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Characterising the Atmospheres of Transiting Planets with a Dedicated Space Telescope

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Abstract

The Exoplanet Characterisation Observatory (EChO) [1] is in ESA assessment phase for a M3 category mission launch in 2022. The mission will observe known transiting exoplanets with the infrared spectroscopy technique for a wide selection of planet types, from hot, close-in Jupiter like planets, to temperate super-Earths in the Habitable Zone of M dwarfs [2]. Our previous study offered a first estimate of the integration times needed, with defined SNR and resolution values in specific wavelength bands, to characterise the atmosphere of these of planets. In this paper we present a study of the full wavelength range of EChO and what signal to noise can be obtained for our target types in two steps: with a fixed SNR value to measure the strength of each molecular feature, and at varying distances and observing durations.

1. Introduction

The science of extra-solar planets is one of the most rapidly changing areas of astrophysics, a combination of ground-based surveys and dedicated space missions has resulted in 760 plus planets being detected (exoplanet.eu, May 2012), and over 1200 that await confirmation [3]. NASA's Kepler mission has opened up the possibility of discovering Earth-like planets in the habitable zone around some of the 100,000 stars it is surveying during its 3 to 4-year lifetime. The new ESA's Gaia mission is expected to discover thousands of new planets around stars within 200 parsecs of the Sun [5]. Meanwhile, transit and combined light methods have allowed the characterisation of the atmosphere of a few hot large bodies close to their star using current space telescopes, e.g. [6, 7, 8, 9] and ground based telescopes [10]. Transiting hot super-Earths, while being very interesting targets since they are absent from our Solar System, are within reach with current telescopes, e.g. GJ 1214b [11], and Cancri 55 e.
We present a study on the detectability of a wide range of molecules in the atmospheres of three planet types:

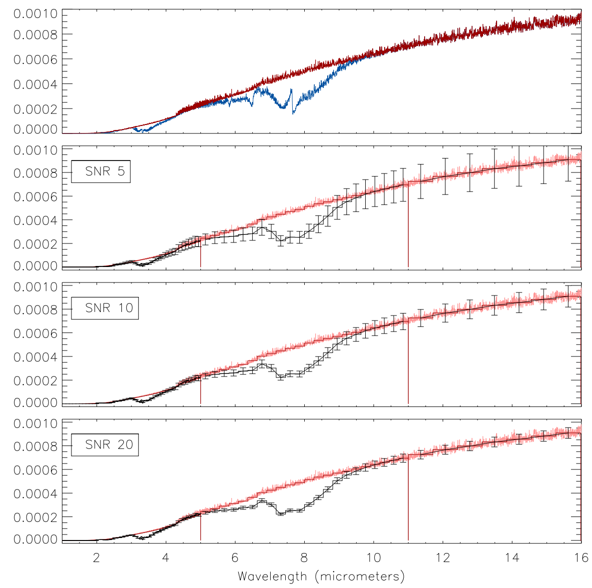

Figure 1: Example of the signal of Methane with abundance of 10^{-5} for a warm Neptune planet like GJ 436b, with fixed SNR values of 5, 10 and 20 for all the resolution bins. Fixing the SNR values allows us to focus on the molecular feature strength.

hot Jupiter, warm Neptune and temperate super-Earth with a dedicated space mission like EChO. The results are presented in two parts: in a first case the change in SNR based on target distance is explored, and in a second part we fix the SNR to study the signal strength of specific molecular features.

2. Results

Here we briefly show results for a warm Neptune like GJ 436b [4], with first in Figure 1 the signature of Methane with an abundance of 10^{-5} with signal strength varying between SNR 5 and 20. Fixing the SNR allows us to understand the unique contribution of the molecule in signal strength, and we do this exercise for a multitude of molecules. We also study the contribution of target distance and observation length, see Figure 2.

