Origins: From the Protosun to the First Steps of Life
Proceedings IAU Symposium No. 345, 2018
B. G. Elmegreen, L. Viktor Tóth & M. Güdel, eds.

doi:10.1017/S1743921319002953

Modeling the Transmission Spectra of WASP-31b

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Abstract. Wasp-31b is a planet of 0.48 Jupiter masses and 1.55 Jupiter radii, with orbital period of 3.4-days around a metal-poor, late-F-type, V = 11.7 dwarf star. The planet has a large atmospheric scale height that makes it a good target for transmission spectroscopy. Sing *et al* (2014) presented an optical and near-IR transmission spectrum of the atmosphere of WASP-31b obtained with the HST and show the presence of a strong potassium line. In contrast, Gibson *et al.* (2017) reports a spectrum of the atmosphere of WASP-31b, obtained with the FORS2 instrument on the VLT and find that there is no strong potassium line. Here, we take those two datasets and, using models, we try to find a case where both solutions are correct by considering different cloud scenarios.

Keywords. planets and satellites: atmospheres - planets and satellites: composition - planets and satellites: individual (WASP-31b)

1. Introduction

Many forefront facilities such as the Hubble Space Telescope and ESOs Very Large Telescope are being pointed at exoplanets to try to find out what their atmospheres are made of. WASP-31b is one of the exoplanets for which its atmosphere has been probed with the HST and VLT. The observed transmission spectrum of WASP-31b is mostly flat, implying that the planet has a cloudy atmosphere, but while one point from previous HST data (the green-circle data point) indicates the presence of a strong Potassium line, the new data from the VLT (small yellow circle) is incompatible with the HST result, showing no strong Potassium line. So how this discrepancy can be explained?

2. ATMO Model Grid

Using a 1D radiative-convective-chemical equilibrium model termed ATMO, Goyal, *et al.* (2017) generated a thousands of models for WASP-31b with varying C-to-O ratio, Temperature, Metallicity and various levels of cloud and haze coverage. We fitted all those models to the two sets of data, the Sing *et al.* (2015) data & the Gibson, *et al.* (2016) one, to find wich ones fit the data well. The two best fit models found have hazes and clouds, both have high metallicities, one has a 2xC/O ratio then the other and a temperature of about 1425k hotter then the other but none of those models can reproduce the strong potassium absorption in the transmission spectrum of WASP-31b observd with HST. See Fig. 2.

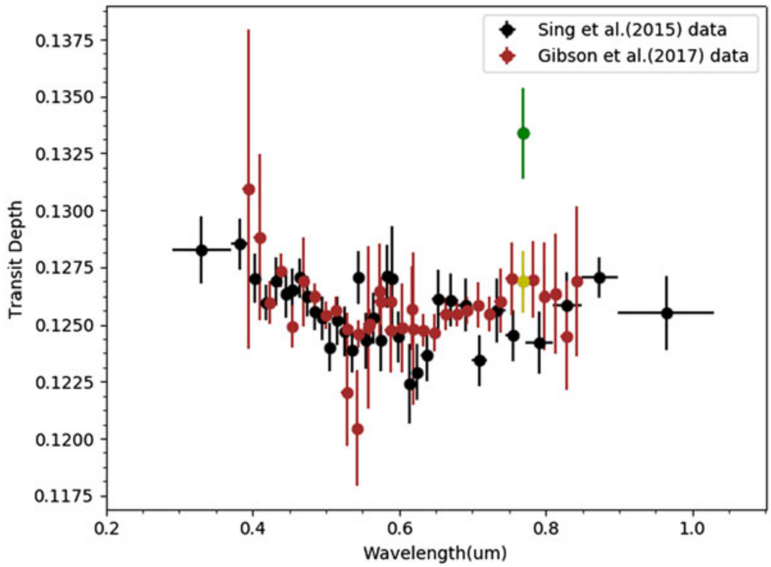

Figure 1. Transmission spectrum of WASP-31b. The black points are the STIS results reported from Sing *et al.* (2015) while The Brouwn one are the FORS2 results reported from Gibson *et al.* (2017).

