The following sections have been generated by the PI using version 2017-1 of the template for Science Proposals. The page limit for these sections is 4 × A4 pages. Font size should not be less than 10 points.

16. SCIENTIFIC RATIONALE

This section needs to discuss the scientific background and aims of the proposal and why you want to make these observations. This section should not exceed 1000 words. Figures and graphics can be included, or appended in Section 21.

M-dwarfs are the most common stars in the Galaxy and are prime targets for exoplanet searches such as Mearth, TRAPPIST and SPECULOOS. They are perfect targets for hunting Earth-sized planets in the habbitable zone, which have orbital periods of 1-2 weeks and produce deep eclipses that will enable the study of atmospheric structures with transmission spectroscopy. Obtaining spectroscopic orbits and transit light-curves for such systems only gives the density of the host star and the surface gravity of the planetary companion. To obtain the planetary mass and radius, an estimate of the host stars mass is needed. This can be done with stellar models, however these are known to underestimate radius and temperature (Gomez Maqueo Chew et al. 2014). The radius anomaly for M-dwarfs has raised fundamental questions in stellar astrophysics. It has been suggest that enhanced magnetic fields suppresses convection, and inflates the radius of M-dwarfs. However, models including magnetic fields require unrealistically high magnetic field strengths to match the observed radii of well-studied M-dwarfs (Feiden Chaboyer. 2014). An alternative to evolutionary models is to use empirical mass and radius measurements from eclipsing binary stars, however there are currently very few calibrators to use in the low-mass regime (Fig. 1). Stars between 0.2 - 0.1 M_{sol} are the most common (and the most representative) stars in the Galaxy. There is an embarring problem in which there are a lack of empirical mass and radius measurements to provide good measurements of which evolutionary models can be tested against.

The WASP survey selects planetary candidates based on the estimated radius of the transiting object ($0.8 - 2R_{\rm Jupiter}$). Objects in this radius range can have masses which vary by three orders of magnitude, spanning from Saturn like planets to brown dwarfs. Radial velocity measurements from the CORALIE échelle spectrograph helped distinguish if the transiting body is a planet or M-dwarf, and the collaboration has yielded over 100 transiting planets (Turner et al, 2016). However, those that are found to be M-dwarfs can be analyzed with a method akin to exoplanets to obtain the mass and radius of both components in the system (Triaud et al. 2013., Gomez Maqueo Chew et al. 2014). These F/G/K-M-dwarf binaries, named EBLMs (eclipsing binary low-mass), cover a wide range of mass, composition, periods, and eccentricities allowing us to probe statistics and the bottom end of the main sequence.

We will calibrate the mass - radius - composition - luminosity relationship for the bottom end of the main sequence using EBLMs discovered by the WASP survey. We have good spectroscopic orbits for more than 200 EBLMs as a results of hundreds of hours of CORALIE time. But to accurately calibrate this relationship requires robust estimates of atmospheric parameters for the primary F/G/K star which dominates the light. Some CORALIE spectra for EBLMs have a signal-to-noise (S/N) too low to get reliable atmospheric parameters leading to this proposal for SALT-HRS spectra. We have included some bright stars in our target list, to compare results from HRS spectra against CORALIE .

For this reason, we request SALT time with the HRS to obtain a single spectrum of high signal-to-noise for all of the EBLMs which have good spectroscopic orbits. This will enable us to accurately measure the effective temperature, composition, $v \sin i$, and $\log g$ to provide exceptional mass and radius estimates from which empirical calibrations can be refined. Such relations will be required as future instruments discover planets in the habitable zone around M-dwarfs. Exiting new discoveries such as the TRAPPIST-1 system (Gillon et al. 2016) and Proxima Centauri b (Anglada-Escude et al. 2016) have attracted attention from the scientific community and public alike, bringing more focus to very low mass stars in exoplanet surveys. Because of this, it is imperative that we accurately constrain empirical calibrations for the bottom of the main sequence so that we can measure planets around M-dwarfs with confidence. We will also address important stellar physics issues with M-dwarfs: how many are inflated? By how much? What causes this phenomena?

17. IMMEDIATE OBJECTIVES

This section needs to present the plan of how you will use the data you will gather to achieve the science goals set out above. There is a 250 word limit.

We require medium resolution spectra with good signal-to-noise so that we can measure the effective temperature, composition and projected rotational velocity of the bright solar-type stars in a large sample of EBLMs. To estimate the minimum S/N we note that Smiljanic et al. 2014 found in their analysis of UVES-FLAMES spectra of FGK stars from the GAIA-ESO survey that precise estimates of Teff and [Fe/H] require a signal-to-noise per pixel of at least 50. Beyond this, systematic errors dominate. Subsequently, we will aim for a S/N per resolution element of 100. However a S/N of 50 will still be good enough to provide reliable atmospheric parameters ($T_{\rm eff} \pm 100\,$K, $\log g \pm 0.2$, [Fe/H] $\pm\, 0.1\,$dex).

18. DATA REQUIREMENTS FOR PROPOSAL COMPLETION

This section should explain what (if any) other observations are needed to complete the science objectives. If time is requested for more than one semester, the justification should be here. There is a 100 word limit.

No additional data will need to be obtained. The HRS spectra will be combined with spectroscopic orbits and WASP photometry to obtain mass and radius to a few per cent (see Fig. 2).