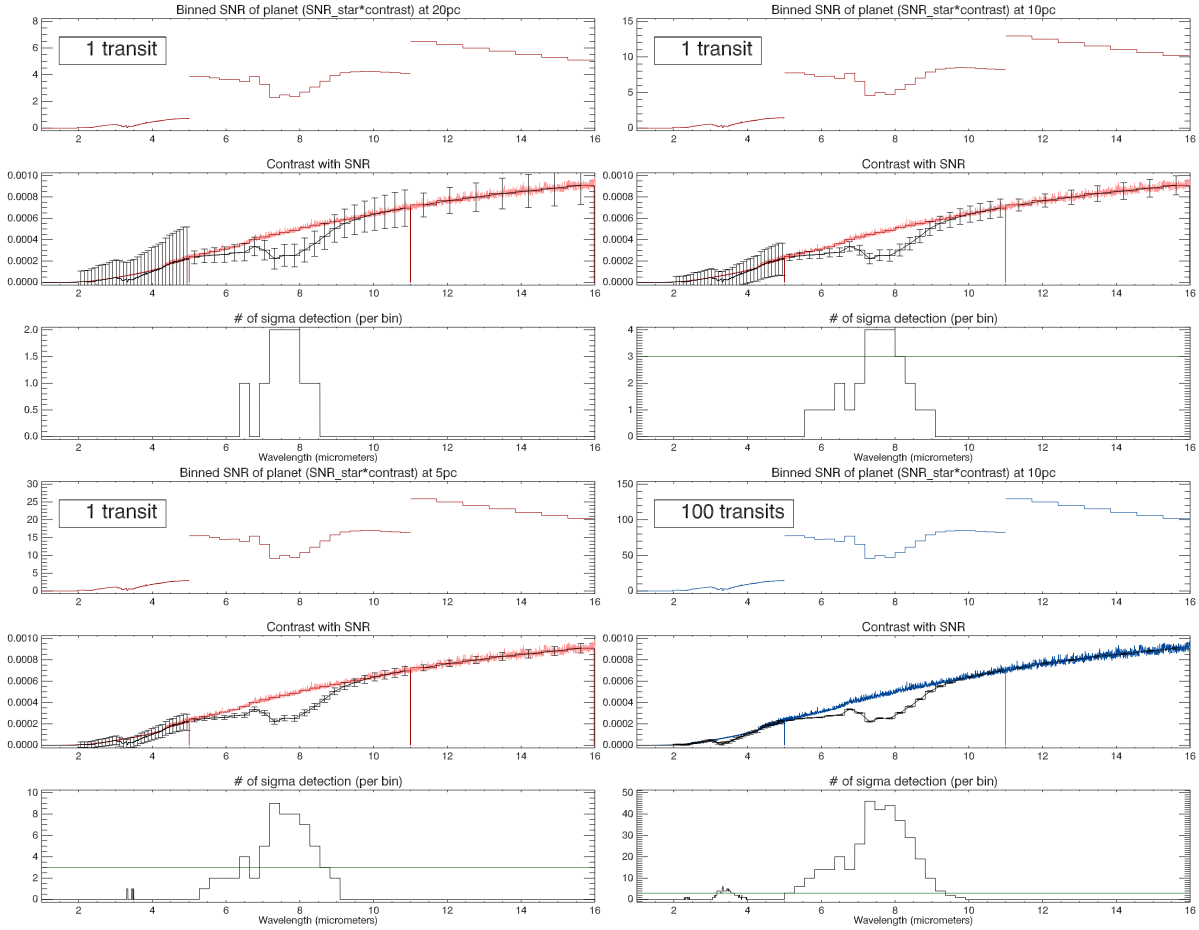

Figure 2: Methane with abundance 10^{-5} in the atmosphere of a GJ 436b like planet, observed with 1 transit at distances of 20, 10 and 5pc (red), and 100 transits at 10pc (blue). The SNR for the planet increases as the target is located closer.

3 Summary

In this presentation we will show what level of characterization can be expected of a mission like EChO for variety of planet types and selection of molecules. Similar results will be shown for hot Jupiters and temperate super-Earths.

References

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