

CHOCOLATE: a new Chromatic Line-Profile Tomography Technique to retrieve Transmission Spectroscopy

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Introduction

When a planet transits its host star it introduces anomalies in the spectrum line-profiles. During transit, these anomalies are reflected in the cross-correlation functions of the spectra (CCFs) and can be related to the planet-star radius ratio through line-profile tomography (LPT). In this way, CHOCOLATE is a chromatic LPT method able to retrieve transmission spectroscopy based on the spectral line distortions produced by the planet and reflected in the CCFs.

Methodology

CHOCOLATE structure can be summarized in 3 sections:

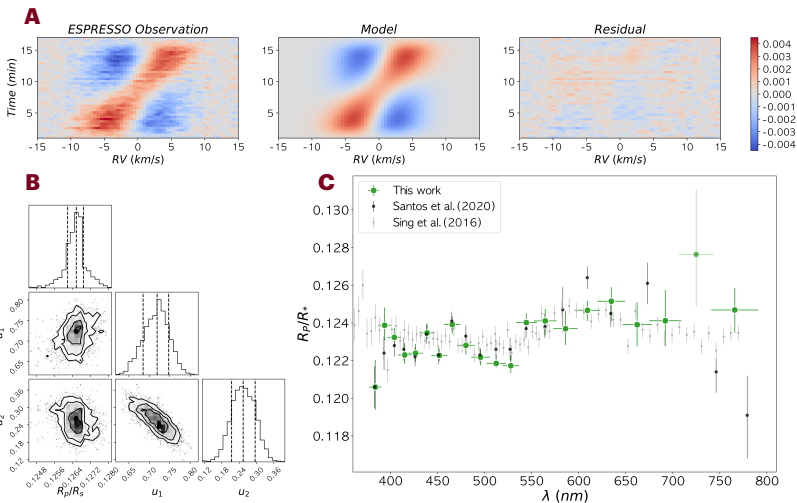
Data Analysis: The data is prepared for a chromatic LPT fitting (see Fig. A, left).

Modeling: LPT models are generated using SOAP tool, which is a software able to simulate the effect of a transiting planet around an active star (see Fig. A, middle).

Fitting: An MCMC fitting procedure is used to fit the SOAP models generated to the observational data (Fig. A), in order to estimate the planet radius in different wavelength bins. During the fitting, the planet-star radius ratio and the limb darkening coefficients are left free (Fig. B).

Data Analysis

We applied CHOCOLATE method to HD209458b planet data from ESPRESSO spectrograph as a reliability test of our method.



We performed the following steps to prepare the data for the chromatic LPT fitting:

1. Normalization of the CCFs.
2. Subtraction of the Keplerian motion of the star.
3. Definition of the wavelength bins.
4. Generation of the master CCF from out-of-transit CCFs.
5. Subtraction of the master CCF.
6. Error estimation.

(Find each step and the methodology detailed in Esparza-Borges et al., 2021)

Conclusions

- We developed CHOCOLATE method, which is a technique based on physical modeling of observational data, and validated its performance obtaining the transmission spectrum of HD209458b (Fig. C).
- The retrieved transmission spectrum agree with previous results obtained by different methodologies, i.e., chromatic R-M (Santos et al. 2020 using the same ESPRESSO data) and multiband photometry (Sing et al. 2016 using HST STIS data) (Fig. C).
- An atmospheric retrieval on our results suggest a hint of detection of H₂O and NH₃.
- CHOCOLATE will be particularly interesting for exoplanets orbiting around young active or moderate/fast rotating stars.

Find CHOCOLATE method and HD209458b analysis detailed in:
Esparza-Borges et al. (2022)

[A&A, Vol. 657, A23](https://arxiv.org/abs/2205.12345)

<https://arxiv.org/pdf/2110.02028>

References

Esparza-Borges, E., et al., 2022, *A&A*, Vol. 657, A23
Santos, N., et al, 2020, *A&A*, Vol. 644, A51
Santos, D.K., et al, 2016, *Nature*, Vol. 529, 7584
SOAP: Boisse et al. (2012); Oshagh et al. (2013); Dumusque et al. 2014

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