Stellar Echoes: Searching for the Reflected Light of Exoplanets

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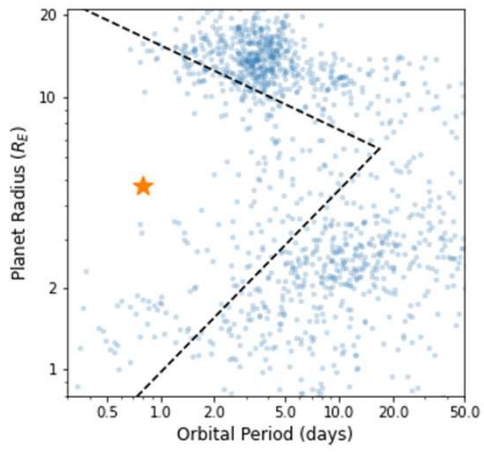
A timeline for reflected light studies of exoplanet atmospheres: Now…

Much can be learned from the reflection spectrum of an exoplanet, from the properties of its clouds to the energy budget and its climate. For Earth-like planets, the spectral features of key biosignatures such as Oxygen can be found in reflection.

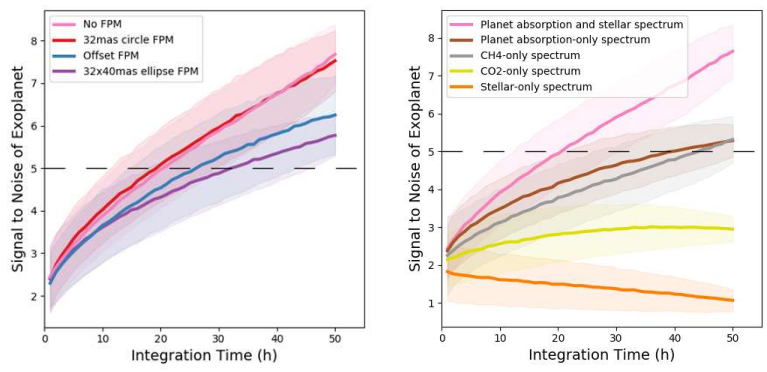
Today, due technological limitations, atmospheric characterisation of exoplanets largely focuses on short-period giant exoplanets. Most of these are studied in transmission and emission as these exoplanets typically have low albedos and so cannot be studied in reflection.

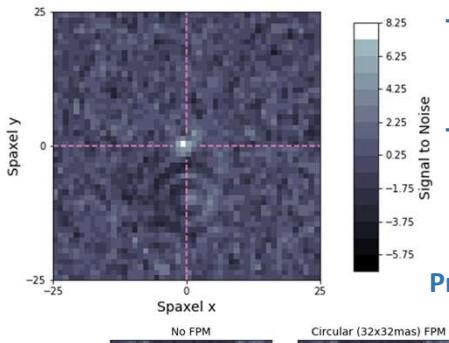
LTT 9779 b is an exception. This highly reflective world is a rare inhabitant of the photoevaporation desert, making its atmosphere is a bit of a puzzle. Studies of its clouds may help reveal how this world survives in the desert.

Vaughan et al. (in prep) uses 16.4-m ESPRESSO 4UT mode data to shed new light on its atmosphere and clouds using High-Resolution Cross-Correlation Spectroscopy. This work also demonstrates the techniques that will be used on Earth-like planets in the coming decades.



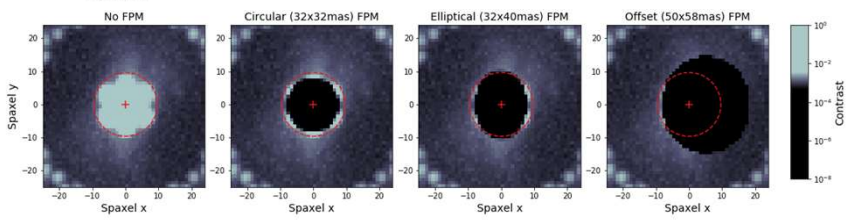
LTT-9779 b is an inhabitant of the Neptune desert and an unusually reflective planet.





The simulated S/N of the detection of Proxima b for:
Top left: different masking scenarios
Top right: different molecules with no focal plane mask

Left: An example detection of Proxima b without the focal plane mask.



The different masking scenarios investigated.

…2030s…

HARMONI is a first-generation integral field unit for the Extremely Large Telescope. It will measure the spectra of directly imaged exoplanets. If a planet is too faint, such as the potentially Earth-like Proxima b, these data can still be used to extract information on a planet using molecule mapping.

Vaughan et al. 2024 show that the reflected light of Proxima b can be characterised with HARMONI with sensitivity to biomarkers such as CH_4. However, the current focal plane mask is too large and covers the orbit of the planet. Different masking scenarios were investigated, and all were shown to lead to a detection of Proxima b. However, changing the mask must be weighed against other science cases.

Vaughan et al. 2024
https://doi.org/10.1093/mnras/stae242

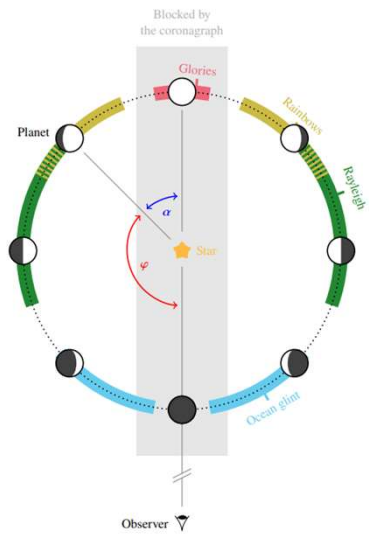
…2040+

The Habitable Worlds Observatory is a future coronagraphic space mission that will measure the reflected light flux of a planet as orbits its star.

Scattering phenomena create peaks in the flux at different planetary phases. If the coronagraph is not blocking the planet, they can be used to detect liquid water!

Vaughan et al. 2023 investigated how the size of the coronagraph affects the number of systems that can be observed at the right planetary phases.

Vaughan et al. 2023
https://doi.org/10.1093/mnras/stad2127



Interesting scattering phenomena may be lost behind the coronagraph.