A&A 499, 967–982 (2009)
DOI: 10.1051/0004-6361/200911691

Astronomy & Astrophysics

Long-term photometric monitoring with the Mercator telescope

Frequencies and multicolour amplitudes of γ Doradus stars⋆,⋆⋆

J. Cuypers[1], C. Aerts[2,3], P. De Cat[1], J. De Ridder[2], K. Goossens[2], C. Schoenaers[1,4], K. Uytterhoeven[2,5,9], B. Acke[2,⋆⋆⋆], G. Davignon[2,5], J. Debosscher[2], L. Decin[2,⋆⋆⋆], W. De Meester[2], P. Deroo[2,10,†], R. Drummond[2,8], K. Kolenberg[2,7], K. Lefever[2,8], G. Raskin[2,5], M. Reyniers[2,6], S. Saesen[2,⋆⋆⋆], B. Vandenbussche[2], R. Van Malderen[2,6], T. Verhoelst[2,⋆⋆⋆], H. Van Winckel[2], and C. Waelkens[2]

1 Koninklijke Sterrenwacht van België, Ringlaan 3, 1180 Brussel, Belgium
e-mail: Jan.Cuypers@oma.be
2 Instituut voor Sterrenkunde, K.U.Leuven, Celestijnenlaan 200 D, 3001 Leuven, Belgium
3 Department of Astrophysics, Radboud University Nijmegen, 6500 GL Nijmegen, The Netherlands
4 Oxford Astrophysics, University of Oxford, Oxford, OX1 3RH, UK
5 MERCATOR Telescope, Calle Alvarez de Abreu 70, 38700 Santa Cruz de La Palma, Spain
6 Koninklijk Meteorologisch Instituut, Ringlaan 3, 1180 Brussel, Belgium
7 Institut für Astronomie, Universität Wien, Türkenschanzstrasse 17, 1180 Wien, Austria
8 Belgisch Instituut voor Ruimte-Aëronomie, Ringlaan 3, 1180, Brussel, Belgium
9 Service d'Astrophysique, IRFU/DSM/CEA Saclay, L'Orme des Merisiers, 91191 Gif-sur-Yvette Cedex, France
10 Jet Propulsion Laboratory, 4800 Oak Grove Drive M/S: 183-900, Pasadena, CA 91109, USA

Received 20 January 2009 / Accepted 5 March 2009

ABSTRACT

Context. γ Dor stars are excellent targets for asteroseismology since the gravity modes present in these stars probe the deep stellar interiors. Mode identification will improve the knowledge of these stars considerably.

Aims. A selected group of γ Dor stars and some candidates were observed with the Mercator telescope to find and/or confirm the periodicities in the light variations and to derive reliable amplitude ratios in different pass bands.

Methods. A frequency analysis was performed on all new data obtained in the Geneva photometric system. In order to have more reliable and accurate frequencies, the new data were combined with similar data from the literature and with Hipparcos observations. A set of frequencies that minimized the residuals in a harmonic fit was searched for while allowing means and amplitudes to vary from one observation set to another.

Results. Frequencies and amplitudes in the photometric passbands of the Geneva system are given for 21 γ Dor stars. We report the discovery of HD 74504 as a newly found γ Dor star.

Conclusions. Our study provides the first extensive multicolour database for the understanding of gravity modes in F-type stars.

Key words. stars: variables: general – stars: oscillations – stars: individual: γ Doradus – techniques: photometric

1. Introduction: γ Doradus stars (γ Dor stars)

As reviewed in the article by Henry et al. (2007) the class of γ Dor stars has now over 60 members. These stars have spectral types of late A or F, luminosity class IV or V and exhibit periodicity in the light variations with periods in the range of 0.3 to 3 days. Line-profile variability is present as well (Mathias et al. 2004; De Cat et al. 2006). There is no doubt that the cause of the variations is pulsation. The modes are high-order gravity modes (g-modes), excited by a flux blocking mechanism at the base of the convective envelope of the stars (Guzik et al. 2000; Dupret et al. 2005).

Because the g-modes probe the deep stellar interior, the γ Dor stars are excellent targets for asteroseismology, particularly since they may exhibit solar-like oscillations as well (Michel et al. 2008). However, mode identificiation is not simple for these stars since the spectrum of g-modes is very dense and only a few modes seem to have high enough amplitudes to be well observed from the ground. Therefore, observables such as photometric amplitude ratios and line-profile variations are extremely useful to identify the modes. By observing light variations in different passbands the identification of the degree ℓ of the pulsation mode becomes possible (Balona & Stobie 1979; Watson 1988; Dupret et al. 2005).

Since this kind of observable is made available with this paper for 21 γ Dor stars, a large number of variable stars of this class will have their modes identified, and parameters for the

⋆ Based on observations collected with the Flemish 1.2-m Mercator Telescope at Roque de los Muchachos, La Palma.

⋆⋆ Tables 5 to 25 are also available at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/499/967

⋆⋆⋆ Fellow of the Fund for Scientific Research, Flanders (FWO).

† NASA Post-doctoral fellow.

Article published by EDP Sciences

physics of stellar models, including e.g. a value for the mixing-length parameter, can in principle be derived. Such seismic inferences are the subject of an accompanying paper (Miglio et al. 2009, in preparation).

2. The instrument and the observations

The Mercator telescope is a 1.2-m telescope located on the Roque de los Muchachos observatory on La Palma, Spain. Since the beginning of its scientific operations in spring 2001 it was equipped with the P7 photometer.

The P7 photometer is the refurbished photometer that has been active on the 70-cm Swiss Telescope at La Silla Chile before. It is a two-channel photometer for quasi simultaneous 7-band measurements ($U, B_1, B, B_2, V_1, V, G$) in the Geneva photometric system (Golay 1966; Rufener & Nicolet 1988; Rufener 1989). The first channel (A) is centred on the star while the second channel (B) is centred on the sky. The filter wheel turns at 4 hertz and a chopper directs both channels alternatively to the photomultiplier. As such, the photomultiplier measures both beams through the seven filters four times per second. In this way quasi-simultaneous measurements of the light in the 7 filters become possible. This makes the instrument very suitable to observe variable stars, since information on the light variations in all filters can be obtained very efficiently.

Furthermore an almost continuous access to the telescope during the year was possible, so the instrument became ideal to monitor stars with periods of the order of days and/or long beat periods of the order of months or years. Here we report on the results of a long-term monitoring of γ Dor stars, while De Cat et al. (2007) discussed the results for a sample of variable OB stars.

