A Search for Temperature Inversion Agents in KELT-20 b With LBT/PEPSI Emission and Transmission Spectroscopy

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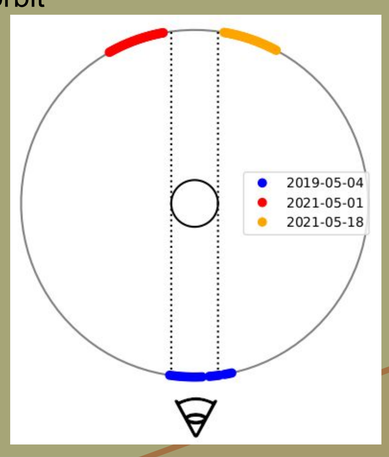
Introduction

- Several ultra hot Jupiters (UHJs) have thermal inversions, but there is only one secure detection of a molecular thermal inversion agent at high spectral resolution (TiO in WASP-33 b; Nugroho et al. 2017)
- Most previous searches used transmission spectroscopy; emission spectroscopy, while more challenging, probes deeper layers of the atmosphere closer to the inversion
- We aim to detect the species responsible for the presence of a temperature inversion in KELT-20 b
- We use LBT/PEPSI with both emission and transmission spectroscopy to set stringent limits on the inversion agent

Methodology

- We observed one transit and two 4.5-hour emission segments on either side of secondary eclipse (shown below)
- We telluric (Molecfit; Smette et al. 2015) and systematic (SYSREM; Tamuz et al. 2005) correct the spectra
- Create model spectra with petitRADTRANS (Mollière et al. 2019)
- Cross-correlate models with spectra, shift CCFs along planetary orbit



Get in Touch!

Any questions about this work? Find me around the conference (if you can recognize me under my mask), or contact:

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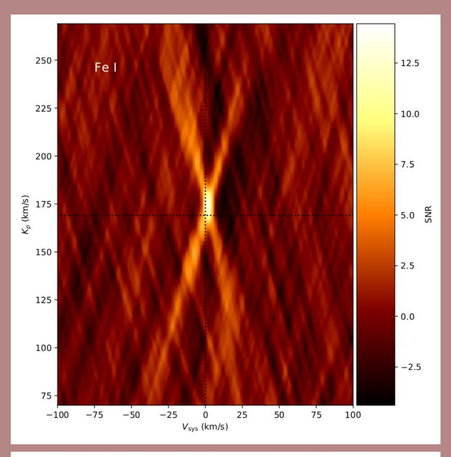
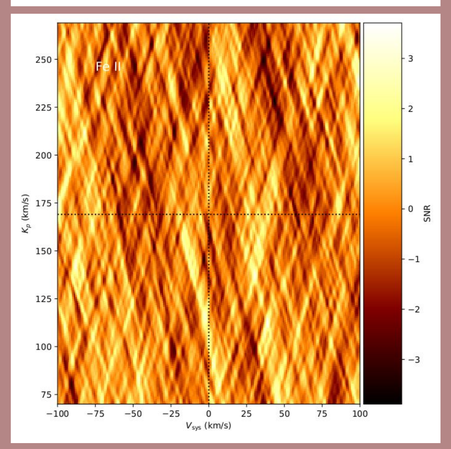
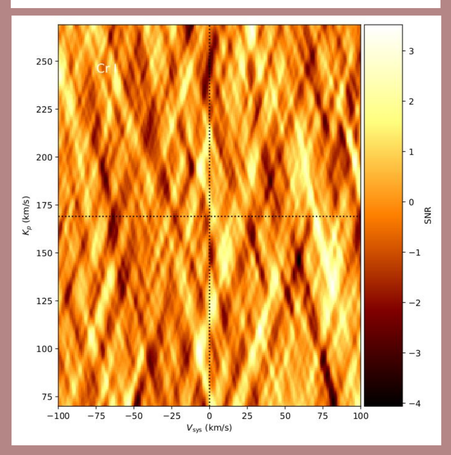
Emission Spectroscopy: Atoms

- We recover the Fe I emission found by Yan et al. (2022) and Borsa et al. (2022) (top plot)
- We are unable to reproduce the detection of Fe II or Cr I by Borsa et al. (2022) despite having much higher SNR (middle and bottom plots).

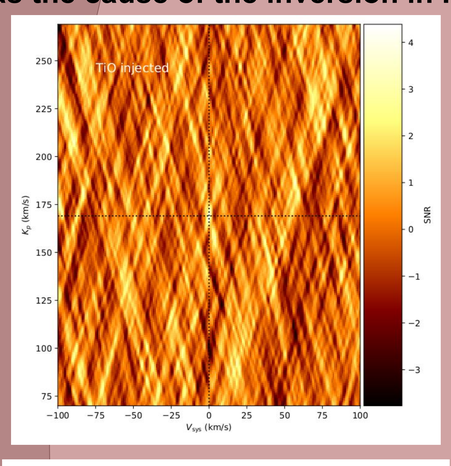


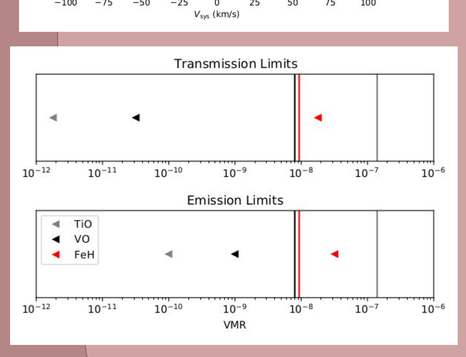




Emission Spectroscopy: Molecules

- We do not detect any emission for TiO, VO, or FeH.
- We conduct injection-recovery testing to estimate volume mixing ratio (VMR) limits (example injected signal at 4σ limit for TiO below).
- The VMR limits for TiO and VO for both transmission and emission are smaller than the concentrations predicted by simple chemical models, **ruling out TiO and VO as the cause of the inversion in KELT-20b.**





Upper limits on the VMR of TiO, VO, and FeH in the atmosphere of KELT-20 b from injection-recovery testing. The vertical dashed lines show the VMR expected for a solar-metallicity atmosphere from a FastChem (Stock et al. 2018) equilibrium chemical model and assuming quenching.

Transmission Spectroscopy: Molecules

- Similarly to the emission results, we do not detect TiO, VO, or FeH in transmission and use injection-recovery tests to set VMR limits.
- Together, these datasets set strict limits on the presence of these inversion agents at two different pressure levels in the atmosphere of KELT-20 b.