Spatial characterization of the trailing and leading limbs of WASP-76 b

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Context

Extreme temperature contrasts between the day and nightside of ultra-hot Jupiters produce significantly asymmetric atmospheres and extreme expansion occurring around the terminator [1]. Over the course of a transit, WASP-76b rotates by about 32 degrees and temporal variations of the observable atmosphere could significantly affect the detectability of constituents. Specifically, the trailing limb of this planet allows us to probe a significant portion of the inflated dayside, which has a higher atmospheric detectability. This effect could mimic the observed time-variability of absorption signals due to condensation, which has been reported for neutral iron in WASP-76 b [2, 3]. However, molecular compounds such as H_2O, CO, or HCN are not expected to rain out in the nightside of WASP-76b (~1000 K) and can be used to study the possible variability due to geometry. Here, we test this possibility using the cross-correlation technique [4,5] and high-resolution (R~80400) near-infrared spectra of WASP-76 b observed with the CARMENES spectrograph.

Results and Conclusions

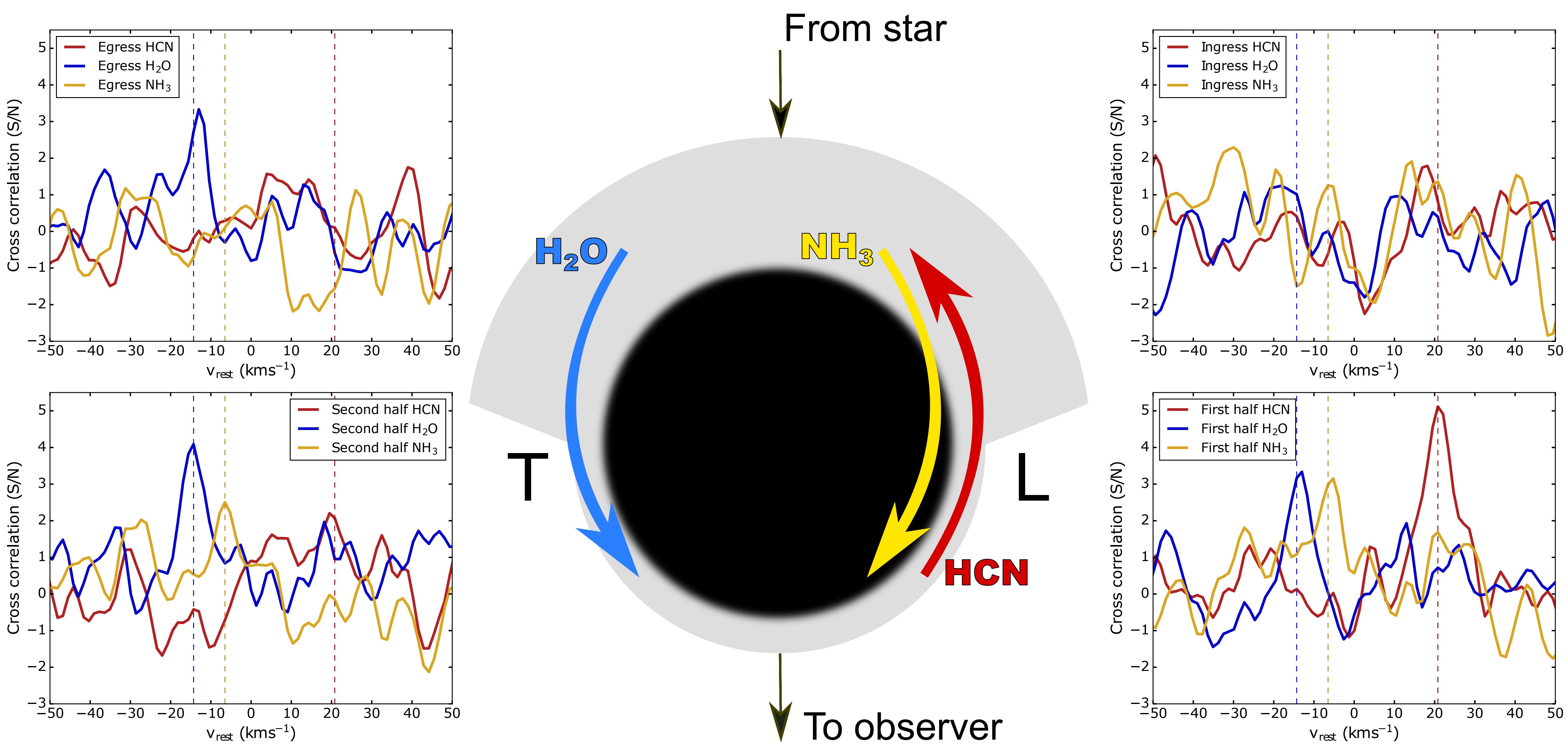

Fig.1. Time-dependence of high-resolution cross-correlation absorption signals of H_2O (blue), HCN (red), and NH_3 (yellow) and basic sketch of the asymmetric WASP-76b atmosphere. The Doppler shift of the signals is indicated by the coloured arrows and the dashed lines in the plots. The trailing and leading limbs of the planet during the transit are indicated by the 'T', and 'L' letters, respectively.

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Table 1. Maximum signal-to-noise ratios, σ-values, planet radial velocity semi-amplitudes, and Doppler shifts of the combined signals.

Molecule	S/N	σ-values	K_P (km s^{-1})	$v_{\rm shift}$ (km s^{-1})
H_2O	5.5	7.4	251 ±38	−14.3 ±2.6
HCN	5.2	7.4	249^{+14}_{-31}	+20.8 ±1.3
NH_3	4.2	6.9	251 ±12	$-6.5^{+2.6}_{-1.3}$

- Detection of **globally-distributed H_2O.** Significantly higher signal at egress *wrt* ingress (“***Ehrenreich effect***”). Potentially due to a larger scale height in the dayside, **cannot be explained by condensation**. The significant blueshift indicates global winds flowing from the day to the nightside.
- Detection of **HCN** from the 1st half of the transit, potentially **coming from the leading limb**. During the 2nd half, the leading limb rotates out of view and the signal disappears. Extreme atmospheric expansion (~3 scale heights) away from the observer redshifts the signal.
- Weak detection of **NH_3**. Expected presence also mainly in the leading limb. Blueshifted behaviour might be due to **wind shears**, but the signal is too weak to extract robust conclusions.

References

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