WASP-SOUTH DETECTION OF HD 219666B TRANSITS PROVIDES AN ACCURATE EPHEMERIS

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The hot-Neptune HD 219666b (= TOI-118.01; Esposito et al. 2019) was an early discovery from Sector 1 of the TESS transit survey (Ricker et al. 2016). Being a rare “Neptune desert” planet, and transiting a bright, $V = 9.9$ star, it is a prime target for further study including atmospheric characterisation. Targeting exoplanet transits with major facilities such as HST and the imminent JWST depends on an accurate ephemeris. The transit period presented by Esposito et al (2019) derives primarily from 4 transits spanning 18 days and has an uncertainty that will amount to several hours by the time that TESS re-observes this region of sky, likely to be in 2021.

Here we report a recovery of the transit in WASP-South data, enabling an ephemeris with a period uncertainty that is a factor of 60 smaller. The 8-camera, WASP-South transit survey (Pollacco et al. 2006) has produced 150 transiting exoplanets (e.g. Hellier et al. 2019a). The transit depth of HD 219666b, at only 0.17%, is shallower than that of any WASP planet (for example the bright-star, super-Neptune WASP-166b has a transit depth of 0.28%; Hellier et al. 2019b). Nevertheless, at $V = 9.9$, and being relatively isolated on the sky, HD 219666 was in the “sweet spot” for WASP-South, both when using 200-mm lenses (observing HD 219666 from 2010–2012), and when using 85-mm lenses (observing 2012–2014). A total of 148,000 photometric data points were obtained on this star.

The standard WASP transit-search code (Collier Cameron et al. 2007) successfully finds the transit, from coverage of 24 partial or full transits over the period 2010 July to 2014 Oct. The code reports the dip as 0.2% deep and 2-hr wide, values consistent with those from TESS (0.17% deep and 2.5-hr wide). The resulting transit ephemeris is:

$$\text{WASP (JD TDB)} = (245 5788.6920 \pm 0.0043) + N \times (6.03446 \pm 0.00007)$$

which compares with the Esposito et al. (2019) ephemeris:

$$\text{TESS (JD TDB)} = (245 8329.1996 \pm 0.0012) + N \times (6.03607 \pm 0.00064).$$

The TESS/WASP period ratio is 1.00027 and thus the chances of a period match to this accuracy being spurious are 1-in-2000, though bear in mind that we have also been looking for period matches with several hundred other TESS candidates where a WASP match is feasible.

At the epoch of the TESS observation the WASP ephemeris predicts the transit to an accuracy of 0.03 day, or 0.005 in phase. Thus the chances of a spurious match within this window are 1-in-100. The TESS epoch actually locates at 420.99999 cycles on the WASP ephemeris. Thus the combination of the period match and the phase match give confidence that the WASP detection is real, with a likelihood of being spurious below 1%.

Taking the difference between the epochs as exactly 421 cycles then leads to the more accurate ephemeris:

$$\text{Combined (JD TDB)} = (245 8329.1996 \pm 0.0012) + N \times (6.034460 \pm 0.000011).$$

The combined ephemeris has a drift of only one minute per year, and should prove useful to those scheduling observations of HD 219666b. The early WASP timing can also contribute to long-term monitoring of any period changes. The revised period is 2.5 TESS error bars from the TESS period, where we note that the last of the 4 TESS transits was at a time of excess noise in the TESS data, which may have affected that timing.

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Figure 1. Portions of the 200-mm WASP-South data on HD 219666. The orange lines mark transit times as found by the search algorithm. There are likely detections of the shallow, 0.17%-deep transit at midpoint times: 245 5396.45, 245 5420.59 & 245 5426.62, and these will be the earliest transits of HD 219666b recorded. While the individual transit events are not necessarily convincing to the eye, the match in both period and phase of the search-algorithm output gives confidence that the detection is real.

REFERENCES

Collier Cameron A., et al., 2007, MNRAS, 380, 1230
Esposito M., et al., 2019, A&A, 623, A165
Hellier C., et al., 2019a, MNRAS, 482, 1379
Hellier C., et al., 2019b, MNRAS, 488, 3067
Pollacco D. L., et al., 2006, PASP, 118, 1407
Ricker G. R., et al., 2016, in Space Telescopes and Instrumentation 2016: Optical, Infrared, and Millimeter Wave. p. 99042B, doi:10.1117/12.2232071