

## Analysis of MERCATOR data - Part II: variable A & F stars

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### Abstract

The results of a frequency analysis of photometric observations of variable A and F stars obtained with the MERCATOR telescope are presented. Already 15  $\gamma$  Dor stars, including a new one, and 3  $\delta$  Scuti stars were analysed in detail. A re-analysis of HIPPARCOS data of these stars was done, as well as a comparison with frequencies found in the literature. Light curve parameters (frequencies, amplitudes and phases) were calculated for the variations in the 7 filters of the Geneva photometric system. The amplitude ratio diagrams of the  $\gamma$  Dor stars are very similar, with only few, but remarkable exceptions.

### 1. Introduction

The MERCATOR telescope is a 1.2-m telescope located on the Roque de los Muchachos observatory on La Palma (Spain). Since the start of scientific observations in the spring of 2001, this telescope has been intensively used to observe variable B, A and F main sequence stars with the P7 photometer, providing quasi-simultaneous observations in the 7 passbands of the Geneva photometric system. The first results obtained after 18 months of observations were already presented by De Cat et al. (2004) and De Ridder et al. (2004). We now present preliminary results after 3 years of collecting data. In Part I (De Cat et al. these proceedings) the analysis of the observations of the variable B stars is discussed. In Part II (this article) the analysis of variable A and F stars is presented, with emphasis on the pulsating  $\gamma$  Doradus stars, hereafter  $\gamma$  Dor stars (see Henry et al. (2005) for a class description and a recent list).

In total about 30 A and F stars were observed regularly. They were selected because they were already known as  $\gamma$  Dor stars, were flagged as variable in the HIPPARCOS catalogue, and/or were considered good candidate  $\gamma$  Dor stars (Handler 1999; Eyer and Aerts 2000). A few stars from other lists (Henry and Fekel 2002; Koen and Eyer 2002) were added as well. In the mean time, the  $\gamma$  Dor character of most of our targets (apart from a few  $\delta$  Scuti stars) has been confirmed, and they are already listed as bona fide  $\gamma$  Dor stars by Henry et al. (2005). Hence, the main goal of our observations is to obtain well defined light curve parameters (frequencies, amplitudes, phases) in the 7 colours of the Geneva photometric system for all the observed variable stars. This allows the application of e.g. the method of photometric amplitudes (Dupret et al. 2003) to identify the pulsation modes.

### 2. Frequency analysis

The time series in the Geneva passbands were subjected to a frequency analysis with a multifrequency least squares method after a first inspection with other methods as PDM

Table 1: Overview of the  $\gamma$  Dor stars observed with the MERCATOR telescope and already analysed in detail ( $HD$  = HD number,  $SP$  = Spectral Type,  $N$  = number of observations used in the analysis,  $T$  = total time span of observations (in days),  $V$  = magnitude  $V$ ,  $\sigma_v$  = standard deviation in filter  $V$ ,  $N_f$  = Number of frequencies identified so far)

$HD$	$SP$	$N$	$T$	$V$	$\sigma_v$	$N_f$
277	F0	154	1148	8.365	0.022	3
2842	F0V	111	1149	7.987	0.023	3
7169	F2V	104	1149	7.280	0.012	2
23874	F0	93	1045	8.198	0.013	1
69715	F1	67	804	7.174	0.022	2
74504	F0	45	793	8.852	0.026	2
86358	F3V	103	804	6.468	0.015	4
100215	Am	173	838	7.982	0.019	4
105458	F0III	291	983	7.757	0.026	3
108100	F2V	196	980	7.116	0.012	2
113867	F0	167	946	6.825	0.028	3
167858	F2V	62	406	6.620	0.024	3
206043	F2V	89	768	5.765	0.010	3
211699	F0	104	1149	9.132	0.029	2
218396	A5V	103	1151	5.966	0.017	3
221866	F2V	146	1149	7.452	0.018	4

(Stellingwerf 1978) or Lomb-Scargle (Scargle 1982). Since our ground-based data-sets suffer from strong (daily) aliasing, we searched for confirmation of our frequency solution in the space-based photometric observations of the HIPPARCOS satellite. Whenever possible, we compared our results with the results published in the literature.

## 2.1 $\gamma$ Doradus stars

In Table 1 we list the  $\gamma$  Dor stars that have a sufficient number of high quality observations (at least 40) spread over a reasonably long interval (minimal 400 days) to allow a meaningful frequency analysis. Observations with a quality flag zero were not included, although for some stars their number is rather high. These observations can still be useful to extract information on multiperiodicity, but this will be elaborated further in a forthcoming paper.

The number of frequencies as given in Table 1 is to be considered as a first estimate. In several cases more frequencies can be identified if a comparison is made with HIPPARCOS and/or other ground-based data. Since this has not yet been done for every star in the list, the number given is a lower limit.