Some of these stars were observed over two years (time span around 370 days), some over three years (time span around 740 days) or four years (1110 days). Stars observed during only one season were not considered in detail. Up to five observations per star were obtained for about two months per season. This resulted in about 130 measurements per star on average, but there is a large spread as can be seen in Table 1.

Photometric observations in the Geneva system are labeled with two quality indices (from lowest quality 0 to highest quality 4), one for the magnitudes, one for the colours (Rufener 1989). In a first analysis we eliminated all observations labeled 0 or 1, but we also carried out a re-analysis with the low-quality observations included. In most cases the difference in the result was negligible. Since some stars were only measured at high airmasses, they almost all automatically received a low index value. Here we used those values as well, since without them the number of observations of those stars would be too low. The errors are slightly larger in such cases, but the results are the same. Observations of standard stars indicate that the errors for the programme stars, which have visual magnitudes between 7 and 9, are in the range 0.005 to 0.010 mag.

3. Selection of the targets

A selection of stars was made out of the lists by Aerts et al. (1998) and Handler (1999), of the Hipparcos selection results and from lists of γ Dor stars, candidate γ Dor or other variables (Koen & Eyer 2002). Since the start of the observations, almost all stars of the list were comfirmed as γ Dor stars. For very few of them, multicolour photometry was available and in several cases the multiperiodicity needed confirmation. The list with the 21 stars with more than 25 observations of good quality, spread over more than one season, is given in Table 1. A number of stars was already (partly) analysed in a previous paper (De Ridder et al. 2004) but for some stars the additional observations proved to be very useful to clarify the multiperiodicity of the light variations.

Fifteen other variable A-F stars were monitored during the same period. Not all showed characteristics of γ Dor stars: a few turned out to be δ Scuti stars, others need some further analysis. The results for these stars will be published in another article.

4. Analysis methods

We used standard methods for the period analysis, but since the light curves of these stars are very sinusoidal, we adopted as a final analysis method a multifrequency least-squares fit with sinusoidal components (Schoenaers & Cuypers 2004), where we searched for the best frequencies in large intervals around an initial solution. This is an extremely computer intensive procedure since the sum of the residuals is a rapidly oscillating function, especially when up to six frequencies had to be considered. To obtain the initial values we used Lomb-Scargle periodogram methods (Lomb 1976; Scargle 1982), and phase dispersion minimization methods (Stellingwerf 1978), each time followed by a prewhitening for a first analysis. The final search was always done with a multifrequency least-squares fit.

For initial values of the frequencies in the Mercator data we usually looked at the B or B1 data, since we expect the highest amplitudes of the light variations in these filters (e.g. Aerts et al. 2004). It happened that the amplitude in other filters (typically V1 or G) became too low for the frequencies to be significant there. We re-analysed the Hipparcos data independently, but we looked only for a local minimum in the least-squares fit in the (wide) neighbourhood of the ground-based solution.

If observations were available from other sources, we combined the Geneva colour V, Johnson V and Hipparcos data. We searched in the combined data for a multifrequency least-squares fit with unknown means and amplitudes for each data source to search for the best frequency (frequencies) to describe all data. We did not use statistical weights on individual observations or groups of data: the data from the literature were of similar quality and the measurement errors about the same as for the Geneva photometry. The Hipparcos data often had larger errors, but since these are important for solving the alias problems, we also gave those equal weights.

Although for individual data sets only frequencies peaking four times above the average signal-to-noise level in the periodogram are acceptable, we relaxed this criterion for the frequencies found with the multifrequency fit technique in the combined data. Frequency solutions of the multifrequency fit were accepted, if a corresponding extremum was found in the periodogram of each data set. In this way we accepted frequencies with peaks 1.5 times above the noise in some of the individual data sets, as shown a posteriori.

In several cases the combination of the data solved the alias or ambiguity problems and it gave, in general, more accurate values for the frequencies. In a few cases, it turned out that observations of the same star(s) were carried out, unintentionally, as in multisite campaigns. Here the gain in frequency determination was obvious. Including the Hipparcos data enlarged the time basis to about 5000 days for almost all stars. We did no colour transformation for the Hipparcos data, since our method takes possible amplitude differences into account. Since the Hipparcos data are not always as accurate as the ground-based data and since the observations sometimes have a rather odd time distribution, there was not always the expected gain in frequency accuracy. In most cases however, the frequency errors became of the order of 10^{-6} d^{-1}.

Amplitude ratios and other characteristics were computed in the different passbands of the Geneva photometric system with frequencies as close as possible to the results of the combined data set. For this purpose we searched again for the closest local minimum in the residuals of the harmonic fit in the Mercator data. In some cases there were differences between the best solution found in the Mercator data alone and this solution. However, differences were small or caused by choosing the wrong alias in the initial solution, as can be seen by comparing Table 1 and Tables 5 to 25.

5. Results on the individual stars

5.1. HD 277 = HIP 623

HD 277 is an F2 star intensively observed by Henry et al. (2001). They found three frequencies and remarked more scatter around light maximum than around light minimum.

The three frequencies found by Henry et al. (2001) were confirmed, although the $2 - f$ alias of their third frequency is more significant in the Mercator data. The high significance of this alias is caused by the limited nightly sampling of our data, combined with the length of the period.

The third frequency as derived from the Hipparcos data (1.3437 d^{-1}) deviates from the third frequency (1.3866 d^{-1}) found by Henry et al. (2001) and from our third frequency (1.38709 d^{-1}) as well. At the moment we have no explanation for this, but the standard deviation of the residuals remaining in the Hipparcos data after prewhitening with the first three frequencies is still higher (0.021 mag) than can be expected from the errors on the measurements (0.017 mag). This could indicate that more (low amplitude) frequencies are present, but they could not be detected in the individual data sets. In the combined data set (Hipparcos, Henry et al. 2001, and Mercator data) a fourth frequency at 0.8349 d^{-1} was detected.

We also observed a few times some extra brightening around light maximum in this star. The standard deviation of the residuals in the Mercator data is about 0.015 mag in $B1$ and 0.011 mag in V. This is an indication of some additional variability.

5.2. HD 2842 = HIP 2510

In previous analyses of the Mercator data (De Ridder et al. 2004; Cuypers et al. 2006) only two frequencies were found, but now the three frequencies, as given by Henry et al. (2005), could be confirmed without any doubt. The three-frequency solution is also clearly present in the Hipparcos data of this star. The frequency given by Koen & Eyer (2002) for the Hipparcos data (1.78085 d^{-1}) is not present in any of the significant three-frequency solutions.

