Potential for Life on Trappist-1 and other Red Dwarf Star Planets

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1. The Trappist-1 system

The To date seven planets have been detected orbiting the "nearby" Red Dwarf star Trappist-1 [1], but the number may be significantly greater. The star is relatively small (0.12 Rsun) and cool (2,550K) compared to our Sun (5,780K). Consequently its radiation flux is low (0.05% that of the Sun), mainly in the infrared, with a spectral peak at ~1μm, well above the Photosynthetically Active Radiation (PAR) waveband of 400 – 700nm, used by Earth vegetation.

2. Habitability and Oxygenic Photosynthesis

At least three of the planets are in the Habitable Zone (defined as regions where surface temperatures may support liquid water), but all six inner planets could have such temperatures, depending on their atmospheres. The six inner, closely orbiting planets (at 0.1-0.35AU), receive a radiation flux 0.3-4 that of Earth, but only ~10% of this is PAR, compared with ~40% on Earth. However, the star-facing hemisphere of tidally locked Trappist-1 planets would receive continuous PAR. Earth at high northerly or southerly latitudes, provides an analogy for the possible outcome. During only 3-4 months per Earth year, the almost continuous low-level radiation, above 80^o north or south, produces lush vegetation (Figure 1).

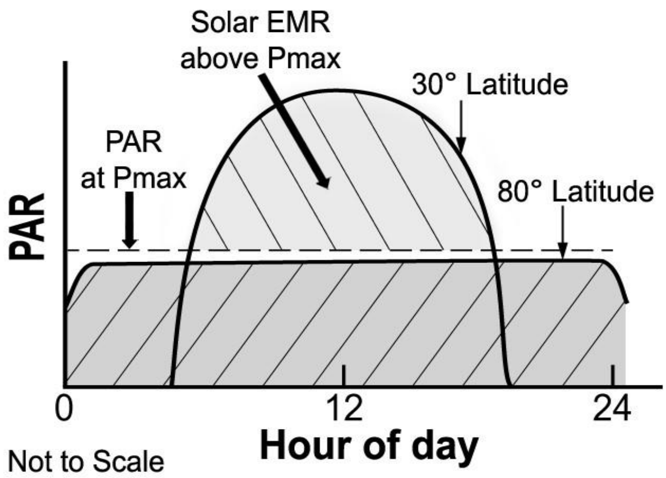

Figure 1: Diagram of the summer radiation regimes in mid and high latitudes on Earth.

The radiation intensity on such a tidally locked planet would be maximum immediately facing the star, falling off to zero, towards the terminator, at 90^o (Figure 2). This would allow plants to "select" the most appropriate radiation regime optimizing their growth.

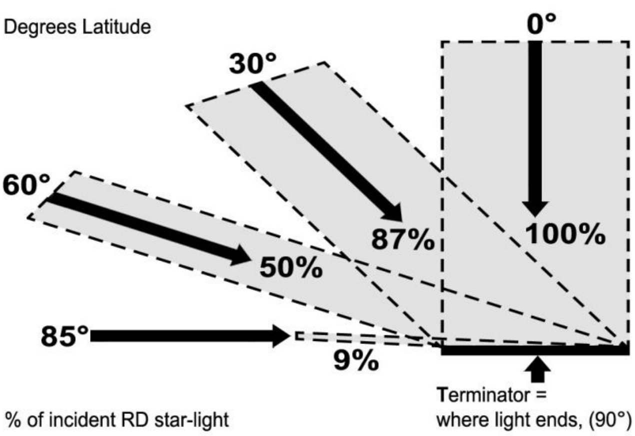

Figure 2. Percentage incident radiation on Tidally Locked Planets as a function of Geographic Latitude.

3. The potential for life

The XUV radiation from Trappist -1 is much higher that of the Sun. This radiation could (possibly, but not necessarily) erode the primary atmosphere and oceans, and directly endanger life, unless life evolves in water or under a dense atmosphere. Dry land plants on Trappist-1 and other RDS planets could possibly evolve to utilize the infrared radiation between 700 and 1,000nm, which is energetically sufficient to drive water splitting oxygenic photosynthesis, an important precursor of complex life. These considerations and the abundance of RD stars, enhance the chance of finding other life clement abodes in the Milky Way [3].

4. References

[1] Gillon, M. et al. 2017, Seven temperate terrestrial planets around the nearby ultracool dwarf star TRAPPIST-1, Nature. 542 (7642): 456-460.

[2] Gale, J. and Wandel A., 2017, The Potential of Planets orbiting Red Dwarf stars to support Oxygenic Photosynthesis and Complex Life, International Journal of Astrobiology 1: 1-8 (2017)

[3] Wandel A., 2016, in "Search for Life: from early Earth to Exoplanets", XII rencontres du Vietnam, https://www.youtube.com/watch?v=gJaz6jim4vs, and in this meeting.

Short Summary

Planets of Red Dwarf stars have an incident radiation and climate pattern very different from Earth. However, their climate modeling and the high abundance of Earth-sized planets in the habitable zone of Red Dwarfs suggest that many such planets may support life clement conditions, oxygenic photosynthesis and eventually complex life.