Signature of the atmospheric asymmetries of hot and ultra-hot Jupiters in light curves

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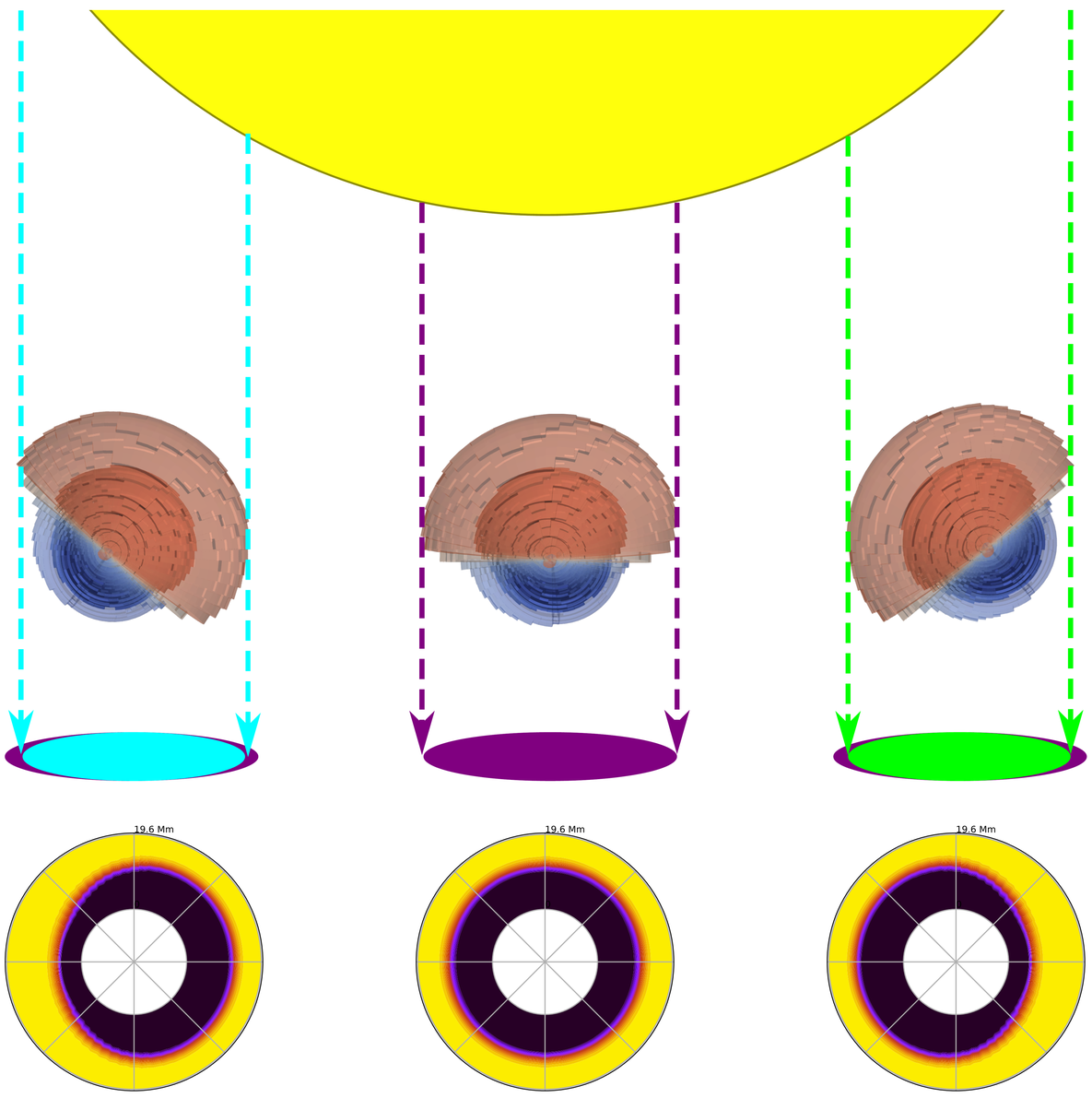
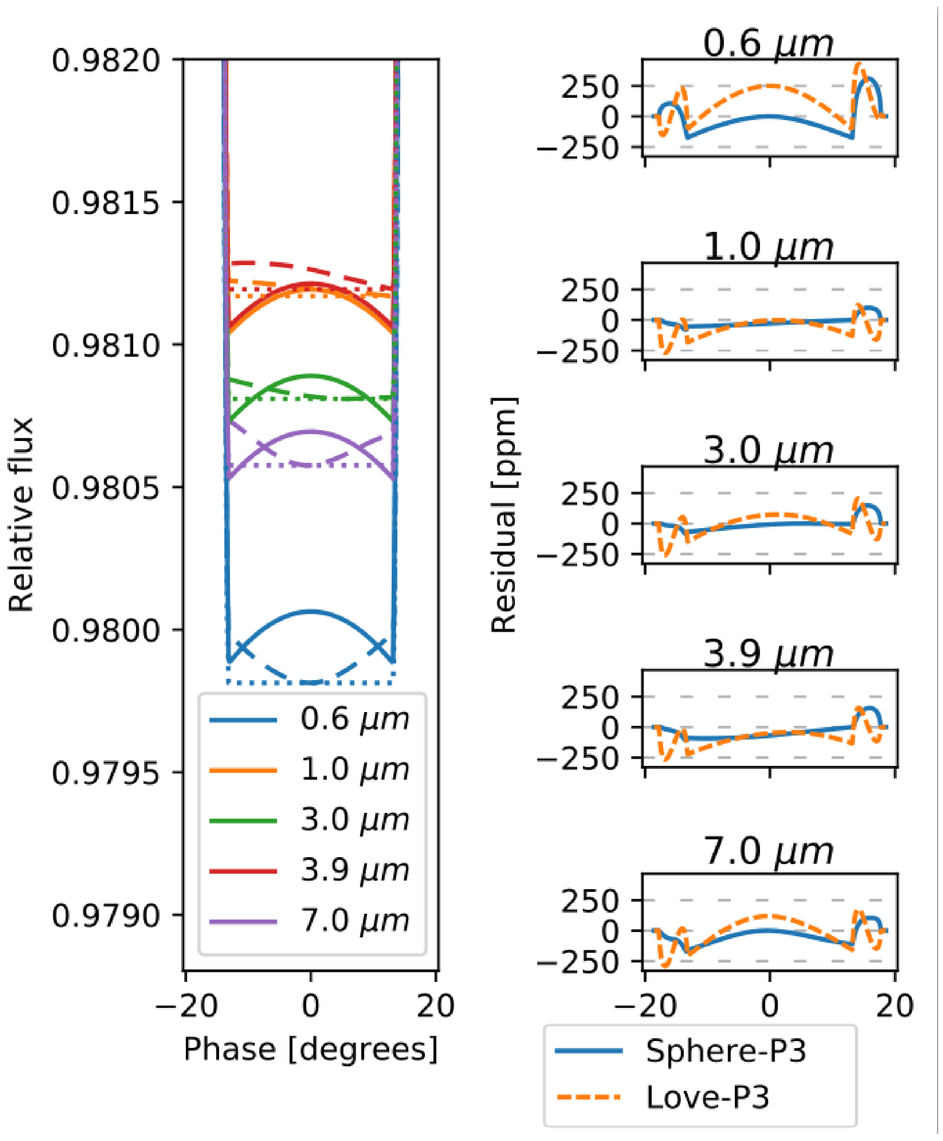
Day-night temperature gradient (Ultra hot Jupiters)

