What could the Extremely Large Telescope see at Proxima Centauri's planet?

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Artist's impression of the surface of the planet Proxima b orbiting the red dwarf star Proxima Centauri. The double star Alpha Centauri AB is visible to the upper right of Proxima itself. Credit: ESO

Proxima Centauri b is the closest exoplanet to Earth. It is an Earth-mass world right in the habitable zone of a red dwarf star just 4 light-years

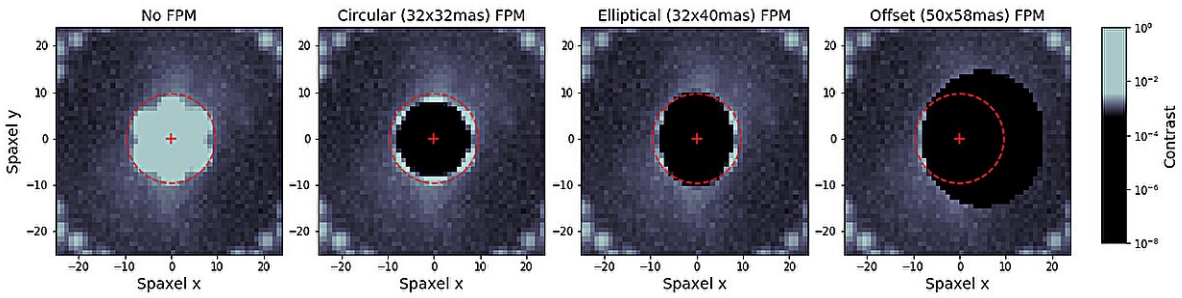
from Earth. It receives about 65% of the energy Earth gets from the sun, and depending on its evolutionary history could have oceans of water and an atmosphere rich with oxygen.

Our closest neighbor could harbor life, or it could be a dry rock, but is an excellent target in the search for alien life. There's just one catch. Our usual methods for detecting biosignatures won't work with Proxima Centauri b.

Most exoplanets are discovered through the transit method, where a planet regularly passes in front of its star from our point of view. We see the recurring dip in a star's brightness, and we know the planet is there. For transiting exoplanets, we can look for changes in the spectrum of the star as the planet transits.

Some of the starlight passes through an exoplanet's atmosphere, and some wavelengths get absorbed by the atmosphere. By looking at the pattern of absorption, we can fingerprint different molecules. This is how we've detected the presence of water, carbon dioxide, and other molecules in exoplanet atmospheres.

But Proxima Centauri b isn't a transiting planet. It was discovered by a different method known as Doppler spectroscopy. When we look at the light from Proxima Centauri, we can see its spectrum redshift and blueshift slightly over time. The gravitational pull of Proxima Centauri b makes the star wobble slightly. So we know the exoplanet is there, and have a good idea of its size and mass, but since it doesn't transit its star we can't observe its atmospheric absorption spectrum.



How different mask designs reveal the orbit of Proxima Centauri B (red dashed circle). Credit: Vaughan et al.

But a new study posted to the *arXiv* preprint server argues there is another way we might find life, using the reflection of starlight off the planet's atmosphere. In principle the idea is simple. Rather than looking for light passing directly through the atmosphere, look instead for light that has reflected off the planet directly. We've done this for planets such as Mars and the outer planets, which don't transit the sun, so we could do it for exoplanets as well.

The problem is that reflected starlight from a planet is tiny compared to the radiance of the star itself. Detecting the reflected light of a planet is like capturing the light of a firefly flittering near the edge of a spotlight. So astronomers have used masks to block the central brilliance of a star and see its family of planets. We have done this to directly observe large gas planets orbiting stars, but not Earth-sized worlds.

In this work, the authors look at the potential for the Extremely Large Telescope (ELT), currently under construction in Northern Chile. Specifically, they consider the High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph (HARMONI), which will be able to capture high-resolution spectra on the ELT. The

team simulated observations of Proxima Centauri using the masking effect to capture the light of its exoplanet. Is it possible for HARMONI to capture enough high-resolution data to discover biogenic molecules?

They found that the answer is no. In its current proposed configuration, the mask configuration is too large and will block most of the light from the exoplanet. But they also found that the configuration could be modified in such a way that the atmosphere of Proxima Centauri b could be studied. It isn't simply a matter of making the mask smaller, since that would allow more starlight to reach the ELT, which would wash out the exoplanet data. The team showed using simulations that making the mask smaller or offsetting it would allow Proxima Centauri b's atmosphere to be studied.

The modifications might affect other science HARMONI has planned and so a decision on this change has not been made yet. As our closest exoplanet neighbor, Proxima Centauri b is on the short list of worlds we will first visit as we send probes beyond our solar system. If it does have life, that would put it at the top of the list.

More information: Sophia R. Vaughan et al, Behind the Mask: can HARMONI@ELT detect biosignatures in the reflected light of Proxima b?, *arXiv* (2024). DOI: 10.48550/arxiv.2401.09589

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