The WFCAM Transit Survey:

Constraining the M-dwarf mass-radius relation

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1 Background: The mass-radius relation

There appears to be a significant discrepancy between observational radius measurements of M dwarfs and the radii predicted from state-of-the-art models. Specifically, the models under-predict stellar radii by 5-10 % and over-predict their effective temperatures by 3-5% (Lopez-Morales & Ribas, 2005). There is a hint that this may be worst above the onset of full convection. Possible interpretations suggest a dichotomy with stellar activity, which may inflate the more active stars (Morales et al. 2010, Jackson & Jeffries 2009). The sample of low-mass EBs remains inadequate, with no stars below $0.2M_{\odot}$ measured to an accuracy better than 3%, leaving stellar evolution models poorly constrained.

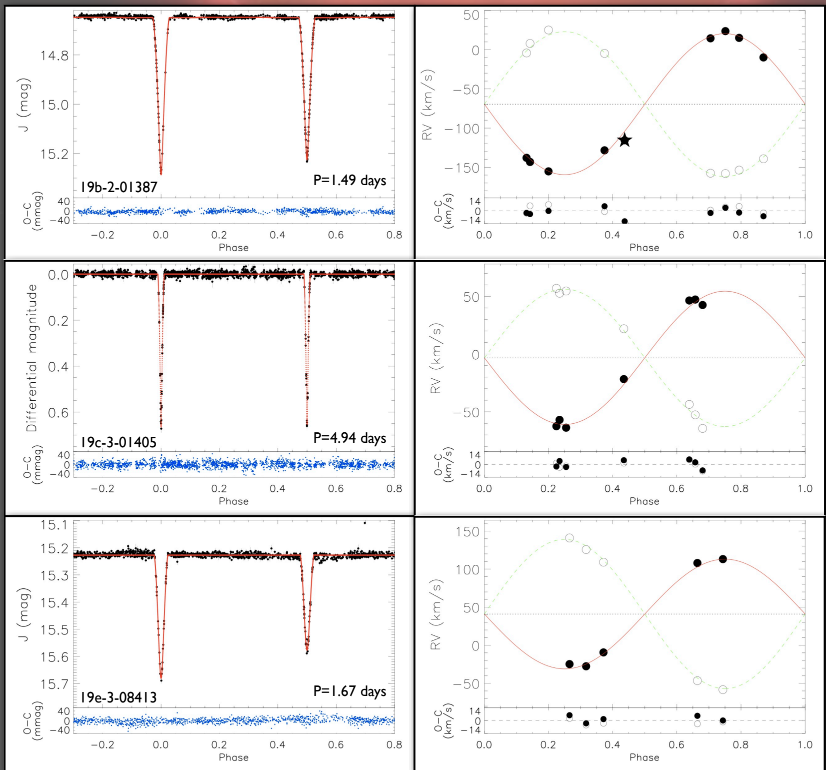

Fig 1: The J-band light curves[1] and RV curves for three newly discovered eclipsing binaries in the WTS. Their derived masses and radii are shown in figure 3.

2 Four new *low-mass* eclipsing binaries

We have uncovered four new eclipsing binaries with all components $<0.6M_{\odot}$. The objects were discovered as part of the WFCAM Transit Survey (WTS) which is a photometric monitoring campaign, operating in the J-band on the United Kingdom Infrared Telescope (UKIRT). The WTS light curves have an RMS scatter <1% for J<16 and a precision of 3-4mmag for the brightest targets. We have measured masses and radii for three of the new EBs by combining the WTS light curves with intermediate resolution spectroscopy from ISIS at the WHT. These three EBs are shown in figure 1. The fourth EB has $L_2/L_1 \sim 0.1$ meaning we couldn't extract a mass ratio with the 4-m WHT (see figure 2) thus we are awaiting observations with the 8-m Hobby-Eberly telescope echelle spectrograph to confirm our estimated masses of $\sim 0.1M_{\odot}+0.2M_{\odot}$, displayed as shaded squares in figure 3.

Our new EBs have radius measurements that appear to deviate from current evolution models for partially radiative stars. We envisage that the WTS will provide a large sample of these objects to provide stringent observational constraints for models.

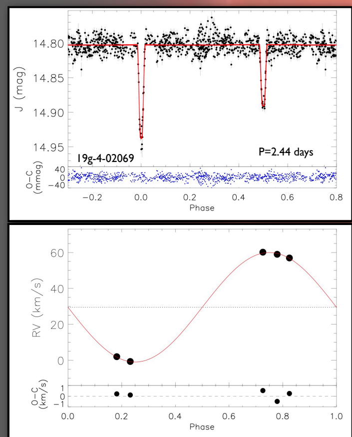

Fig. 2: Light curve (left) and RV curve (right) of a new, very low-mass EB from the WTS. Based on the available data and the Nextgen models we estimate masses of $\sim 0.1M_{\odot}+0.2M_{\odot}$. The object populates the desert of observations in the fully convective regime.

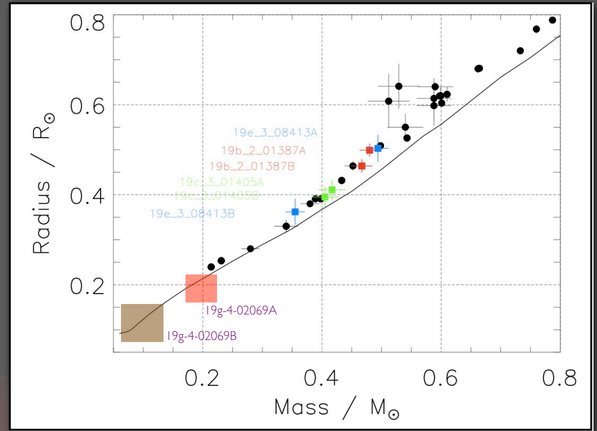

Fig. 3: Mass vs. radius for known low-mass eclipsing binaries and our new discoveries. The black circles show known systems with masses and radii reported with errors <10%. The red, green and blue squares correspond to the primary and secondary components in the upper, middle and lower panels of figure 1, respectively. The solid black line is the 1 Gyr isochrone from the Baraffe et al., (1998) evolution models. Above the fully convective region, reported radii deviate significantly from the model.

3 Conclusions

- ★ We present four newly discovered low-mass eclipsing binaries with masses and radii measured to accuracies ~3-7%.
- ★ Their radii appear inflated compared to current stellar evolution models, in agreement with the few existing EB measurements.
- ★ The short periods of these EBs indicate rapid rotation and thus give support to the interpretation that rotation, magnetic activity and accretion history may be the key to the correct modelling of the evolution of low-mass stars.

References: Baraffe et al., 1998, A&A, 337; Birkby et al., 2010, in prep; Jackson & Jeffries, 2009, MNRAS, 399; Morales et al., 2010, ApJ, 718; López-Morales & Ribas, 2005, ApJ, 631. [1]Light curves modelled with jktEBOP (http://www.astro.keele.ac.uk/~jkt)

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