Follow Up of Transiting Hot Jupiters with the OpenScience Observatories

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HAT-P-23b Transit Measurements

Previous studies have disagreed whether HAT-P-23b is an inflated hot Jupiter on an eccentric orbit (Bakos et al. 2011, Ciceri, et al. 2015). We obtained 11 new transit observations with PIRATE, complemented by 6 observations made with POST, a 0.4m UK located telescope. Data reduction and photometry was carried out using Astrommage (Collins et al. 2015) and the transits modelled using ExofastV2 (Eastman et al. 2019) with radial velocity, broadband photometry and Gaia parallax data from the literature. In our analysis we confirm HAT-P-23b is likely inflated and on a circular orbit.

- $e = 0.027$ is consistent with a circular orbit.
- $R_P = 1.308^{\pm 0.004} R_J$, 4% smaller than previously reported.

Concurrent Host Star Monitoring

Motivated by a suspected ~3% variation in HAT-P-23 brightness (Sada et al. 2016), we obtained monitoring observations covering 50 nights over a 93 day period consecutive with our transit observations. We detected a clear 7.015d periodic variation, though with a smaller amplitude than expected, which we attribute to stellar rotation due to surface spots.

WASP-52b Transit Measurements

WASP-52b is a 0.4Mhot Jupiter orbiting an active host star. We obtained 8 new transits with the OSO telescopes with 5 transits obtained using POST. Our new transit observations show no obvious signs of spot crossing events typical in the literature, e.g. Manser et al. (2017). We do detect an ~0.3 mag variation in the host star brightness from out-of-transit data and find a tentative trend towards deeper transits with decreasing host star brightness. Together these indicate WASP-52 is still active but the spot latitude has migrated away from the transit chord.

WASP-52b Transit Timing

Our analysis of the new transit mid-times and reanalysis of those from the literature slightly prefers a quadratic ephemeris with $\Delta T = 0.07$ and $\Delta \text{BIC} = 1.53$ compared to a linear ephemeris. We calculate a period change $\Delta P / P = -38.6 \pm 4 \times 10^{-6}$ and find that orbital decay due to tidal interaction is unlikely. A plausible explanation is transit mid-time errors introduced through undiscovered spot crossing events. We predict further observations through the 2021 season will be able to confirm or refute this suspected period change (below).

Transit Timing

In July 2018 the OSO telescopes were upgraded with GPS shutter timing control. Before the upgrade of GPS timing control the 1σ uncertainty in the O-C determinations for HAT-P-23b transits improved almost three fold. At the same time the calculated mean O-C value before and after the upgrade, remained consistent to within 7 seconds, well within the typical transit mid-time measurement uncertainties.

References

Bakos et al. (2011), Astrophysical Journal, 742
Ciceri et al. (2013), Astronomy & Astrophysics, 577, A55
Collins et al. (2019), The Astronomical Journal, 153
Eastman et al. (2013), AJ, 146, 1360
Kolb et al. (2018), RTSRE Proceedings Vol. 1, No. 1, 127
Sada et al. (2016), Publications of the Astronomical Society of the Pacific, 128

Photometric Stability

- Between two and six measurements of HAT-P-23 obtained each night.
- 50 nights of observations over a 93 day period.
- 95% of observations made at airmass < 1.4.
- Average nightly scatter was 0.007 mag.
- 1σ uncertainty for the mean nightly check star magnitude over the entire 93 day period was 0.002 mag.

Performance

The excellent photometric performance of the telescopes at the OSO can be seen in the lightcurve below which is a phase fold of five complete transits of WASP-52b made through an Rc filter with PIRATE.

The grey dots are the photometric measurements supplemented with Astrommage (Collins et al, 2011) and the green line is the transit model calculated using ExofastV2 (Eastman et al. 2016). The red dots are 3-minute bins of the data which achieves an average out-of-transit RMS of 575ppm. This compares excellently with measurements of WASP-52b made with the 1.54m DK telescope with out-of-transit RMS residuals of 850ppm and individual transits of SpB (Kosal et al. 2015).

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ABSTRACT

We have been using the Open University OpenScience Observatories (OSO) to undertake follow up observations of known transiting hot Jupiters for the past three years. Here we present recent system characterisation and transit timing results for WASP-52b and HAT-P-23b and report on the performance of the observatory.

The OSO consists of two 0.4 meter class telescopes (PIRATE and COAST) used for undergraduate distance learning and research (Kolb et al 2018). The telescopes, located at Teide Observatory on Tenerife at an altitude of 2390m, can be operated remotely in real time for teaching or fully autonomously via an automated scheduler. Teide Observatory provides an excellent location for monitoring with typical seeing of 0.6” and an average 280 clear nights per year. Our new observations, supplemented with additional data from a telescope located in the UK and previously published results, show that HAT-P-23b is slightly less inflated than previously reported and not eccentric. We found that a linear ephemeris is the best fit to the available timing data. For WASP-52b we slightly prefer a quadratic ephemeris indicative of period change. Further observations through the 2020-21 observing season should discriminate between the linear and quadratic ephemerides.