Exploring The Atmospheric Dynamics of WASP-127b through CRIRES+ High-Resolution Infrared Transmission Spectroscopy

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Observations and cross-correlation results

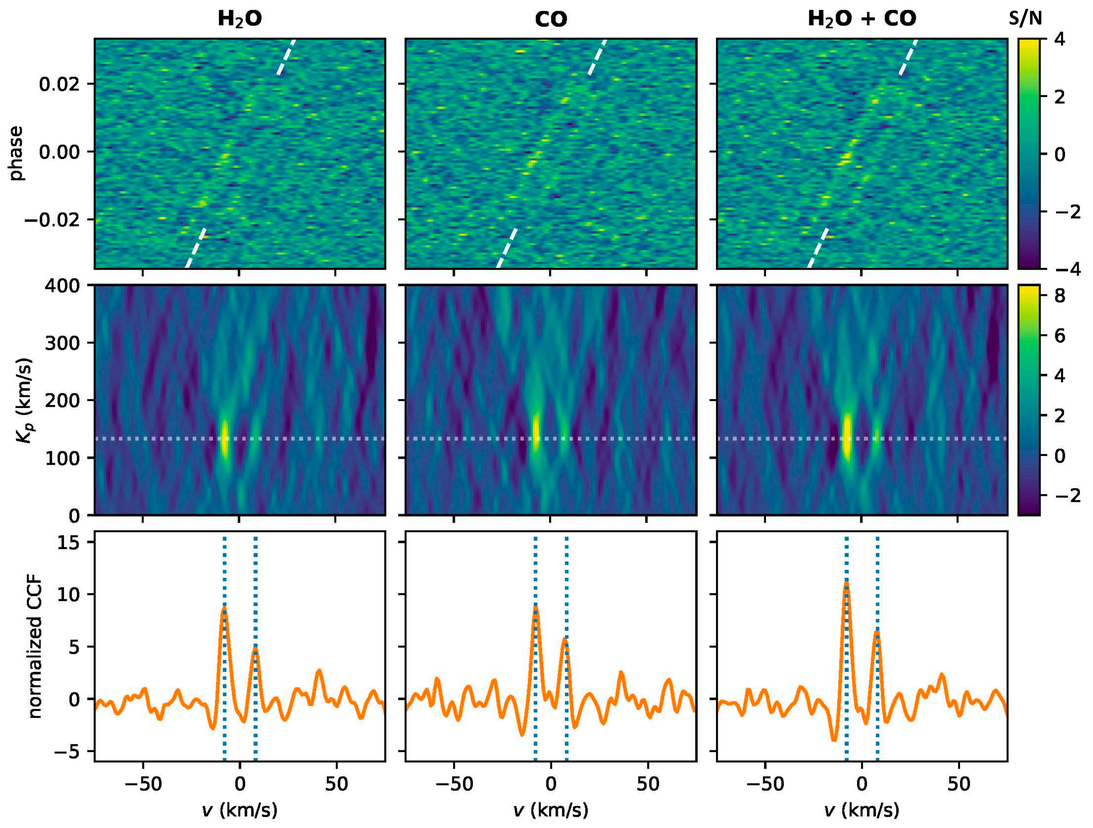
We investigated the transmission spectrum of the atmosphere of **WASP-127b** using data of one transit event observed in the K-band using **CRIRES+.** The spectral resolution achieved during the night was **R~140'000**.

Using the cross-correlation method we detect **CO** and **H_2O** but no CH_4 nor CO_2. Previously CO had not been unambiguously identified in this planet[11,12].

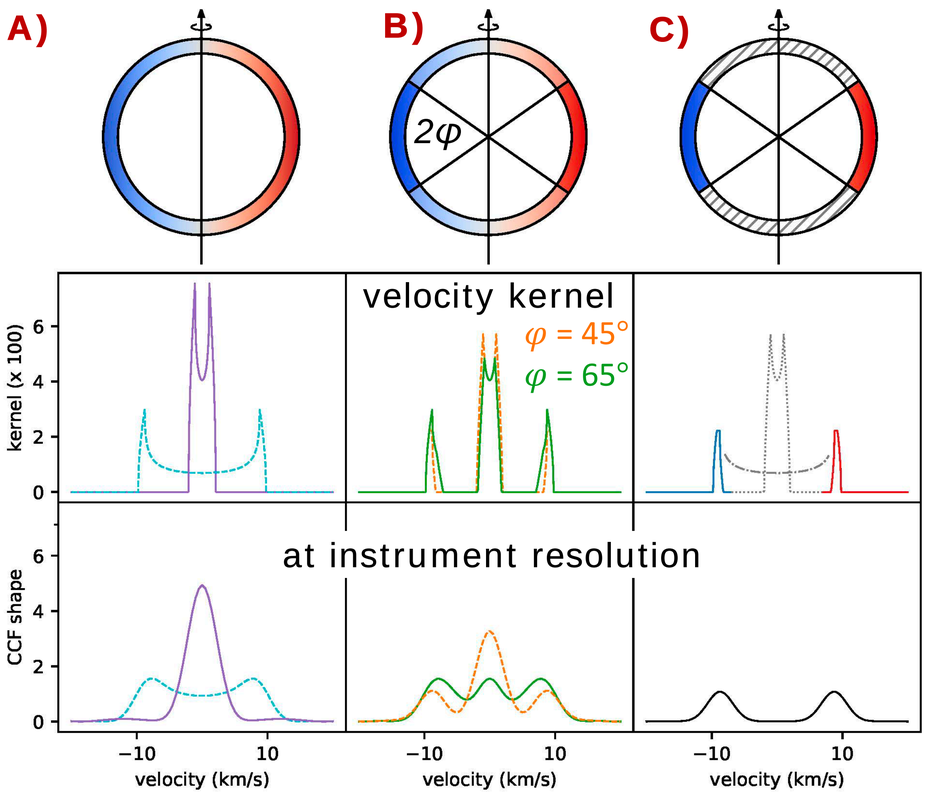
The signals show **2 resolved peaks** at ±8 km s^{-1}, which we can trace back to the evening and morning terminator of the planet.

