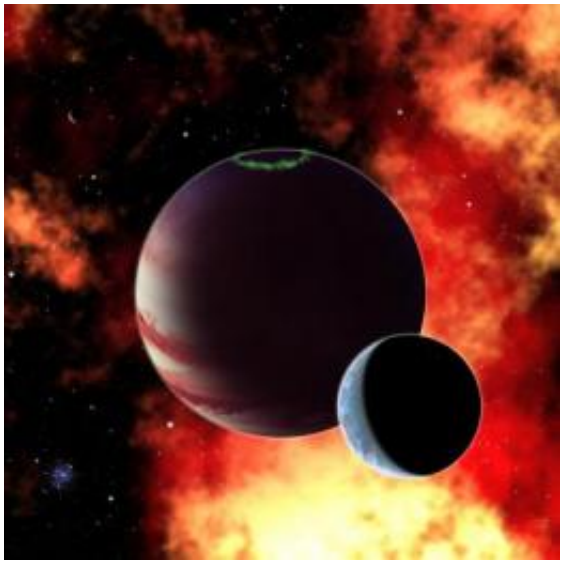

This artist's conception shows a hypothetical gas giant planet with an Earth-like moon similar to the moon Pandora in the movie Avatar. New research shows that, if we find such an "exomoon" in the habitable zone of a nearby star, the James Webb Space Telescope will be able to study its atmosphere and detect key gases like carbon dioxide, oxygen, and water. The key is to find a planet that transits its star, and then find a moon orbiting that planet more than one stellar radius away, so that the moon can be studied independently of the planet. Moreover, an alien moon orbiting the gas giant planet of a red dwarf star may be more likely to be habitable than tidally locked Earth-sized planets or super-Earths. Credit: David A. Aguilar, CfA

In the new blockbuster Avatar, humans visit the habitable - and inhabited - alien moon called Pandora. Life-bearing moons like Pandora or the Star Wars forest moon of Endor are a staple of science fiction. With NASA's Kepler mission showing the potential to detect Earth-sized objects, habitable moons may soon become science fact. If we find them nearby, a new paper by Smithsonian astronomer Lisa Kaltenegger shows that the James Webb Space Telescope (JWST) will be able to study their atmospheres and detect key gases like carbon dioxide, oxygen, and water vapor.

"If Pandora existed, we potentially could detect it and study its atmosphere in the next decade," said Lisa Kaltenegger of the Harvard-Smithsonian Center for Astrophysics (CfA).

So far, planet searches have spotted hundreds of Jupiter-sized objects in a range of orbits. Gas giants, while easier to detect, could not serve as homes for life as we know it. However, scientists have speculated whether a rocky moon orbiting a gas giant could be life-friendly, if that planet orbited within the star's habitable zone (the region warm enough for liquid water to exist).

"All of the gas giant planets in our solar system have rocky and icy moons," said Kaltenegger. "That raises the possibility that alien Jupiters will also have moons. Some of those may be Earth-sized and able to hold onto an atmosphere."

Kepler looks for planets that cross in front of their host stars, which creates a mini-eclipse and dims the star by a small but detectable amount. Such a transit lasts only hours and requires exact alignment of star and planet along our line of sight. Kepler will examine thousands of stars to find a few with transiting worlds.

Once they have found an alien Jupiter, astronomers can look for orbiting moons, or exomoons. A moon's gravity would tug on the planet and either speed or slow its transit, depending on whether the moon leads or trails the planet. The resulting transit duration variations would indicate the moon's existence.

Once a moon is found, the next obvious question would be: Does it have an atmosphere? If it does, those gases will absorb a fraction of the star's light during the transit, leaving a tiny, telltale fingerprint to the atmosphere's composition.

The signal is strongest for large worlds with hot, puffy atmospheres, but an Earth-sized moon could be studied if conditions are just right. For example, the separation of moon and planet needs to be

large enough that we could catch just the moon in transit, while its planet is off to one side of the star.

Kaltenegger calculated what conditions are best for examining the atmospheres of alien moons. She found that alpha Centauri A, the system featured in Avatar, would be an excellent target.

"Alpha Centauri A is a bright, nearby star very similar to our Sun, so it gives us a strong signal" Kaltenegger explained. "You would only need a handful of transits to find water, oxygen, carbon dioxide, and methane on an Earth-like moon such as Pandora."

"If the Avatar movie is right in its vision, we could characterize that moon with JWST in the near future," she added.

While alpha Centauri A offers tantalizing possibilities, small, dim, red dwarf stars are better targets in the hunt for habitable planets or moons. The habitable zone for a red dwarf is closer to the star, which increases the probability of a transit.

Astronomers have debated whether tidal locking could be a problem for red dwarfs. A planet close enough to be in the habitable zone would also be close enough for the star's gravity to slow it until one side always faces the star. (The same process keeps one side of the Moon always facing Earth.) One side of the planet then would be baked in constant sunlight, while the other side would freeze in constant darkness.

An exomoon in the habitable zone wouldn't face this dilemma. The moon would be tidally locked to its planet, not to the star, and therefore would have regular day-night cycles just like Earth. Its atmosphere would moderate temperatures, and plant life would have a source of energy moon-wide.

"Alien moons orbiting gas giant planets may be more likely to be habitable than tidally locked Earth-sized planets or super-Earths," said Kaltenegger. "We should certainly keep them in mind as we work toward the ultimate goal of finding alien life."

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