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Foam: A Python package for Forward Asteroseismic Modelling of gravity modes

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Summary

`Foam` is a python package to perform forward asteroseismic modelling of gravity modes. It automates and streamlines a considerable fraction of the modelling process, and can be configured to use various different modelling methodologies. This includes different ways to match the theoretically predicted oscillations to observations, the option to use different sets of observables to compare to their theoretically predicted values, the use of different merit functions to determine the goodness of fit, and the option to consider nested subgrids in a statistically meaningfull way. See Michielsen et al. (2021) and Michielsen et al. (2023) (under revision) for an application of these methodologies to model observed gravity modes.

Statement of need

The impact of massive stars on our universe is not to be underestimated. Through stellar winds and supernovae, they are the dominant suppliers of chemical elements, influencing the availability of these elements for the formaton of new stars and planets. In this respect, massive stars provided the building blocks of our galaxy, the solar system, and Earth as we know it. During approximately 90% of their evolution, macroscopic element transport in and near the convective cores of these massive stars has a large influence on their life. It both prolongs the main- sequence lifetime of stars and enlarges the mass of the helium core at the end of the main sequence, which significantly influences all later stages of their evolution. However, these transport processes provide the largest uncertainties in stellar structure and evolution models for massive stars, due to our poor understanding of macroscopic element transport and limited number of useful observations to test the theories. (See e.g. Anders & Pedersen (2023) for a review on this topic.)

Through asteroseismology, the study of stellar pulsations, we gain the means to unravel the interior structure of stars (Conny Aerts et al., 2010; C. Aerts, 2021). Gravity modes in particular have a high sensitivity to the properties of the near-core region. We can exploit the probing power of gravity modes, observed in e.g. Slowly Pulsating B-type stars (Waelkens, 1991), to investigate the physics in the interior of these stars, particularly the transition region between the convective core and radiative envelope.

`Foam` was developed to streamline the forward modelling process of gravity modes, including multiple options and considerations in the statistical analysis of the grids of stellar equillibrium models.

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