Phase-Resolved Emission Spectroscopy of the Ultra-Hot Jupiter KELT-20 b

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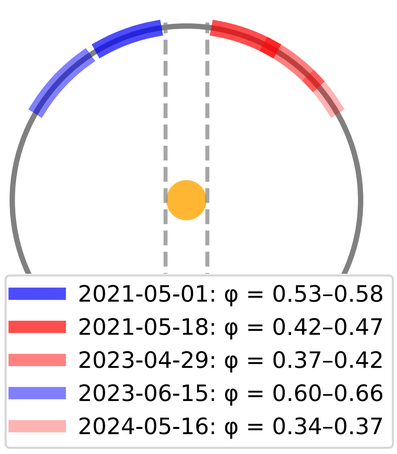
Overview

- Studying the dayside emission of exoplanets as a function of orbital phase at very high spectral resolution allows us to understand the 3D nature of their atmospheres in unprecedented detail
- Using our atmospheric retrieval method, we measure the abundances of Fe I, Ni I, and Ca I in the dayside atmosphere of the ultra-hot Jupiter exoplanet KELT-20 b:
  $\log(\text{Fe I}_{VMR}) = -5.86^{+0.36}_{-0.29}$, $\log(\text{Ni I}_{VMR}) = -7.08^{+0.39}_{-0.33}$, and $\log(\text{Ca I}_{VMR}) = -9.11^{+0.42}_{-0.33}$
- We retrieve our pre-eclipse and post-eclipse datasets separately to probe the 3D nature of the atmospheric thermal structure and chemical abundances as a function of orbital phase
- We find evidence for a enhanced abundance of both Fe I and Ni I in the combined post-eclipse (morning-side dominant) datasets compared to the combined pre-ecplise (evening-side dominant) datasets of KELT-20 b

Data

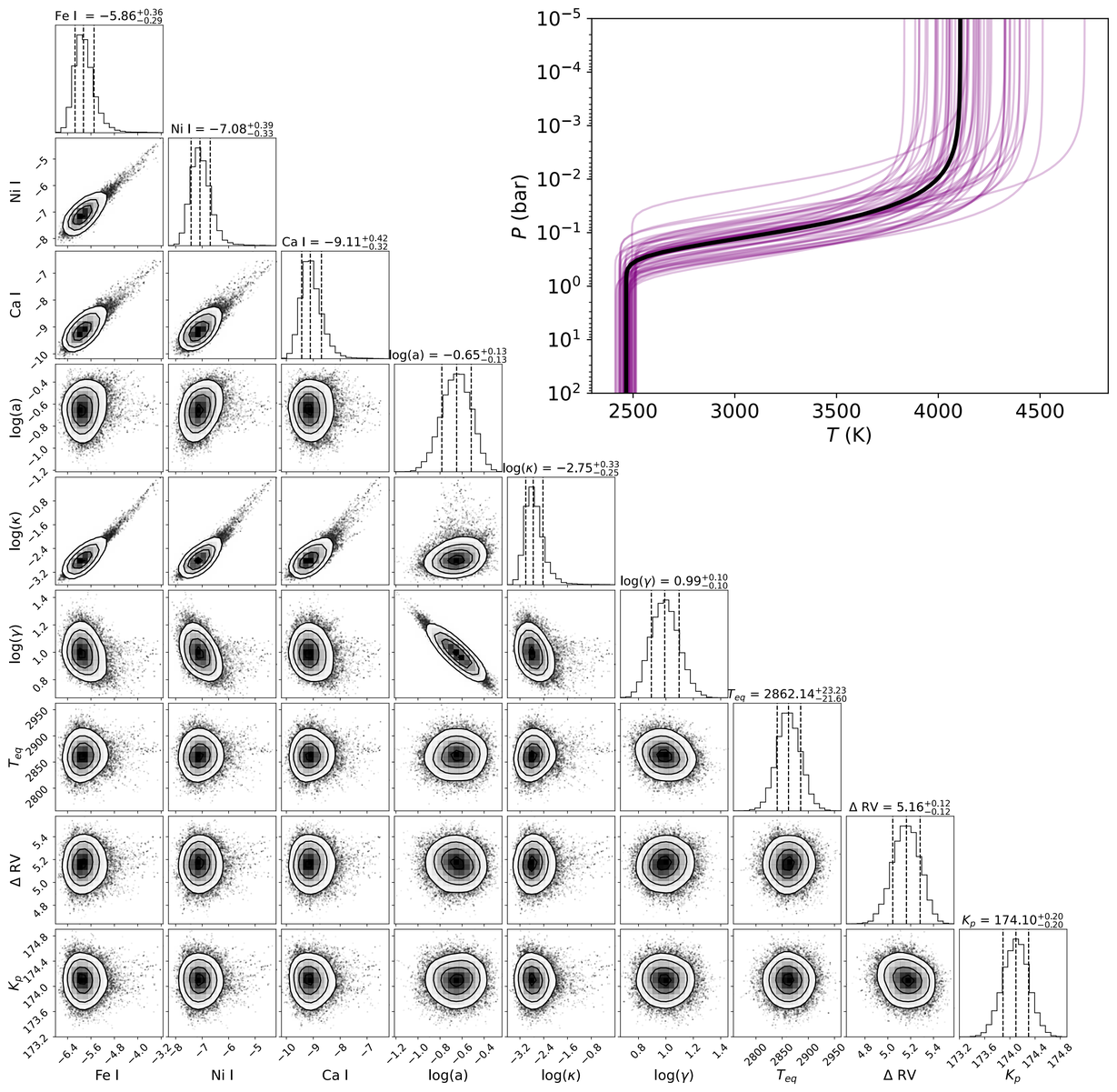


- 5 nights of observation with PEPSI, an optical spectrograph on the LBT with R=130,000
- 229 spectra near secondary eclipse

