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Hybrid stars with a simultaneous δ Scuti and γ Doradus stars pulsational behaviour

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Abstract. Computations of theoretical instability strips for δ Scuti (Sct) and γ Doradus (Dor) stars are presented. The time-dependent convection (TDC) theory of Gabriel (1996) and Grigahcène et al. (2005) is adopted in our models. The theoretical Instability Strips (IS) obtained for δ Sct and γ Dor stars overlap indicating a possibility of hybrid stars showing simultaneously both γ Dor IS and δ Sct excited modes. Models with unstable long periods gravity modes (γ Dor type) show also unstable short periods pressure modes (δ Sct type). First example of such a star is given by Henry & Fekel (2005).

Key words. Stars: oscillations – Convection – Stars: interior – Stars: variables: general

1. Introduction

Because of their location in the HR diagram, early when the γ Dor new class of pulsating stars was discovered, the question arised of the relationship between them and the δ Sct stars (Breger & Beichbuchner 1996). Search of stars pulsating simultaneously with δ Sct p-modes and γ Dor g-modes have been done by Handler & Shobbrook (2002) and recently by Henry & Fekel (2005).

2. Theoretical models

Fig. 2 shows theoretical IS for γ Dor (dashed lines) for $\ell = 1$ modes and δ Sct red edge (dashed-pointed line) for the fundamental radial mode, computed with our TDC non-adiabatic models with $\alpha = 1.8$. Asterix symbols and filled squares are observed positions of bona fidae γ Dor stars given by Handler (2002) and Martín (2003a) respectively. Dots represent the observed positions of δ Sct stars from the catalogue of Rodríguez, López-Gonzalez & López de Coca (2000). A significant part of the γ Dor IS is inside the δ Sct one. All the theoretical models in this intersection have both types of unstable modes. Existence of hybrid δ Sct - γ Dor is predicted by our theoretical models (Grigahcène et al. 2005). Fig. 1 gives the damping rate (negative for excited modes) as a function of period (en hours). It shows clearly that models with unstable long periods g-modes have also unstable short periods p-modes. These short period unstable modes are the typical δ Sct type modes.

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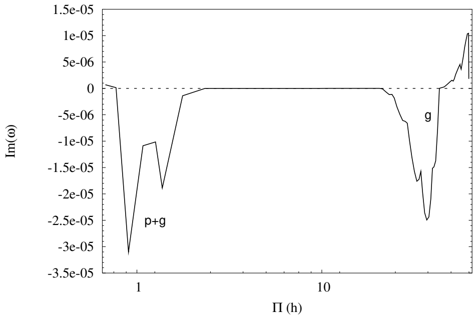

Fig. 1. Simultaneous excitation of g and p-modes for the same model: $M = 1.6M_{\odot}$, $\alpha = 1.8$ and $T_{eff} = 6995$ K.

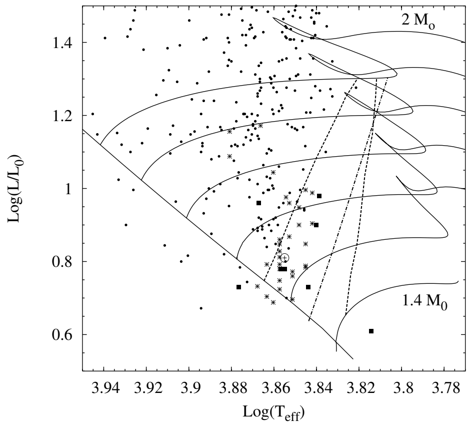

Fig. 2. Theoretical IS for γ Dor (dashed lines) and δ Sct red edge (dashed-pointed line), compared with observations of *bona fide* γ Dor stars ($*$) of Handler (2002) and (■) of Martín (2003a) and observations of δ Sct stars ($\cdot$) of Rodríguez, López-Gonzalez & López de Coca (2000). ($\oplus$) is the hybrid star of Henry & Fekel (2005).

3. Systematic observational search

First example of a star pulsating with both γ Dor and δ Sct frequencies is given by Henry & Fekel (2005) (circled plus in Fig. 2). It shows periods: 0.0484 d < period < 0.4033 d. It lays in the intersection between theoretical γ Dor and δ Sct IS. A systematic search for the γ Dor in 10 open clusters was performed Martín (2003a) by using uvby photometry. From these observations, eight new γ Dor were found (filled squares Fig. 2). On the light of the TDC theoretical results, a new Fourier analysis has been made with the goal of detecting high frequencies in their frequency spectra. Two codes have been used: Multifre (Martín 2003b) and the same method as Rodríguez et al. (1998). No δ Sct type frequencies have been found in these stars.

4. Conclusions

We conclude that there are no theoretical arguments against the existence of hybrid δ Sct - γ Dor variables. It is very important to continue the search of such stars (even a first discovery has been done), which would be of considerable interest for asteroseismology: high order g-modes allow probing the deep interior while p-modes allow probing the more superficial layers.

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