Role of the impact parameter in exoplanet transmission spectroscopy

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Introduction – The impact parameter degeneracy

There are cases of reported discrepancies in the literature concerning the atmospheric characterization of exoplanets. One effect that can contribute to the inconsistencies is the degeneracy of the impact parameter, ***b***, with the optical slope.

$$b = \frac{a_{semi}}{R_*} \cos i$$

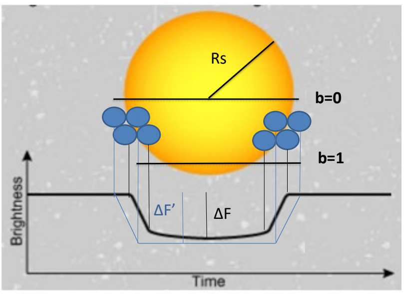


Fig. 1: The impact parameter of the system and its role in the obtained light curves during a transit event

Impact Degeneracy driven by the Limb Darkening !

Methods

- Synthetic light curve fit with transit models of deviating impact parameters
- Fixed parameters with combinations of the inclination, ***i***, and the semi major axis in units of stellar radii, a_{semi}/R_s
- Fixed all parameters except R_p/R_s and the period

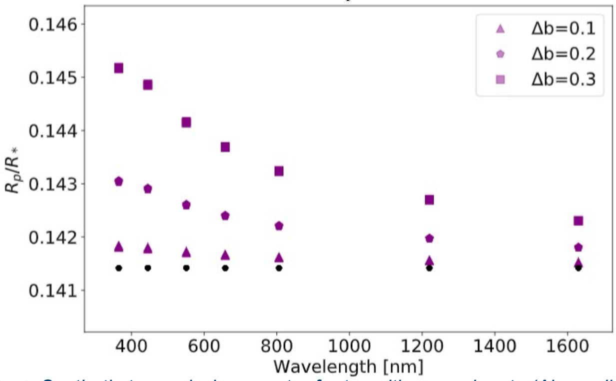
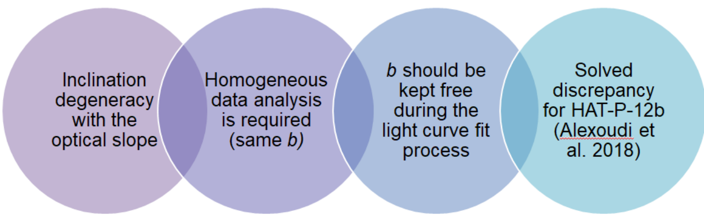


Fig. 2: Synthetic transmission spectra for transiting exoplanets (Alexoudi et al. 2020). We show the spectral slopes derived with fixed orbital parameters in combinations that yield the same impact parameter. The symbols indicate different values of b. *Nine such configurations overlap in three sequences according to their Δb deviation from the original setup (black dots).*

Conclusions



References

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Results

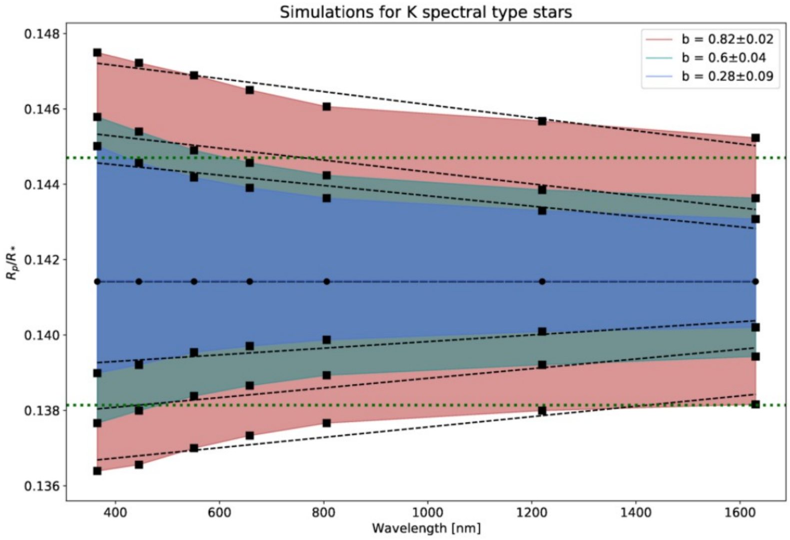

Fig. 3 Effect of b +/- Δb on the transmission spectra of three different groups of exoplanets, showing an introduced slope and an offset for different b values (Alexoudi et al. 2020). Black dots show the synthetic spectra of each subgroup, and black squares show the respective derived spectra with the variation in b. The colored areas illustrate the error envelope for each case. Dashed black lines show the linear regression fits on each spectrum, and dotted green lines indicate two atmospheric scale heights from the predefined input value for R_p/R_*.

The only fully explained case

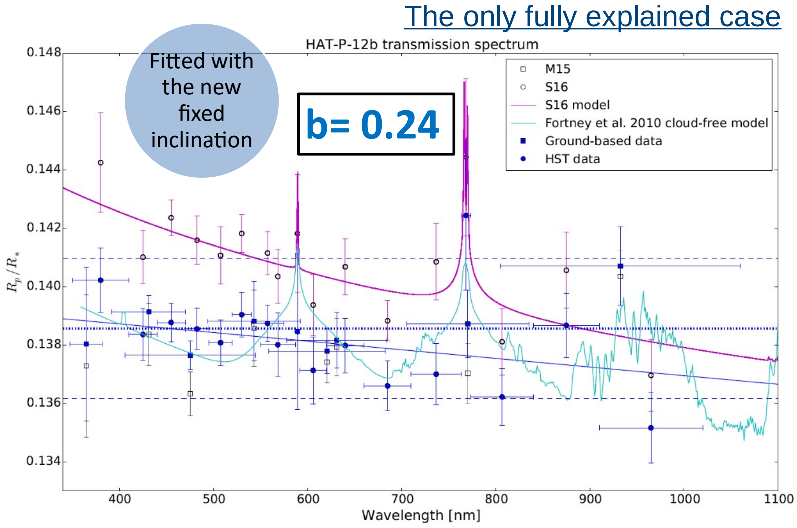

Fig. 4: The transmission spectrum of HAT-P-12b as derived from the homogeneous re-analysis of all data from the ground and from the HST with their associated error bars (Alexoudi et al. 2018). For reference, we over-plotted the values obtained by Mallonn et al. 2015 (M15 - black empty squares). The blue dashed lines show plus-minus two scale heights from the weighted average value of k (blue dotted line). In magenta, the values of Sing et al. 2016 (S16) are given together with the suggested atmospheric model (magenta solid line). Over-plotted as cyan solid line is a cloud-free, solar-composition model of HAT-P-12b from Fortney et al. (2010) for comparison. The blue solid line is a linear regression of the weighted k values.