HD 74504 is a new  $\gamma$  Dor star. Koen and Eyer (2002) re-analysed the HIPPARCOS data of this F0 star and found a frequency of  $1.9058 \text{ d}^{-1}$ . In the MERCATOR data of this star at least two frequencies are identified:  $1.9057 \text{ d}^{-1}$  and  $1.8210 \text{ d}^{-1}$ . Moreover, since the combination of  $1.9058 \text{ d}^{-1}$  and  $1.8212 \text{ d}^{-1}$  is also one of the best two-frequencies solutions in the HIPPARCOS data, we classify this star a bona fide  $\gamma$  Dor star. A candidate for a third frequency in this star is  $1.2564 \text{ d}^{-1}$ . A diagram with the amplitude ratios normalised to the highest amplitude (i.e. in the filter B1 of the Geneva system) is shown in Fig. 1. The observed 'plateau'-like shape near the B filters is also present in the amplitude ratios of HD 218396. For most of the other  $\gamma$  Dor stars, the amplitude ratio curves resemble those of HD 100215 shown in Fig. 2.

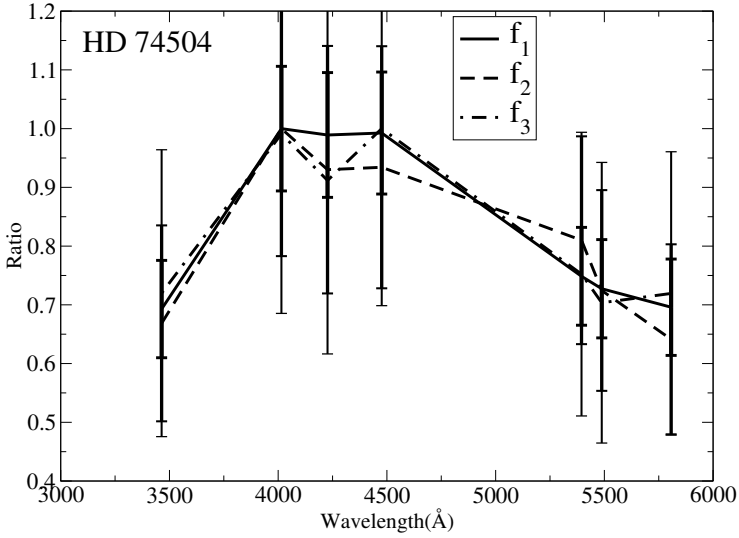


Figure 1: Amplitude ratios (normalised to the amplitude in filter B1 of the Geneva system) for HD 74504.

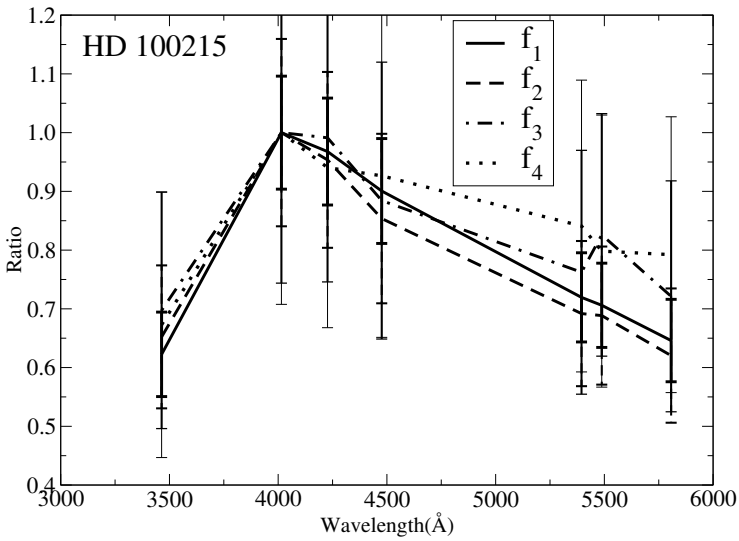


Figure 2: Same as Fig. 1 but for HD 100215.

## 2.2 $\delta$ Scuti stars

The stars HD 94117 (F2,  $V = 7.01 \text{ mag}$ ) and HD 104573 (A5,  $V = 8.14 \text{ mag}$ ) are most probably  $\delta$  Scuti stars. HD 94117 was not known as a  $\delta$  Scuti star and has at least two frequencies:  $6.2738 \text{ d}^{-1}$  and  $7.9066 \text{ d}^{-1}$ . HD 104573 has been presented before (De Ridder et al., 2004).

## 3. Conclusions

Thanks to the continuous monitoring during several years, well defined and accurate light curve parameters in the 7 filters of the Geneva photometric system were obtained with the MERCATOR telescope. At least one new  $\gamma$  Dor star (HD 74504) had been discovered and also one multiperiodic  $\delta$  Scuti star (HD 94117) was found.

For about 15  $\gamma$  Dor stars reliable amplitudes were obtained for their multiperiodic light variations. The graphs with amplitude ratios as a function of wavelength all look very similar, except that in a few cases the amplitudes do not drop off very steep after the B1 filter. The results of a complete analysis of the whole data set will be presented in a forthcoming paper. The mode identification for these stars will start soon.

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