We note a **lack of signal at planet rest frame**, where signals from the planetary poles would be expected.

What can explain this interesting velocity distribution of the material? Let's check the velocity kernel of a rotating atmosphere!



Explanation of the velocity kernel



A) Solid body rotation → **double peaked velocity kernel**
At low rotational velocities (e.g. tidally locked rotation), the two signals **remain unresolved at instrument resolution**. At **higher velocities** (~10 km s^{-1}) the two signals can be resolved.
The **plateau** between the two peaks stems from material at the poles.

B) If the super-rotation is constrained to an **equatorial jet,** and the polar regions rotate at tidally locked velocity, the profile has a third peak instead of a plateau.

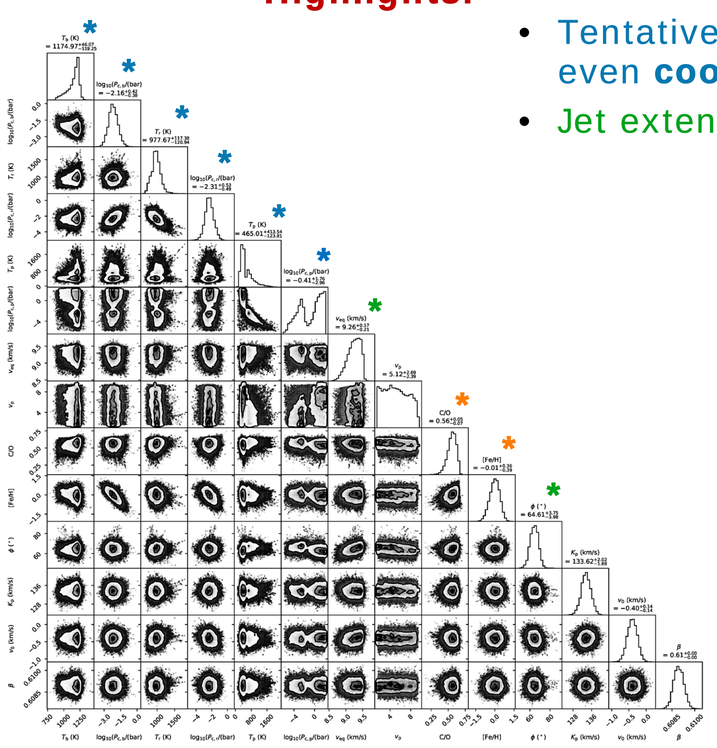
C) Since we detect neither a plateau nor a third peak, we conclude that atmospheric **signals at the polar regions are likely muted**.

Let's check what a 2D retrieval says!

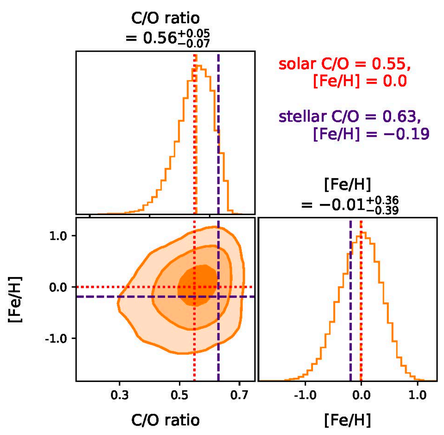
Full retrieval with simplified 2D model

Highlights:

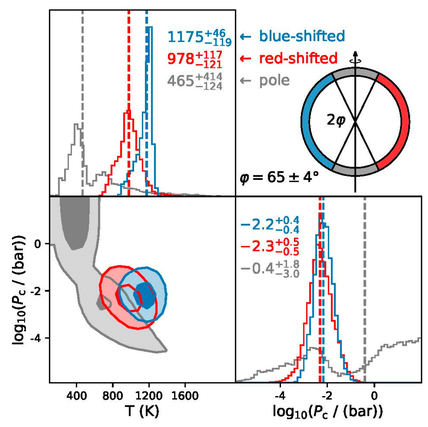
- **Solar C/O ratio and metallicity**, also in agreement with the values for the host star.
- Tentatively cooler temperatures for the morning terminator than the evening terminator and even **cooler temperatures or a higher cloud deck at the polar regions.**
- Jet extends to latitudes of 65° and has a **supersonic jet velocity** of 9.3 km s^{-1}



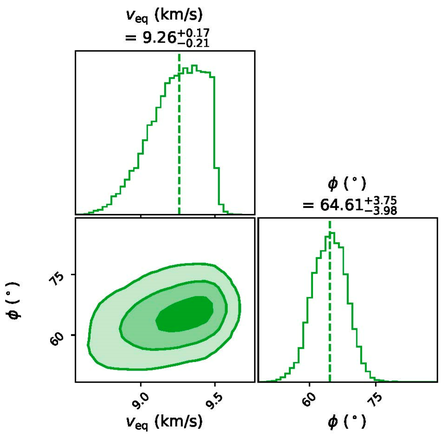
Composition



2D temperatures and cloud deck pressure



Jet speed and width



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11. Spake et al. 2021, MNRAS, 500, 4042
12. Boucher et al. 2023, MNRAS, 522, 5062

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Check out the paper on arXiv:
https://arxiv.org/abs/2404.12363