Ultra-hot Jupiters are characterized by a strong day-to-night temperature gradient.
This means the day-side scaleheight is enlarged compared to the night-side. This is shown in the following figure (the atmosphere is enlarged for visual purposes):



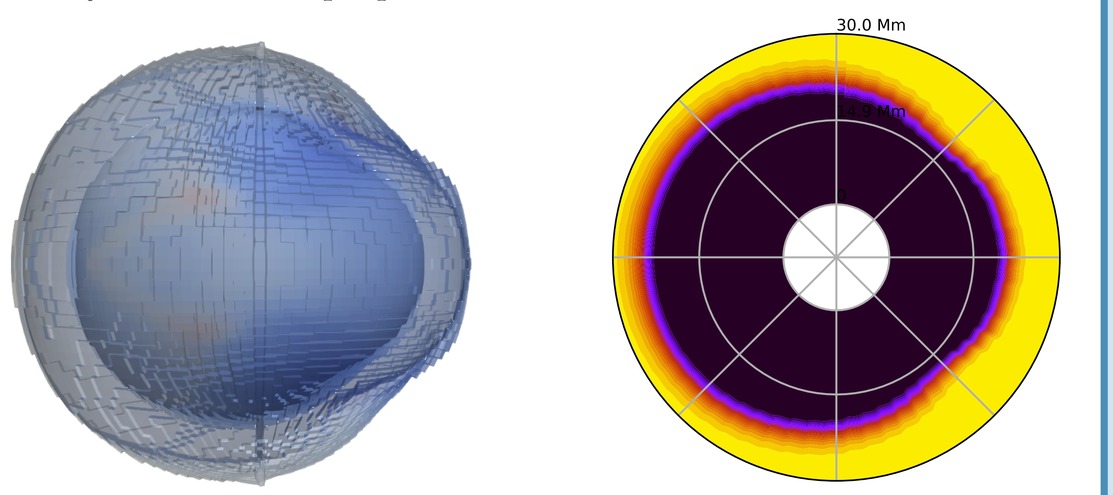
During the ingress and egress, a part of the night-side is visible, reducing the projected shadow of the planet. The fact that the shadow is larger at mid-transit creates a sort of U-shape lightcurve, as shown in the following figure in dashed line.