Retrieval Framework

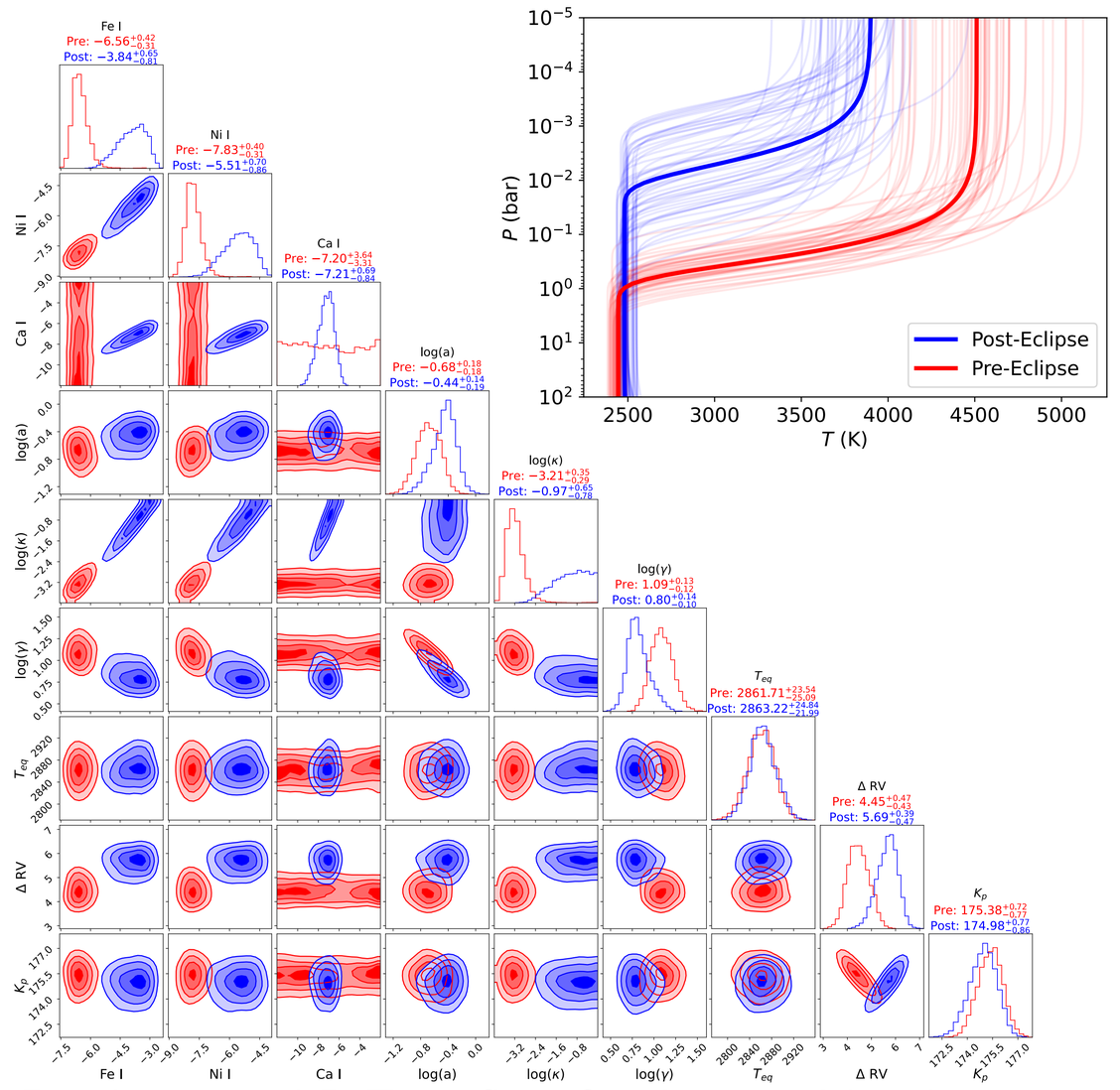
- Our Bayesian retrieval framework uses the `emcee` tool (Foreman-Mackey et al. 2013) to obtain the best-fit parameters and uncertainties
- We create the forward model using `petitRADTRANS` (Mollière 2019) assuming constant-with-altitude abundances and using the Guillot (2010) parameterization of the pressure-temperature (P-T) profile.
- We set uniform priors on all parameters except equilibrium temperature, where we use a Gaussian prior by independently measuring the dayside temperature using the eclipse transit depth with TESS

Combined Datasets Retrieval



- Combined retrieval results for KELT-20 b. The medians and 1-σ confidence intervals are denoted in the histograms with dashed lines.
- Inset plot shows retrieved P-T profile. Thinner purple lines represent 50 P-T profiles randomly extracted from the MCMC posteriors.
- The altitude of the thermal inversion is consistent with previous results (e.g. Borsa et al. 2022; Yan et al. 2022; Fu et al. 2022; Kasper et al 2023).

Phase-Resolved Retrievals



- Retrieval and P-T profiles for the combined pre- and post-eclipse datasets performed separately
- Notably higher VMRs of Fe I and Ni I dominated by the φ= 0.53-0.58 dataset, but we note the strong degeneracy between κ and chemical abundance.

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And see the poster by **Marshall Johnson** for an overview of the PIRANGA collaboration

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