Bull. Soc. R. Sci. Liège, 2023, **92**(2), 99–102 *Peer-reviewed conference paper*
doi:10.25518/0037-9565.11278

The close binary fraction of He-rich hot subdwarfs from SALT and TESS

E. J. SNOWDON[1,2,*], C. S. JEFFERY[1] and S. SCHLAGENHAUF[1,3]

[1] Armagh Observatory and Planetarium, UK
[2] Queen's University Belfast, UK
[3] Astrophysical Institute and University Observatory Jena, Germany
[*] Corresponding author: edward.snowdon@armagh.ac.uk

Paper presented at the 10th Meeting on "Hot Subdwarfs and Related Objects"
University of Liège (Belgium), June 13–17, 2022

Abstract

The Southern African Large Telescope (SALT) survey of He-rich hot subdwarfs has identified several binary candidates from variable or anomalous radial velocities, or unusually high rotational velocities. Many SALT survey objects have also been observed by the Transiting Exoplanet Survey Satellite (TESS). TESS light curves provide orbital periods and can also give clues about the nature of binary systems by distinguishing ellipsoidal variations from reflection effects. We present a summary of the candidate binary fraction within the SALT survey, as well as a breakdown of the identified candidates by spectral and helium class.

Keywords: hot subdwarfs, binaries, SALT, TESS

1. Introduction

Binary interaction channels for the formation of hot subdwarfs, such as those proposed by Han et al. (2002) do not account well for He-rich hot subdwarfs. Alternative channels based on the mergers of He-rich white dwarfs (Zhang and Jeffery, 2011) should produce either single stars, or stars in wide binaries. The existence of He-rich hot subdwarfs in close binaries has not been conclusively established, but would require further explanation. By searching for such systems, we aim to improve our understanding of subdwarf formation. The first step is to identify candidate close binary systems in existing survey data.

2. SALT and TESS observations

An ongoing medium- and high-resolution spectroscopic survey at the Southern African Large Telescope (SALT) has been focusing on identifying He-rich hot subdwarfs (Jeffery et al., 2021). The principal objectives are to identify both chemically-peculiar hot subdwarfs, and sequences connecting different chemically-peculiar populations. The survey has identified candidate binary systems from anomalous or variable radial velocities, as well as unusual line broadening. Many SALT survey objects have also been observed by the Transiting Exoplanet

