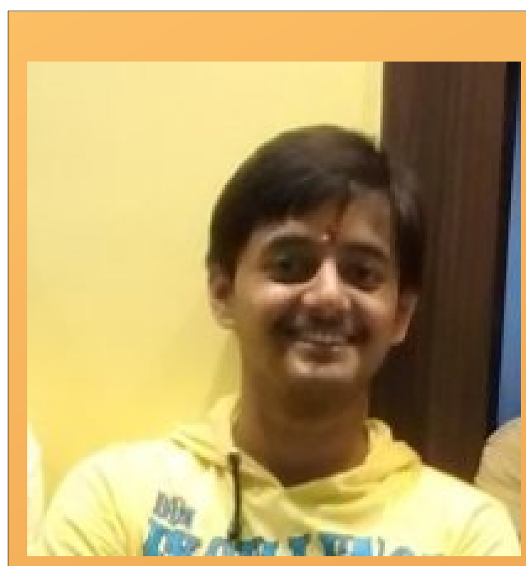

Planetary atmospheres characterised by CHEOPS and TESS in the presence of stellar activity

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ABSTRACT : The Transiting Exoplanet Survey Satellite (TESS) will certainly provide a collection of exoplanets around nearby bright stars, and the CHaracterizing ExOPlanet Satellite (CHEOPS) will be useful for follow-up studies. Due to their operations in different pass-bands, the apparent planetary radius measured with the two instruments may differ if the planet has an atmosphere[1] and/or the host star is active. In this respect, we study the fractional difference in the transit depth in the two pass-bands of CHEOPS and TESS as function of the atmospheric properties of exoplanets and stellar activity of the host stars.

