The habitability of Proxima Centauri b

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Proxima b is a planet with a minimum mass of 1.3 $M_\oplus$ orbiting within the habitable zone (HZ) of Proxima Centauri, a very low-mass, active star and the Sun's closest neighbour. Here we investigate a number of factors related to the potential habitability of Proxima b and its ability to maintain liquid water on its surface [1].

The analysis of data from multiple facilities shows that the top-of- atmosphere average XUV irradiance on Proxima b is 0.293 W m^{-2}, that is, nearly 60 times higher than Earth, and that the total irradiance is 877±44 W m^{-2}, or 64±3% of the solar constant but with a significantly redder spectrum [2]. Interestingly, our spectral energy distribution analysis revealed a ~20% excess in the 3–30 μm flux of the star that is best interpreted as arising from warm dust in the system, possibly as a result of planet formation processes.

We discuss different scenarios regarding the time evolution of the star's spectrum [1,3], which is essential for modeling the flux received over Proxima b's lifetime. We show that Proxima b's obliquity is likely null and its spin is either synchronous or in a 3:2 spin-orbit resonance, depending on the planet's eccentricity and level of triaxiality. The evolution of Proxima b's water inventory follows from the spectral energy distribution and the calculation of the hydrogen loss from the planet using an improved energy-limited escape formalism. Despite the high level of stellar activity, we find that Proxima b is likely to have lost 0.5-2 Earth ocean's worth of hydrogen (EO_H), depending on the assumptions, before it reached the HZ 90–200 Myr after its formation. The largest uncertainty is the initial water budget, which is not constrained by planet formation models. From our work, we conclude that Proxima b is a viable candidate habitable planet. Additional studies on the current habitability of Proxima b will also be discussed [3,4].

If we assume that Proxima b could have retained enough volatiles to sustain surface habitability, one can use a 3D Global Climate Model (GCM) to simulate Proxima b's atmosphere and water cycle for its two likely rotation modes (the 1:1 and 3:2 spin-orbit resonances) [5]. We find that a broad range of atmospheric compositions can allow surface liquid water. On a tidally-locked planet with a surface water inventory larger than 0.6 Earth ocean, liquid water is always present (assuming 1 bar of N_2), at least in the substellar region. For smaller water inventories, water can be trapped on the night side, forming either glaciers or lakes, depending on the amount of greenhouse gases. The GCM also produces reflection/emission spectra and phase curves for the different rotations and surface volatile inventories. We find that atmospheric characterization will be possible by direct imaging with forthcoming large telescopes thanks to an angular separation of 7λ/D at 1 μm (with the E-ELT) and a contrast of ~10^{-7}. The magnitude of the planet will allow for high-resolution spectroscopy and the search for molecular signatures, including H_2O, O_2, and CO_2. Within a decade, it will be possible to image Proxima b and possibly determine whether this exoplanet's surface is habitable.

Finally, we briefly discuss if photosynthesis could function currently on Proxima b, in spite of having only 3% of the photosynthetically active radiation (400–700 nm) of Earth. Because of the very red spectrum, the oxygenic photic zone would be only ~10 m deep in water compared with ~200 m on Earth. Nevertheless, a substantial aerobic or anaerobic ecology could be possible on Proxima b [6].

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Short Summary

Proxima b is a planet with a minimum mass of 1.3 MEarth orbiting within the habitable zone of Proxima Centauri, a very low-mass, active star and the Sun’s closest neighbour. Here we investigate the potential habitability of Proxima b and its ability to maintain liquid water on its surface.