Atmospheric characterisation of the ultra-hot Jupiter MASCARA-2b/KELT-20b

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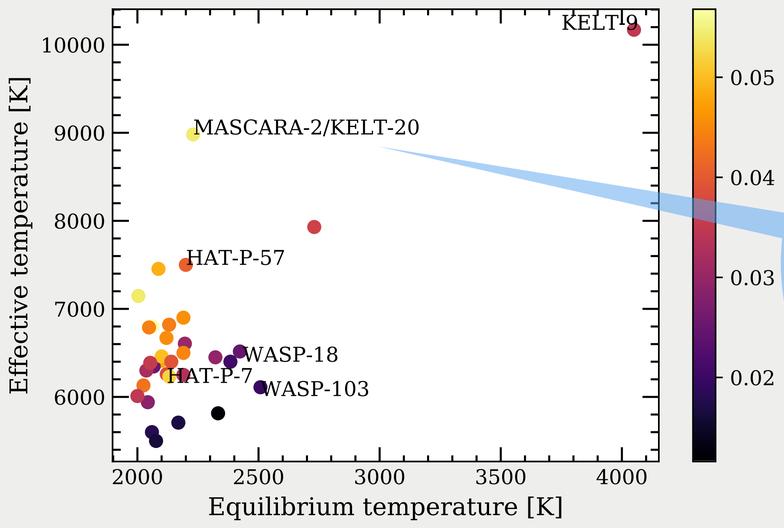
Ultra-hot Jupiters are those hot Jupiters located very close to their host stars, which are strongly irradiated and consequently their equilibrium temperatures are higher than 2000 K. Here we present the atmospheric analysis of one of those known ultra-hot Jupiters, MASCARA-2b/KELT-20b, using high resolution observations with HARPS-N and CARMENES spectrographs. We detect NaI, Hα, Hβ, CaII and FeII.

MASCARA-2b/KELT-20b

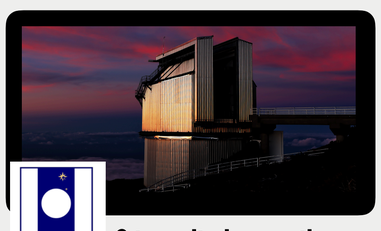


PLANET: 3.5 days period, Mp < 3.51 M_J, Rp = 1.83 R_J
STAR: V = 7.6, vsin i = 114 km/s, $M_\star = 1.89\ M_\odot$, $R_\star = 1.60\ R_\odot$

Talens et al. 2018, Lund et al. 2017

Sample of ultra-hot Jupiters from exoplanets.eu. Some host stars' name are shown as reference. In the colour bar we show the semi-major axes of the systems (in AU.)