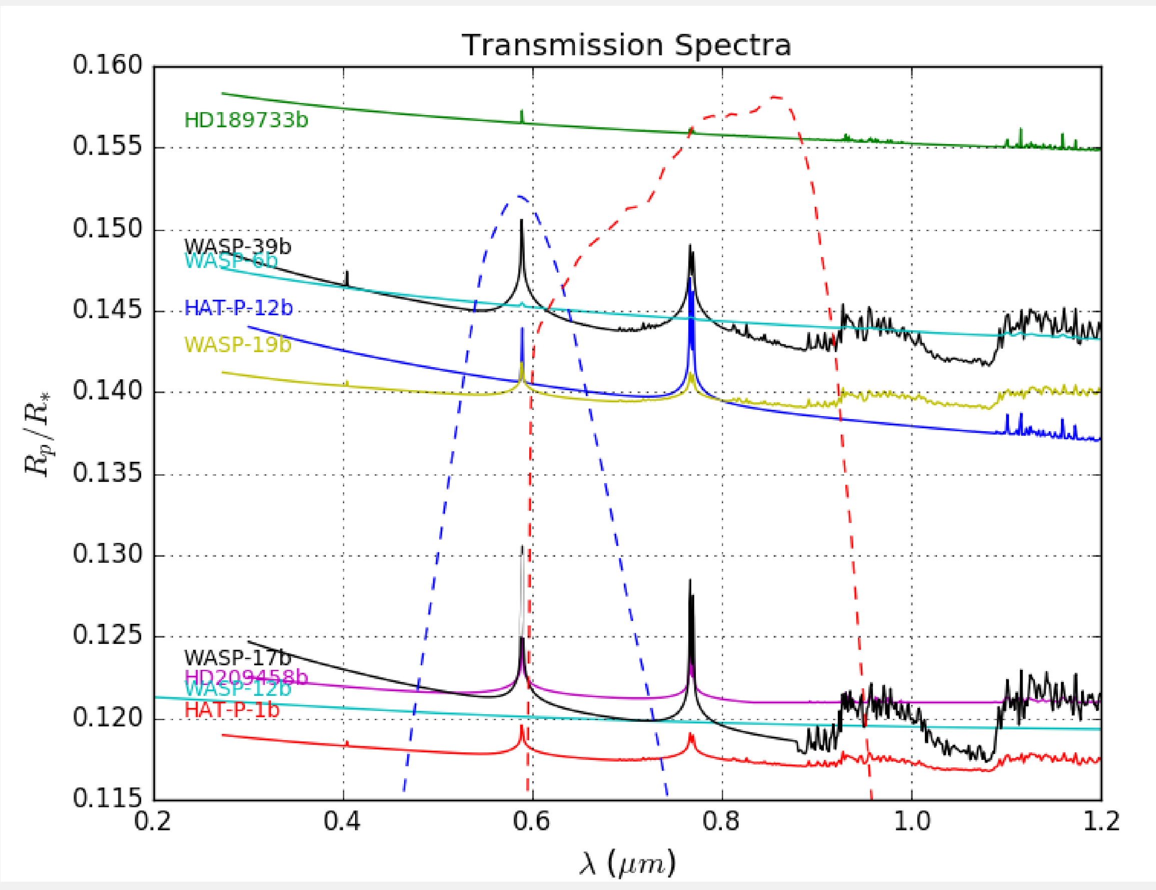


Fig 1. D. Sing's catalog of exo-atmospheres[3]. Blue and red dashed lines are the CHEOPS and TESS response functions respectively (scaled down).

Method

- Transit light curves provide information on the relative planetary radius $k=R_p/R_*$.
- Rayleigh scattering in the atmosphere makes k wavelength dependent, especially in the visible part of the spectrum.
- Observations of transit depths in different pass-bands can differ depending on the extent of Rayleigh scattering and the size of the atmosphere.

