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Signs of Ionized Iron Beyond the Roche Lobe of HD 209458b from NUV Observations

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Abstract

Ultraviolet transit observations probe the upper atmosphere of exoplanets, where mass loss occurs. The unique properties of the HD 209458 system give its transiting hot Jupiter a pivotal role in our understanding of exoplanet atmospheres, few other planets will ever enable such precise measurements of their upper- and lower-atmosphere properties.

Our analysis of the archival *HST*/STIS NUV transmission observations of HD 209458 b shows evidence for ionized iron (at a 3σ confidence), and no evidence for neutral iron. Further, we find no evidence for absorption by neutral nor ionized magnesium. While our non-detection of neutral magnesium resolves the tension with theoretical models from previous results, our results are at odds with lower-atmosphere models resulting from optical and infrared observations.

These upper-atmosphere observations indicate that hydrodynamic escape is strong enough to carry atoms as heavy as iron beyond the planetary Roche lobe. However, lower-atmosphere observations suggest the presence of cloud condensates, with condensation curves indicating that iron-bearing species should condense before magnesium-bearing species, trapping these species in the lower atmosphere.

This intricate relationship between lower- and upper-atmosphere properties makes the combination UV and optical/infrared observations more valuable than the sum of it parts when characterizing an atmosphere. Further NUV observations of targets like HD 209458 b can place stronger constraints in the planet's upper-atmosphere composition, revealing additional iron and magnesium features (currently tentative at $< 2\sigma$). Such constraints will put us in a better position to characterize HD 209458 b as a whole, particularly before the imminent launch of the *James Webb Space Telescope*.