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A. Siebert, K. Baillié, M. Béthermin, F. Cantalloube, E. Josselin, N. Lagarde, J. Malzac, J. Richard, L. Selliez, O. Venot (eds)

STUDYING MASSIVE STAR POPULATIONS WITH SYMPHONY

K. Thomson-Paressant[1], D. M. Bowman[1,2], The SYMPHONY Team[1] and The Mercator Telescope Team[2]

Abstract. The SYMPHONY project is dedicated to studying the internal structure and dynamic processes of massive stars. Understanding the interiors of these stars is essential for addressing some of the most complex and enduring questions in stellar astrophysics. By combining high-resolution spectroscopic data with complementary photometric observations, we investigate various stellar phenomena and properties.

Keywords: asteroseismology, stars: binaries, stars: early-type, stars: emission-line, Be, stars: evolution

1 Introduction

Massive stars are key drivers of galactic evolution. Through their intense radiation, strong stellar winds, and explosive demises as supernovae, they enrich the interstellar medium and influence star formation across cosmic timescales. Despite their importance, many aspects of massive star evolution remain poorly understood, particularly the complex interplay between rotation, pulsation, magnetic fields, and circumstellar environments. Probing the deep interiors and surface dynamics of these stars is crucial for explaining their evolution, variability, and ultimate fate (Langer 2012). Understanding these stellar interiors is crucial to addressing some of the most persistent and complex questions in stellar astrophysics, including the evolutionary pathways of blue supergiants and the physical origins of stochastic low-frequency variability observed in many massive stars (Bowman 2023).

With this goal in mind, we have performed a combined photometric and spectroscopic analysis of ∼900 massive OB(A)-type stars, using the HERMES@Mercator spectrograph (Raskin et al. 2011) and the TESS satellite (Ricker et al. 2015), and present herein results on the demographics of variability displayed in the sample. Building on previous studies (e.g. Burssens et al. 2020), this work comprises the largest sample of such stars to date.

2 Data analysis and population demographics

The HERMES spectra were continuum normalised automatically utilising the SUPPNet neural network (Różański et al. 2022). We then analysed the Hα and HeI line regions at 6563 and 6678 Å respectively and their surroundings to look for radial velocity variability, resulting from either binarity or pulsation, and simultaneously sought stars showing emission features in these regions. We also inspected the 5200 Å region to look for a characteristic depression that has been shown to be a reliable indicator for magnetism in chemically peculiar (CP) stars (Maitzen 1976).

We retrieved 2-minute cadence TESS data from the Mikulski Archive for Space Telescopes (MAST) at the Space Telescope Science Institute*. We utilised data that were processed via the Pre-search Data Conditioning Single Aperture Photometry (PDCSAP) method, and looked for significant peaks that corresponded to pulsation modes, rotational frequency, and any harmonic-like structures that might appear in the Fourier spectra.

The results of our analysis are presented in Fig. 1, with spectroscopic characterisation on the left, and photometric on the right.

[1] School of Mathematics, Statistics and Physics, Newcastle University, Newcastle upon Tyne, NE1 7RU, United Kingdom
[2] Institute of Astronomy, KU Leuven, Celestijnenlaan 200D, 3001 Leuven, Belgium
*`https://archive.stsci.edu/missions-and-data/tess`

