

Photometric Mode Identification in the Two γ Doradus Stars HD 12901 and HD 48501 *

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Abstract. We perform photometric mode identification in the two γ Doradus stars HD 12901 and HD 48501. We have gathered extensive seven-colour Geneva photometry for these two stars, which reveals three frequencies for each of the two stars. The lightcurves in all seven colours are perfectly in phase with each other for all the frequencies in both stars. The amplitude ratios point towards $\ell = 1$ modes.

Keywords: γ Doradus stars, gravity modes, multicolour photometry

1. Introduction

The γ Doradus stars constitute a recently-discovered class of (multi-periodic) non-radial gravity-mode oscillators with periods in the range 0.5 – 3 days. They are situated along the main sequence in the HR diagram, just below the classical instability strip. Krisciunas (1998) and Zerbi (2000) review respectively the history of the discovery and the current observational status of this group of variables. The cause of the excitation of the modes is still controversial (cf. Guzik et al. 2000 versus Löffler, this conference).

As most of the γ Doradus stars have very long beat-periods, of the order of months or even years, it is a non-trivial observational task to discover them. Many new members of the class were found from the HIPPARCOS photometry (Aerts et al. 1998, Handler 1999). Meanwhile, large (follow-up) ground-based discovery campaigns have also been organised. Mathias et al. (this conference) are currently performing an extensive long-term spectroscopic monitoring campaign for northern objects. The current number (July 2002) of *bona fide* γ Doradus stars is 30. For an updated list of class members and candidates we refer to the web page maintained by G. Handler:

<http://www.astro.univie.ac.at/~gerald/gdorlist.html>

* Based on observations gathered with the Swiss 0.7m telescope equipped with the photometer P7, situated at La Silla, Chile



Table I. The amplitudes (expressed in mag) of the three detected frequencies in each of the two γ Doradus stars.

filter	HD 12901			HD 48501		
	f_1	f_2	f_3	f_1	f_2	f_3
U	0.0140	0.0062	0.0058	0.0129	0.0132	0.0065
B ₁	0.0218	0.0106	0.0106	0.0186	0.0192	0.0093
B	0.0204	0.0106	0.0106	0.0180	0.0187	0.0086
B ₂	0.0197	0.0101	0.0094	0.0167	0.0183	0.0082
V ₁	0.0150	0.0078	0.0080	0.0138	0.0139	0.0059
V	0.0148	0.0074	0.0079	0.0134	0.0135	0.0065
G	0.0135	0.0066	0.0074	0.0121	0.0124	0.0057

Eyer & Aerts (2000) set up a large multicolour photometric search campaign with the Swiss 0.70 m telescope at La Silla and monitored 11 F0–F9 stars with a high dispersion in the Geneva database that fitted the observational window of a few 3-week runs. Three of the stars indeed turned out to be good γ Doradus candidates. Our current study elaborates further on more extensive Geneva datasets of two of these new γ Doradus stars, HD 12901 (F0V) and HD 48501 (F2V), with the specific goal to perform detailed frequency analysis and mode identification. We have analysed 174 and 184 measurements for respectively HD 12901 and HD 48501, spread over 6566 and 7245 days.

2. Period Analysis

We performed period analysis on the Geneva data with different methods, which all lead to 3 statistically significant frequencies for both stars: $f_1 = 1.21562 \text{ c d}^{-1}$, $f_2 = 1.39594 \text{ c d}^{-1}$ and $f_3 = 2.18637 \text{ c d}^{-1}$ for HD 12901 and $f_1 = 1.09401 \text{ c d}^{-1}$, $f_2 = 1.29050 \text{ c d}^{-1}$ and $f_3 = 1.19927 \text{ c d}^{-1}$ for HD 48501. The corresponding amplitudes (in mag) are listed in Table I.

We show in Fig. 1 the phase diagrams for the main frequency of HD 12901 for the data obtained in the seven Geneva filters. This figure is representative for all the frequencies found in the two stars. The five additional phase diagrams for the seven colours can be found in Aerts et al. (2003). Visual inspection of the phase diagrams and of Table I demonstrates that the amplitude is each time largest in the B₁ filter and the variations in all the different filters are perfectly in phase within the measurement errors.

