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First unambiguous asteroseismologic modelling of a γ Doradus star

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Abstract. An asteroseismologic model of the γ Dor star 9 Aurigae is discussed in this work. This is the first time a complete asteroseismologic scheme for analyzing γ Dor stars is applied. From standard photometric observations (at least three oscillation frequencies, a photometric error box in the HR diagram and multicolor photometric observations, in this case in the Strömgren system) we can reduce the possible theoretical models for this star, providing constraints to the stellar parameters as mass, overshooting, metallicity, MLT parameter α , Brunt-Väiälä integral (I_{th}), etc. Simultaneously, an estimate of the modal identification of the observed frequencies is also obtained.
This can be possible by the application, for the first time, of a complete procedure where different theoretical and computational techniques, recently developed, are linked and compared with photometric observations. The Frequency Ratio Method (FRM) and the Time Dependent Convection (TDC) theory are the basis of this complete procedure.

Key words. Stars: γ Dor – Stars: 9 Aurigae – Stars: Modeling

1. Introduction

The principal achievement of asteroseismology is to improve our knowledge of the stellar interiors by using additional observational constraints: the oscillation frequencies. To do so, the first step to be done is to identify the modes these frequencies belong to. This will make it possible to better define the theoretical model fitting all the observational constraints, giving information about the accuracy of the theories describing the star and the ad hoc parameters some theories have.

With the recent development of some techniques for comparing theoretical predictions with observations, mainly the Frequency Ratio Method (FRM) (Moya et al. 2005; Suarez et al. 2005) and the Time Dependent Convection (TDC) (Grigahcène et al. 2005; Dupret et al. 2005; Dupret et al. 2005), we are now able to construct construct a self-consistent procedure to test theoretical predictions maximizing the constraints. This procedure, applied to the γ Dor star 9 Aurigae gives as a result a single possible model fitting all observations within the present theoretical descriptions.

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Table 1. 9 Aurigae model characteristics

Mass	T_{eff}	$\log g$	$\log \frac{L}{L_\odot}$	$\log \frac{R}{R_\odot}$	Age (My)	[Fe/H]
1.4	7006	4.28	0.63	1.41	600	-0.1

Table 2. 9 Aurigae theoretical characteristic and modal identification

α_{MLT}	I_{th}	α_{ov}	n_1	n_2	n_3	ℓ
1.6	681.5	0.3	57	59	133	2

2. Self-consistent procedure

The minimum observational requirements needed to apply this procedure are 1) a photometric error box in the HR diagram, and 2) at least three pulsational frequencies observed in multicolor photometry. Nevertheless spectroscopic information will be also very useful. The starting point is the photometric error box and the three frequencies. For 9 Aurigae the observational characteristics and observational frequencies (f_1 = 0.7948 cycle d^{-1}, f_2 = 0.7679 cycle d^{-1} and f_3 = 0.3429 cycle d^{-1}) are obtained from Zerbi et al. (1997).

The FRM gives a first restriction in modal identification, overshooting, metallicity, mass and $T_{\rm eff}$. Taking into account only models given by the FRM we can study the instability of the theoretical frequencies with TDC, providing in addition, predictions for the multicolor photometric observables. Comparing these predictions with the observations the number of possible models fulfilling all the observational constraints is highly reduced. In this case only one model from our grid has been selected (see Tabs 1 and 2).

3. Problems

Some problems has been encountered: 1) The Strömgren filters ratio u/y cannot be reproduced by the models, 2) the frequency f_3 is never predicted overstable and 3) α_{ov} is larger than expected.

Nevertheless the obtaining of only one theoretical model fulfilling all the observational constraints make it possible to test the accuracy of the theory used.

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