Towards consistent mapping of distant worlds: secondary-eclipse scanning of the exoplanet HD189733b

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Mapping distant worlds is the next frontier for exoplanet infrared photometry studies. Ultimately, constraining spatial and temporal properties of an exoplanet atmosphere will provide further insight into its physics. For tidally-locked hot Jupiters that transit and are eclipsed by their host star, the first steps are now possible.
Our aim is to constrain an exoplanet's shape, brightness distribution (BD) and system parameters from its light curve. Notably, we rely on the eclipse scanning.
We use archived Spitzer 8-{\mu}m data of HD189733 (6 transits, 8 secondary eclipses, and a phase curve) in a global MCMC procedure for mitigating systematics. We also include HD189733's out-of-transit radial velocity measurements.
We find a 6-{\sigma} deviation from the expected occultation of a uniformly-bright disk. This deviation emerges mainly from HD189733b's thermal pattern, not from its shape. We indicate that the correlation of the orbital eccentricity, e, and BD (uniform time offset) does also depend on the stellar density, \rho*, and the impact parameter, b (e-b-\rho*-BD correlation). For HD189733b, we find that relaxing the e-constraint and using more complex BDs lead to lower stellar/planetary densities and a more localized and latitudinally-shifted hot spot. We obtain an improved constraint on the upper limit of HD189733b's orbital eccentricity, e<0.011 (95%), when including the RV measurements.
Our study provides new insights into the analysis of exoplanet light curves and a proper framework for future eclipse-scanning observations. Observations of

the same exoplanet at different wavelengths will improve the constraints on its system parameters while ultimately yielding a large-scale time-dependent 3D map of its atmosphere. Finally, we discuss the perspective of extending our method to observations in the visible, in particular to better understand exoplanet albedos.

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