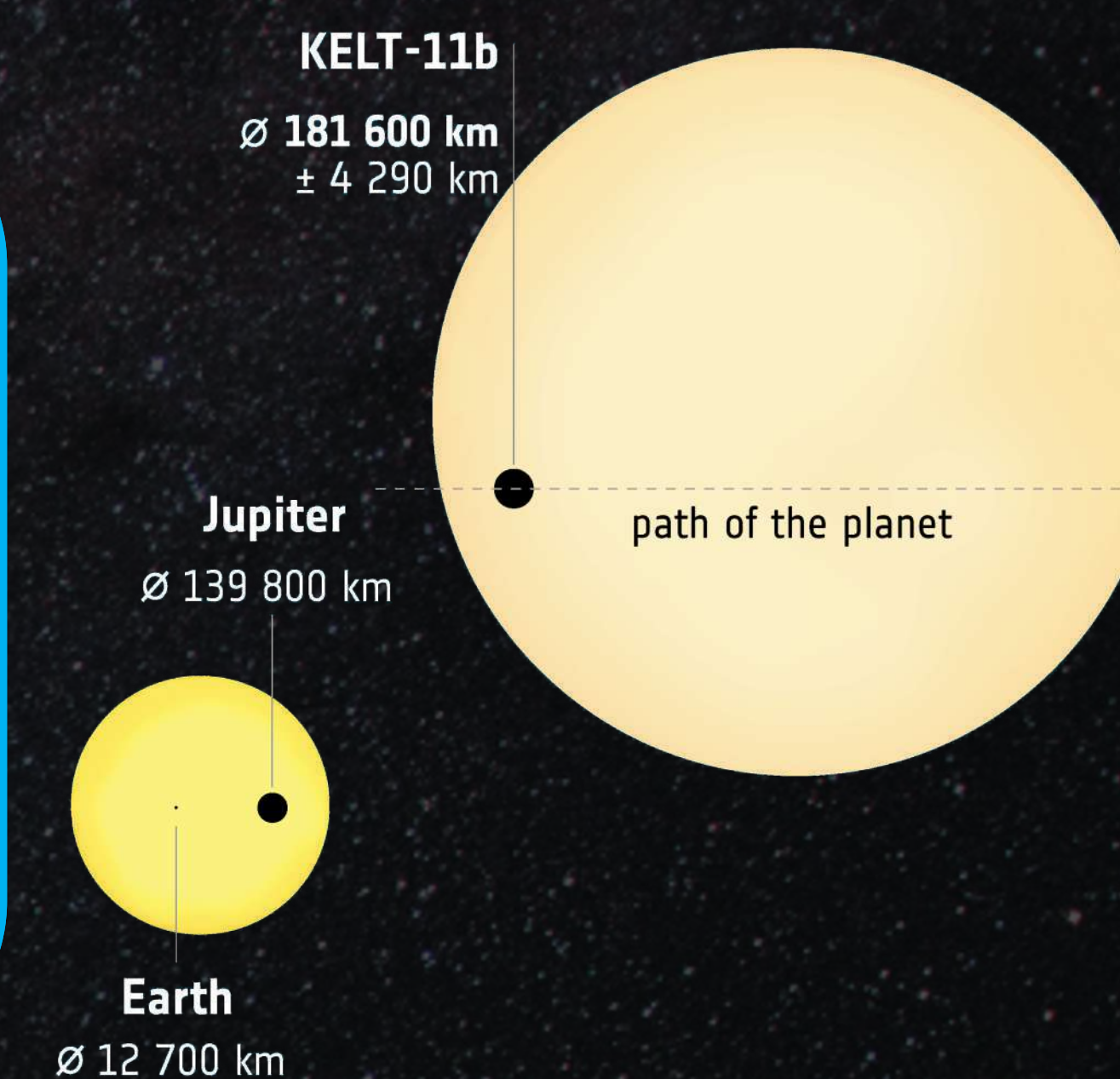


Context :

KELT-11b is an exoplanet with very favourable **parameters** for atmospheric characterization: bright host star ($V=8$), with a light and hot atmosphere, but it transits its host star for 7 hours. Due to the Earth daily cycle, high-resolution spectroscopy from ground-based observations is restricted to exoplanets that transit their host star for less than 5 hours, because of the need to have many in-transit spectra to extract the planetary signal and out-of-transit spectra to build a high signal-to-noise baseline.

Parameters :

- $M = 0.205 M_{\text{Jup}}$
- $R = 1.35 R_{\text{Jup}}$
- $P = 4.736 \text{ d}$
- $T_{\text{eq}} = 1712 \text{ K}$
- $H = 2763 \text{ km}$



Methods :

To overcome the long transit issue, we observed the KELT-11 system in the visible with the HARPS spectrograph mounted on the ESO 3.6m telescope in La Silla in two sets of **three nights in a row**: before, during and after the transit, with the same calibration frames for each night in a set. We obtained 122 in-transit spectra and 222 out-of-transit spectra. This huge amount of data allows us to build a high signal-to-noise out-of-transit master.