Fekel et al. (2003) observed no velocity changes in the 2 spectra they obtained, but Mathias et al. (2004) did. The latter also mentioned possible line-profile variations in the blue wing of the lines.

5.3. HD 7169 = HIP 5674

Three frequencies are easily recognized in the Mercator data. Two frequencies are in common with the Henry & Fekel (2003) results, but their second frequency (2.7640 d^{-1}) is probably an alias of the frequency 1.76031 d^{-1} found both in the Mercator and Hipparcos data.

This star has 136 Mercator measurements over the period 2001 to 2003, but was unfortunately only once observed in 2004. Therefore, the errors on the results are larger than usual.

5.4. HD 23874 = HIP 17826

So far only one frequency (2.2565 d^{-1}) has been accepted for this star (Henry & Fekel 2003), since the second frequency found by Handler (1999) in the Hipparcos data could not be confirmed. However, more than one frequency is expected given the large residuals in all data sets. In the Mercator data a secondary frequency at 2.8883 d^{-1} or its alias at 1.8856 d^{-1} is significant. A two-frequency search in the data of Henry & Fekel (2003) gave also 2.2565 and 1.8849 d^{-1} as one of the most significant solutions. By combining the Henry & Fekel data, the Mercator data and the Hipparcos data, the two frequencies could be calculated more precisely.

5.5. HD 48271 = HIP 32263 = V553 Aur

Handler (1999) found two frequencies for this star in the Hipparcos data: 0.5244 and 0.8688 d^{-1}. Only one frequency is given by Henry & Fekel (2003): 0.9125 d^{-1}. Martín et al. (2003) suggested the presence of four frequencies in the Hipparcos data. Our analysis confirmd these four frequencies, although for the second frequency an alias is found to be more significant in the Mercator data and the fourth frequency is only marginally significant. The combination of the data sets, with the Hipparcos data included, solves the alias problems and indicates a stable four-frequency solution.

5.6. HD 62454 = HIP 37863 = DO Lyn

For this star Kaye et al. (1999) found five frequencies: 1.60146, 1.43678, 1.73671, 1.83372, 1.80753 d^{-1} in their multi-site campaign of 1997 and 1998 and they suggested one more near 2.9 d^{-1}. The first three have amplitudes larger than 0.01 mag in V and are well identified. The others have smaller amplitudes. With our multifrequency fit techniques, we found in the data of Kaye et al. (1999) the frequencies 1.60139, 1.43675, 1.73637, 1.83373, 1.80793 d^{-1}, all very close to the given solution.

The most significant frequency in the Hipparcos data is 1.3329 d^{-1}. This frequency is not related to any of the other frequencies, but this could be due to the odd time distribution of the Hipparcos data.

In the Mercator data of 2001 to 2004 the main frequency found in filters B and $B1$ is 1.5985 d^{-1}. This could be an alias of the first frequency given by Kaye et al. (1999). In the other filters this frequency cannot unambiguously be identified. A frequency at 1.2032 d^{-1} is present in all filters.

It seems impossible to connect the frequency solutions of the different campaigns for this star. This could mean that the frequencies and/or the amplitudes in this star are not stable over a longer period or, more likely, that a (different) combination of more frequencies is necessary to describe the data adequately.

The star is a double-lined spectroscopic binary (Kaye 1998) and orbital parameters were given by Kaye et al. (1999) and Mathias et al. (2004). Line profile variations were observed in the primary star by Mathias et al. (2004).

We do not expect a large influence of the secondary component on the pulsational behaviour given the relatively long orbital

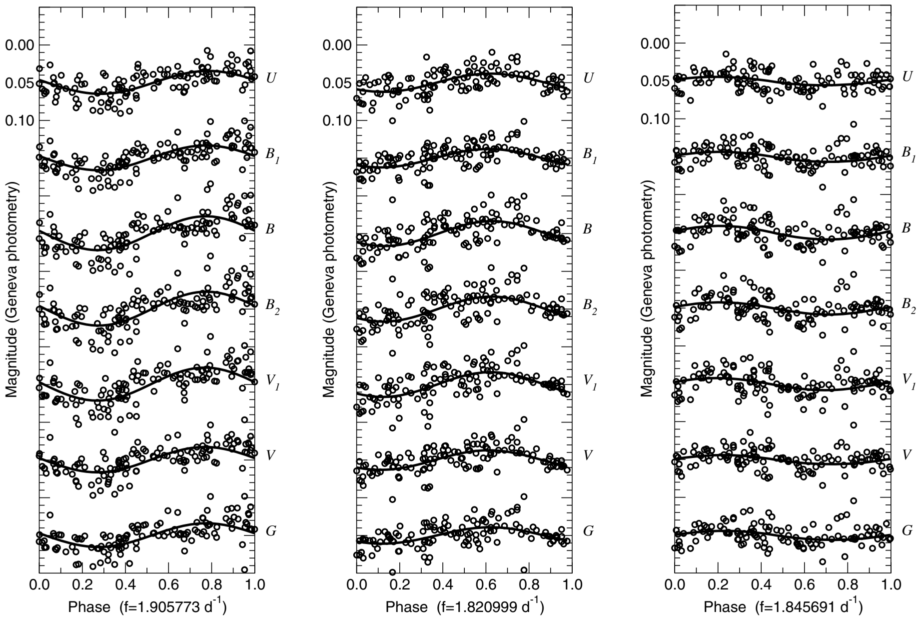

Fig. 1. Phase diagrams of the seven-colour photometry of the newly discovered γ Dor star HD 74504 for the indicated frequencies.

period of 11.615 days, but currently we have no explanation for the variation of the frequency spectrum from season to season.

5.7. HD 69715 = HIP 40791

HD 69715 was confirmed as a γ Dor star by Henry et al. (2005). The two frequencies found by them, 2.4566 and 2.4416 d^{-1} with error 0.0002 d^{-1}, are confirmed in the Mercator data, 2.45642 and 2.44120 d^{-1} with error 0.00007 d^{-1}. In the Hipparcos data a two-frequency solution with 2.0129 and 2.36462 d^{-1} is present, as already indicated by Martín et al. (2003), but a well defined local minimum is found for 2.45630 and 2.44139 d^{-1} as well. Therefore, in the combination of all data sets, highly accurate values for these frequencies could be found (errors less than 0.00001 d^{-1}). The time span of the observations obtained by Martín et al. (2003) for this star was probably too short to separate these two frequencies. As a consequence, it is not surprising that other values for the frequencies were found, although one of their results, 2.425 d^{-1}, is close to the two frequencies given here. Mathias et al. (2004) observed no line-profile variations in the spectra, pointing to very low velocity amplitudes, probably due to rotational line broadening ($v \sin i$ = 145 km s^{-1}).

