K2 Target Proposal Campaign 0

Detached solar-type eclipsing binaries from the WASP survey

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Accurate masses and radii can only be obtained for exoplanets in transiting systems, but these measurements are limited by the accuracy of the radius estimate for the host star. The solution to this problem is to characterize in detail stars similar to planet host stars in detached eclipsing binary stars (DEBS). We are using the WASP archive to find targets for the K2 mission suitable for calibrating our models of planet host stars. We propose 2 K-dwarf+M-dwarf DEBS for Campaign 0.

Standard stellar models under-predict the radii of some low mass stars by $\gtrsim 10\%$ (Fig. 1). Similar errors may be present for solar-like stars ($M \sim M_{\odot}$), but this is unclear because an error in the model radius can be masked by a compensating error in the assumed age. It is only possible to measure precise ($\pm 1\%$) model-independent masses and radii for low-mass stars from careful analysis of high-quality data for stars in detached eclipsing binary stars (DEBS). These stars give the best evidence for a radius anomaly and will be the key to understanding this problem. The prime suspect for this radius anomaly is magnetic fields caused by rapid stellar rotation, but this cannot be the whole story because there are at least two examples of low mass stars that are not rapid rotators but that clearly show a radius anomaly (Kepler 16B and LSPM J1112+7626).

As an alternative to stellar models, we have developed empirical calibrations of the stellar radii based on observable quantities to estimate the radii of host stars to WASP planets, i.e. $R_{\rm star} = f(\rho_{\star}, {\rm T_{eff}}, {\rm [Fe/H]})$. However, most of the stars in DEBS studied to-date are unsuitable for calibrating models of planet host stars (Fig. 2). Many of these stars lack any useful estimate of their surface composition and several are too faint (V$\gtrsim$ 13) for high resolution spectroscopy to be feasible. Most of these stars are in binaries with very short orbital periods ($P_{\rm orb} \lesssim 3$ days) and are forced to co-rotate with the orbit and so they show much higher levels of magnetic activity than planet host stars. For stars more massive than about $0.8M_{\odot}$ the unknown age of the star can hide a real radius anomaly caused by magnetic fields or some other effect. This is less of a problem if there is a large difference in mass between the stars because the requirement that both stars are coeval then puts strong constraints on their age.

For the Campaign 0 field we have identified two eclipsing K-type stars with periods of 4.5 and 9.8 d (Fig. 3). The M-dwarf companions contribute about 5% and 0.5% of the light in these systems, i.e., bright enough so that we can measure their radial velocities from optical or infrared spectroscopy and so measure model-independent masses. The Kepler lightcurves will enable us to measure very precise radii for the stars from the geometry of the total eclipses, and to quantify the contribution of any starspot activity to the uncertainties on the radii. The systems are bright enough for us to use echelle spectroscopy to determine [Fe/H] for the primary star. The eclipse duration is about 4.5 h so long-cadence data are sufficient to measure precise radii.

We expect ~2 suitable targets for this project in each K2 mission field, so this project has the potential to double the number of stars suitable for calibrating models of exoplanet host stars and to extend the calibration into the M-dwarf regime.

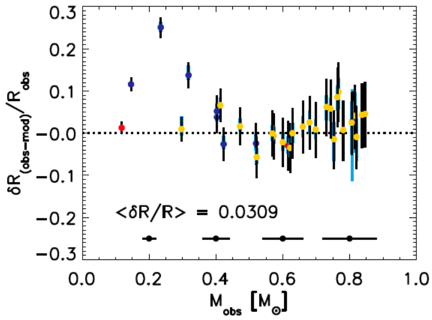

Figure 1: Error in the radius for the best-fitting stellar model for stars measured by interferometry, blue/yellow/red = metal-poor/solar/metal-rich. (Spada et al., 2013ApJ...776...87S).

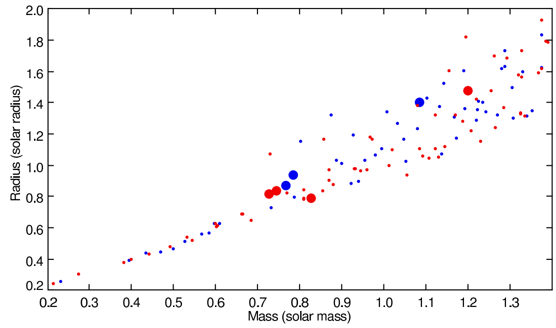

Figure 2: Masses and radii of stars in detached eclipsing binaries suitable for calibrating models of planet host stars. (Data from *www.astro.keele.ac.uk/~jkt/debcat*)

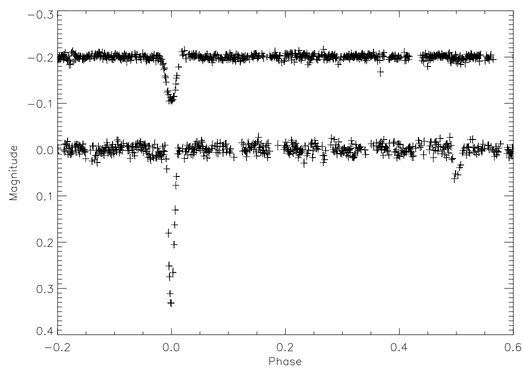

Figure 3: Binned WASP lightcurves of the target stars.