On the bio-habitability of Red Dwarf planets and estimating the abundance of biotic planets with future telescopes

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1. Introduction

The Earth-sized planets detected in the Habitable Zone of Trappist-1, Proxima Centauri and numerous other M-type stars [1], suggests that biotic planets may be found around our nearest neighbor-stars [2,3]. A key condition in such a scenario is the question whether planets orbiting red dwarf stars could support life.

2. The bio-habitable atmospheric range

Using a simple model for the surface temperature distribution [4,5] we express the the habitable zone limits of red dwarf stars and the habitability condition for their planets in terms of the atmospheric pressure, composition and heat convection. We argue that habitable planets of red dwarf stars may have conditions for liquid water for a wide range of atmospheric properties. We apply these results to Proxima b and the Trappist-1 planets (fig. 1), elaborating on the hypothesis that Earthlike oxygenic photosynthesis could evolve on such planets and produce oxygen-rich atmospheres [6,7].

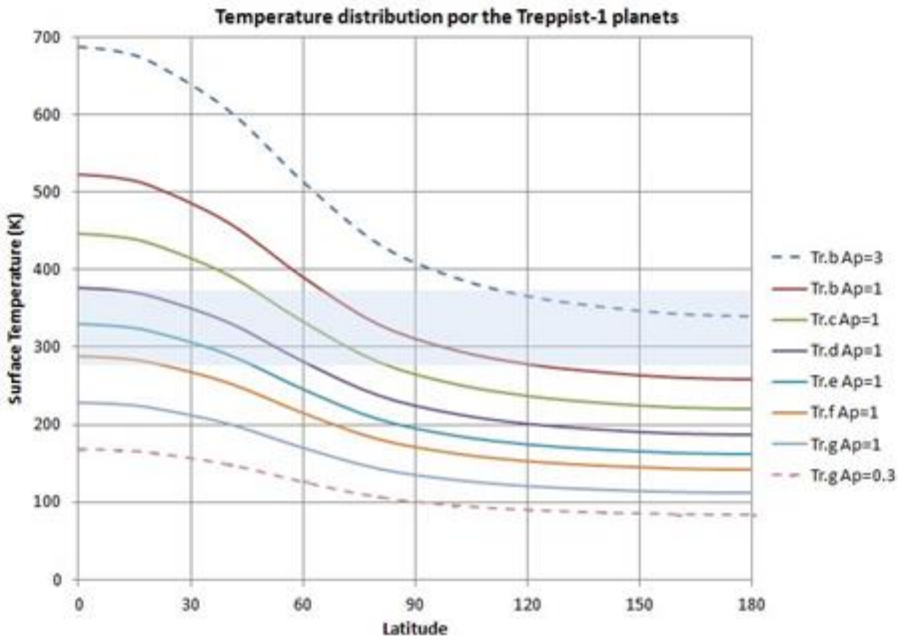

Figure 1: Surface temperature profiles for the Trappist-1 planets with an assumed Earthlike atmosphere (*Ap=1*) and with an an increased and decreased greenhouse effect (dashed). The temperature range of liquid water (at 1 bar) is indicated by the shaded blue area.

3. Estimating the abundance of biotic planets

These results are applied to predict the abundance of biotic planets from the spectral signature of atmospheric Ozone, Oxygen and water in planets of nearby M-stars, which may be obtained with JWST and other telescopes planned to be operational in the near future. We calculate the expected number of such planets as a function of the distance (fig. 2) at which future missions might be able to detect planetary spectral signatures. We discuss the implications to detecting M-dwarf planets that actually have liquid water and oxygen and suggest how it will be possible to estimate the abundance of such planets using TESS and future exoplanet missions. Observing a statistically significant sample of planets for spectral signatures of water and oxygen could yield an estimate of the abundance of biotic planets and of the probability for the evolution of organic life.

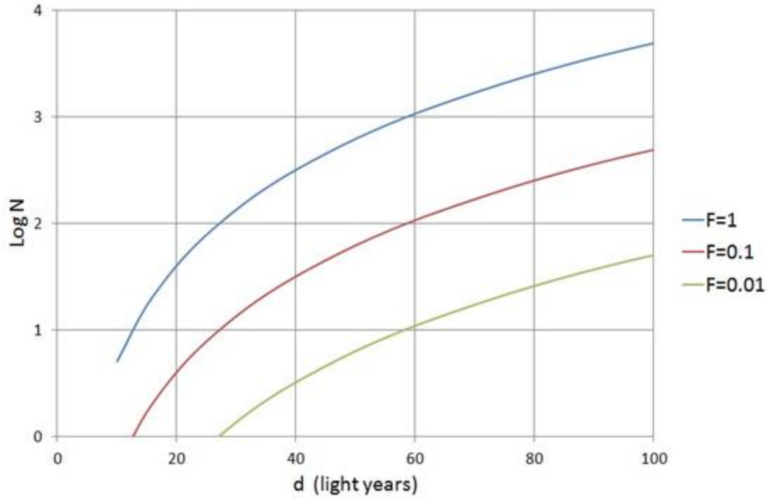

Figure 2. The number of planets with oxygenic bio-signatures expected within a distance d, for several values of the bio-habitability parameter F, the product of the abundance of biotic planets and the probability to find Earth sized planets in the HZ of red dwarfs.

4. References

[1] Dressing C.D. and Charbonneau D. (2015)The Occurrence of Potentially Habitable Planets Orbiting M Dwarfs Estimated from the Full Kepler Dataset and an Empirical Measurement of the Detection Sensitivity. Astrophys J., 807, 45-67.

[2] Wandel, A. (2015) On the Abundance of extraterrestrial life after the Kepler mission. Int. J. of Astrobiology, 14, 511–516.

[3] Wandel, A. 2017, How far are Extraterrestrial Life and Intelligence after Kepler? Acta Astronautica, 137, 498-503.

[4]Haberle, R., McKay, C., Tyler, D., & Reynolds, R. 1996, in Circumstellar Habitable Zones., ed. L. Doyle, 29.

[5] Wandel, A. 2016, in "Search for Life: from early Earth to Exoplanets", XII rencontres du Vietnam, https://www.youtube.com/watch?v=gJaz6jim4vs; Ap.J. (submitted)

[6] Gale, J. and Wandel A., (2017) The Potential of Planets Orbiting Red Dwarf Stars to Support Oxygenic Photosynthesis and Complex Life. Int. J. of Astrobiology, 16:1, 1-9.

[7] Gale, J. and Wandel A., (2017) Potential for Life on Trappist-1 and other Red Dwarf Star Planets, this meeting.

Short Summary

We estimate the number of M-star planets having biosignatures detectable with JWST and future missions. With a statistically significant sample of such planets it may be possible to estimate of the abundance of biotic planets and of the probability of life.