5.8. HD 74504 = HIP 43062

This is a star from the list by Koen & Eyer (2002) and it is the only star in our sample that is not yet catalogued as variable star. It has all the properties of a γ Dor star. The frequency in the Hipparcos data as listed by Koen & Eyer (2002) is 1.9057 d^{-1}. This frequency (1.90570 ± 0.00005 d^{-1}) is found easily in the Mercator data, where at least one more frequency could be identified (1.8210 ± 0.0001 d^{-1}). Although this frequency could be an alias, we prefer this value since a two-frequency analysis of the Hipparcos data gives 1.9058 and 1.8212 d^{-1} as the best two-frequency solution. In the combined data set we found 1.905773 and 1.820999 d^{-1}. The next frequency candidate here is 1.845691 d^{-1}. Phase diagrams constructed with the frequencies found are given in Fig. 1.

5.9. HD 86358 = HIP 48895 = HR 3936

For this γ Dor star, identified as such by Handler (1999) and Koen & Eyer (2002), four frequencies were known from the observations published by Fekel et al. (2003). In the Hipparcos data we identified three of those four frequencies. In the Mercator data the four frequencies (or some clear aliases) are significant as well, but an additional high amplitude variation with frequency 1.00286 d^{-1} (or an alias near 1.0014 d^{-1}) is present. Its amplitude (0.022 mag in V, but smaller in other filters) is not comparable at all with the little extra power in the periodogram near 1 d^{-1} mentioned by Fekel et al. (2003) and seems large for a stellar oscillation frequency. It is difficult to explain why a frequency corresponding to one cycle per sidereal day is so significant in this dataset and only marginally or not at all significant in other datasets. It could be an artefact of e.g. imperfect extinction corrections, but in that case we would expect this frequency to be significant in other Mercator data sets as well. This is not the case. After prewhitening with this frequency, it was possible to find a well-defined set of four frequencies in the Mercator data and in the combined data as well. In a five-frequency fit, the variations associated with the frequency near 1 d^{-1} still have a significant amplitude. Therefore we calculated the associated amplitudes for this frequency as well.

Indications of the binarity of this star were given by Fekel et al. (2003) and Henry & Fekel (2003). The spectra published by Mathias et al. (2004) clearly showed the binarity and indications of line-profile variations in the slow rotator. Griffin (2006) discussed the system extensively and gave revised orbital elements and mass estimates. In principle, the frequency 1.00286 d^{-1} or 1.00139 d^{-1} found in the Mercator data could be a one day alias of a smaller frequency related to the orbital period of this system (33.7 days), but this is unlikely in view of the estimated inclination of 45° as given by Griffin (2006).

5.10. HD 100215 = HIP 56275

This star is a well known γ Dor star. The four frequencies given by Henry & Fekel (2003), or daily aliases are present in the

Mercator data as well. The frequencies were refined by combining all data including the Hipparcos data, but some of the results can still be one year aliases of the true frequencies. A candidate for a fifth frequency, present also in the combined data set, is 1.54354 d^{-1}. The star is a binary system of which Griffin (2006) gives high-precision orbital elements.

5.11. HD 105458 = HIP 59203

Henry et al. (2001) found six frequencies in the data for this star. We can easily confirm four of them (or their aliases) in the Mercator data. The six-frequency solution is a local minimum as well and is also present in the combined V data. Therefore, amplitude ratios for all frequencies could be estimated. In the Hipparcos data alone, the frequencies are difficult to find. There 0.7151 d^{-1} appears as a first frequency, although a frequency of 1.3210 d^{-1} is present as well.

5.12. HD 108100 = HIP 60571 = DD CVn

The frequencies found in the Mercator data are compatible with the results of Breger et al. (1997) and Henry & Fekel (2002). The Hipparcos data are very noisy and could not give independent information. Breger et al. (1997) indicated possible amplitude variations and this might be a reason for not finding the frequencies in a data set with a small number of observations. However, combining the Hipparcos data and the data of Henry & Fekel (2002) with the Mercator data leads to a well-defined three-frequency solution. Mathias et al. (2004) report that this star is a binary with line-profile variations in the slow rotator.

5.13. HD 113867 = HIP 63951

Henry & Fekel (2003) found five frequencies (0.8887, 2.0084, 1.7785, 2.8965 and 0.8841 d^{-1}) and they indicated that there could be some alias problems in their final solution. One of their frequencies is doubtful since it differs only by 0.0046 d^{-1} from the main frequency and this is at the limit of reliable extraction from an observational campaign of less than 250 days for this star. In the Mercator data a similar solution could be found (0.8884, 1.0056, 1.7761, 1.8910, 0.8834 d^{-1}). By combining the data of Henry & Fekel (2003) with the Mercator data and the Hipparcos observations, some ambiguities regarding day and year aliases could be resolved. A six-frequency solution (0.88838, 1.00420, 1.77757, 1.89378, 0.88681, 1.42221 d^{-1}) was obtained from this analysis. The sixth frequency (or its alias at 2.42 d^{-1}) is also marginally present in Fig. 18 of Henry & Fekel (2003). The frequency analysis for this star is not decisive. There is one period extremely close to 1 day. The third frequency nearly equals the sum of the first and fifth frequency. As a result not all alias problems nor ambiguities related to possible sum or double frequencies are completely resolved yet. Some indications of closely spaced frequencies near the main frequency are present. The star is very likely to be a binary, as suggested by Henry & Fekel (2003) and confirmed by Mathias et al. (2004). It is not clear which component is the γ Dor star. Since the components are estimated to have spectral type A9 and F1, both stars could be γ Dor stars.

5.14. HD 167858 = HIP 89601 = HR 6844 = V2502 Oph

There is no doubt that this binary star (orbital period: 4.48518 days (Fekel et al. 2003)) is a multiperiodic variable. Two frequencies (near 0.765 and near 0.697 d^{-1}) are significant in all data sets. The third frequency in the Mercator data is near the second frequency cited in Aerts et al. (1998). We identified five frequencies in the combined data, including the third frequency given by Henry & Fekel (2003). One frequency is close to the $2 - f$ alias of the second frequency and this may hamper the frequency analysis of individual ground-based data sets. There is a lot of scatter in the light curves and some excess scatter at maximum brightness.

