The effect of stellar pulsations on the mass loss of AGB stars

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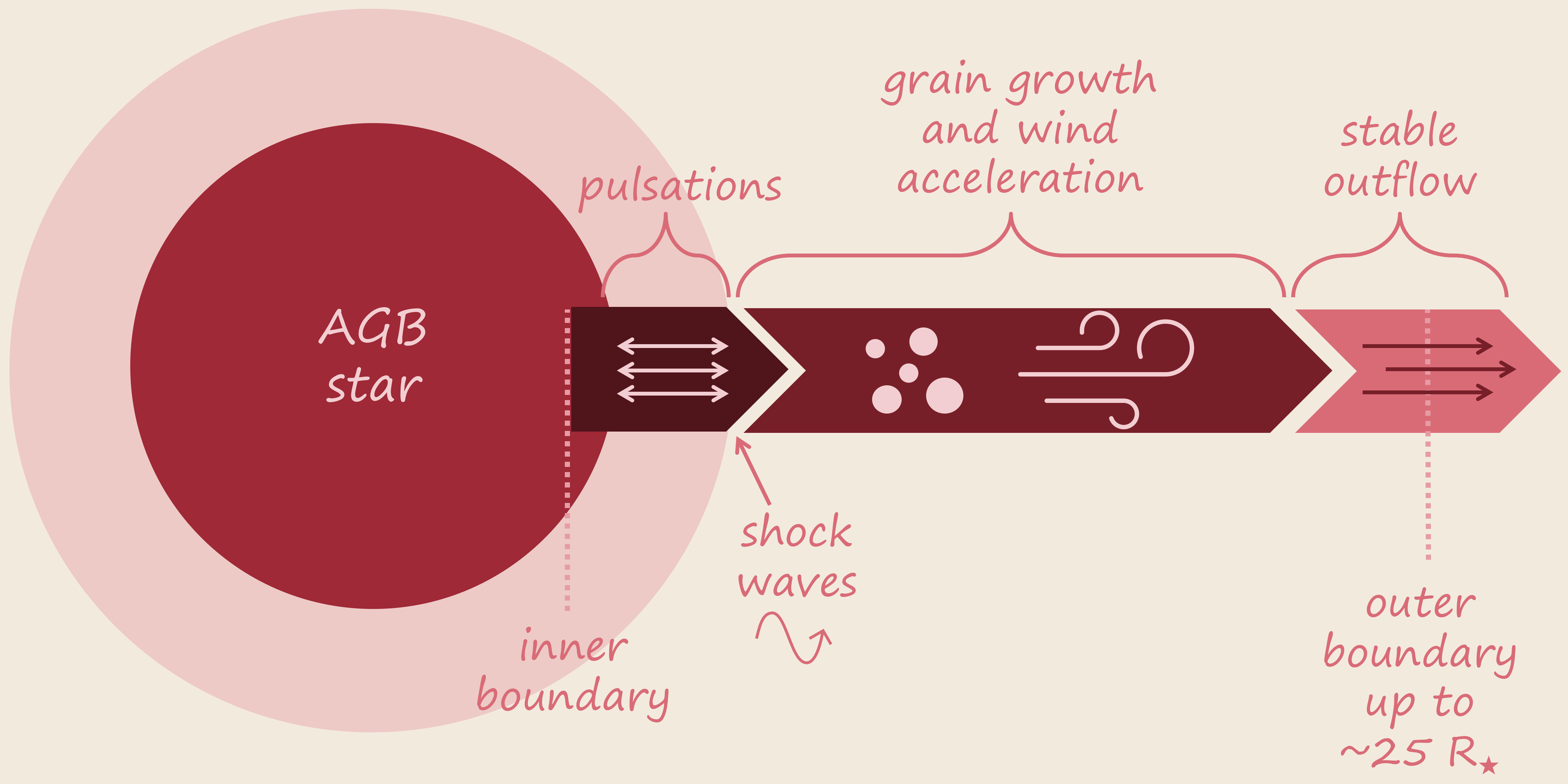
Introduction

Evolved stars on the asymptotic giant branch (AGB) lose mass through slow stellar winds, driven by radiation pressure on dust grains formed in the atmosphere. Stellar pulsations are critical to this process, as the timing between dust growth (typically at low temperatures, such as during luminosity minima) and increasing luminosity is essential for initiating the winds (*Liljegren et al. 2016, A&A 589, A130*).

