Stars and their variability observed from space
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KIC 9163796 – A BENCHMARK BINARY FOR AGE DETERMINATION

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Abstract. Binary systems constitute a valuable tool in astrophysics for gaining a deeper understanding of stellar evolution and determining stellar ages. That is particularly true for the double-lined binary KIC 9163796, which has a mass ratio of almost unity but varies significantly in temperature, luminosity and Lithium abundance. This paper outlined our approach to generate a combined stellar model for it using the MESA stellar-evolution code. By combining the available observational data with the models we derived, we aimed to find the best-fitting models for both components and to extrapolate the system's age from them.

Keywords: stars:binaries, evolution, solar-type, individual: KIC 9163796

1 Introduction

Gravitationally-bound binary stars provide valuable constraints on stellar models because we can assume that the two stars share characteristics such as age, initial metallicity and distance. The key difference between the two stellar components is mass, since that is the parameter which sets the pace for stellar evolution. Even in the case of non-eclipsing binary systems, the unprojected mass ratio of both binary components is conveyed by the ratio of the radial-velocity amplitudes. Our poster discussed an ongoing)modelling analysis of KIC 9163796. It consists of two oscillating red-giant stars orbiting each other with a period of ∼120 days ($e = 0.692 \pm 0.002$). They have a mass ratio of 1.5 ± 0.5 % (Beck et al. 2018). While such stars would appear on the main sequence as almost indistinguishable stellar twins, the increased pace of stellar evolution leads to substantial differences in effective temperature, luminosity and lithium abundance on the low-luminosity section of the red-giant branch (Fig. 1).

2 Modelling with MESA

This work used the 1-D stellar evolution package MESA (Modules for Experiments in Stellar Astrophysics, Paxton et al. 2011) to model the evolution of the components of the binary system. We began calculating a grid for stellar masses and metallicities in the realm of the observed values and their uncertainties. Starting from the pre-main sequence models, we evolved each model through the observed position in the Hertzsprung–Russel diagramm (Fig. 1). Within the grid, the models will then be compared to the parrameters inferred from spectroscopy and seismology through a figure of merit. We plan to achieve this by implementing a χ^2-test on the calculated models, which first have to be interpolated to correct for the different step sizes in each model. The boundary conditions, implied through membership in a binary system will furthermore guide the pre-selection of tracks. the resulting best fitting models will ultimately furnish us with an estimate of the age of the binary system.

3 The System

Although the two components of KIC 9163796 are very similar in mass and composition, they differ significantly in temperature (∼15%), surface gravity (∼50%) and luminosity ratio (60:40). Both stars undergo the First-Dredge up (FDU), however the primary is in a more advanced state of FDU than the secondary (Beck et al. 2018). Observations from *Kepler* (Borucki et al. 2010) and the HERMES Spectrograph (Raskin et al. 2011), the double-lined binary (SB2) system has a mass ratio $q = 1.015 \pm 0.005$, where the primary mass is $M_1 = 1.39 \pm 0.06\, M_\odot$. The primary has a Lithium abundance of 1.31 ± 0.08 dex, while for the secondary it is 2.55 ± 0.07 dex (Beck et al. 2018). This system constitutes a perfect example of the effects of a small mass difference on the evolution of a star.

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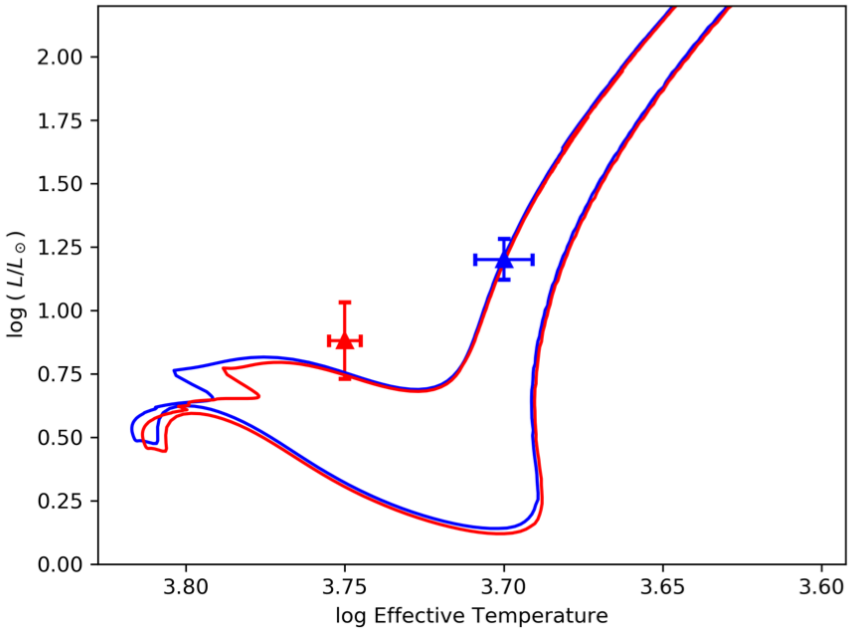

Fig. 1. H–R Diagram showing two stellar models from MESA having a mass ratio of 1.015 (red and blue lines), plus the observed positions of the primary and secondary components of KIC 9163796 including their uncertainties (blue and red triangles).

4 Conclusions

This study has shown that double-lined highly-constrained binaries contribute to our knowledge about stellar evolution, and thereby act as a benchmark for stellar astrophysics. In particular, systems like KIC 9163796 enable us to constrain stellar ages much more precisely than for single stars.

We acknowledge the whole community behind the stellar-evolution code MESA. The most recent version and documentation of MESA can be downloaded at `http://mesa.sourceforge.net`.

References

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