5.15. HD 175337 = HIP 92837

One frequency is clearly present in all the data sets of this star (Hipparcos, Henry et al. 2005, and Mercator data). The Hipparcos data have a few outliers that strongly influence the period search. No secondary frequency could be identified unambiguously.

5.16. HD 195068 = HIP 100859 = HR 7828 = V2121 Cyg

This star was sometimes observed on the same dates by Henry et al. (2005) and by the Mercator telescope team. The three-frequency solution was easily confirmed in the combined data. A candidate for a fourth frequency occurs near 0.28 or its alias at 1.28 d^{-1}, between f_1 and f_2. The first frequency found by Jankov et al. (2006) in spectroscopic data (1.61 d^{-1}) is not significantly present in any of the photometric data sets.

5.17. HD 206043 = HIP 106897 = HR 8276 = NZ Peg

For this star only three frequencies of the set of five found by Henry et al. (2001) were significant in the Mercator data. However, a local minimum in the residuals exists for the five-frequency solution both in the Mercator and in the combined data sets. One extra frequency was found in the combined data as well. Also for the six-frequency solution there was convergence to a local minimum in the residuals for the Mercator data. Therefore, amplitudes could be calculated for all six frequencies in the Geneva filters. As expected the amplitudes of frequencies f_4, f_5 en f_6 are small.

5.18. HD 207223 = HIP 107558 = HR8330 =V372 Peg

In the Mercator data the one year alias of the frequency given by Aerts & Kaye (2001) and Guinan et al. (2001) is found. The Hipparcos data on its own are not very useful to resolve the ambiguity but in the combined data there is a slight preference for the frequency 0.38538 d^{-1}.

5.19. HD 211699 = HIP 110163 = PR Peg

Only three of the four frequencies (or of their aliases) found by Henry et al. (2007) are significant in the Mercator data. Their second frequency near 1.12 d^{-1} is not found, but is apparent in the combined data. Furthermore, as already remarked by Henry et al. (2007), their fourth frequency is equal to the difference between f_1 and f_2, or, $f_2 = f_1 + f_4$. Adding a second harmonic to the fourth frequency significantly improves the fit. This adds to the puzzling state of this star as already reported by Mathias et al. (2004), since line-profile variations were observed, but also changes of the equivalent widths of the line. Stellar activity is suggested as an explanation. This could mean that one of the frequencies might be related to rotation.

Table 1. Results of the frequency analysis of the Mercator data.

HD number	HIP number	Spectral type	N	T(d)	f_1(d^{-1})	f_2(d^{-1})	f_3(d^{-1})	f_4(d^{-1})	f_5(d^{-1})	f_6(d^{-1})
277	623	F0	239	1148	1.11109	1.08130	1.38709			
2842	2510	F0V	109	1149	1.71270	1.53729	1.67063			
7169	5674	F2V	96	1149	1.8225	1.9245				
23874	17826	F0	127	1045	2.2567	1.8856				
48271	32263	F0	88	869	0.9123	0.8586	0.9314	1.7327		
62454	37863	F0	158	847	1.5985:					
69715	40791	A5	64	805	2.45642	2.44120				
74504	43062	F0	122	794	1.90574	1.82101	1.84570			
86358	48895	F3V	100	805	1.1216	1.2930	1.1869	1.1423	1.00286	
100215	56275	Am	169	839	1.32191	1.42201	1.27911	1.6159:		
105458	59203	F0III	340	985	1.32084	1.25034	1.40903	0.94631	1.55279	1.09007
108100	60571	F2V	196	980	1.40132	1.32726	1.34071:			
113867	63951	F0	163	946	0.88841	1.00553	1.89101	1.77613	0.88340	1.42185
167858	89601	F2V	62	407	0.7650	0.6984	1.0734			
175337	92837	F5	40	752	1.27109					
195068	100859	F5	189	766	1.25054	1.29843	0.96553	0.28517		
206043	106897	F2V	158	1163	2.4324	2.3596	2.5243			
207223	107558	F3V	115	1163	0.38287					
211699	110163	F0	97	1149	0.9327	1.1963	1.1635			
218396	114189	A5V	95	1151	1.9806	1.7326	0.7676			
221866	116434	A3m	135	1149	0.8384	0.8772	0.8572			

The spectral type is from literature. N is the number of observations used, T is the total time span in days. Frequencies not significant in all colour filters are indicated by a colon.

Table 2. Frequencies obtained by combining data sets as described in the text. The definition of the colums is the same as in Table 1.

HD number	HIP number	Spectral type	Source	N	T(d)	f_1(d^{-1})	f_2(d^{-1})	f_3(d^{-1})	f_4(d^{-1})	f_5(d^{-1})	f_6(d^{-1})
277	623	F0	HLM	864	5371	1.11101	1.08099	1.38704	**0.83469**		
2842	2510	F0V	HLM	435	5377	1.71268	1.53725	1.66799			
7169	5674	F2V	HLM	548	5384	1.82259	1.92502	***1.76031***			
23874	17826	F0	HLM	493	5385	2.25651	**1.88562**				
48271	32263	F0	HLM	580	5109	***0.91236***	***0.87189***	***0.92314***	***1.75472***		
62454	37863	F0	HLM	264	5084	1.60156	1.43631	1.73694	1.83413	1.81079	
69715	40791	A5	HLM	580	4816	2.456426	2.441492				
74504	43062	F0	H M	213	5113	1.905773	**1.820999**	**1.845691**			
86358	48895	F3V	HLM	598	5169	1.289696	1.185229	1.121666	1.142454	**0.997646**:	
100215	56275	Am	HLM	946	5213	1.32188	1.42207	1.27905	1.61480	**1.54354**	
105458	59203	F0III	HLM	1043	5215	1.32083	1.25036	0.94632	1.40903	1.09021	1.55261
108100	60571	F2V	HLM	747	5192	1.32572	1.40136	1.36542			
113867	63951	F0	HLM	722	5180	0.88838	***1.00420***	***1.89379***	1.77757	1.42221	
167858	89601	F2V	HLM	622	4532	0.76508	0.69845	1.30185	**1.60558**	**1.07551**	
175337	92837	F5	HLM	372	4869	1.271134					
195068	100859	F5	HLM	610	4994	1.250511	1.298422	0.965416	**0.284863**		
206043	106897	F2V	HLM	600	5366	2.35944	2.43242	2.52427	2.26551	2.59895	**2.46092**
207223	107558	F3V	H M	204	5351	***0.385383***					
211699	110163	F0	HLM	617	5472	0.93280	1.12646	1.16322	0.19377		
218396	114189	A5V	H M	169	5394	1.980518	1.732528	***0.767562***			
221866	116434	A3M	H M	304	5394	0.877197	0.838478	1.715664			

In the column "source" H means Hipparcos data, M Mercator data and L indicates that other data from literature were used as well. Values in bold indicate newly found frequencies, bold italics means an alias of a previously known frequency was used.