$$Diff = \frac{k_{Cheops} - k_{Tess}}{k_{avg}} \times 100\%$$

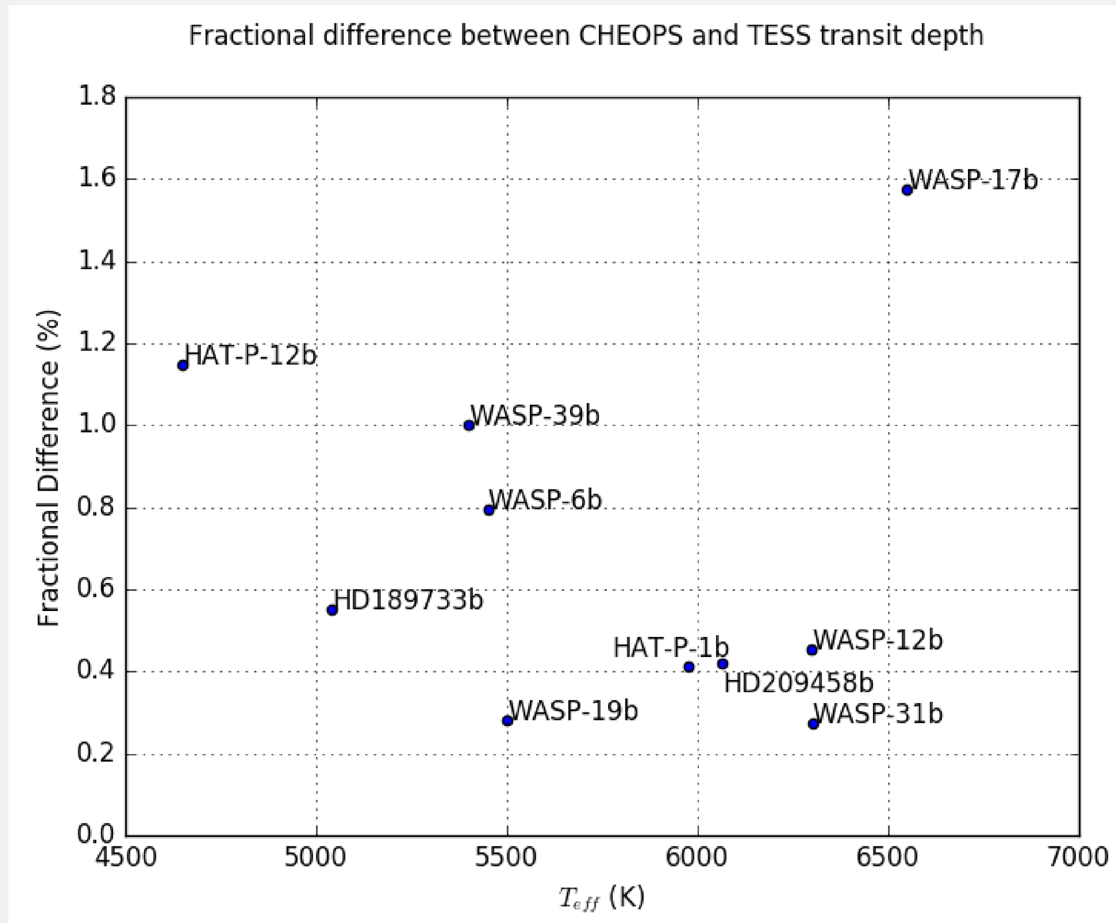
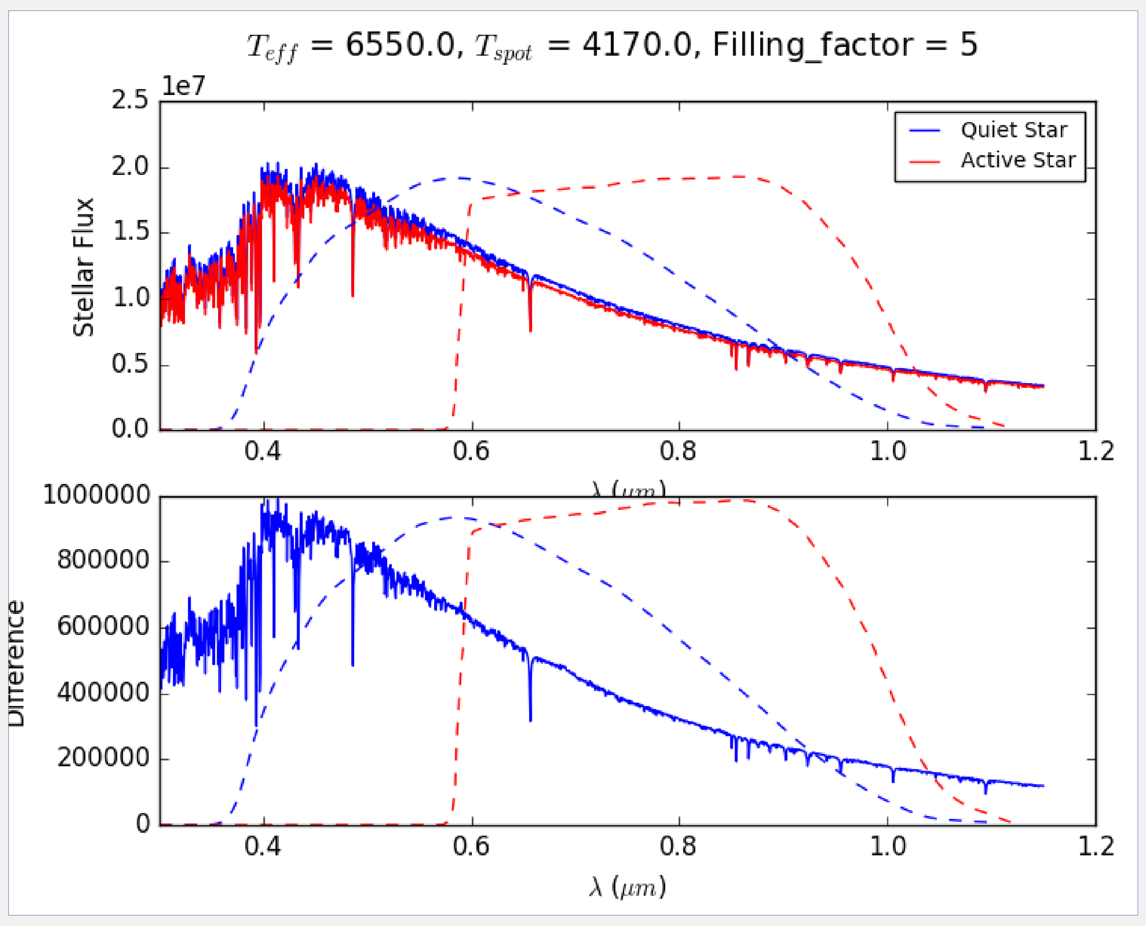


Fig 2. Fractional difference vs host star's effective temperature for the planets in Fig. 1.

Rayleigh scattering or stellar activity?

- Spots on stellar disk modify the overall stellar spectrum (Fig. 3).
- The effect of stellar activity, if not taken into account, may be mistaken as a signature of the atmosphere of exoplanets.
- For a given exoplanet and its atmosphere, the difference between CHEOPS and TESS increases with increasing T_{eff}. On the other hand, the effect of activity decreases with T_{eff} (Fig. 4).
- With our simulations, the difference between CHEOPS and TESS is expected to be maximized when the atmosphere is characterized by strong Rayleigh scattering. For example, in Fig.5 we show the effect of an atmosphere with scattering particle's size of 0.5 μm.