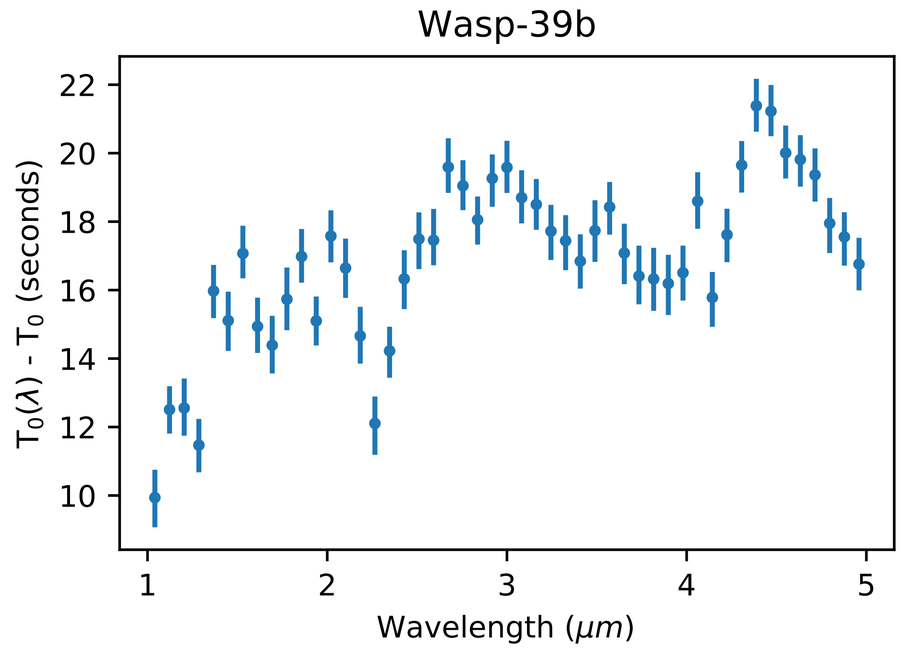
The signal could be thus mistaken for limb-darkening [1]. A spherical model such as batman [2] is not suited to match this kind of lightcurve. In [3], the authors proposed to explain observations of ultra-hot Jupiters using an ellipsoid model that would reflect tidal deformation. However, as shown by the figure above, the atmospheric impact on the signal has a reverse effect to that of tidal deformation (dashed vs solid line).

East-west asymmetries (Hot Jupiters)

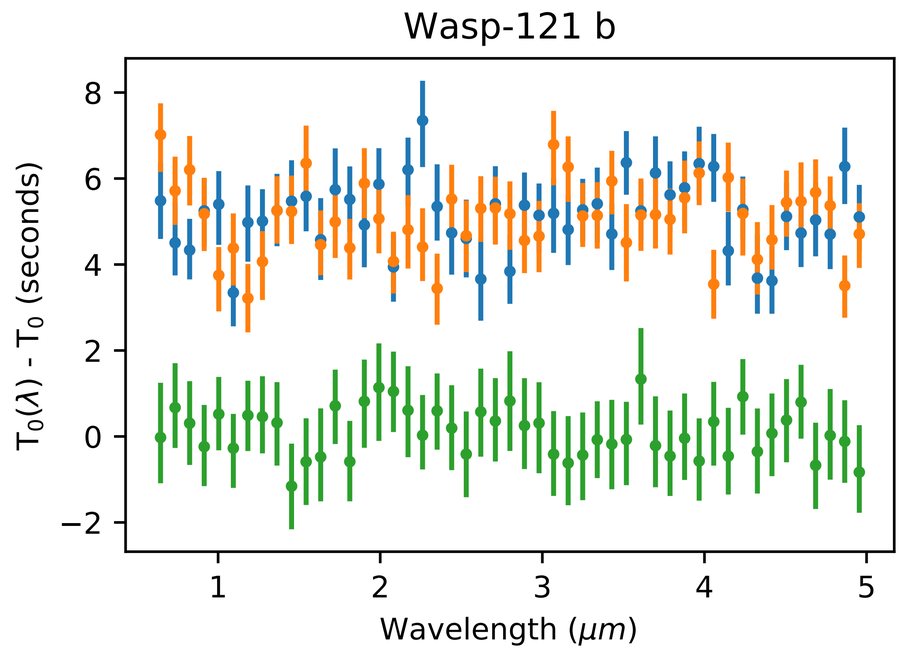
East-west asymmetries are more readily observable in Hot Jupiters. The figures below show, on the left, the temperatures maps (in 3D), for pressures superior to 0.1 Pa, from the point of view of the observer, and, on the right, the transmittance map (dark is opaque). The atmosphere scaleheight is multiplied by 10 for visual purposes.



The east-west asymmetry leads to the retrieved central transit time by a spherical model (here batman [2]) to be delayed by a few seconds. The difference of the asymmetry is dependent on the wavelength and leads to a variation of the central transit time retrieved.



This is much less visible in ultra-hot Jupiters:



References

1 Falco et al (2024) *Signature of the atmospheric asymmetries of hot and ultra-hot Jupiters in light curves*, published in A&A

2 Kreidberg (2015) *batman: BAsic transit model cAlculatioN in python*, published in Publications of the Astronomical Society of the Pacific

3 Maxted (2016) *ellc: A fast, flexible light curve model for detached eclipsing binary stars and transiting exoplanets*, published in A&A