This study investigates how the pulsation period influences stellar winds by computing two grids of 1D radiation-hydrodynamical wind models using the DARWIN code (see the schematic on the right). The grids consist of models with varying stellar parameters, including effective temperature, luminosity, and mass. The periods for each grid are determined by a **luminosity or mean density relation**, as detailed below. For models that develop winds, dust and wind properties are calculated at the outer boundary.

DARWIN

Dynamic Atmosphere and Radiation-driven Wind models based on Implicit Numerics

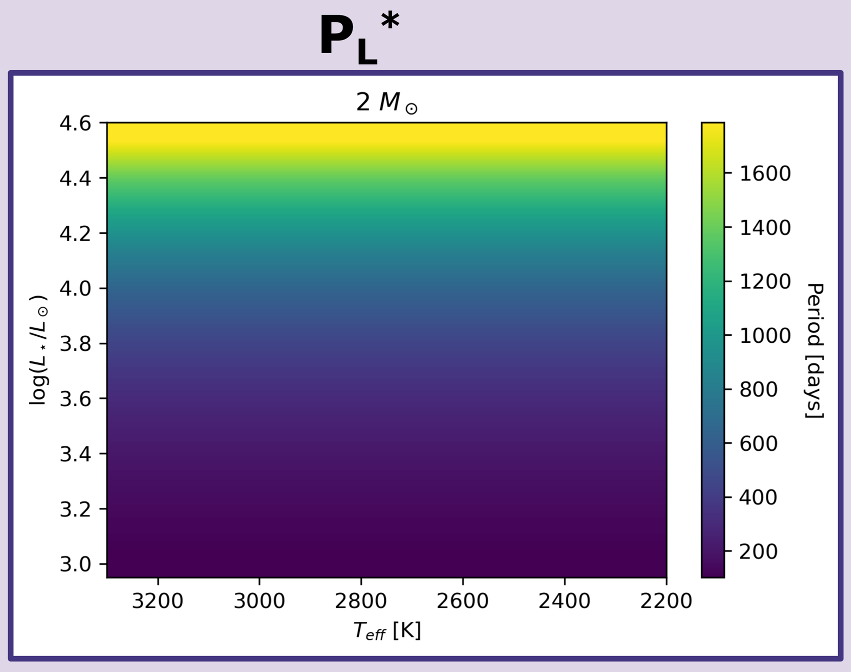


Schematic overview of a pulsating AGB star and the boundaries of the 1D radiation-hydrodynamical code DARWIN that is used to compute the atmosphere and wind models. Pulsations are simulated by sinusoidal variations of the radius and luminosity at the inner boundary, defined by a pulsation period and a piston velocity amplitude.

