Tidally locked exoplanets may be more common than previously thought

August 14 2017

This artist's concept depicts a planetary system. Credit: NASA/JPL-Caltech

Many exoplanets to be found by coming high-powered telescopes will probably be tidally locked—with one side permanently facing their host star—according to new research by astronomer Rory Barnes of the University of Washington.

Barnes, a UW assistant professor of astronomy and astrobiology, arrived at the finding by questioning the long-held assumption that only those stars that are much smaller and dimmer than the sun could host orbiting planets that were in synchronous orbit, or tidally locked, as the moon is with the Earth. His paper, "Tidal Locking of Habitable Exoplanets," has been accepted for publication by the journal *Celestial Mechanics and Dynamical Astronomy*.

Tidal locking results when there is no side-to-side momentum between a body in space and its gravitational partner and they become fixed in their embrace. Tidally locked bodies such as the Earth and moon are in synchronous rotation, meaning that each takes exactly as long to rotate around its own axis as it does to revolve around its host star or gravitational partner. The moon takes 27 days to rotate once on its axis, and 27 days to orbit the Earth once.

The moon is thought to have been created by a Mars-sized celestial body slamming into the young Earth at an angle that set the world spinning initially with approximately 12-hour days.

"The possibility of tidal locking is an old idea, but nobody had ever gone through it systematically," said Barnes, who is affiliated with the UW-based Virtual Planetary Laboratory.

In the past, he said, researchers tended to use that 12-hour estimation of Earth's rotation period to model exoplanet behavior, asking, for example, how long an Earthlike exoplanet with a similar orbital spin might take to become tidally locked.

"What I did was say, maybe there are other possibilities—you could have slower or faster initial rotation periods," Barnes said. "You could have planets larger than Earth, or planets with eccentric orbits—so by exploring that larger parameter space, you find that in fact the old ideas

were very limited, there was just one outcome there."

"Planetary formation models, however, suggest the initial rotation of a planet could be much larger than several hours, perhaps even several weeks," Barnes said. "And so when you explore that range, what you find is that there's a possibility for a lot more exoplanets to be tidally locked. For example, if Earth formed with no moon and with an initial 'day' that was four days long, one model predicts Earth would be tidally locked to the sun by now."

Barnes writes: "These results suggest that the process of tidal locking is a major factor in the evolution of most of the potentially habitable exoplanets to be discovered in the near future."

Being tidally locked was once thought to lead to such extremes of climate as to eliminate any possibility of life, but astronomers have since reasoned that the presence of an atmosphere with winds blowing across a planet's surface could mitigate these effects and allow for moderate climates and life.

Barnes said he also considered the planets that will likely be discovered by NASA's next planet-hunting satellite, the Transiting Exoplanet Survey Satellite or TESS, and found that every potentially habitable planet it will detect will likely be tidally locked.

Even if astronomers discover the long-sought Earth "twin" orbiting a virtual twin of the sun, that world may be tidally locked.

"I think the biggest implication going forward," Barnes said, "is that as we search for life on any exoplanets we need to know if a planet is tidally locked or not."

More information: Tidal Locking of Habitable Exoplanets,