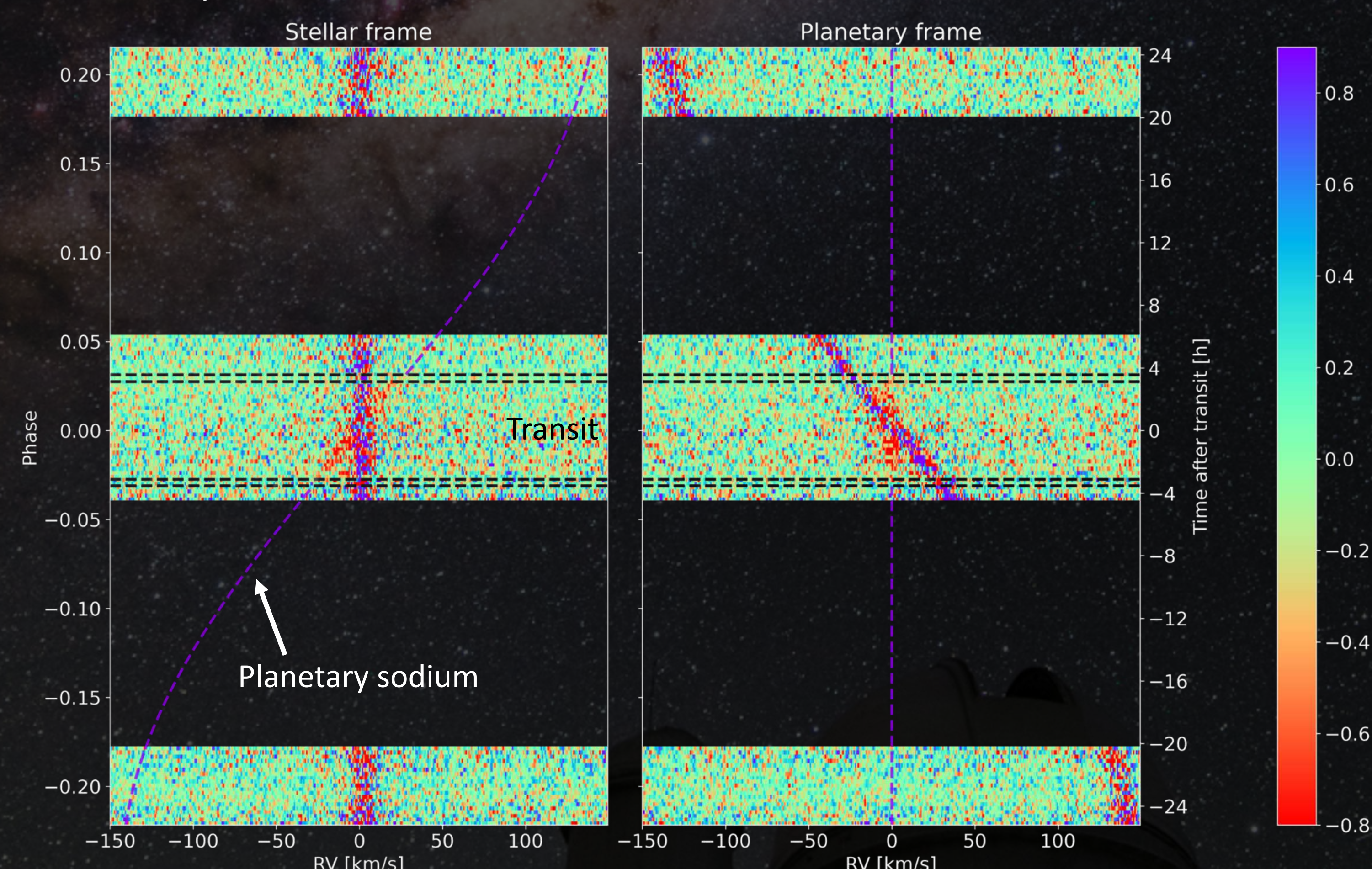
From these spectra, we compute the combined **transmission spectrum** following these steps:

1. Telluric correction with Molecfit
2. Master-out computation for each set of data
3. Individual spectra and master normalization
4. Individual transmission spectra computation
5. Shift each spectrum to planetary rest-frame
6. Limb-darkening correction
7. Weighted average if individual spectra
8. Relative absorption calculation