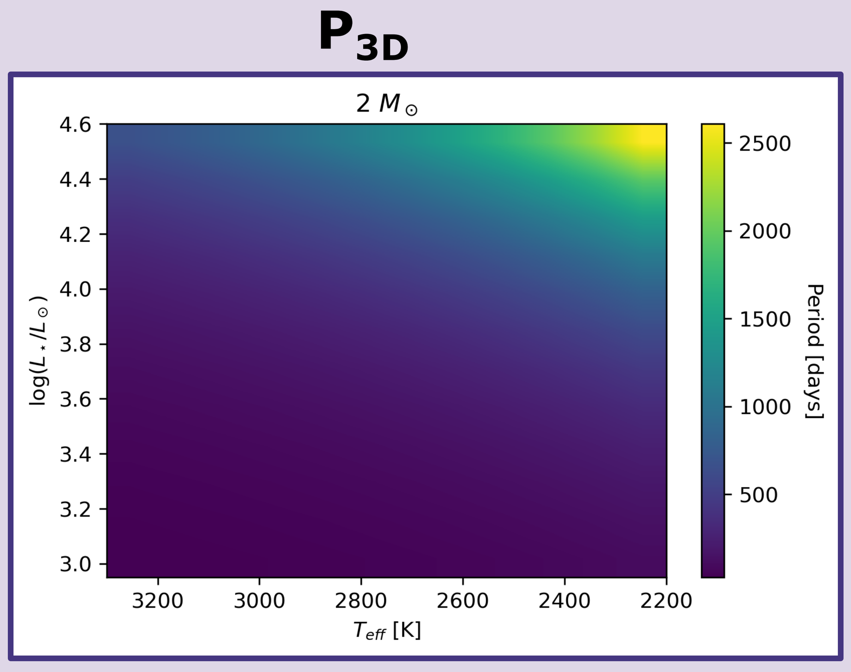
Pulsation periods

Period-luminosity relations (P_L) are derived by fitting a linear relation to the periods and bolometric magnitudes of observed stars. However, these observations show significant scatter, meaning stars with different luminosities may have similar periods. Another method for determining the period is through the **period-mean density relation (P_{3D})**, which depends on both mass and radius. *Ahmad et al. (2023, A&A 669, A49)* derived such a period-mean density relation from their 3D models of AGB stars, providing a realistic representation of the scatter seen in observed stars. In this study, we explore how these different period-relations affect the results of our atmosphere and wind models. The diagrams to the right show how the different pulsation periods change with effective temperature and luminosity for a 2 $M_\odot$ star.