Observations



3 transit observations

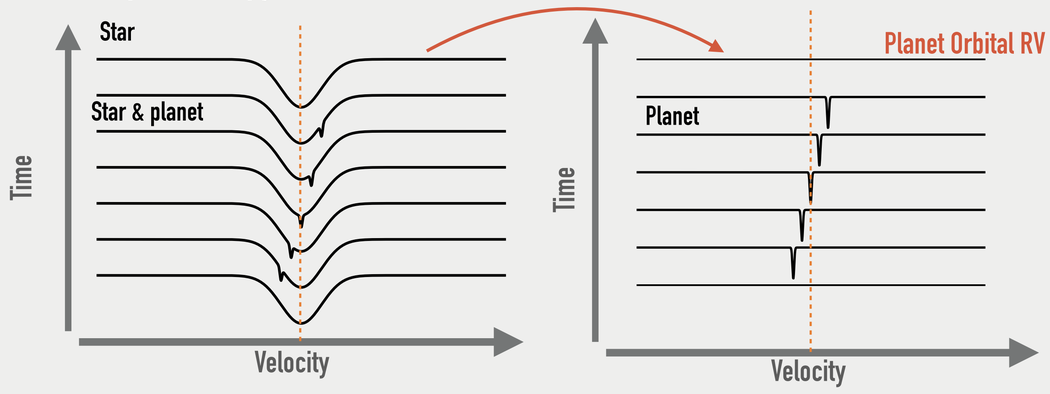
1 transit observation

1.5 transits photometry monitoring

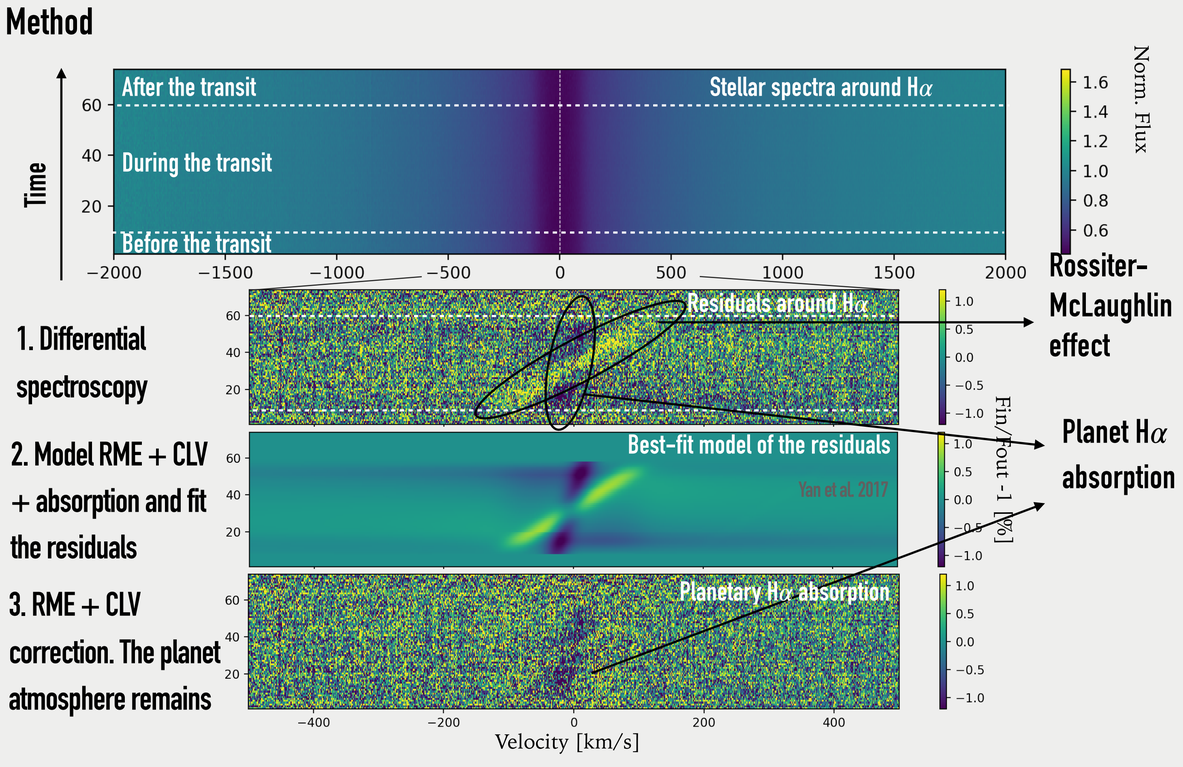
Transmission spectroscopy method

Differential spectroscopy between in- and out-of-transit observations

Redfield et al. 2008, Wyttenbach et al. 2015



Method



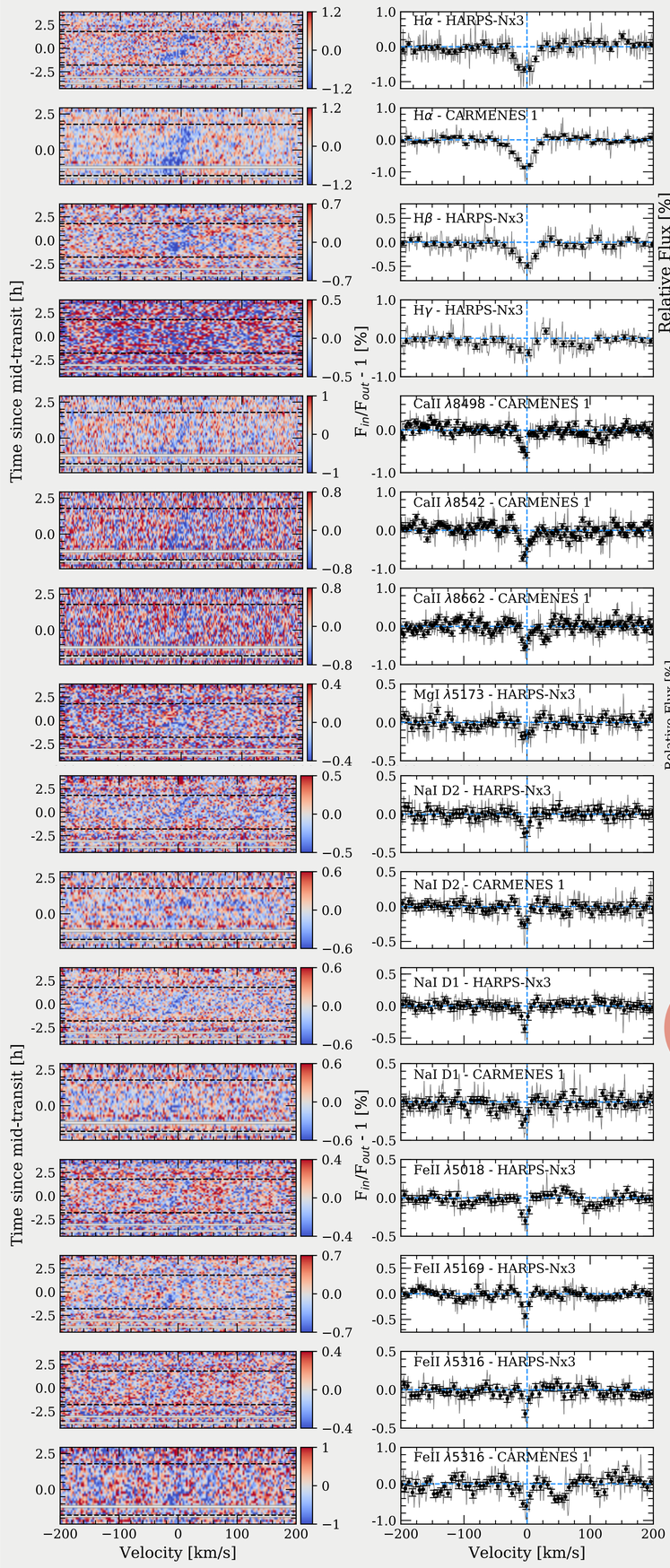
1. Differential spectroscopy
2. Model RME + CLV + absorption and fit the residuals
3. RME + CLV correction. The planet atmosphere remains