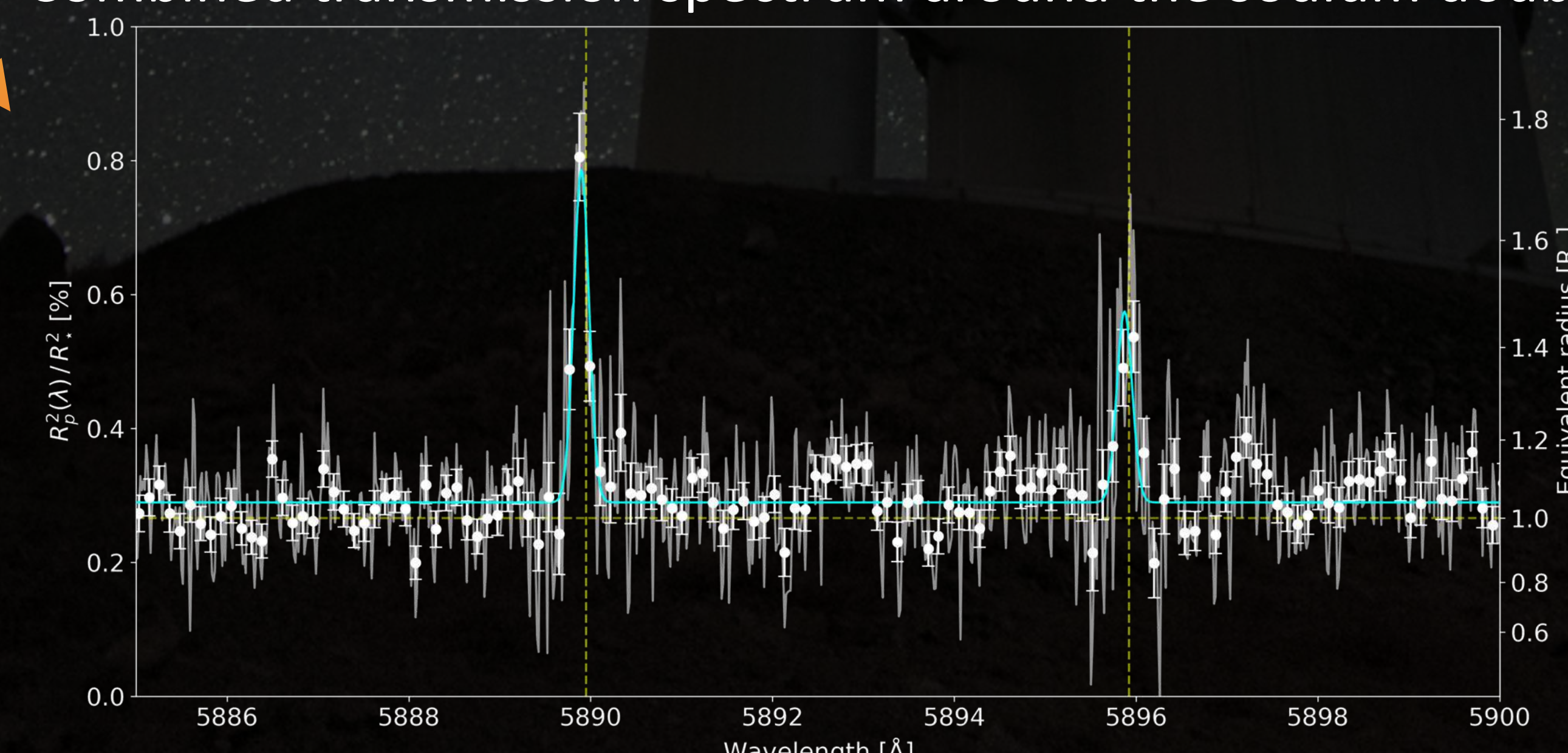
We then analyse the absorption around the **sodium doublet** (at 5890 and 5886 Å) from the atmosphere of KELT-11b. These lines in the visible range have a large cross-section and are thus very suitable for detection.

Results :

Individual transmission spectra binned in phase, where the sodium absorption lines from the doublet have been co-added :



Combined transmission spectrum around the sodium doublet :



Fit : Absorption: Na D2: $0.50 \pm 0.06 \%$ Na D1: $0.29 \pm 0.05 \%$
FWHM: $1.5 \pm 0.2 \text{ km/s}$ Blueshift: $-2.5 \pm 0.5 \text{ km/s}$

Conclusions :

- **KELT-11b** is an extremely inflated sub-Saturn orbiting a bright star and as such is a prime choice for atmospheric characterization.
- Its long transit of 7 hours makes it difficult for ground-based observations. Therefore, the system is observed for three days in a row: before, during and after the transit, in order to gather many in- and out-of-transit spectra.
- This method of combining 3 nights shows promising results and is robust, albeit risky. It allows us to compute a high signal-to-noise merged transmission spectrum, and also extends the field of exoplanet atmospheres that can be characterized.
- During the transit of KELT-11b, an excess absorption of sodium of 0.50% (8σ) and 0.29% (6σ) is detected, for the D2 and D1 lines respectively.
- Analysis of the RM effect shows that its host star is a slow rotator and that KELT-11b is in a near-polar orbit (-77.86 ± 2.36 degrees). Wind modelling finds day-to-night side winds of $5.44 \pm 0.97 \text{ km/s}$.