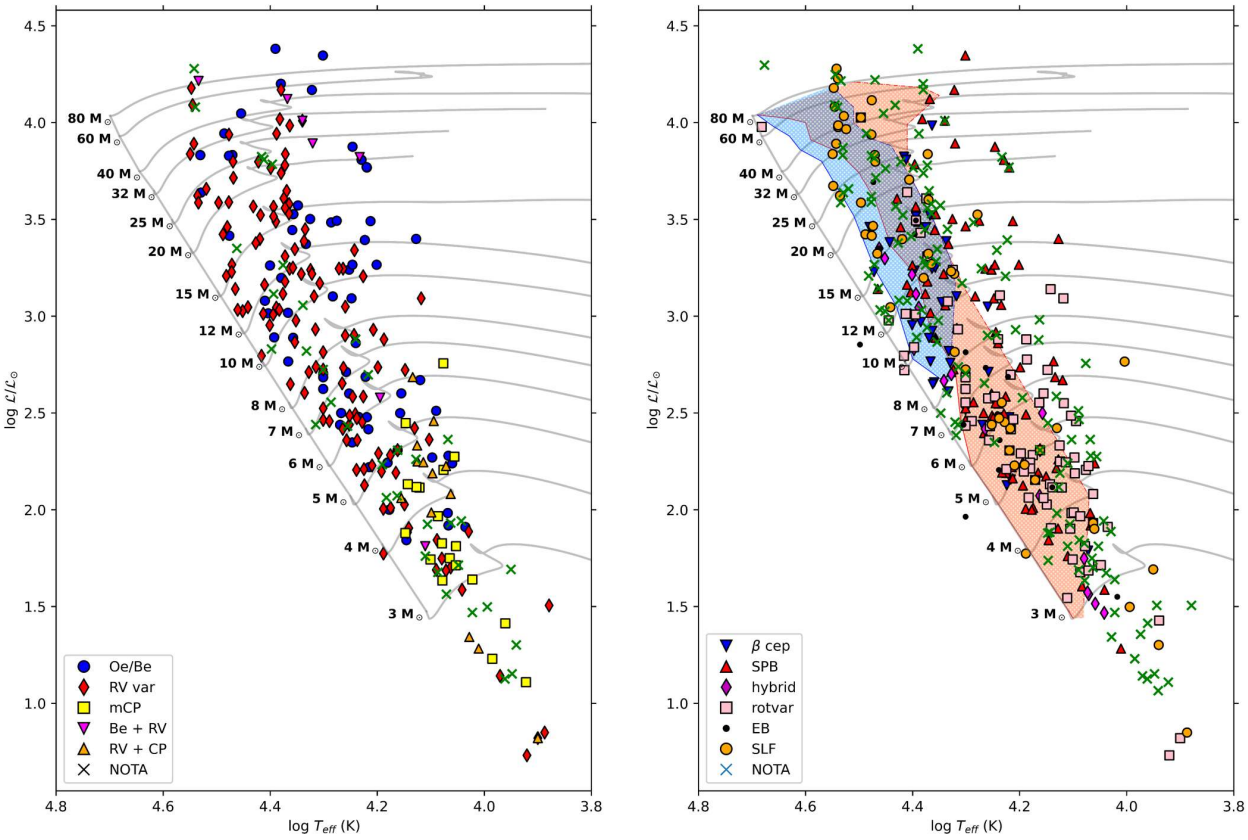

Fig. 1. Spectroscopic Hertzsprung-Russell diagrams showing the classification of a subset of stars in our sample from spectroscopy (left) and photometry (right). For the photometric case, the instability strips corresponding to p-mode (blue) and g-mode pulsations (red) are also drawn. Stars not presenting any of the other features shown in the respective legends are labelled as 'NOTA' (None Of The Above).

From this analysis, we have been able to identify and characterise a large list of targets suitable for various follow-up studies. For example, we have classified over 370 pulsating stars, ideal for asteroseismic analysis, as well as over 100 Oe/Be stars for which the formation and dissipation of their disks could prove to be extremely informative. Through these efforts, we will contribute these target lists to the wider community for their science goals as well as our own.

3 Conclusions

We are combining high-resolution HERMES spectroscopic data with complementary photometric observations from TESS to assess various stellar properties and phenomena. This multi-faceted approach not only enhances our understanding of individual stellar characteristics but also contributes to the identification of promising targets for future in-depth studies. These include candidates for detailed asteroseismic modelling, the representation of binarity, investigations into circumstellar disk activity in Oe/Be stars, and explorations of the interplay between magnetism and pulsations in massive stars. Through this work, SYMPHONY aims to lay the groundwork for next-generation studies of massive stellar evolution and variability.

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