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Exoplanet Spectro-photometry with Twinkle

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Abstract

Twinkle is a 45cm space telescope conceived to characterise extrasolar planets and Solar System objects over a broad wavelength range. From a sun-synchronous polar orbit vantage point, Twinkle's highly-stable instrument will allow the photometric and spectroscopic observation of a wide range of planetary classes around different types of stars, with a focus on bright sources close to the ecliptic. The planets will be observed through transit and eclipse photometry and spectroscopy, as well as phase curves, eclipse mapping and multiple narrow-band time-series.

1. Introduction

As of April 2018, over 3700 exoplanets have been discovered (nearly 3000 of which transit their stars) as well as 4500 Kepler candidate planets. On top of this, future surveys will detect thousands more. However, our current knowledge of their atmospheric, thermal and compositional characteristics is still very limited.

Twinkle, is a space science observatory equipped with a visible (0.4 - 1μm) and infrared (1.3 - 4.5μm) spectrometer (split into two channels at 2.42μm), designed to be launched within three to five years. Twinkle will operate in a low Earth, Sun-synchronous orbit and provide on-demand observations of a wide variety of targets within wavelength ranges that are currently not accessible using other space telescopes or accessible only to oversubscribed observatories in the short-term future.

The ability of Twinkle's infrared spectrometer to characterise the currently known exoplanets has been assessed. The spectral resolution achievable by combining multiple observations has been studied for various planetary and stellar types. Spectral retrievals have been simulated for some well-known planets (HD 209458 b, GJ 3470 b and 55 Cnc e).

TESS is predicted to find more than 4500 planets around bright stars [3] and Twinkle's capability to observe these potential future detections has also been studied.

2. Methodology and Results

Over 500 currently known transiting exoplanets lie within Twinkle's field of regard and the ESA radiometric model [2, 4] has been adapted to Twinkle's instrumentation to calculate its performance for each of these planets. A science requirement of SNR > 7 has been assumed and the resolution achievable with a given number of transit or eclipse observations determined [1]. This first iteration of assessing Twinkle's performance for exoplanetary science has shown that many planets are potentially observable with Twinkle and the achievable resolutions for a given number of transits/eclipses is shown in Figure 1.

In this study it is found that a large numbers of targets could be studied with simple photometry in a single observation. Simultaneous photometric measurements in the optical and infrared would allow for rigorous constraints on the planetary, stellar and orbital parameters of a system as well as precise measurements of transit timing variations (TTVs) present in some multi-planet systems.

Twinkle observations at higher spectral resolution will enable to probe atmospheric chemical and thermal properties, with the potential to revisit them many times over the mission lifetime to detect variations such as non-uniform cloud cover.

From the catalogue of predicted TESS detections it is found that the number of planets suitable for photometric follow up could triple whilst, for spectroscopy, the number of targets could double.

Spectral retrievals with Twinkle have been simulated using Tau-REx and Figure 2 shows the spectra obtained for 55 Cnc e assuming 10 eclipse observations.

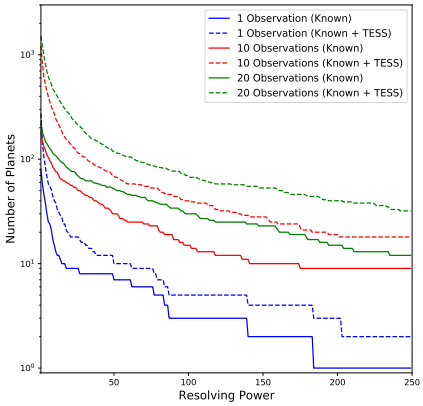

Figure 1: Number of known and predicted TESS planets with Twinkle's field of regard for which SNR > 7 is achievable at a given resolving power

3. Summary and Conclusions

From the exoplanets known today it has been found that Twinkle could probe a large number of planets. Further surveys will reveal thousands of new exoplanets, of which many will be located within Twinkle's field of regard. TESS in particular is predicted to discover many targets around bright stars which will increase the number of exoplanets Twinkle could observe and simulated TESS detections have been analysed to confirm this.

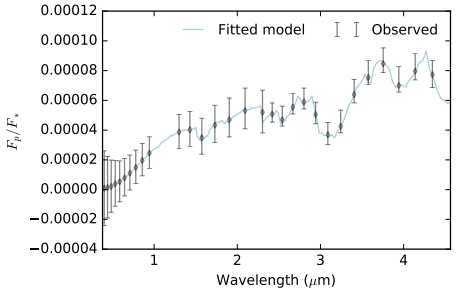

Figure 2: Spectra retrieved for 55 Cnc e (cloud free, CO = 1x10^{-3}, C_2H_2 = 1x10^{-5}, HCN = 1x10^{-5}) at R = 10 ($\lambda < 2.42\mu$m) and R = 20 ($\lambda > 2.42\mu$m) with 10 eclipse observations

Acknowledgements

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