Stability analysis of oscillation modes in massive stars

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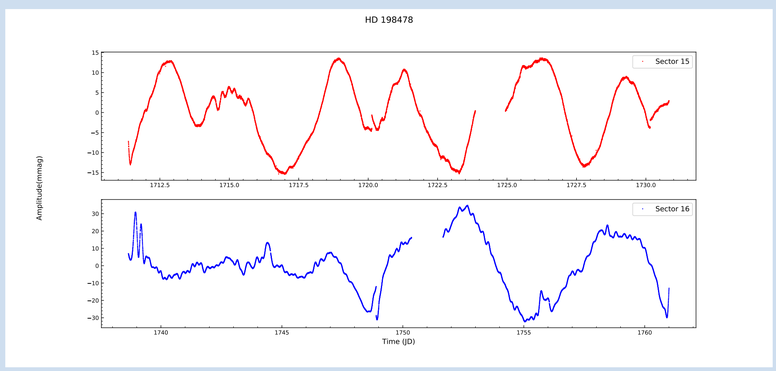
Abstract

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 mass-loss rate, with the aim to provide clues about the connection between strange modes instabilities and mass-loss events.

Introduction

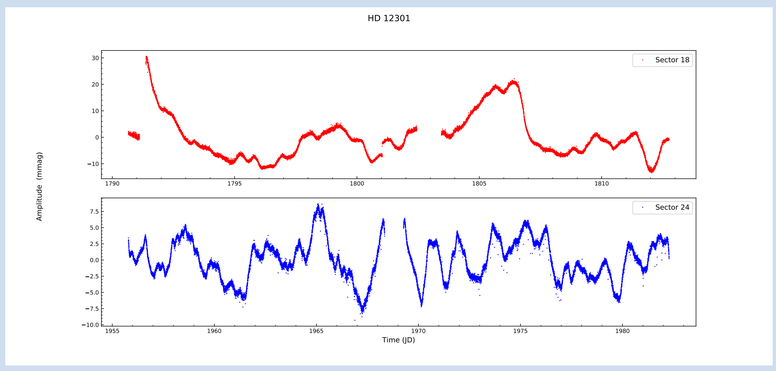
Numerous theoretical studies suggest the existence of strange modes in massive stars [1]. This modes are non-linear non-adiabatic modes, whose instabilities are not excited by the classical κ-mechanism. To confirm the excitation of strange modes and to determine their final fate, modes that are identified to be unstable in the linear 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 type of modes has been recently suggested for 55Cyg as well as their connection with its mass loss [2].



TESS light curve for different sectors for 55 Cyg

Motivated by this fact, we searched for peculiar behaviours in TESS light curves of B supergiants similar to the one in 55 Cyg (see above). We identified a promising sample of stars whose light curves change drastically between sectors. One example is shown below for the B4Ia star HD12301. Its variability could indicate strange mode pulsation linked to variable mass-loss.



TESS light curve for different sectors for HD 12301

With the aim to further study strange mode oscillations in different evolutionary stages and understand when these oscillations are triggered as well as their connection with mass loss through stellar winds, we begin a systematic analysis of linear instabilities in massive stars before the RSG stage.

Evolutionary models

We developed evolutionary models with MESA code [3] for different initial masses from 50 to 65 solar masses with an initial metalicity of 0.02.

We adopted Reimers prescription for the mass loss during the cool regime and Vink prescription for the hot regime with different efficiency. In the figure, continious and dashed lines correspond to an efficiency of 1 and 0.33, respectively.

Besides, we adopted the classical mixing length theory with $\alpha = 1.5$.

