The Shocking Transit Variability of HD 189733b

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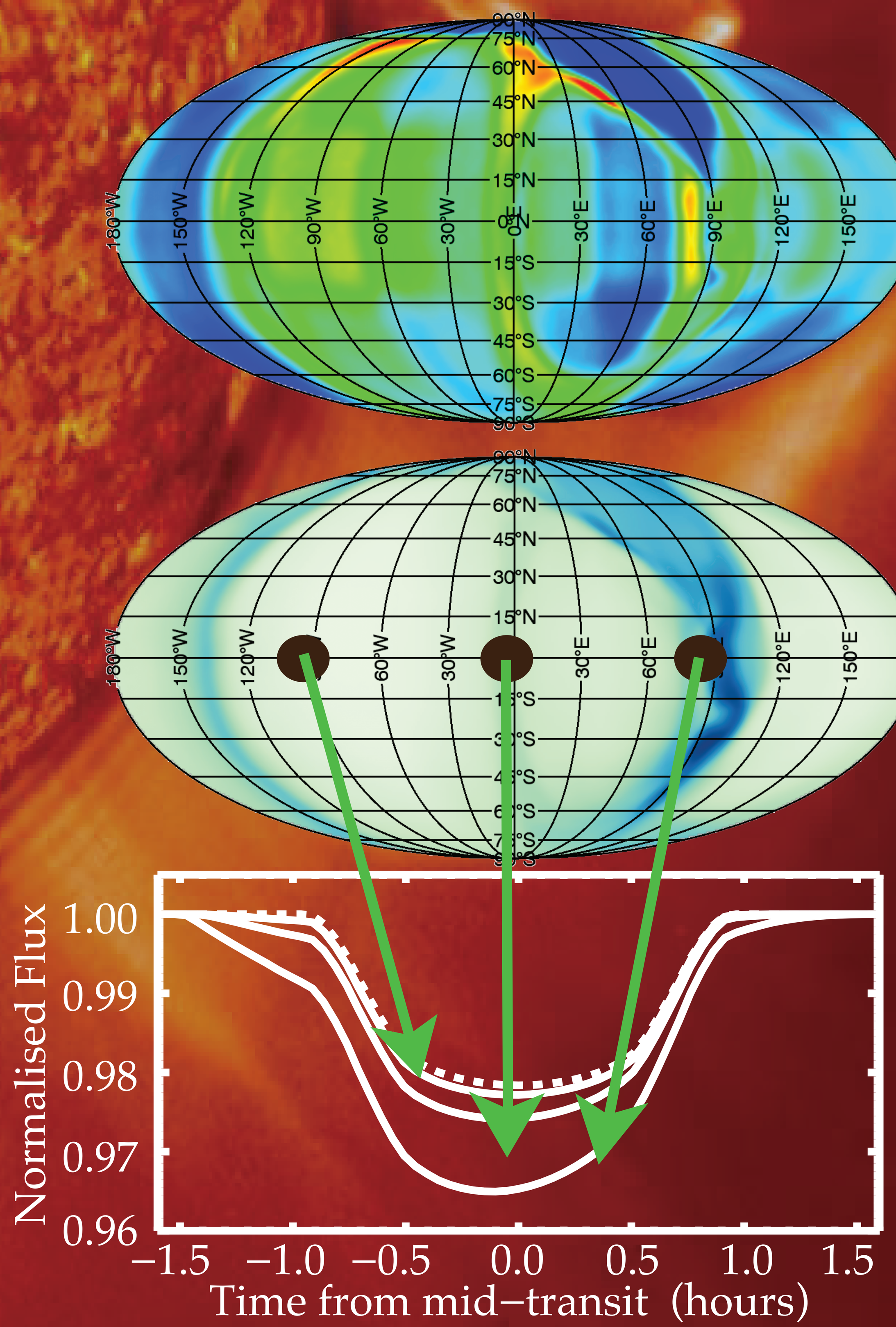
1. Introduction

- Asymmetries in exoplanet transit light curves have proved a useful tool for probing the atmospheres of hot-Jupiter's.
- The early-ingress and additional absorption found in the near-UV light curve of WASP-12b by Fossati et al. (2010) has been attributed to the presence of a shock around the magnetosphere of the planet (Vidotto et al. 2010). Llama et al. (2011) modelled a simple shock and were able to reproduce the near-UV light curve of WASP-12b.
- Observations of the hot-Jupiter HD 189733b have revealed transient asymmetries in the light curve of the planet at various wavelengths.
- Fares et al. (2010) observed HD 189733 in June 2007 and again a year later in July 2008. They used Zeeman-Doppler Imaging to recover the magnetic topology of the star.
- Here we investigate the stellar wind of the host star HD 189733 to show how variability in the wind may change the observed transit light curves .

2. The Model

- The magnetic maps are used as input to a three-dimensional MHD stellar wind model that enables us to determine the local wind conditions around the planet HD 189733b.
- At every point the planet orbits through around the star we recover the density of the stellar wind, the wind speed, total pressure and the magnetic field strength which enables us to fully define the geometry of the resultant shock.
- We use the shock model of Wilkin et al. (1996) and extend it to create a three-dimensional model which can be integrated along the line-of-sight to create the projected absorption profile that would be observed at the orbit of the planet. We assume a planetary magnetic field strength of 14G.
- We then simulate the planet and shock transiting over a limb-darkened stellar disc using the limb-darkening law of Claret et al. (2004) to produce the near-UV light curve. A transit of a planet and bow shock is shown in the left figure.

