Massive Stars Near and Far
Proceedings IAU Symposium No. 361, 2024
J. Mackey, J. S. Vink, & N. St-Louis, eds.
doi:10.1017/S1743921322003143

Stability analysis of radial oscillation modes in massive stars

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Abstract. During the evolution of massive stars, their properties change significantly. But stellar parameters of massive stars have the biggest uncertainties in stellar astrophysics, specifically in the post-main sequence stages where blue supergiant stars are located. These stars experience mass loss events during their evolution which are supposed to be related to strange-modes instabilities. In this work, we explore the stability of oscillation modes in massive stars for different masses, and a range of mass-loss rates, with the aim to provide clues about the connection between strange modes instabilities and mass-loss events.

Keywords. stars: early-type, stars: interiors, stars: mass loss

1. Introduction

Numerous theoretical studies suggest the existence of strange modes in massive stars (Gautschy et al. 1990). These are non-linear non-adiabatic modes whose instabilities are not excited by the classical κ-mechanism. To confirm the excitation of strange modes and to determine their final fate, unstable modes in the linear stability analysis need to be followed into the non-linear regime. If the pulsation velocity exceeds the escape velocity, it would be a direct evidence for mass loss. The presence of these modes has been suggested for 55 Cyg as well as their connection with its mass loss (Kraus et al. 2015). With the aim to further study strange mode oscillations in different evolutionary stages and to understand when these oscillations are triggered as well as their connection with mass loss, we initiated a systematic analysis of linear instabilities in massive stars.

2. Evolutionary and pulsational models

Using MESA (Paxton et al. 2019) we developed evolutionary models of stars with a metalicity of 0.02 and with initial masses between 50 and 65 solar masses up to the A-type supergiant regime (see Fig. 1). We adopted Vink recipe (Vink et al. 2001) for the mass loss. We considered different wind efficiencies (η) to account for reductions in mass loss rates due to wind inhomogeneities. Left and right panels in Fig. 1 correspond to η equal to 0.5 and 1, respectively. The numbers indicate the actual mass at two effective temperatures considered. The classical mixing length theory was adopted with $\alpha = 1.5$.

We employed the GYRE code (Townsend & Teitler 2013) to calculate non-adiabatic radial oscillations for models that have reached temperatures of 20 000 K and 10 000 K, corresponding to early- and late-type B supergiants. We restrict to modes between 0.032 c/d and 1 c/d, the typical range for strange-mode pulsations. The unstable modes obtained for $\eta = 0.5$ and 1 are shown in the left and right panels of Fig. 2.

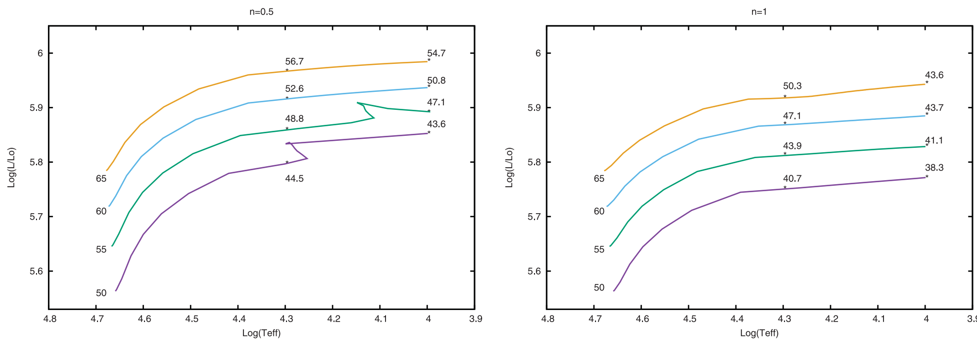

Figure 1. HR diagram for stars with different initial masses and wind efficiency.

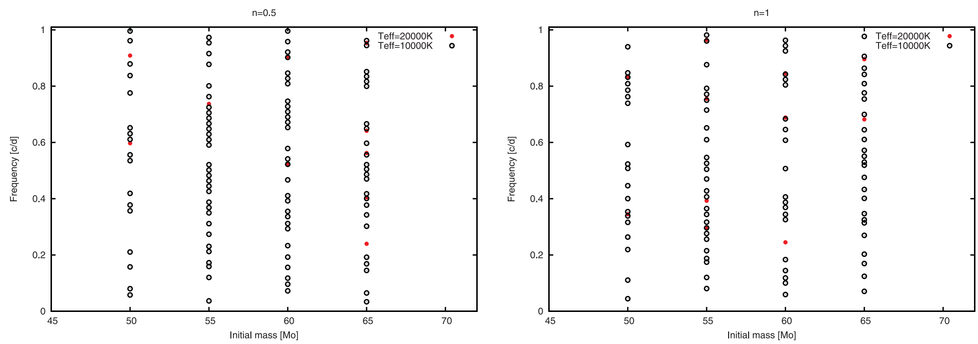

Figure 2. Non-adiabatic radial modes in B supergiants with different initial mass and η.

3. Conclusions

This project is the first step to study radial strange modes in massive stars and their interplay with mass loss through stellar winds. Excited modes are found in all stellar models, and their number significantly increases for late-type B supergiants. For these, the models with lower η also seem to show more excited modes, possibly due to the higher L/M which helps the radiative pressure to act in favor of their excitation. Non-linear stability analysis is required to properly study the link between these unstable modes (possible strange modes) and their contribution to the total mass loss from evolved massive stars.

Acknowledgements

We acknowledge financial support from the Czech Science Foundation (GAČR 20-00150S). The Astronomical Institute Ondřejov is supported by RVO:67985815. This project has received funding from the European Union's Framework Programme for Research and Innovation Horizon 2020 (2014-2020) under the Marie Skłodowska-Curie Grant Agreement No. 823734.

Supplementary material

To view supplementary material for this article, please visit http://dx.doi.org/10.1017/S1743921322003143.

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https://doi.org/10.1017/S1743921322003143 Published online by Cambridge University Press