Astrobiology News July 2023:
Are Red Dwarf Exoplanets Habitable?

Check out the list of potentially habitable exoplanets on the website of the Planetary Habitability Laboratory[1] (PHL) and you'll see that almost all of these worlds orbit M stars (red dwarfs), stars that are much cooler and dimmer than our Sun. Four of the seven Earth-sized exoplanets that comprise the TRAPPIST-1 system can be found among PHL's "conservative sample of potentially habitable exoplanets," the list that imposes the most stringent criteria of habitability for inclusion. The TRAPPIST-1 system is of particular interest, since it is "only" 40 light-years away and it contains the largest number of Earth-sized worlds observed to transit[2] their star.

All seven TRAPPIST-1 exoplanets are high-priority targets for the JWST to determine whether they have atmospheres, and, if so, what the composition of those atmospheres might be. Results for the two innermost TRAPPIST-1 worlds (b and c, which are not on PHL's potentially habitable list) have been reported recently,[3] and indicate that these worlds have no appreciable atmospheres. TRAPPIST-1 c was a bit of a disappointment, as it was thought it might be analogous to Venus, which has a very thick carbon dioxide atmosphere.[4]

Red dwarfs comprise about 75% of all stars and are extremely long-lived; however, there are several factors that may prove to be problematic for the habitability of worlds that orbit these stars. Young red dwarfs experience bouts of intense flares that may sterilize their worlds. Furthermore, most red dwarf exoplanets are "tidally locked" to their stars, such that only one side of the exoplanet ever faces its star. Another issue has to do with the lack of Jupiter-sized worlds in red dwarf systems. Jupiter's presence is thought to have shielded the Earth from potentially catastrophic impacts in the early days of our Solar System; however, a recent study led by Emily Pass of the Center for Astrophysics[5] reports finding no Jupiter-sized worlds orbiting the 200 red dwarfs that were examined.[6]

Does this mean habitable worlds orbiting red dwarfs are rare or non-existent? No - we don't know enough about these worlds to make that claim at this point in time. However, even if habitable red dwarf exoplanets are rare, roughly 20% of the approximately 200 billion stars in our galaxy are similar to the Sun, and these stars may harbor habitable, Earth-like worlds. Jupiter-sized exoplanets orbiting Sun-like stars at distances comparable to Jupiter's orbit about the Sun are common. However, it is more difficult to identify Earth-sized exoplanets in the habitable zones of Sun-like stars than in the habitable zones of red dwarfs, so there is a selection effect at play when we consider the present list of potentially habitable exoplanets.

---

[1] https://phl.upr.edu/projects/habitable-exoplanets-catalog
[2] All seven worlds have orbits that pass in front of, and behind, their star in a matter of days.
[3] See https://www.theclergyletterproject.org/pdf/abnews42023.pdf for results on TRAPPIST-1 b.
[4]https://www.nasa.gov/feature/goddard/2023/webb-rules-out-thick-carbon-dioxide-atmosphere-for-rocky-exoplanet
[5] https://arxiv.org/abs/2305.19357
[6]https://manyworlds.space/2023/06/07/the-makeup-of-red-dwarf-solar-systems-may-seriously-limit-the-formation-of-earth-sized-planets/

Meanwhile, the scientific community is anxiously awaiting JWST's results for TRAPPIST-1 d,e,f, and g, all of which are currently considered to be potentially habitable. Given the ubiquity of red dwarfs, the presence and composition of atmospheres around the worlds of TRAPPIST-1 could tell us a lot about the general prospects for exoplanet habitability in our galaxy.

Until next month,

Grace

Grace Wolf-Chase (she/her/hers)
Senior Scientist; Senior Education & Communication Specialist
Planetary Science Institute
gwolfchase@gmail.com
https://www.psi.edu/about/staffpage/gwchase
Vice President, Center for Advanced Study in Religion and Science
(CASIRAS)