5.20. HD 218396 = HIP 114189 = HR 8799 = V342 Peg

There is little doubt that this star has at least two frequencies. The first two frequencies (1.9791 and 1.7368 d^{-1}) found in the multisite campaign presented in Zerbi et al. (1999) are present in the Mercator data as well (1.9806 and 1.7326 d^{-1}). Since their multisite campaign was relatively short, there is agreement within the errors. Combining the data with the Hipparcos measurements reveals another frequency, 0.76762 d^{-1}, which could be an alias of the frequency f_4 = 0.2479 d^{-1} of Zerbi et al. (1999).

5.21. HD 221866 = HIP 116434

It is known that for some time series of observations of multiperiodic variations, the technique of consecutive prewhitening will not yield the correct solution (see e.g. Cuypers & Minarini 1998). The Hipparcos measurements of this star are another

Table 3. Average magnitudes of the γ Dor stars in the Geneva photometric system.

HD number	U	$B1$	B	$B2$	$V1$	V	G
277	9.2075	8.7915	7.8194	9.2134	9.0873	8.3666	9.4687
2842	8.7691	8.3682	7.4092	8.8170	8.7050	7.9858	9.0944
7169	8.1116	7.7034	6.7373	8.1385	8.0028	7.2810	8.3826
23874	9.0657	8.6702	7.6947	9.0866	8.9212	8.1980	9.2914
48271	8.2670	7.8668	6.9094	8.3160	8.1995	7.4807	8.5860
62454	7.9513	7.5519	6.5841	7.9808	7.8535	7.1336	8.2365
69715	7.9669	7.5578	6.6032	8.0114	7.8897	7.1708	8.2751
74504	9.6144	9.2039	8.2523	9.6614	9.5673	8.8519	9.9629
86358	7.2567	6.8881	5.9217	7.3235	7.1841	6.4625	7.5631
100215	8.7886	8.3636	7.4040	8.8074	8.6996	7.9816	9.0866
105458	8.5229	8.1213	7.1688	8.5793	8.4753	7.7584	8.8683
108100	7.9628	7.5625	6.5931	7.9882	7.8371	7.1152	8.2101
113867	7.6159	7.1823	6.2260	7.6367	7.5425	6.8253	7.9382
167858	7.4093	6.9926	6.0277	7.4350	7.3337	6.6143	7.7259
175337	8.2102	7.8103	6.8335	8.2302	8.1012	7.3784	8.4828
195068	6.5117	6.0955	5.1233	6.5300	6.4220	5.6994	6.8119
206043	6.5605	6.1317	5.1674	6.5809	6.4790	5.7572	6.8713
207223	6.9961	6.6026	5.6300	7.0305	6.8966	6.1730	7.2762
211699	9.9568	9.5352	8.5691	9.9679	9.8425	9.1226	10.2255
218396	6.6524	6.2587	5.3186	6.7531	6.6774	5.9601	7.0853
221866	8.2668	7.7669	6.8081	8.2177	8.1670	7.4528	8.5775

Table 4. Calibration of effective temperature, gravity and metallicity based on the Geneva colours of the γ Dor stars. Δ is the formal calibration error.

HD number	T_{eff}(K)	Δ	log g	Δ	[M/H]	Δ
277	6995	60	4.38	0.11	0.11	0.08
2842	7091	61	4.49	0.08	–0.12	0.10
7169	6905	53	4.29	0.13	–0.09	0.09
23874	6720	47	4.04	0.15	–0.06	0.08
48271	7050	60	4.47	0.08	–0.15	0.10
62454	6997	57	4.45	0.11	0.03	0.09
69715	6987	58	4.39	0.10	–0.24	0.10
74504	7221	62	4.50	0.08	–0.14	0.10
86358	6910	54	4.47	0.13	–0.11	0.10
100215	7109	59	4.40	0.07	–0.04	0.09
105458	7144	62	4.50	0.07	–0.20	0.11
108100	6809	50	4.17	0.15	–0.08	0.09
113867	7195	62	4.40	0.08	–0.10	0.10
167858	7177	61	4.46	0.07	0.01	0.09
175337	6993	59	4.44	0.12	0.12	0.08
195068	7133	61	4.46	0.08	0.07	0.09
206043	7144	60	4.41	0.07	–0.07	0.09
207223	6952	54	4.43	0.12	0.01	0.09
211699	6984	56	4.34	0.10	0.00	0.09
218396	7355	67	4.57	0.07	–0.71	0.18
221866	7480	66	4.36	0.07	0.14	0.09

example of this phenomenon. In the Hipparcos series a first frequency appears near 0.90 d^{-1}, but only multifrequency fits lead to a solution compatible with the other sets of observations. In the final three-frequency solution, the frequency near 0.90 d^{-1} is not present anymore. When the Mercator and Hipparcos data were combined (the Henry & Fekel 2002 data were not used), very precise values for the frequencies could be found (errors less than 0.00001 d^{-1}). The frequencies are not independent: in the Mercator data the third frequency is the mean of f_1 and f_2, in the data of Henry & Fekel (2002) and in the Hipparcos data the second frequency is the sum of the two others (within the errors). Adding a harmonic to the third frequency of the Mercator data improves the fit. The two main frequencies are also in agreement with values published by Kaye et al. (2004). Their spectroscopic observations indicate that HD 221866 is a spectroscopic binary with an orbital period of 135 days and a mass ratio of 1.11 ± 0.03.

6. Summary of the results

The results of the frequency analysis of the Mercator data are summarized in Table 1. For the combined data the frequency solution can be found in Table 2. The errors on the frequencies are of the order of the last decimal given, typically 10^{-5}–10^{-6} d^{-1}.

For all stars with a well-defined frequency solution in the combined data, the amplitudes in the different filters of the Geneva photometric systems were calculated. For each individual star, we give a summary of the results based on the Mercator data in Tables 5 to 25. The errors on the frequencies (and the periods) were calculated with the expressions given by

Table 5. HD 277.