P_L*

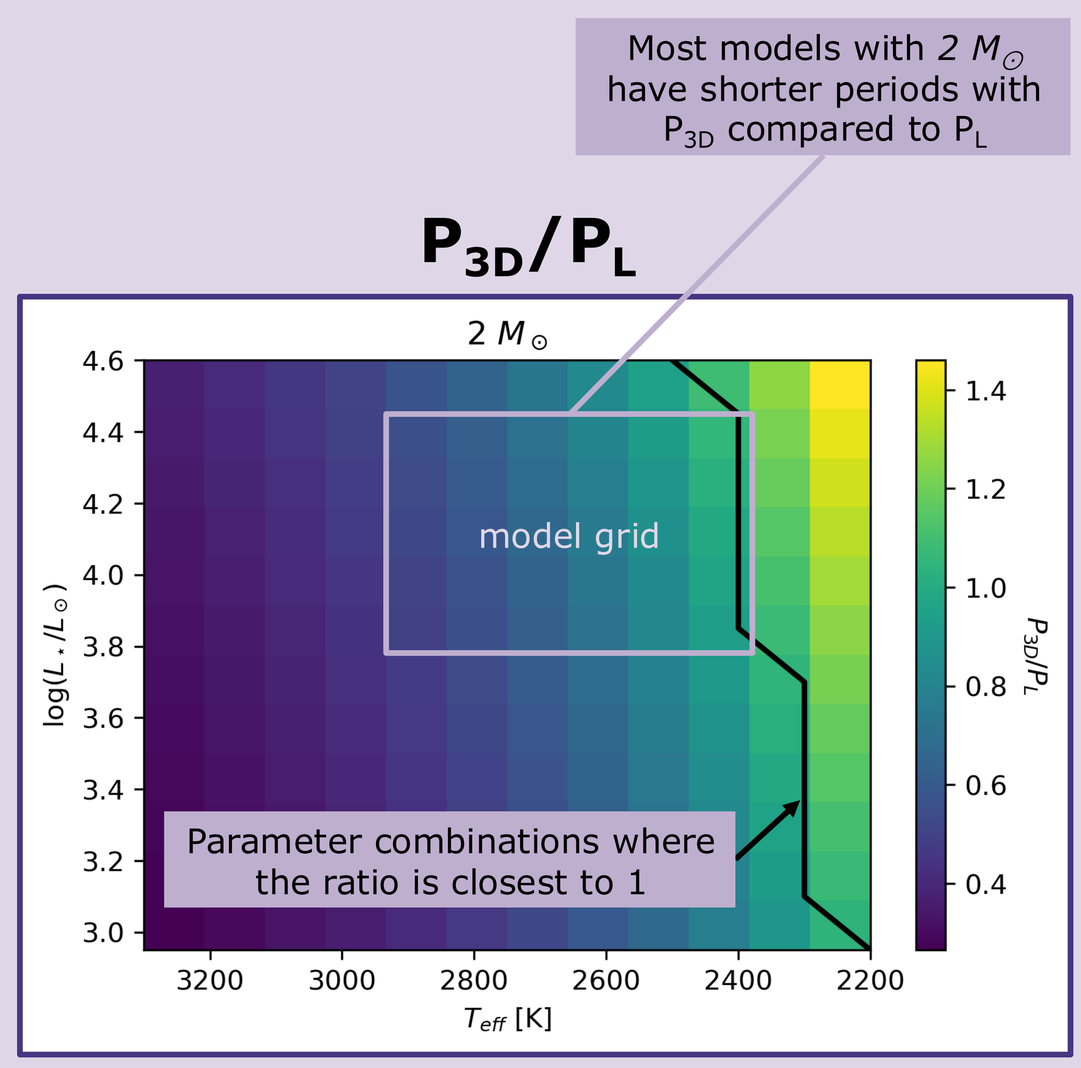


P_{3D}



* From Whitelock et al. (2009, MNRAS 394, 795)

P_{3D}/P_L



Ratio between the two diagrams presented to the left. The model grid box show the range in temperature and luminosity for the *2 $M_\odot$* models that we computed. Each square has a step size of *100 K* and *log 0.15 $L_\star/L_\odot$*.