Rossiter-McLaughlin effect

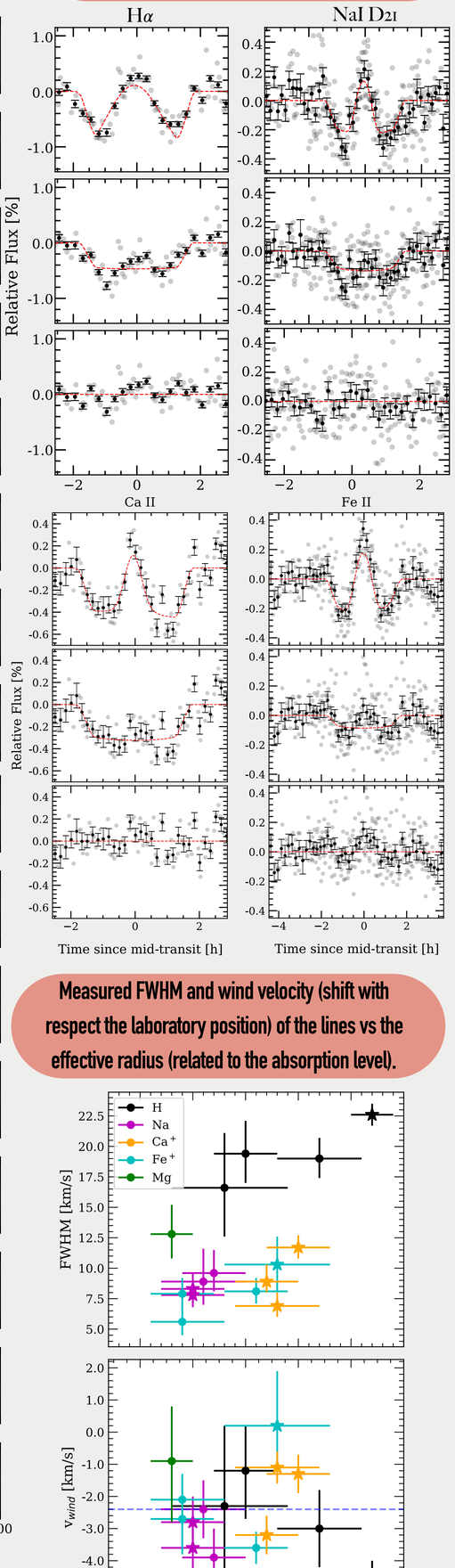
Planet Hα absorption

Results

Left: Residual 2D maps after correcting the CLV and RM effects. Right: transmission spectrum computed with the residuals in the 2D map.



Transmission light curves computed for some of the detected spectral lines.



Measured FWHM and wind velocity (shift with respect the laboratory position) of the lines vs the effective radius (related to the absorption level).

Discussion

Several studies (Parmentier et al. 2018, Arcangeli et al. 2018, Bell & Cowan 2018 and Helling & Rimmer 2019) show that in ultra-hot Jupiters the stellar radiation heats the gas to T>3000K, leading to large day-night side differences (Helling et al. 2019):

- **Hot cloud-free day-side** that forms a thermal ionosphere: H, Na, K, Ca, Ti, Al, Fe, Mg, Si are present in their atomic form and could be singly ionised, with Na+, Ca+, K+, Al+, and Ti+ being more abundant than their neutral atomic or ionic form.
- **Cold cloudy night-side** where thermal ionisation is smaller and the elements remain in their neutral state of ionisation or are bound in molecules.

The detection of HI, NaI, CaII, and FeII in MASCARA-2b is consistent with these theoretical works. The shifted absorption suggests strong winds emerging from the day-side and transporting hot and ionised material into the terminator.