HD 277		Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:			9.2075	8.7915	7.8194	9.2134	9.0873	8.3666	9.4687
	Errors:			0.0008	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008
	Amplitude errors:			0.0011	0.0013	0.0013	0.0013	0.0011	0.0011	0.0011
f_1		1.11111	0.90000	0.0251	0.0359	0.0344	0.0318	0.0259	0.0246	0.0223
Errors		0.00002	0.00002							
	Amplitude ratios:			0.70	1.00	0.96	0.88	0.72	0.69	0.62
	Errors:			0.04	0.05	0.05	0.05	0.04	0.04	0.04
f_2		1.08135	0.92477	0.0102	0.0134	0.0129	0.0118	0.0095	0.0090	0.0083
Errors		0.00006	0.00005							
	Amplitude ratios:			0.76	1.00	0.96	0.88	0.71	0.67	0.62
	Errors:			0.11	0.14	0.14	0.13	0.11	0.10	0.10
f_3		1.38708	0.72094	0.0087	0.0131	0.0128	0.0117	0.0090	0.0093	0.0083
Errors		0.00006	0.00003							
	Amplitude ratios:			0.66	1.00	0.98	0.90	0.69	0.71	0.64
	Errors:			0.11	0.15	0.14	0.14	0.11	0.11	0.10
f_4		0.83461	1.19816	0.0064	0.0076	0.0071	0.0072	0.0061	0.0055	0.0059
Errors		0.00009	0.00013							
	Amplitude ratios:			0.85	1.00	0.94	0.95	0.79	0.72	0.77
	Errors:			0.21	0.25	0.24	0.24	0.20	0.19	0.19

Table 6. HD 2842.

HD 2842		Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:			8.7691	8.3682	7.4092	8.8170	8.7050	7.9858	9.0944
	Errors:			0.0009	0.0012	0.0011	0.0011	0.0009	0.0008	0.0008
	Amplitude errors:			0.0013	0.0017	0.0016	0.0015	0.0013	0.0012	0.0012
f_1		1.71270	0.58387	0.0244	0.0348	0.0336	0.0317	0.0255	0.0249	0.0229
Errors		0.00003	0.00001							
	Amplitude ratios:			0.70	1.00	0.97	0.91	0.73	0.71	0.66
	Errors:			0.05	0.07	0.06	0.06	0.05	0.05	0.05
f_2		1.53729	0.65050	0.0137	0.0218	0.0209	0.0194	0.0158	0.0146	0.0140
Errors		0.00005	0.00002							
	Amplitude ratios:			0.63	1.00	0.96	0.89	0.72	0.67	0.64
	Errors:			0.08	0.11	0.10	0.10	0.08	0.08	0.07
f_3		1.67063	0.59858	0.0089	0.0122	0.0119	0.0117	0.0095	0.0096	0.0092
Errors		0.00007	0.00003							
	Amplitude ratios:			0.73	1.00	0.98	0.96	0.78	0.79	0.75
	Errors:			0.15	0.19	0.19	0.18	0.15	0.15	0.14

Table 7. HD 7169.

HD 7169		Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:			8.1116	7.7034	6.7373	8.1385	8.0028	7.2810	8.3826
	Errors:			0.0006	0.0006	0.0006	0.0006	0.0006	0.0005	0.0006
	Amplitude errors:			0.0008	0.0009	0.0008	0.0008	0.0008	0.0007	0.0008
f_1		1.82262	0.54866	0.0125	0.0211	0.0195	0.0182	0.0137	0.0138	0.0133
Errors		0.00003	0.00001							
	Amplitude ratios:			0.59	1.00	0.92	0.86	0.65	0.66	0.63
	Errors:			0.05	0.06	0.06	0.05	0.05	0.04	0.04
f_2		1.92465	0.51957	0.0057	0.0081	0.0077	0.0075	0.0054	0.0056	0.0050
Errors		0.00007	0.00002							
	Amplitude ratios:			0.70	1.00	0.95	0.92	0.67	0.68	0.61
	Errors:			0.12	0.16	0.15	0.15	0.12	0.12	0.12
f_3		1.76050	0.56802	0.0027	0.0049	0.0045	0.0043	0.0033	0.0032	0.0039
Errors		0.00014	0.00005							
	Amplitude ratios:			0.55	1.00	0.92	0.87	0.67	0.66	0.80
	Errors:			0.19	0.26	0.24	0.23	0.20	0.19	0.21

Montgomery & O'Donoghue (1999) or Breger et al. (1999), but only the largest value over the filters is given. In general the difference is less than a factor of 2. The errors on the amplitudes were calculated with the standard deviations of the final

Table 8. HD 23874.

HD 23874			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		9.0657	8.6702	7.6947	9.0866	8.9212	8.1980	9.2914
	Errors:		0.0010	0.0011	0.0008	0.0011	0.0010	0.0008	0.0009
	Amplitude errors:		0.0014	0.0015	0.0011	0.0015	0.0014	0.0012	0.0013
HD 23874	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	2.25664	0.44314	0.0138	0.0220	0.0216	0.0200	0.0150	0.0147	0.0133
Errors	0.00005	0.00001							
	Amplitude ratios:		0.63	1.00	0.98	0.91	0.68	0.67	0.60
	Errors:		0.08	0.09	0.08	0.09	0.08	0.07	0.07
f_2	1.88559	0.53034	0.0073	0.0092	0.0081	0.0084	0.0060	0.0061	0.0060
Errors	0.00012	0.00003							
	Amplitude ratios:		0.79	1.00	0.87	0.91	0.65	0.65	0.65
	Errors:		0.20	0.22	0.18	0.22	0.18	0.17	0.18

Table 9. HD 48271.