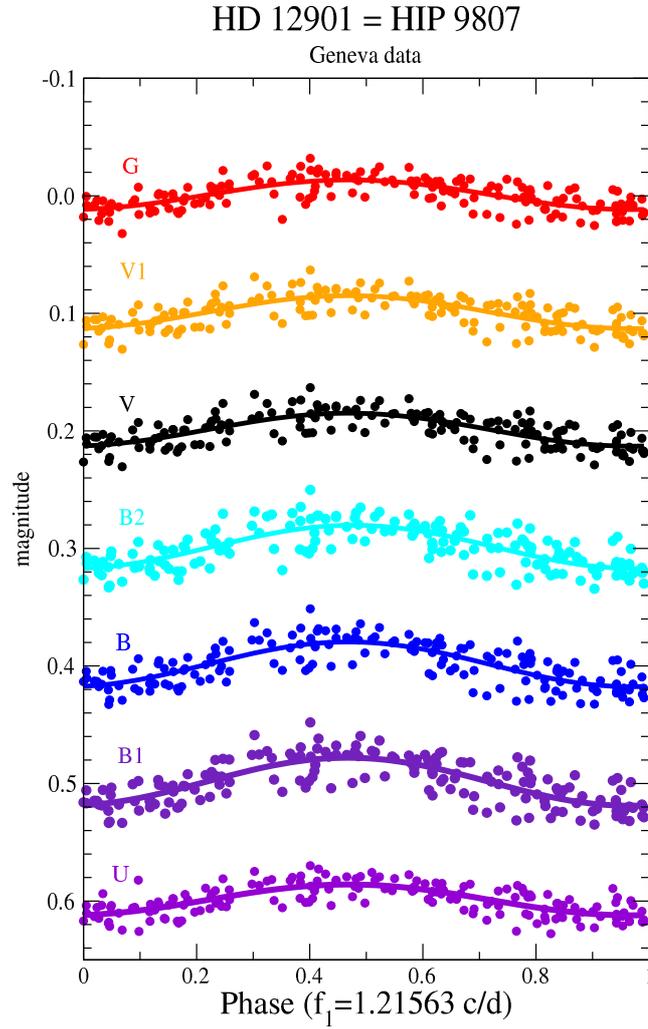


Figure 1. Phase diagrams of the seven-colour photometry of the γ Doradus star HD 12901 for the frequency $f_1 = 1.21562$ c d $^{-1}$.

3. Mode Identification

The observed amplitude ratios are subsequently used for mode identification. In the case of γ Doradus stars, we do not know the properties of the surface convective layer well enough to fix the mixing length parameter α .

We therefore kept the amplitudes and phases of the non-adiabatic temperature eigenfunctions as free parameters with the restriction that the phases be equal for the three modes. We have determined theoretical amplitude ratios under these conditions for $\ell = 1, \dots, 4$. The result is that only an $\ell = 1$ mode is able to explain the observed ratios for the three frequencies for the two stars. A comparison between theoretical and observed amplitude ratios with respect to the U filter for the three frequencies of the two stars is shown in Aerts et al. (2003).

4. Conclusions and Future Work

We have disentangled 3 frequencies in the observed multicolour light variations of the γ Doradus stars HD 12901 and HD 48501. These frequencies are typical for high-order g-modes in such stars. The amplitudes are largest in the blue wavelength range.

The amplitude ratios are only compatible with dipole modes and with non-adiabatic temperature eigenfunctions of extremely low amplitude. Preliminary theoretical modelling (see Dupret et al., this conference) shows that the observed amplitude ratios and phases are better explained for models with lower values of α , i.e. for thin surface convection layers of typically $\alpha = 0.5$. We will elaborate further on this important point in the near future, as it will allow us to obtain better knowledge of the superficial convection zone of the γ Doradus stars and hence also of the excitation mechanism.

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