Transiting Planets
Proceedings IAU Symposium No. 253, 2008
Frédéric Pont, Dimitar Sasselov & Matthews Holman, eds.

doi:10.1017/S1743921308026938

MOST Spacebased Photometry of HD 189733: Precise Timing Measurements for Transits Across an Active Star

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Abstract. We have measured transit times for HD 189733 passing in front of its bright (V = 7.67) chromospherically active and spotted parent star. Nearly continuous broadband photometry of this system was obtained with the *MOST* (Microvariability & Oscillations of STars) space telesope during 21 days in August 2006, monitoring 10 consecutive transits. We have used these data to search for deviations from a constant orbital period which can indicate the presence of additional planets in the system that are as yet undetected by Doppler searches. We find no variations above the level of ±45 s, ruling out planets in the Earth-to-Neptune mass range in a number of resonant orbits. We find that a number of complications can arise in measuring transit times for a planet transiting an active star with large star spots. However, such transiting systems are also useful in that they can help to constrain and test spot models. This has implications for the large number of transiting systems expected to be discovered by the CoRoT and Kepler missions.

See Miller-Ricci *et al.* 2008 *ApJ*, 682, 593 for more details.

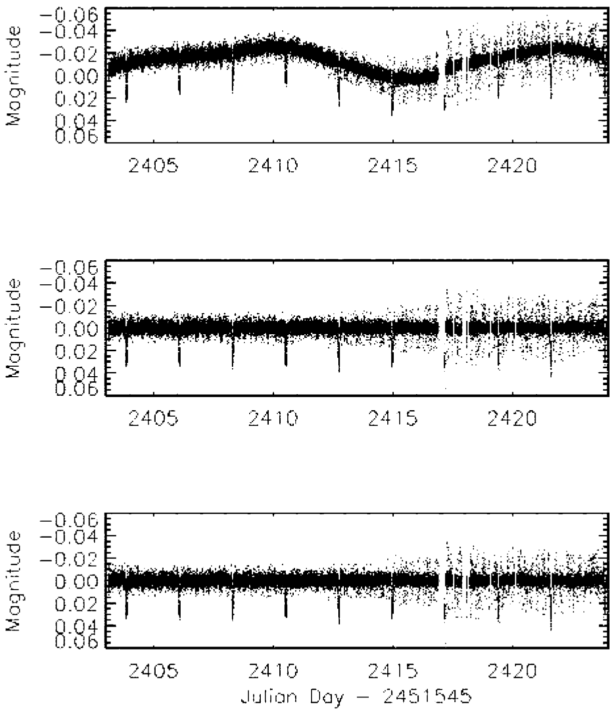

Figure 1. Top: *MOST* light curve of HD 189733. During the first 14 days of the observing run *MOST* monitored HD189733 with a duty cycle of 94%. For the last 7 days the duty cycle was reduced to only 46% as the telescope was splitting its time between two primary science targets. Rotational modulation due to star spots on the surface of HD 189733 ban clearly be seen in the light curve at a level of about 3%. The presence of two or more star spots is needed to explain the shape of the out of transit data. Bottom: For subsequent transit timing analysis we remove the underlying variability of the host star by smoothing the out of transit data and subtracting it from the light curve.

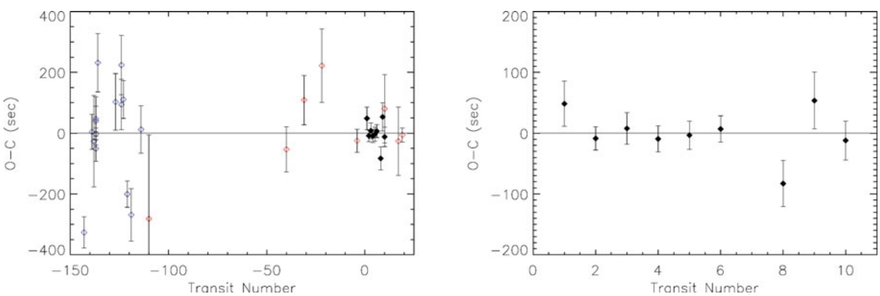

Figure 2. Left: Transit times for HD 189733. The ordinate plots the deviation from a constant orbital period model as a function of transit number. Here we show all of the available transit times from *MOST* (black symbols), Bakos *et al.* (2006; blue symbols), and Winn *et al.* (2007; red symbols). **Right:** Transit times for HD 189733 showing only the 9 *MOST* transit times that we obtained for well-sampled transits. *Refs: Bakos, G. Á., Knutson, H., Pont, F., et al. 2006, ApJ, 650, 1160 Winn, J. N., Holman, M. J., Henry, et al. 2007, AJ, 133, 1828*

https://doi.org/10.1017/S1743921308026938 Published online by Cambridge University Press

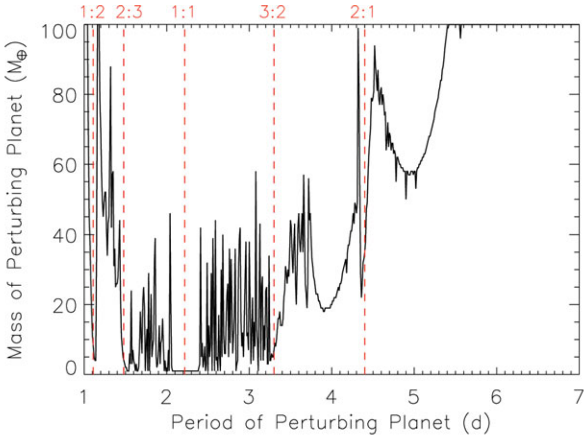

Figure 3. Maximum mass allowed for a perturbing planet in the HD 189733 system, which still remains consistent with the *MOST* transit times. Planets occupying the region of parameter space above the black curve are ruled out with 95% confidence by comparison of the transit timing data to results from n-body simulations.

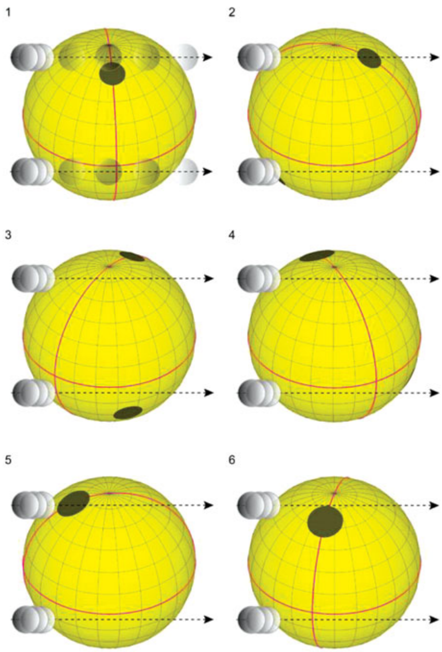

Figure 4. Spot model for HD 189733 at the time of the *MOST* observing run. Snapshots from the model have been taken at the times of the six complete transits observed by *MOST*, and the position of the transiting planet has been overlaid. The spot model fits two circular star spots to the variability seen in the *MOST* light curve (Figure 1). We assume circular star spots and solid-body rotation, and have allowed each of the star spots to evolve in size over the duration of the 21-day observing run. The star spots are assumed to be 1,000 K cooler than the rest of the photosphere. The projected tracks of the transiting planet are also shown, with two tracks for each transit since only the orbital inclination, not its orientation (north vs. south) is known. A northern hemisphere transit is ruled out if the spot model is correct, since effects of the planet moving across the large star spot in thie region would be readily visible in the transit light curve.

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