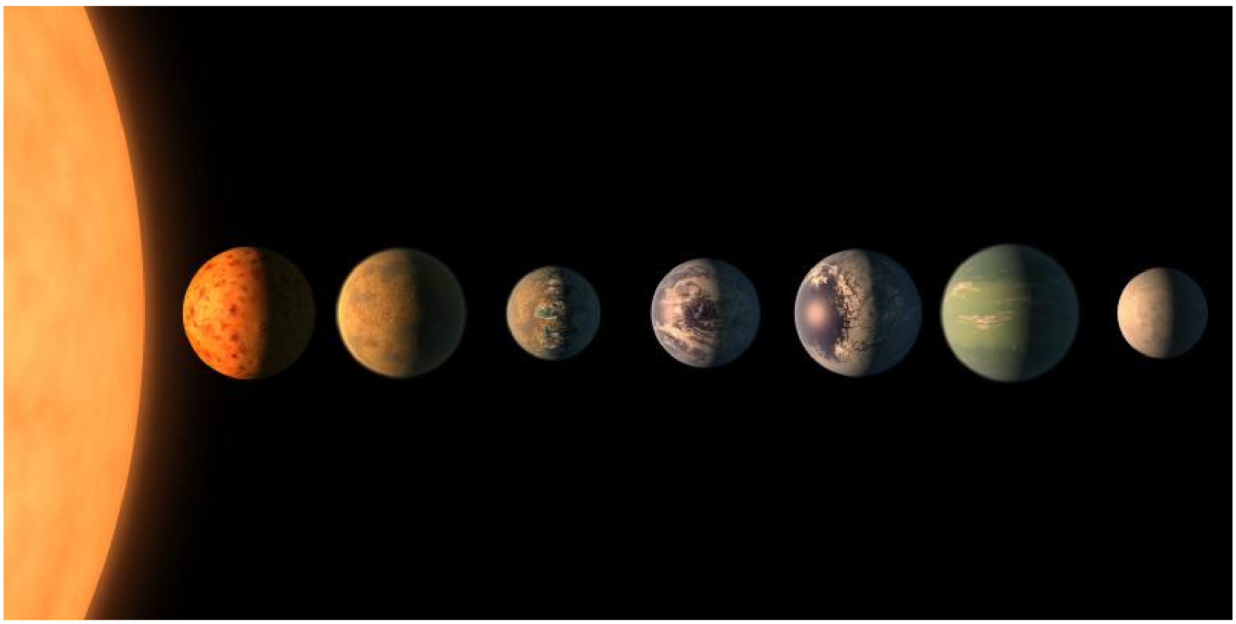
Could Trappist-1's seven earth-like planets have gas giant siblings?

September 5 2017



An artist's conception of the TRAPPIST-1 planetary system courtesy of NASA/JPL-Caltech.

New work from a team of Carnegie scientists (and one Carnegie alumnus) asked whether any gas giant planets could potentially orbit TRAPPIST-1 at distances greater than that of the star's seven known planets. If gas giant planets are found in this system's outer edges, it could help scientists understand how our own Solar System's gas giants like Jupiter and Saturn formed.

Earlier this year, NASA's Spitzer Space Telescope thrilled the world as it revealed that TRAPPIST-1, an ultra-cool dwarf star in the Aquarius constellation, was the first-known system of seven Earth-sized planets orbiting a single star. Three of these planets are in the so-called habitable zone—the distance from the central star at which liquid water is most likely to be found.