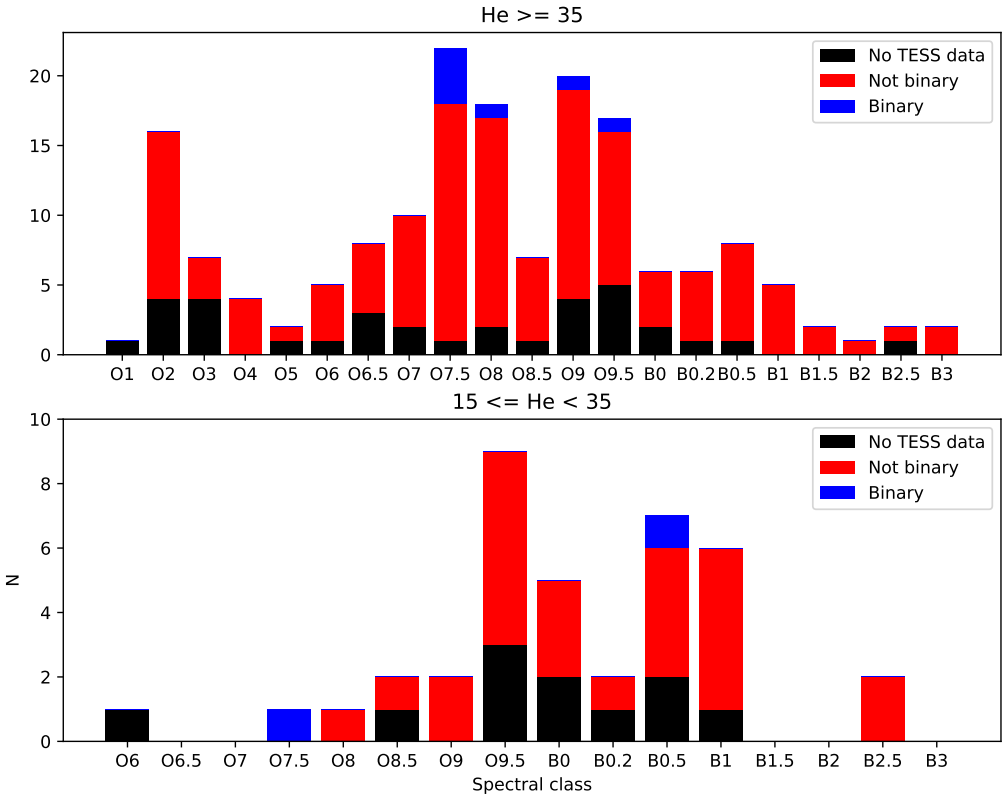

Figure 1: Observed binary fractions of SALT hot subdwarfs arranged by spectral and helium classes (Drilling et al., 2013). He-rich objects are shown above and intermediate-He objects below.

Survey Satellite (TESS). Lomb-Scargle periodograms derived from TESS light curves can yield the orbital frequencies of binary candidates. This method is most effective for close binaries with periods of < 1 d.

3. Results

Out of 338 SALT catalogue stars, 2 minute cadence TESS data are available for 232. 24 variables were identified from their periodograms. Of these, 8 were found to have an intermediate or high He abundance (He class ≥ 15). The majority are classified by SALT as He-rich sdOs, plus one intermediate-He sdO and one intermediate-He sdB. 3 objects showed evidence of ellipsoidal deformation, 5 showed evidence of reflection effects, none showed eclipses. Orbital frequencies ranged from 0.5 to 4 cycles per day. There was no correlation between orbital period and the spectral or Helium classes. A breakdown of detections by class is shown in Fig. 1.

4. Conclusions

The SALT survey objects have been cross referenced with TESS data to identify binary candidates. The fraction of close ($p \leq 2\,\mathrm{d}$) binary candidates was found to be 24 out of 232 objects ($\sim 10\%$), of which 8 ($\sim 3\%$) had a Drilling helium class of ≥ 15 (Drilling et al., 2013). All of the He-rich candidates were sdO stars, with sdO7.5 being most common. The intermediate-He candidates contained both sdO and sdB. Follow-up analysis of all candidates is needed to verify their parameters and determine their orbits.

Acknowledgments

EJS is supported by STFC via UKRI PhD doctoral training grant ST/R504609/1. Armagh Observatory and Planetarium is funded by direct grant from the Northern Ireland Department for Communities, which also provides for membership of the UK SALT Consortium. Funding for TESS is provided by NASA's Science Mission Directorate.

Further Information

Author contributions

Conceptualization (CSJ), Data Curation (EJS, CSJ, SS), Formal Analysis (EJS, SS), Funding Acquisition (CSJ), Investigation (EJS, CSJ, SS), Methodology (EJS, CSJ), Project Administration (CSJ), Resources (CSJ), Software (EJS, CSJ), Supervision (CSJ), Validation (CSJ), Visualization (EJS), Writing - original draft (EJS), Writing - review & editing (EJS, CSJ).

Conflicts of interest

The authors declare no conflict of interest.

References

Drilling, J. S., Jeffery, C. S., Heber, U., Moehler, S. and Napiwotzki, R. (2013) An MK-like system of spectral classification for hot subdwarfs. Astron. Astrophys., 551, A31. https://doi.org/10.1051/0004-6361/201219433.

Han, Z., Podsiadlowski, P., Maxted, P. F. L., Marsh, T. R. and Ivanova, N. (2002) The origin of subdwarf B stars – I. The formation channels. Mon. Not. R. Astron. Soc., 336(2), 449–466. https://doi.org/10.1046/j.1365-8711.2002.05752.x.

Jeffery, C. S., Miszalski, B. and Snowdon, E. J. (2021) The SALT survey of helium-rich hot subdwarfs: methods, classification, and coarse analysis. Mon. Not. R. Astron. Soc., 501(1), 623–642. https://doi.org/10.1093/mnras/staa3648.

Zhang, X. and Jeffery, C. S. (2011) Evolutionary models for double helium white dwarf mergers and the formation of helium-rich hot subdwarfs. Mon. Not. R. Astron. Soc., 419(1), 452–464. https://doi.org/10.1111/j.1365-2966.2011.19711.x.