Fig 3. Stellar flux in units of ergs/sec/cm²/A for a quiet star and a spotted star[2]. CHEOPS and TESS responses are scaled up accordingly.



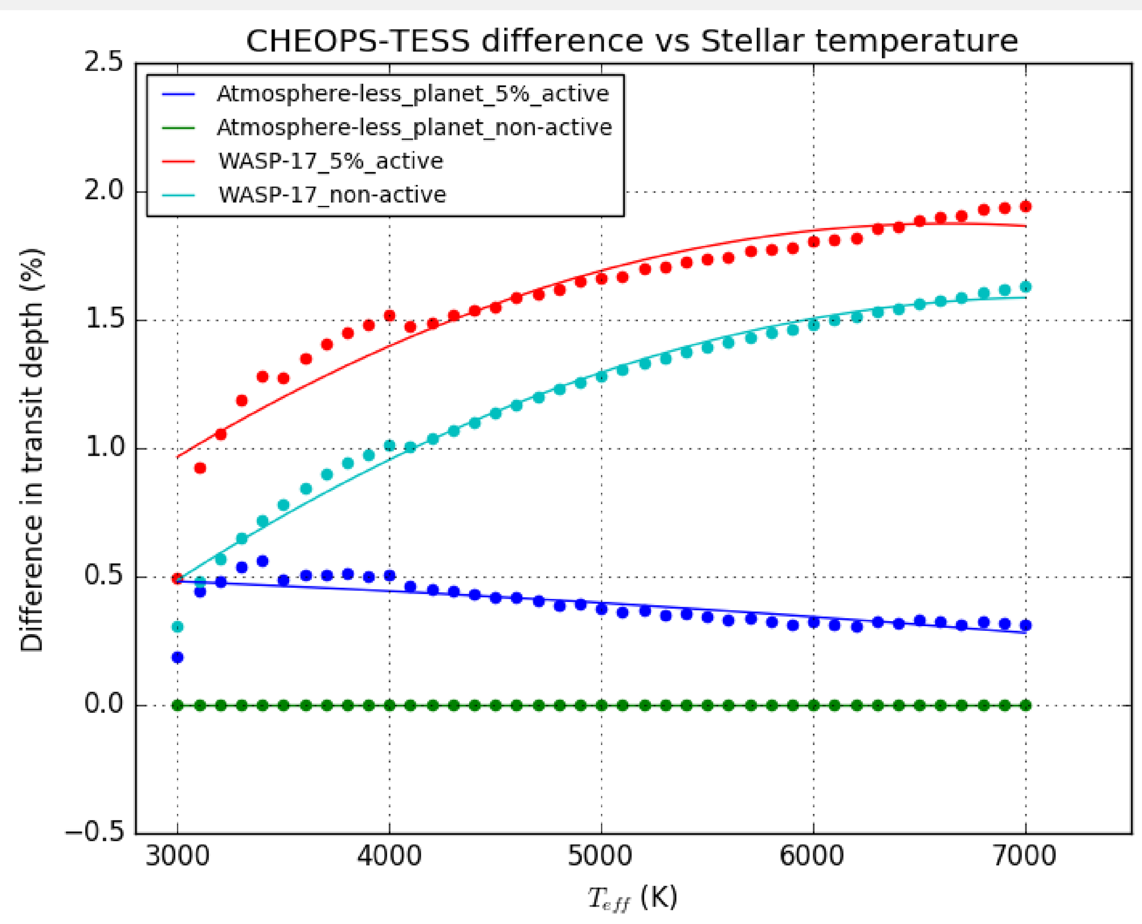
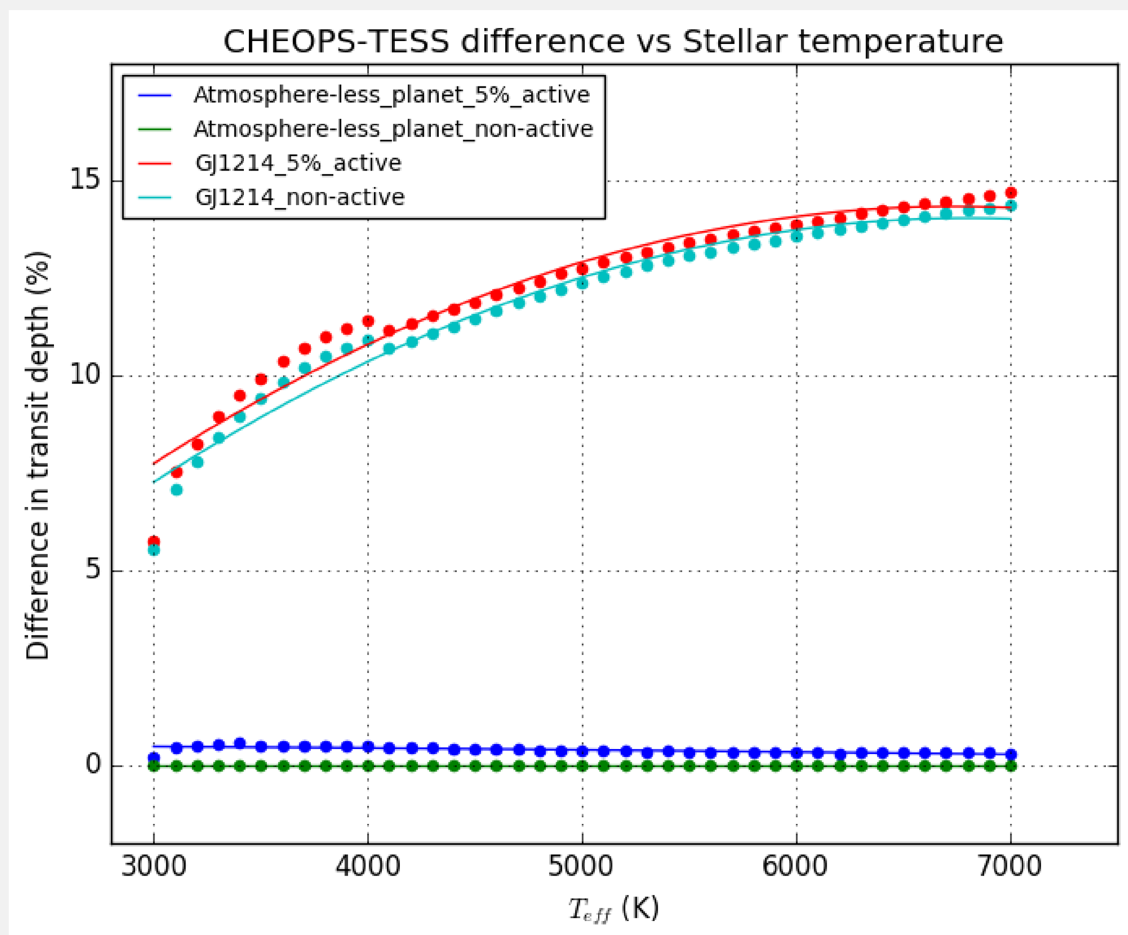


