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A Hot Jupiter in a Nearly Polar Orbit

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Abstract. We measured the spin-orbit misalignment for WASP-79b, a transiting hot Jupiter from the WASP survey. Using the Rossiter-McLaughlin effect during the transit event, we determined the sky-projected obliquity to be $\lambda = -106^{+10}_{-8}{}^{\circ}$. This result indicates that the planet is in a nearly polar orbit.

Keywords. planets and satellites: formation — stars: individual (WASP-79) — techniques: radial velocities

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1. Introduction

Key additional insights into the formation, migration, and evolution of the more than 900 exoplanets known (as at June 2013), can be obtained from the measurement of the sky-projected spin-orbit angle of exoplanetary systems through spectroscopic measurements of the Rossiter-McLaughlin effect (Winn *et al.* 2005).

We have carried out spectroscopic follow-up measurements of the Rossiter-McLaughlin effect for WASP-79b, a recently discovered hot Jupiter from the WASP Southern Hemisphere transit survey (Smalley *et al.* 2012). WASP-79b has a mass M_P of $0.90 \pm 0.09\, M_J$, radius R_P of $1.70 \pm 0.11\, R_J$, and orbits an F5 star with $T_{eff} = 6600 \pm 100$K (Smalley *et al.* 2012). We detect the radial velocity anomaly due to the Rossiter-McLaughlin effect and determine that it is in a nearly polar orbit (Addison *et al.* 2013).

2. Rossiter-McLaughlin Effect

The Rossiter-McLaughlin effect is an anomaly in the radial velocity curve of a host star that is seen during an exoplanetary transit caused as the planet occults the stellar disk (Rossiter 1924; McLaughlin 1924; Ohta *et al.* 2005). Measurement of this anomaly provides us with an estimate of the projected rotational velocity of the stellar disk ($v \sin i_\star$) and the projected spin-orbit angle (λ) between the planetary orbital axis and the stellar spin axis (Winn *et al.* 2005).

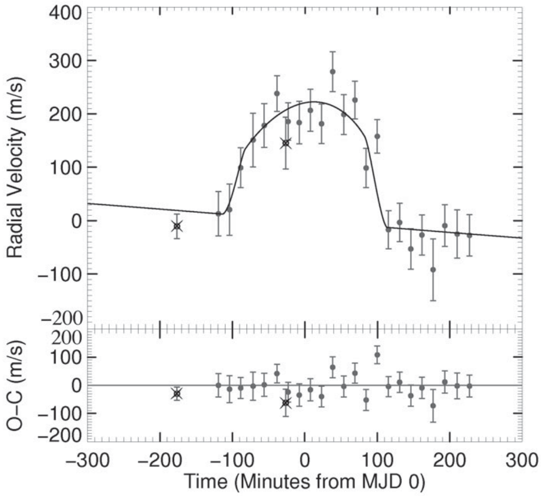

Figure 1. Spectroscopic radial velocities of WASP-79 plotted as a function of time along with the best fitting main-sequence model and corresponding residuals. The filled circles are our data, while the two open cross-circles are velocities by Smalley *et al.* (2012).

3. Observations, Analysis, & Results

WASP-79 was observed using the CYCLOPS2 (see Horton *et al.* 2012) optical-fiber bundle feeding the UCLES echelle spectrograph on the 3.9 m Anglo-Australian Telescope. The data was reduced and wavelength calibrated using custom MATLAB routines (Wright and Tinney, in prep. & see Addison *et al.* 2013). Radial velocities were computed using the IRAF task, *fxcor*, by cross-correlation with a spectrum of a bright template star (HD86264) of similar spectral type.

We have developed a modeling system (the Exoplanetary Orbital Simulation and Analysis Model, or ExOSAM) to determine λ and $v \sin i_\star$ from the planetary orbit, a calculated in-transit lightcurve, and a velocity anomaly Hirano *et al.* (2010).

Smalley *et al.* (2012) derived two preferred solutions for WASP-79 – one with it on the main sequence ($R_\star = 1.64 \pm 0.08\ R_\odot$) and one with it evolved just off the main sequence ($R_\star = 1.91 \pm 0.09\ R_\odot$). Using parameters from both solutions, we found $\lambda = -106^{+10}_{-8}{}^\circ$ and $v \sin i_\star = 17.5^{+1.3}_{-1.4}$ kms^{-1} for the main sequence case and $\lambda = -85^{+13}_{-33}{}^\circ$ and $v \sin i_\star = 16.0^{+1.3}_{-1.3}$ kms^{-1} for the non-main sequence case (Addison *et al.* 2013). Figure 1 shows the observed positive Rossiter-McLaughlin velocity anomaly, indicating that WASP-79b is in a nearly polar orbit. Only a handful of planetary systems display such extreme orbits. Additional samples of spin-orbit measurements will help to provide clearer insights into the mechanisms driving planetary migration and spin-orbit misalignments.

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