19. TECHNICAL JUSTIFICATION

This section should be limited to 500 words and needs to clearly demonstrate that you have used the SALT instrument simulation tools to find a configuration which makes sense and matches your science goals, including the S/N required. It needs to verbalize the overall observing strategy and to demonstrate that you understand the overheads involved in the observations and hence a justification of the total time requested.

The medium resolution of the HRS is a compromise between resolution to measure equivalent widths and throughput. We use the HRS simulator with a Kurucz model spectrum at solar values and V magnitude of 12.5 to estimate the time taken to achieve a S/N of 100 at the center of the wavelength range (see HRS simulation attached). For this model, we find an exposure time of 1200s is sufficient to achieve this in the red arm. Since we have a numerous EBLM systems, we scale this exposure dependent on the Vmag:

$$t_{exp} = 1200 \times 10^{0.4*({\rm Vmag}-12.5)}. \tag{1}$$

We enforce a maximum exposure time of 1200 s and a minimum of 300 s as very short exposure times would be inefficient. This proposal is well suited to priority 4 because the targets are bright stars and the require S/N can be built up from multiple observations if some spectra are affected by cloud. The sky background contribution is negligible for for bright stars and so we place no constraints on moon phase.

The construction of the target list comes from a list of 118 EBLMs, 38 of which have masses $< 0.2\,{\rm M}_{\rm sol}$, which are known to be of interest from the analysis of spectroscopic orbits (Triaud et al. 2017 in prep.). We calculated the visibility for all potential targets with the SALT visibility tool. We removed targets which had a maximum visibility of less than 1 hour for the upcoming semester.

20. REFERENCES

A list of all relevant references.

Gomez Maqueo Chew et al. 2014, aap, 572, A50
Turner et al, 2016. PASP, 128, 4401
Anglada-Escudé et al. 2016, Nature, 536, 437
Southworth, J. 2014, ASP, 496, 164-165
Feiden & Chaboyer, 2014, ApJ, 789, 53F
Gillon et al. 2016, Spitzer Proposal, 13067
Smiljanic et al. 2014, A&A, 570, 122
Triaud et al. 2013. A&A, 549, A18

21. ADDITIONAL RELEVANT FIGURES AND GRAPHICS

Any additional figures or graphics not already inserted in the text boxes can be placed here, provided the 4 page limit is maintained.

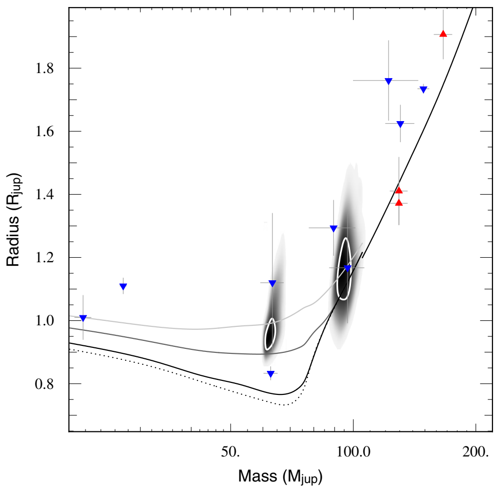

Figure 1: Mass-radius diagram for heavy planets, brown dwarfs and low-mass stars. Inverted blue triangles show eclipsing/transiting SB1s, upright red triangles denote interferometric measurements. The two posterior probability density distributions for WASP-30-b and J1219-39b are drawn in grey with 1 - σ confidence regions drawn in white. Image take from Triaud et al. 2013.

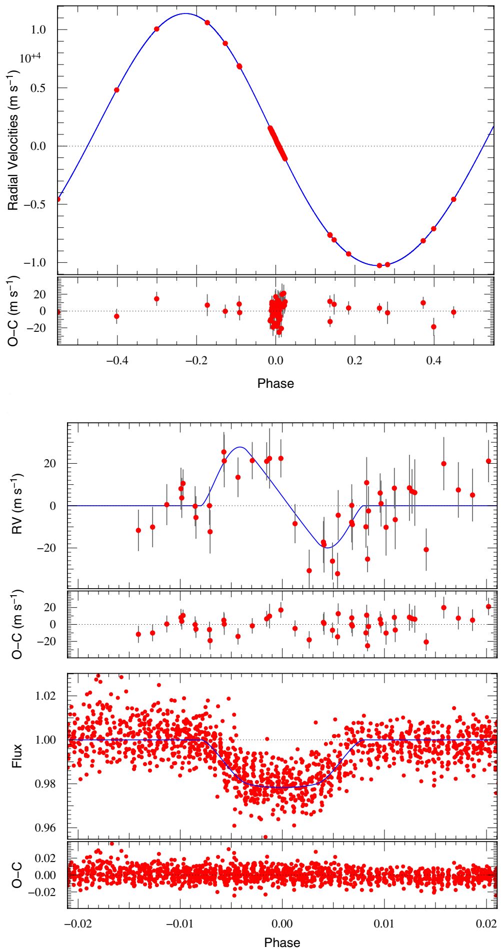

Figure 2: Top: CORALIE radial velocities on J1219-39 plotted with an eccentric Keplerian model and their residuals. Middle: zoom on the Rossiter-McLaughlin effect. Bottom: WASP photometry and model over-plotted. Image taken from Triaud et al. 2013.