Transmission spectroscopy of WASP-7 b with UVES

Detection of Na I D_2 and tentative D_1 line absorption

Hossein Rahmati

Hossein Rahmati[1,2], Stefan Czesla[3], Sara Khalafinejad[4], and Paul Mollière[5]

Abstract

- The hot Jupiter WASP-7b orbits an F-type star, HD 197286, with an orbital period of 4.954 days. The planet shows an obliquity of 86 °± 6°, and has an equilibrium temperature of 1530 ±45 kelvin.
- The high-resolution transmission spectroscopy has allowed the individual Na I line to be resolved and provides the Na D lines a powerful probe to constrain the upper atmosphere. We used this technique to study the atmosphere of WASP-7 b via the Na D lines.

Data and methods

- We analyzed a spectral transit time series of 89 high-resolution spectra of the Ultraviolet and Visual Echelle Spectrograph (UVES).

a. We used the telluric lines for an accurate alignment.

b. We carried out a telluric correction with molecfit.

c. Stellar magnetic activity investigated by the Ca II H and K, and Hα lines.

d. Center-to-limb variation (CLV) and Rossiter-McLaughlin (RM) effects modeled using synthetic spectra.

e. Transmission light curves derived in 0.45 Å wide passbands.

f. Transmission spectrum obtained by weighting average residual spectra.

Results

- The star shows no identifiable flares.
- The transmission spectra and light curves show signs of the CLV and the RM.
- Na I D_2 line: We detect a line contrast of 0.50 ± 0.06% (at ∼8.3σ level) and a FWHM of 0.13 ± 0.02 Å.
- Na I D_1 line: We derived a line contrast of 0.13 ± 0.04% (at ∼3.2σ level), which is considered a tentative detection.

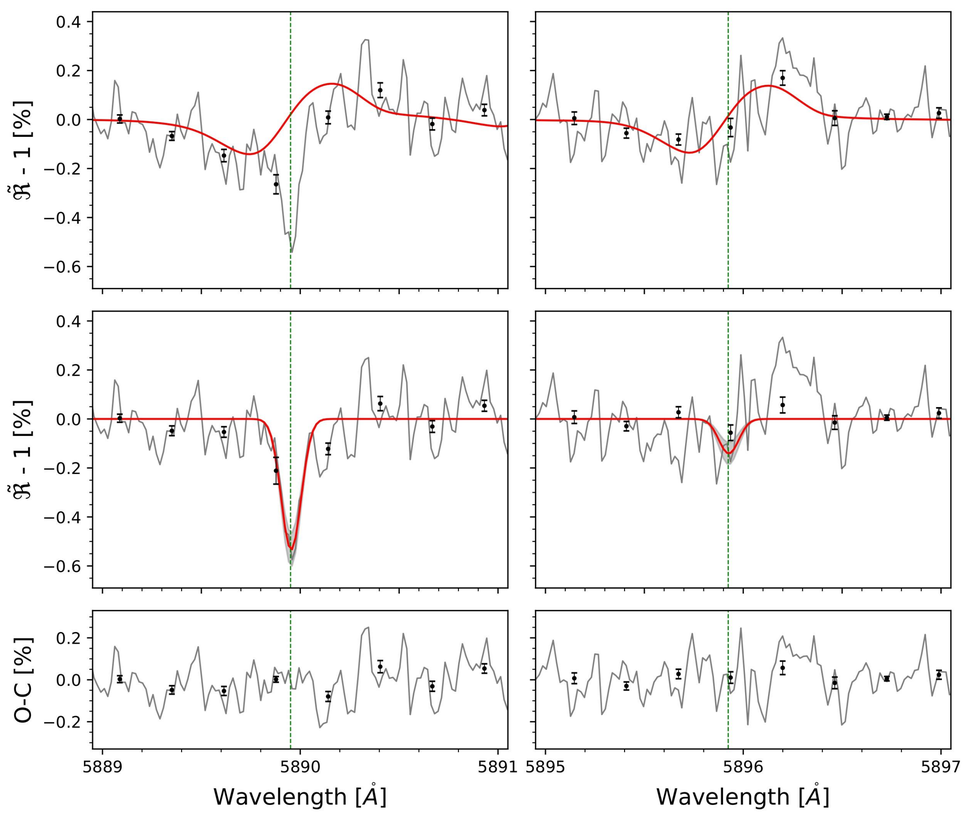

Fig. 1. Transmission spectrum of Na I D_2 *(left column)* and Na I D_1 *(right column)* lines. Top panels: observed transmission spectrum (gray), with best-fit model representing the CLV and RM effects (solid red). Middle panels: observed transmission spectrum with the best-fit Gaussian absorption (red), and with the model shown in the upper panels subtracted (gray). The gray shades indicate 1σ uncertainty. Bottom panel: Residuals of the best-fit model. The black data points correspond to binning by a factor of 15.