Fig. 4 Simulations for a planet with fixed k=0.129 in the V band, orbiting main sequence stars with different T_{eff}. Here we assume the WASP-17b-like atmosphere. "Rock" implies an atmosphere-less planetary disk. The error bar is computed simulating the WASP-17 system (V=11.6, Spectral type G0) with CHEOPSim.

Fig. 5 Same as in Fig.4, for k=0.11 using the GJ1214b-like synthetic atmosphere with particle's size of 0.5 μm[1].



CONCLUSION

- We did our calculation using D. Sing's spectral library of atmospheres of hot-jupiters[3]. The maximum difference that we find for the list of shown planets is 1.57% (WASP-17b). We also find that the CHEOPS-TESS transit depth difference is too small to detect in most cases. In a few favorable cases, where the planet to star radius ratio is large and the star itself is bright enough, this difference can be measured above the uncertainties.
- For moderately active stars, the major source of the CHEOPS-TESS difference is attributed to Rayleigh scattering in the exoplanetary atmosphere, while the effect of stellar activity is within 0.3-0.4% with 5% spot coverage. Therefore, the effect due to the planetary atmosphere and the stellar activity can be distinguished if the *k* factor is measured with an accuracy of a few percent.
- Our simulations show that this technique is applicable for planets with large planet-to-stellar radius ratio around low-activity F-G stars.

Acknowledgement

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