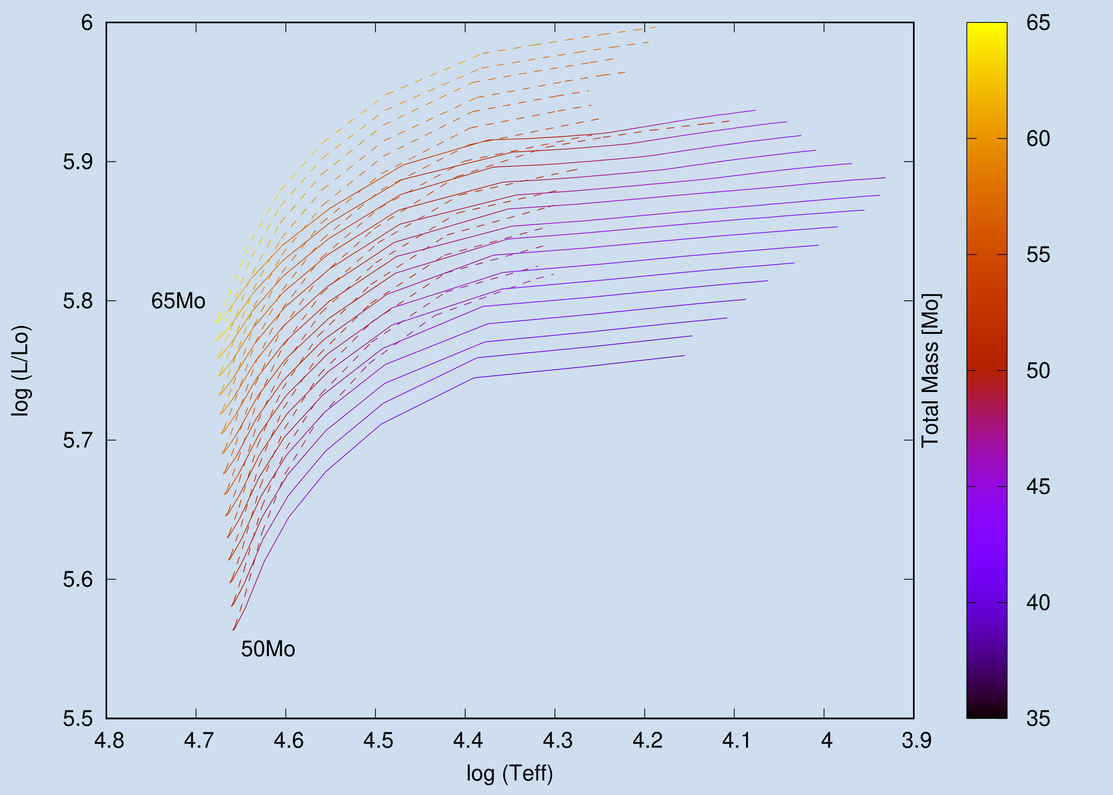
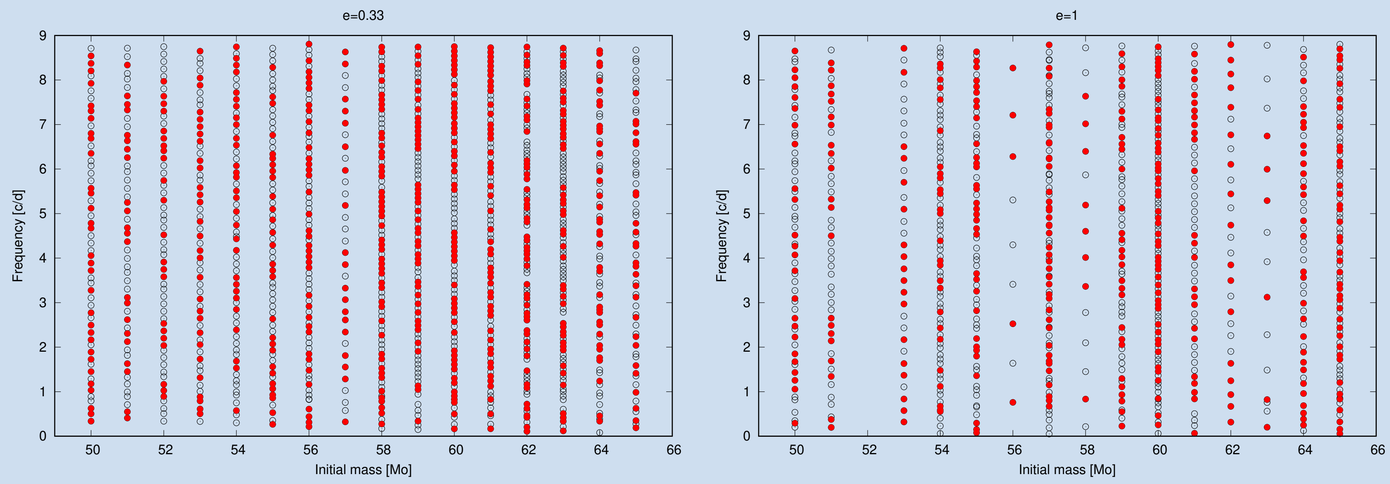


Figure 1: *HR diagram with different initial masses and wind efficiency.*

Non-adiabatic modes

We calculated non-adiabatic radial oscillations for those models with a central concentration of hydrogen in the core of 0.04. We employed GYRE code [4] under the NAR approximation and we calculated oscillation modes between 0.04 c/d and 8.8 c/d.

In the figure we show the results of the radial non-adiabatic frequencies obtained for the different wind efficiencies employed, along with the unstable modes depicted with full red circles.



Conclusions & future works

This project is the first step for the study of strange modes in massive stars and their interplay with mass loss through stellar winds.

We found that different wind efficiency impact differently on the modes instability, but there can be many additional causes for such instabilities.

In order to properly study the link between these unstables modes (possible strange modes) and the mass loss we will perform a non-linear stability analysis.

We will perform similar studies for more evolved massive stars up to the post-RSG stage.

References

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