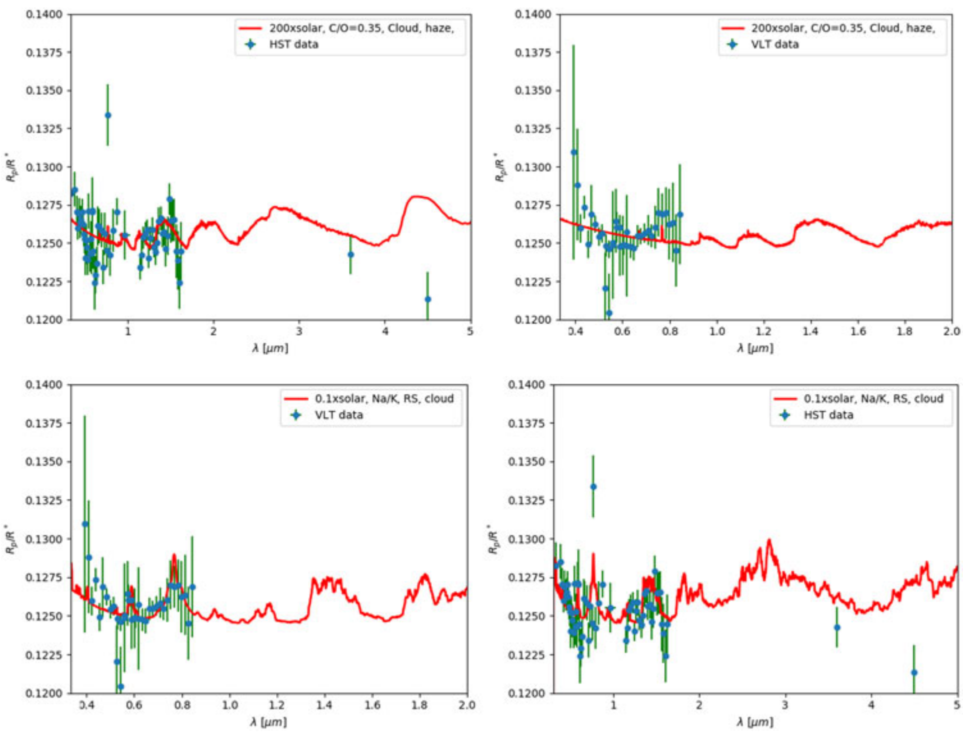

Figure 2. In the upper panel, the best fit models found for the atmosphere of WASP-31b using Atmo code. The best fit models found with Exo_Transmit for WASP-31b are shown in the bottom panel.

https://doi.org/10.1017/S1743921319002953 Published online by Cambridge University Press

Table 1. Table showing the entire parameter space of the Exo_Transmit grid. The temperature is with respect to the planetary equilibrium temperature (T_{eq}).

	Temperature (K)	Metallicity (x solar)	N_a/K	Haze RS augmentation factor	Cloud cloud-top pressure in (Pa)
Sing *et al.* (2015)	1300	0.1	0.1	1	5000
Gibson et al. (2016)	1300	0.1	0.1	1	4800

3. Exo_Transmit Model Grid/Results

Using Exo_Transmit code (Kempton *et al.* (2017)), we generated more then 2000 models for the atmosphere of WASP-31b with varying the C-to-O ratio, the metallicity and Na/K ratio. We simulated those spectra with clouds by varying the cloud-top pressure. With this code, we fitted the two sets of data, the Sing *et al.* (2015) data & the Gibson, *et al.* (2016) one with the same parameters of the planet, see Table.1, exept for where the cloud deck is. As we see in Fig. 2, the two sets of data are consistent with low Sodium abundance $\frac{N_a}{K} = 0.1$ and with an atmospheric model of 0.1xsolar metallicity. The two observations (Sing *et al.* (2015) data & the Gibson, *et al.* (2016)) can be reproduced with the same atmospheric parameters for the planet, just changing the height of the cloud deck, with cloud-top pressure of 5000 pa and 4800 pa respectivelly. Because we are looking at the terminator of the planet, it could be possible that the cloud structure in the terminator was different in each observation epoch. So that means that the presence of a thik cloud in the epoch of Gibson observations obscured the absorption line of Potassium could explain the lack of Potassium feature in the transmission spectra of VLT data.

4. Conclusion

Briefly, the absence of the strong Potassium line in the epoch of Gibson observations could be explained by the presence of a tick cloud in that epoch.

References

E. M. Kempton *et al.* 2017, *PASP*, 129, 044402
J. M. Goyal, *et al.* 2018, *MNRAS*, 474, 5158
N. P. Gibson, *et al.* 2017, *MNRAS*, 467, 4591
Sing D. K., *et al.* 2015, *MNRAS*, 446, 2428

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