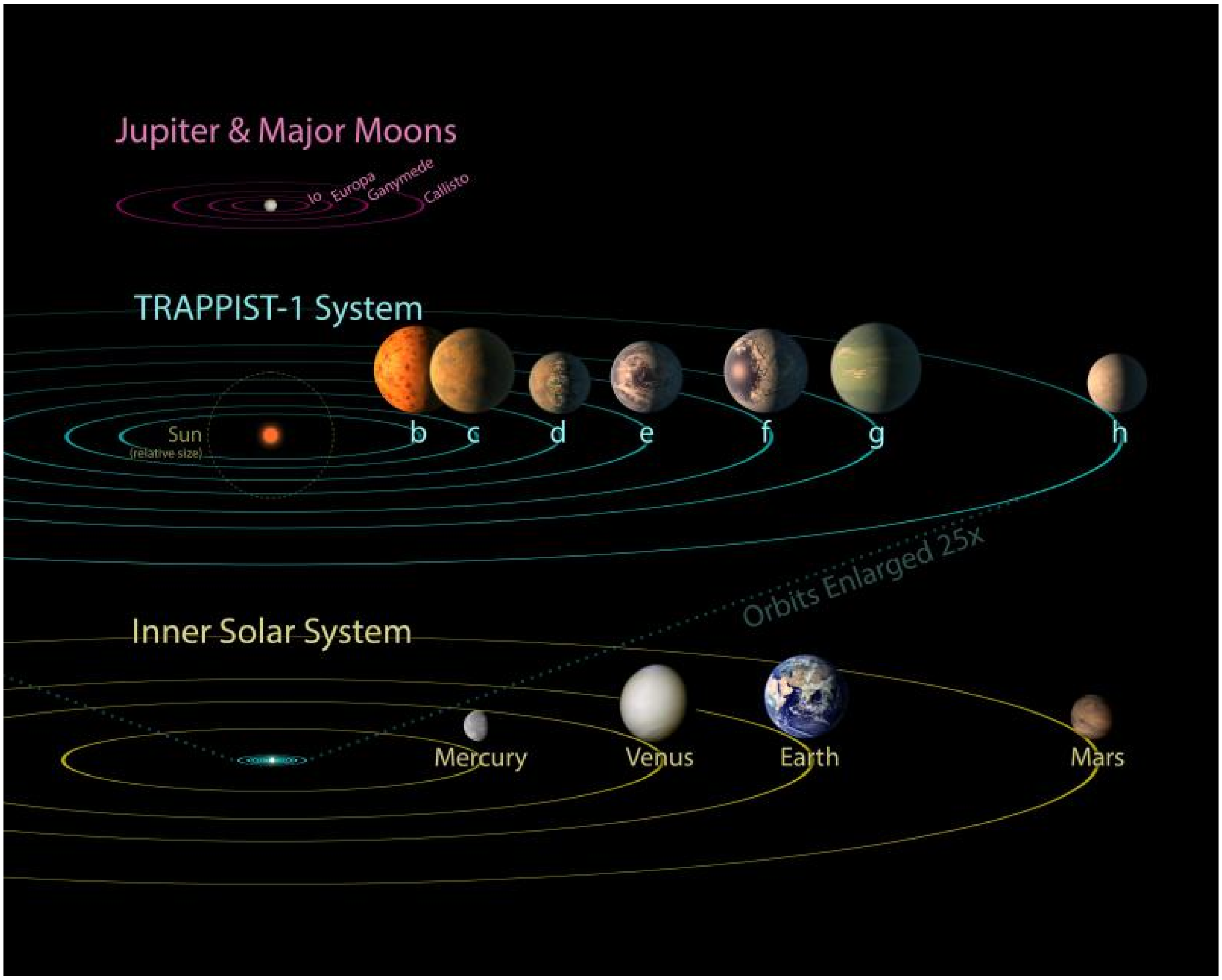
But it's possible that like our own Solar System, TRAPPIST-1 is also orbited by gas giant planets at a much-greater distance than the Earth-sized planets that we already know are part of the system.

"A number of other star systems that include Earth-sized planets and super-Earths are also home to at least one gas giant," said Carnegie's Alan Boss, who is first author on the team's paper, published by The *Astronomical Journal*. "So, asking whether these seven planets have gas giant siblings with longer-period orbits is an important question."

To begin answering, Boss turned to the ongoing planet-hunting survey he co-runs with Carnegie co-authors Alycia Weinberger, Ian Thompson, and others. They have a special instrument on the du Pont telescope at Carnegie's Las Campanas Observatory called the CAPSCam—the Carnegie Astrometric Planet Search Camera. It searches for extrasolar planets using the astrometric method, by which a planet's presence can be detected indirectly through the wobble of the host star around the stellar system's center of mass.

Using CAPSCam, Boss and his colleagues—including Carnegie's Tri Astraatmadja and Guillem Anglada-Escudé, a former Carnegie fellow now at Queen Mary University of London—determined the upper limits for the mass for any potential gas giant planets in the TRAPPIST-1 system. They found that there are no planets larger than 4.6 times Jupiter's mass orbiting the star with a period of 1 year, and no planets larger than 1.6 times Jupiter's mass orbiting the star with 5-year periods.

(These periods might not seem very long in comparison to Jupiter's nearly 12-year period, but TRAPPIST-1's seven known planets have periods ranging from 1.5 to 20 days.)



All seven TRAPPIST-1 planets could easily fit inside the orbit of Mercury, our own Solar System’s innermost planet. Alan Boss and his colleagues investigated whether it’s possible that the TRAPPIST-1 system could contain gas giant planets on much longer-period orbits than the seven known terrestrial ones. Image is courtesy of NASA/JPL-Caltech.

"There is a lot of space for further investigation between the longer-period orbits we studied here and the very short orbits of the seven known TRAPPIST-1 planets," added Boss.

If long-period gas giant planets are found in the TRAPPIST-1 system, then it could help resolve a longstanding debate about the formation of our own Solar System's gas giant planets.

In our Sun's youth, it was surrounded by a disk of gas and dust from which its planets were born. Earth and the other terrestrial planets were formed by the slow accretion of rocky material from the disk. One theory for gas giant planet formation contends that they also begin by the accretion of a solid core, which eventually contains enough material to gravitationally attract a large envelope of surrounding gas.

The competing theory holds that our own gas giant planets formed when the Sun's rotating disk of gas and dust took on a spiral arm formation. The arms increased in mass and density until distinct clumps formed and rapidly coalesced into baby gas giants.

One drawback of the first option, called core accretion, is that it can't easily explain how gas giant planets form around a star as low in mass as TRAPPIST-1, which is twelve times less massive than the Sun. However, Boss's computational models of the second theory, called disk instability, have indicated that gas giant planets could form around such red dwarf stars.

"Gas giant planets found on long-period orbits around TRAPPIST-1 could challenge the core accretion theory, but not necessarily the disk instability theory," Boss explained.

More information: Alan P. Boss et al. Astrometric Constraints on the Masses of Long-period Gas Giant Planets in the TRAPPIST-1 Planetary

System, *The Astronomical Journal* (2017). DOI: 10.3847/1538-3881/aa84b5

Provided by Carnegie Institution for Science