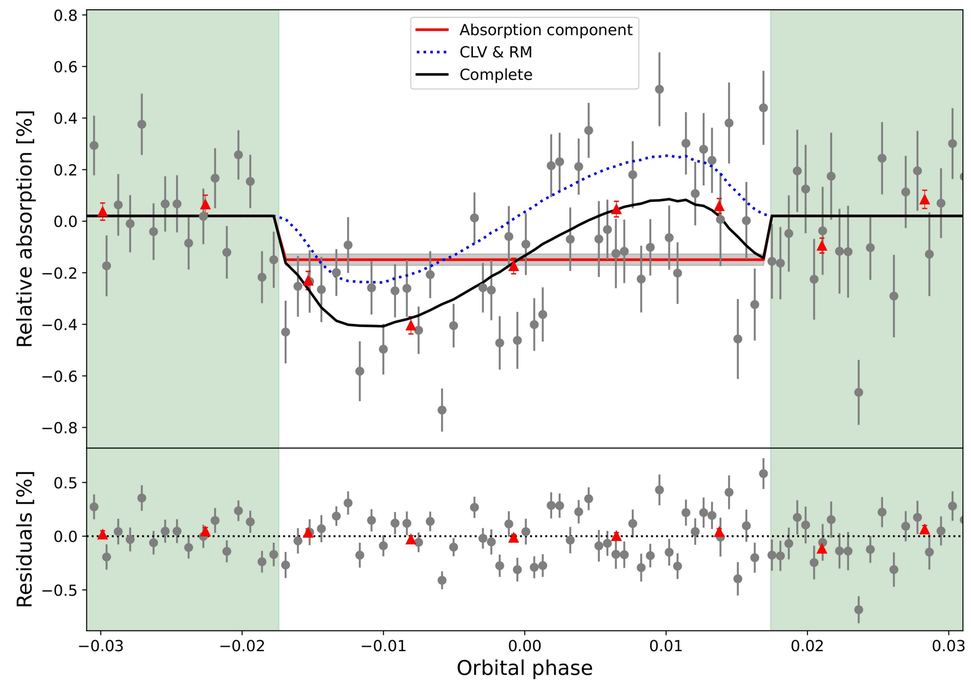

Fig. 2. Transmission light curves of WASP-7 b around the Na I D_2 line. Top panel: Observation transmission light curves (gray) and modeled transmission light curves of the RM and the CLV (dotted blue line) for the 0.45 Å integration band centered on the Na I D_2 line. The dashed red line is the absorption component using a box model, and the gray shades denote its 1σ uncertainty. The solid black line is the best-fit combined model and the red points show binning by a factor of ten. Bottom panel: Residuals for binned and unbinned data. Green shades indicate out-of-transit time throughout.

Comparison to other Na I D_2 signal

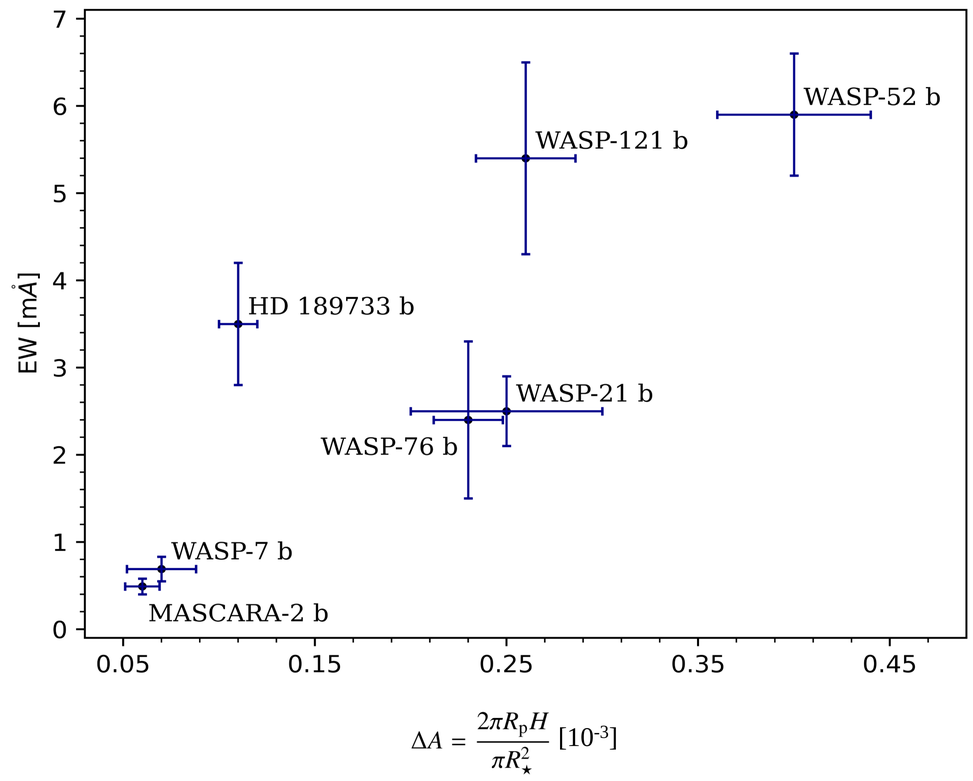

Fig. 3. Comparison of excess absorption as measured by the EWs of Gaussian fits to the D_2 line with the fractional atmospheric coverage coverage ΔA.

Conclusion

Transmission spectroscopy is one of the prime techniques to study the atmospheric composision of exoplanets. We used this technique and studied the atmosphere of WASP-7 b via the Na D lines. The PLATO mission will launch soon and will discover small planets in the habitable zone of Sun-like stars. Therefore, follow-up observations of these planets are key to study their atmospheric composition and to search for a possible sign of life.

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1 Department of Physics and Astronomy, Heidelberg University, Germany
2 Department of Physics, Bu-Ali Sina University, Hamedan 65178, Iran
3 Thüringer Landessternwarte Tautenburg, Sternwarte 5, 07778 Tautenburg, Germany
4 Landessternwarte, Zentrum für Astronomie der Universität Heidelberg, Königstuhl 12, 69117 Heidelberg, Germany
5 Max-Planck-Institut für Astronomie, Königstuhl 17, 69117 Heidelberg, Germany

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E-mail: hossein.rahmati@stu.uni-heidelberg.de