Results and conclusions

2 $M_\odot$

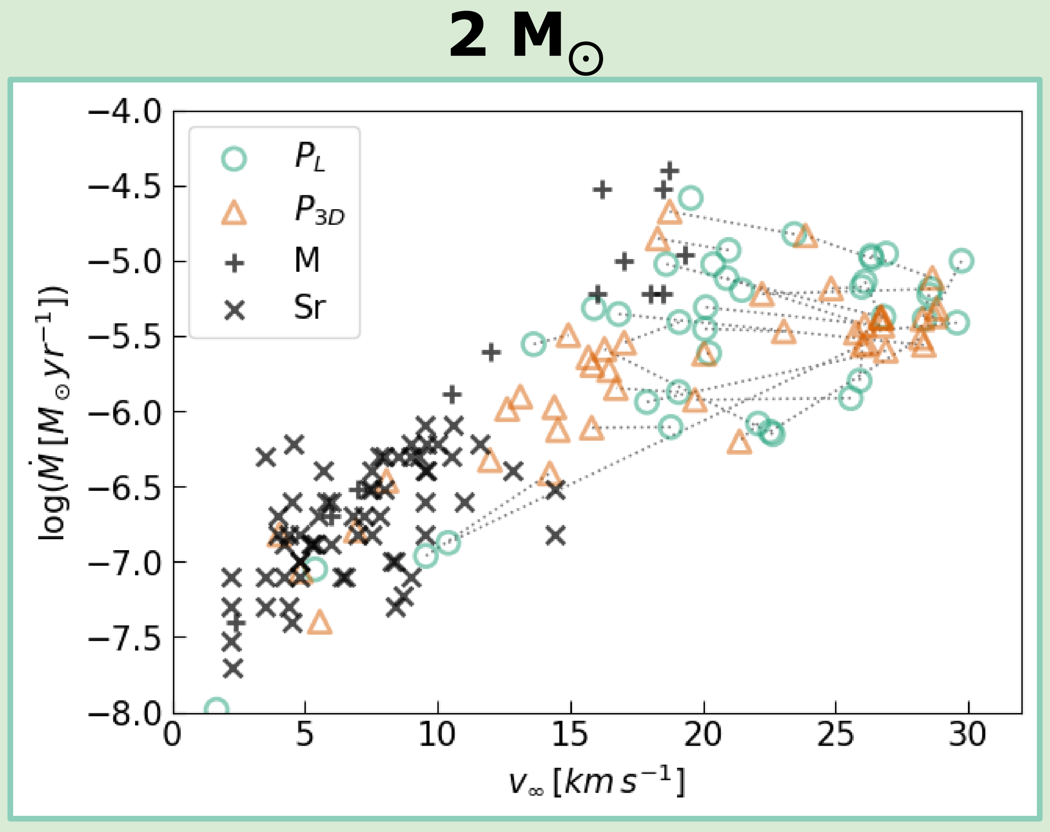


Fig. 1: Wind velocity vs mass-loss rate plot of the models (P_L, P_{3D}) compared to observations by *González Delgado et al. (2003, A&A 411, 123)* (M) and *Olofsson et al. (2002, A&A 391, 1053)* (Sr). Dotted lines connect models with identical stellar parameters (only differing in pulsation period).

0.75–3 $M_\odot$

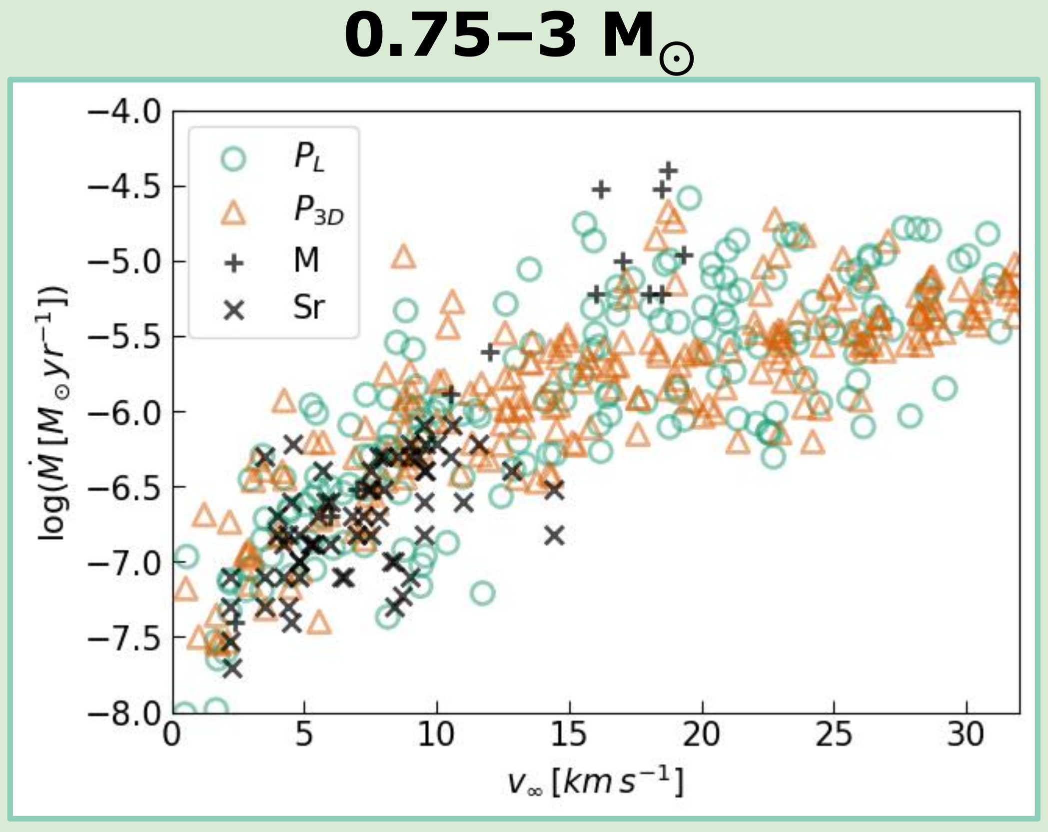


Fig. 2: Same as Fig. 1 but including models with 0.75, 1.0, 1.5, 2.0, 2.5 and 3.0 solar masses.

Changing the pulsation period leads to the following conclusions:

★ Shorter periods → More models result in winds, pushing the wind/no-wind boundary in terms of stellar parameters

★ These models show low mass loss rates/low wind velocities (see Fig. 1, triangles without connecting lines)

★ Large changes for individual models but the overall distribution of models is similar (see Figs. 1 and 2)

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erc European Research Council Established by the European Commission

ex WINGS

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