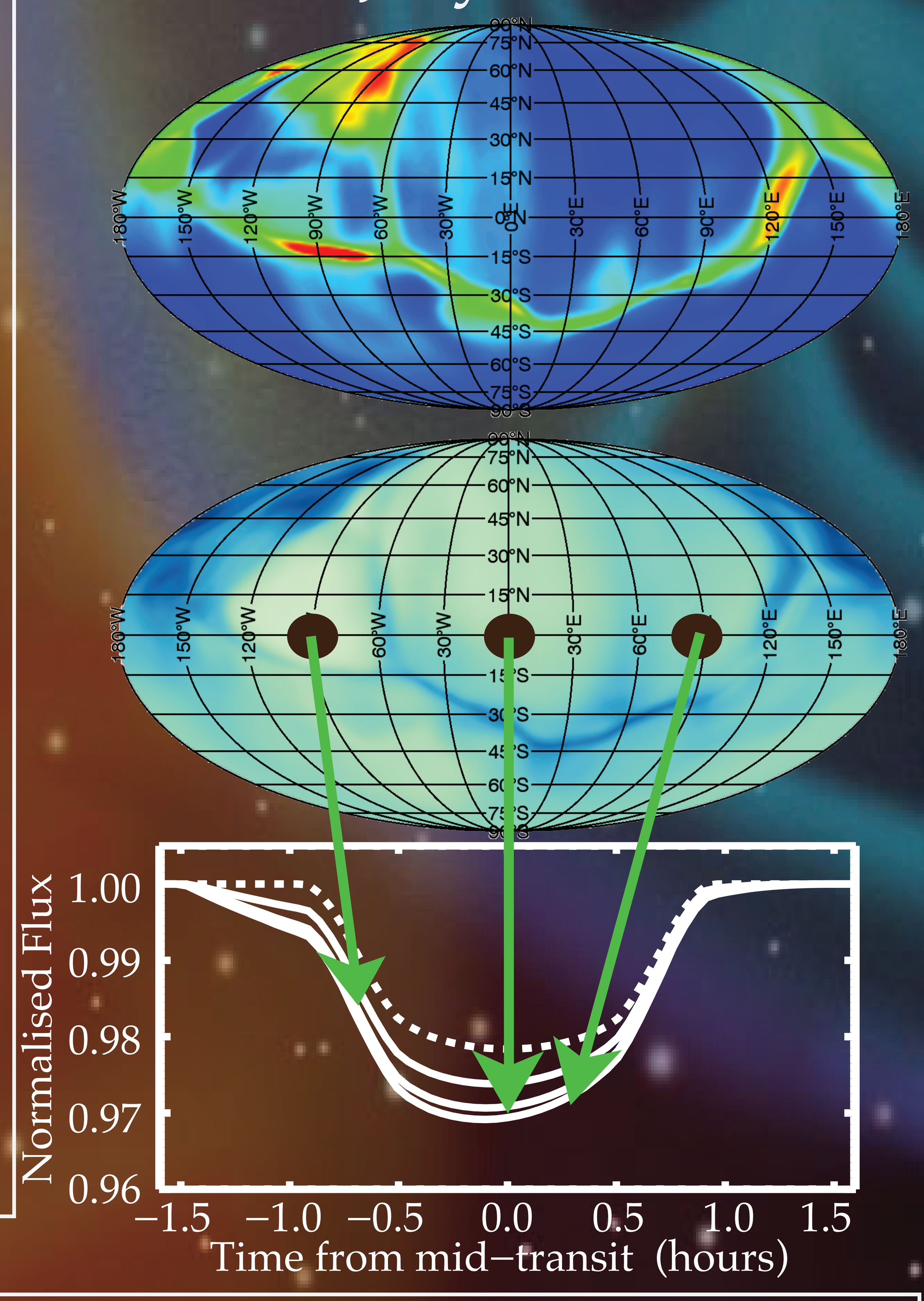
June 2007



3. Results

- Shown is the total pressure (top) and density (middle) of the stellar wind for June 2007 (left) and July 2008 (right).
- In both epochs of observation, we find the stellar wind to be highly structured. The wind has also evolved with the magnetic evolution of the host star.
- The bottom panel shows a selection of simulated near-UV light curves for the planet and resultant bow shock (solid) and an optical model, i.e. where no shock has been detected (dashed).
- In all cases we find the near-UV transits begin before and are deeper than the optical transit. This is because the shock transits ahead of the planet and ocullts additional star light.

July 2008



4. Conclusions and Prospects

- We have shown that near-UV tranists of the hot-Jupiter HD 189733b would be deeper and longer than the simultaneous optical observations due to the presence of additional absorbing material from a bow shock.
- We have found that the light curves can vary in both depth and timing due to the density of the stellar wind changing as the planet orbits around the star.
- Near-UV transit observations are therefore a good method for studying the stellar wind and its interaction with the planet's mangetosphere.

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