Kepler K2 observations of the hot Jupiters WASP-47b & WASP-75b

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The stars WASP-47 (EPIC 206103150) and WASP-75 (EPIC 206154641) are both on-silicon for K2 Field 3 and are the only transiting-exoplanet hosts currently known in Fields 2 and 3. Both are relatively bright stars (V = 11.9 and 11.5) of spectral types G6 and F9 respectively.

The planets WASP-47b and WASP-75b are both hot Jupiters. WASP-47b has $P_{\rm orb}$ = 4.16 d, M = 1.14 $\rm M_{Jup}$ and R = 1.15 $\rm R_{Jup}$. WASP-75b has $P_{\rm orb}$ = 2.48 d, M = 1.07 $\rm M_{Jup}$ and R = 1.27 $\rm R_{Jup}$. Neither of these shows the "inflated" radii often seen in hot Jupiters. For details of the planets see Hellier et al. 2012 (MNRAS, 426, 739) and Gomez et al. 2013 (A&A, 559, A36).

Science aims:

The $\sim$ 80 days of K2 observations will cover $\sim$ 19 transits of WASP-47b and $\sim$ 32 of WASP-75b. Our aims are:

(1) Better parameterisation of the transit lightcurve and thus of the masses, radii and densities of the planets. Kepler-quality photometry will greatly exceed the currently available ground-based transit photometry. For example, for WASP-47b only one follow-up lightcurve (with the 1.2-m EulerCAM) has been obtained. With these targets being bright compared to most Kepler planet hosts, this is an opportunity for a precision of parametrisation currently only available for a handful of systems.

(2) By observing many transits of these relatively bright stars we can look for star spots in the transits, which if detected would reveal the magnetic activity of the star, and allow determination of the relative angle of the planet orbit against the stellar spin (e.g. Sanchis-Ojeda et al. 2012, Nature 487, 7408 on Kepler-30).

(3) We can look for transit-timing variations over the 80 days, which would indicate the presence of additional planets. Most hot Jupiters do not show such TTVs, indicating that any additional bodies are on much longer orbits, but finding any closer-in third body would be highly significant and thus is worth attempting.

(4) We can look for the phase curve over the planet's orbit, as would result from the heated face of the planet. Such have been detected in Kepler photometry of close-in planets around bright stars (e.g. KOI-13). However, there are only 5 hot-Jupiter systems in the original Kepler field that are as bright or brighter than our targets, and thus adding to the number of phase curves for hot Jupiters is highly worthwhile. In particular, WASP-75b, in a 2.48-d orbit around a hot, 11th-mag F-star is a prime candidate.

(5) We will look for the occultations of the planets, which should be detectable at these magnitudes and would give information on the planets' temperatures. The phase of the occultation also ties down the eccentricity of the planet's orbit, in a manner orthogonal to RV observations. Tight constraints on hot-Jupiter eccentricities are important for understanding the dynamical history of hot-Jupiter orbits, believed to result from Kozai migration from orbits much further out.

Short v Long Cadence:

Some of the above science could be achieved with LC data, and we request this if insufficient SC slots are available. However, SC would be far better for much of the science, particularly the parametrisation of the transit, looking for the planet occultation, and looking for star spots.

To investigate the parametrisation of the transit (and hence planetary masses and densities) we generated model transit light curves using the JKTEBOP code (Southworth, 2008, MNRAS, 386, 1644) and covering the full duration of the K2 observations of Field 3. These were resampled to the LC and SC cadences with Gaussian noise added corresponding to a six-hour photometric precision of 90 ppm (Howell et al., 2014, arXiv:1402.5163). The synthetic data were then modelled with Monte Carlo simulations to determine the best-fitting parameters and robust errorbars.

We find that the fractional radii of star and planet are better determined by factors of 2.5 to 4.5 from the SC data versus the LC data, raising them to the quality of space-based results versus being equivalent to merely a good ground-based study (see also the discussions for Kepler-5 and Kepler-8 in Southworth, 2011, MNRAS, 416, 2166).

The SC data yield planetary radii which are better by between 2 and 3 σ, and planetary densities which are similarly improved. Full error budgets for the analyses show that the SC data are minor contributors to the overall uncertainties in the system parameters, whereas the LC data would be the dominant source of uncertainty, just as existing ground-based data are at present.

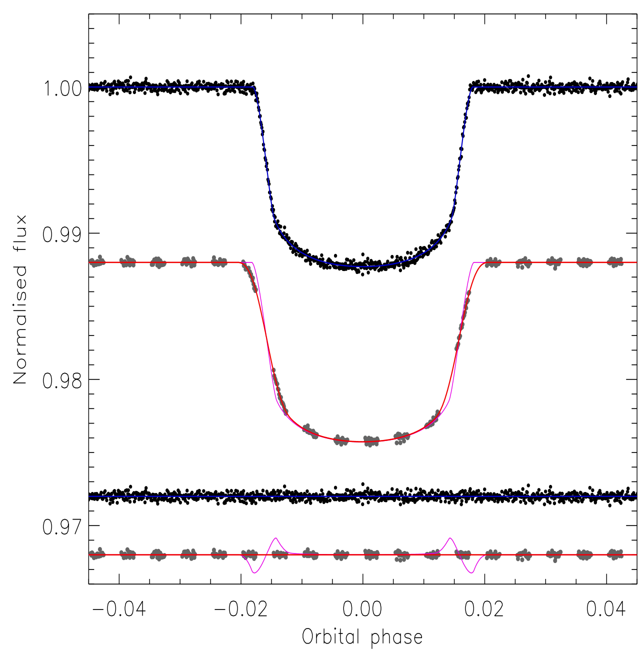

Fig. 1: Simulated SC data (top) v LC data (middle) and the difference in the fitted models (bottom). For WASP-47b.