High-resolution Transmission Spectroscopy of MASCARA-2 b with EXPRES

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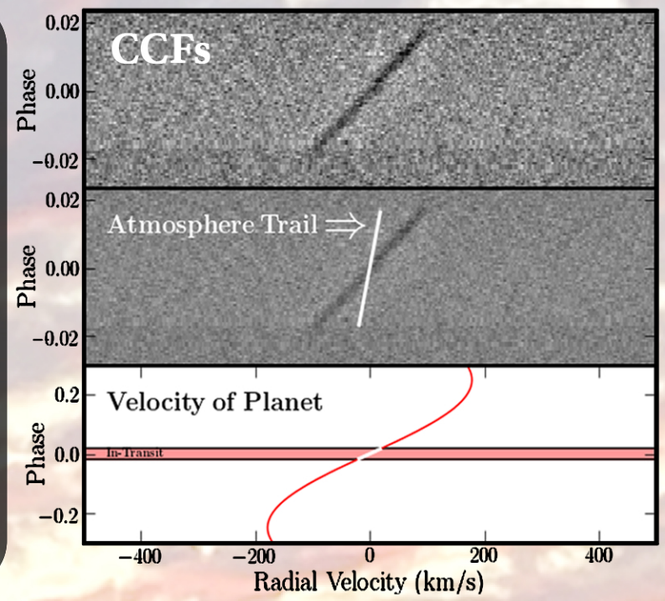
Abstract

The Ultra-hot Jupiter (UHJ) MASCARA-2b completes an orbit in 3.5 days and reaches temperatures of 2200 K [1]. Its atmosphere makes an exquisite laboratory for studying high-temperature chemistry and thermal structure. **We present new detections of Mg I and Cr II, confirmation of Fe I, Fe II and Na [2,3], and evidence for nightside condensation of Iron** in its atmosphere. Our results represent the first exoplanetary atmospheric study with the Extreme PREcision Spectrograph (EXPRES) [4].

Methods

We observed one transit with EXPRES. As the planet transits, it imprints absorption lines on the stellar spectrum, Doppler shifted by the orbital motion. We (1) correct tellurics with a model spectrum; (2) divide in-transit spectra by the master out-of-transit stellar spectrum; (3) obtain the cross-correlation function (CCF) between the transmission spectra and a model template [5]; and (4) stack the CCFs in phase with the planet



Results

Reported detections (Mg I, Cr II, Fe I, Fe II, Na) have CCF signals ≥4σ. The Fe II signal was slightly stronger in the second-half of transit, possibly due to chemistry differences in morning and evening terminators, and cooling/condensation of Fe on the nightside. We obtain tight constraints on the aligned orbit via the Rossiter-McLaughlin effect.

Implications

These detections join several other high-resolution studies of UHJs: KELT-9b [6], WASP-121b [7, 8], WASP-33b [9], WASP-76 [10] where atomic and/or ionic species are reported. These probe processes including day-to-night side winds at the terminator, condensation, atmospheric escape, and photoionization. Atoms and ions may be responsible for thermal inversions in UHJ atmospheres [11]. A larger sample of detections will help confirm the underlying dynamics and chemistry.

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