Motivation

Most of the attempts to characterize exoplanetary atmospheres have been performed through the use of transmission spectroscopy (multiband photometry) of transiting exoplanets. In transmission spectroscopy, observations of the planetary transit in different wavelengths allow us to determine the planet-to-star radius ratio as a function of color (and thus the planetary radius if the stellar radius is known). The inferred variation in the planet-to-star radius ratio as a function of wavelength can then be interpreted as due to the presence of differential absorption in the planetary atmosphere.

In most transmission spectroscopy studies, however, the impact of stellar activity on the estimate of the planetary radius has not been taken into account. Only in a few cases the influence of “non-occulted” stellar spots (spots that are not occulted by the planet during the transit) was considered (Knutson et al. 2011, Pont et al. 2007; Sing et al. 2011).

The main objective of this paper is to examine the possible impact of the presence of stellar activity features, such as spots and plages, on transmission spectra. In particular, and for the first time, we explore the presence of differential absorption in the planetary atmosphere.

Simulating activity

In the figures below we show the results of simulations intended to evaluate the effect of the occultation of stellar active regions (spots and plages) on the measurement of planet radii as a function of color. Top panel shows the results for a M-dwarf star, while the lower panel for a G-dwarf. Different configurations of spots and planet radii are considered (Oshagh et al. 2014).

The simulations show that an overestimation on the planet to star radius ratio can be quite considerable (10%) if plages are present, particularly in the blue side of the spectrum, where the stellar active regions show the higher contrast. The results suggest that stellar spot/plages may play a very important role in the interpretation of the results.

HD 189733b and GJ 3470b

To demonstrate the application of our idea, we showed that transmission spectroscopy measurements of the active stars HD 189733 and GJ 3470, and especially the derived excess of the planet radius observed in the bluer part of the spectrum (Sing et al. 2011, Pontet al. 2013, Nascimbeni et al. 2013), can almost exactly be reproduced by assuming the occultation of active regions (plages) by the planet during the transit.

We found that the observed transmission spectrum of HD 189733b can be reproduced simply by considering the overlap of HD 189733b with a stellar plage with filling factor of 1.96% and a temperature contrast of 100 K with respect to the stellar photosphere (see figure below, left).

The plage’s filling factor which was needed to justify the observed excess planet radius of GJ470b is around 2.56% with a temperature contrast of 100 K with the stellar photosphere (see figure below, right). These results are discussed in Oshagh et al. (2014).

To address this problem we propose future observers to observe multiple transit events at a given wavelength. This will likely allow to monitor the variations of transit depth as a function of time, and access the impact of potential stellar spot/plage occultations. We note, however, that in the case of a very active star all transits could be affected by the occultation of active regions. Alternatively, simultaneous multiband photometric observations for several hours before and after the transit could help us to disentangle the effects of stellar activity from real planet radius variations. In the figure below we show one simulation of in and out of transit flux variations expected in different bands, if a spot is present in the stellar photosphere of a rotating star (Oshagh et al. 2014).

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