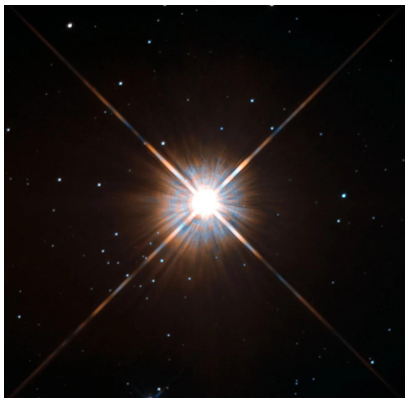
Planets of Proxima Centauri –Exoplanets in Our Backyard

Kehan Zou, Department of Astronomy, University of Tokyo

What Is Proxima Centauri, and Where Is It?

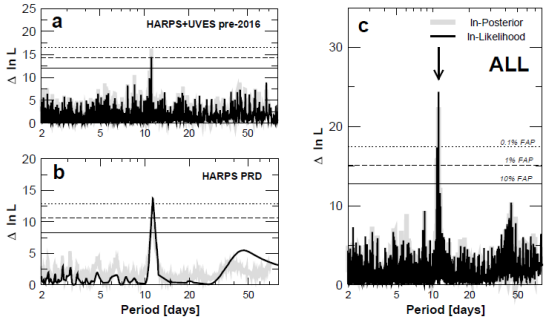
Proxima Centauri is the star closest star to the Sun at 4.25 lightyears in the constellation Centaurus. It is an M-type red dwarf star in the main sequence, with an effective temperature of around 3000K. Its mass and diameter are 0.12 and 0.15 times of those of the Sun, respectively. Due to its vicinity to our solar system, we may have a chance to physically reach the planets of Proxima Centauri, shall there be any.



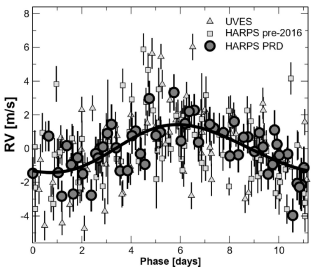
A photo of Proxima Centauri taken by the Hubble Space Telescope in 2013.

The Discovery of Proxima Centauri b

Confirmed by Anglada-Escudé et al. in 2016 using data from the High Accuracy Radial velocity Planet Searcher (HARPS) and the Ultraviolet and Visual Echelle Spectrograph (UVES), Proxima Centauri b is an exoplanet orbiting Proxima Centauri with a period of 11.2 days. Its mass is 1.3 times that of the Earth. The most astounding discovery of Anglada-Escudé et al. is that Proxima Centauri b orbits its host star at a distance around 0.05AU, which is inside the habitable zone. The derived equilibrium blackbody temperature of Proxima Centauri b is around 234K.



Left panel: the 11.2-day Doppler signal detected from the HARPS+UVES pre-2016 data (a) and the HARPS Pale Red Dot campaign (b), and in all data combined (c). Black lines correspond to the statistic, while the gray thick represent the logarithm of the Bayesian posterior density (see text, arbitrary vertical offset applied to for visual comparison of the two statistics). The horizontal solid, dashed and dotted lines represent a 10, 1, and 0.1 per cent false alarm probability thresholds of the frequentist analysis, respectively. (Anglada-Escudé et al., 2016)

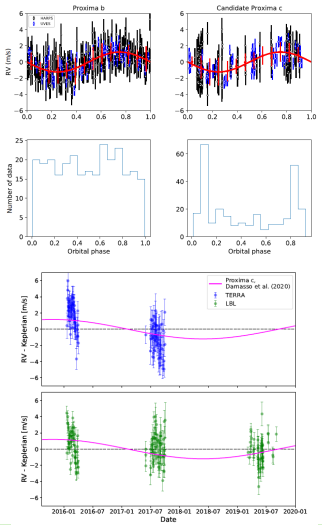


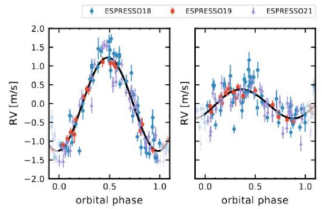
Right panel: radial velocity measurements from all datasets folded into the 11.2-day period. The black line represents the best Keplerian fit to this phase folded representation of the data. (Anglada-Escudé et al., 2016)

Other Planets Around Proxima Centauri?

In 2020, Damasso et al. reported the discovery of a potential new planet around Proxima Centauri, which is then named Proxima Centauri c. The orbital period of the planet is around 1900 days. While Damasso et al. looked optimistically to the confirmation of a new planet, a later study by Artigau et al. casts doubts over the existence of Proxima Centauri c, as its observational data could have originated from system effects of the telescope.

In early 2022, Faria et al. proposed another possible candidate planet of Proxima Centauri, the Proxima Centauri d, based on an earlier study on observational data of the star. The orbital period of Proxima Centauri d is around 5 days. Faria et al. estimated the mass of Proxima Centauri to be around 0.26 Earth mass, making it the lightest planet detected by the RV method so far if it exists.





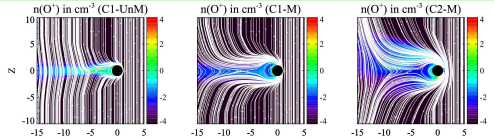
Upper left panel: phase-folded RV measurements and measurement distribution along the orbit of Proxima Centauri b (left) and c (right). (Damasso et al., 2020)

Lower left panel: residual time series for Proxima Centauri with the LBL and HARPS-TERRA datasets after subtracting the Proxima b and d Keplerian solutions of Faria et al. (2022) provided by Artigau et al. (2022). The inconsistency between the upper and lower panels provides evidence against the possibility for Proxima Centauri c.

Upper right panel: RV data phase-folded to the orbital periods of Proxima Centauri b (left) and d (right) provided by Faria et al. (2022).

Is Proxima Centauri b Habitable?

One of the most intriguing aspects of Proxima Centauri b is its habitability. Proxima Centauri b is exposed to strong stellar flare, magnetic field, UV flux and X-ray flux from Proxima Centauri, and may have been tidal locked to its host star. Despite these factors that prevent Proxima Centauri b from sustaining an atmosphere and liquid water on its surface, Anglada-Escudé et al. (2016) concluded optimistically that such factors are non-definitive in disproving the habitability of Proxima Centauri b. However, scientists have remained incredulous over the habitability of Proxima Centauri b. An atmospheric simulation by Dong et al. (2017) indicated that Proxima Centauri b may suffer strong atmospheric erosion from its host star, and thus may not be able to sustain a habitable environment for life to emerge. The habitability of Proxima Centauri b remains debated as of now.



The simulation results of Dong et al. (2017), showing the logarithmic scale contour plots of the oxygen ion density with magnetic field lines (white) for all three cases discussed in the work. The authors noted that their results show significantly larger atmospheric losses on Proxima Centauri b than that on the Earth regardless of the existence of a magnetic field.

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