HD 48271			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		8.2670	7.8668	6.9094	8.3160	8.1995	7.4807	8.5860
	Errors:		0.0009	0.0011	0.0011	0.0011	0.0009	0.0009	0.0008
	Amplitude errors:		0.0013	0.0016	0.0016	0.0015	0.0013	0.0013	0.0012
HD 48271	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	0.91236	1.09606	0.0206	0.0288	0.0278	0.0272	0.0212	0.0211	0.0190
Errors	0.00004	0.00005							
	Amplitude ratios:		0.71	1.00	0.96	0.94	0.74	0.73	0.66
	Errors:		0.06	0.08	0.08	0.07	0.06	0.06	0.06
f_2	0.87189	1.14693	0.0087	0.0111	0.0111	0.0092	0.0080	0.0074	0.0073
Errors	0.00011	0.00014							
	Amplitude ratios:		0.78	1.00	1.00	0.83	0.72	0.67	0.66
	Errors:		0.16	0.20	0.20	0.18	0.16	0.15	0.14
f_3	0.92314	1.08326	0.0020	0.0019	0.0019	0.0031	0.0034	0.0039	0.0042
Errors	0.00053	0.00062							
	Amplitude ratios:		0.47	0.46	0.46	0.73	0.82	0.94	1.00
	Errors:		0.34	0.41	0.41	0.40	0.39	0.40	0.40
f_4	1.75472	0.56989	0.0070	0.0103	0.0090	0.0082	0.0058	0.0057	0.0060
Errors	0.00015	0.00005							
	Amplitude ratios:		0.68	1.00	0.87	0.80	0.56	0.56	0.58
	Errors:		0.17	0.22	0.21	0.19	0.16	0.15	0.15

Table 10. HD 62454.

HD 62454			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		7.9513	7.5519	6.5841	7.9808	7.8535	7.1336	8.2365
	Errors:		0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
	Amplitude errors:		0.0009	0.0009	0.0009	0.0009	0.0009	0.0008	0.0009
HD 62454	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.60111	0.62457	0.0068	0.0110	0.0099	0.0095	0.0083	0.0077	0.0075
Errors	0.00009	0.00003							
	Amplitude ratios:		0.62	1.00	0.90	0.87	0.76	0.70	0.69
	Errors:		0.10	0.12	0.11	0.11	0.10	0.09	0.10
f_2	1.43619	0.69629	0.0039	0.0072	0.0063	0.0059	0.0049	0.0051	0.0044
Errors	0.00015	0.00007							
	Amplitude ratios:		0.55	1.00	0.88	0.83	0.68	0.71	0.61
	Errors:		0.14	0.18	0.17	0.16	0.15	0.14	0.14
f_3	1.73637	0.57591	0.0051	0.0069	0.0066	0.0061	0.0049	0.0049	0.0043
Errors	0.00013	0.00004							
	Amplitude ratios:		0.74	1.00	0.96	0.88	0.71	0.70	0.62
	Errors:		0.16	0.19	0.18	0.17	0.16	0.15	0.15
f_4	1.83401	0.54525	0.0050	0.0075	0.0072	0.0067	0.0048	0.0052	0.0042
Errors	0.00013	0.00004							
	Amplitude ratios:		0.68	1.00	0.97	0.90	0.64	0.69	0.56
	Errors:		0.14	0.17	0.17	0.16	0.14	0.14	0.13
f_5	1.81124	0.55211	0.0056	0.0067	0.0065	0.0065	0.0045	0.0047	0.0045
Errors	0.00013	0.00004							
	Amplitude ratios:		0.84	1.00	0.97	0.97	0.66	0.69	0.67
	Errors:		0.17	0.19	0.19	0.19	0.16	0.15	0.16

Table 11. HD 69715.

HD 69715			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		7.9669	7.5578	6.6032	8.0114	7.8897	7.1708	8.2751
	Errors:		0.0006	0.0008	0.0007	0.0007	0.0007	0.0006	0.0007
	Amplitude errors:		0.0009	0.0011	0.0010	0.0010	0.0010	0.0009	0.0010
HD 69715	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	2.45643	0.40709	0.0094	0.0134	0.0127	0.0121	0.0091	0.0086	0.0073
Errors	0.00010	0.00002							
	Amplitude ratios:		0.70	1.00	0.95	0.90	0.68	0.65	0.54
	Errors:		0.09	0.11	0.10	0.11	0.09	0.09	0.09
f_2	2.44124	0.40963	0.0092	0.0115	0.0111	0.0101	0.0076	0.0073	0.0064
Errors	0.00011	0.00002							
	Amplitude ratios:		0.80	1.00	0.96	0.87	0.66	0.64	0.56
	Errors:		0.11	0.13	0.12	0.12	0.10	0.10	0.10

Table 12. HD 74504.

HD 74504			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		9.6144	9.2039	8.2523	9.6614	9.5673	8.8519	9.9629
	Errors:		0.0011	0.0013	0.0013	0.0013	0.0011	0.0011	0.0011
	Amplitude errors:		0.0016	0.0019	0.0019	0.0018	0.0016	0.0016	0.0016
HD 74504	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.90574	0.52473	0.0220	0.0325	0.0326	0.0317	0.0244	0.0239	0.0228
Errors	0.00005	0.00001							
	Amplitude ratios:		0.68	1.00	1.00	0.97	0.75	0.73	0.70
	Errors:		0.06	0.08	0.08	0.08	0.06	0.06	0.06
f_2	1.82101	0.54915	0.0177	0.0241	0.0239	0.0240	0.0191	0.0180	0.0158
Errors	0.00007	0.00002							
	Amplitude ratios:		0.73	1.00	0.99	0.99	0.79	0.75	0.66
	Errors:		0.09	0.11	0.11	0.11	0.09	0.09	0.08
f_3	1.84570	0.54180	0.0075	0.0107	0.0121	0.0105	0.0081	0.0090	0.0081
Errors	0.00015	0.00004							
	Amplitude ratios:		0.62	0.88	1.00	0.87	0.67	0.74	0.67
	Errors:		0.17	0.21	0.22	0.20	0.16	0.17	0.17

Table 13. HD 86358.

HD 86358			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		7.2567	6.8881	5.9217	7.3235	7.1841	6.4625	7.5631
	Errors:		0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
	Amplitude errors:		0.0008	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008
HD 86358	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.18526	0.84370	0.0101	0.0158	0.0160	0.0145	0.0105	0.0108	0.0093
Errors	0.00006	0.00004							
	Amplitude ratios:		0.63	0.99	1.00	0.91	0.66	0.67	0.58
	Errors:		0.06	0.08	0.08	0.07	0.06	0.06	0.06
f_2	1.28995	0.77522	0.0102	0.0150	0.0144	0.0135	0.0095	0.0097	0.0084
Errors	0.00007	0.00004							
	Amplitude ratios:		0.68	1.00	0.96	0.90	0.64	0.65	0.56
	Errors:		0.07	0.09	0.08	0.08	0.07	0.07	0.07
f_3	1.12170	0.89150	0.0110	0.0147	0.0147	0.0131	0.0110	0.0110	0.0103
Errors	0.00006	0.00004							
	Amplitude ratios:		0.75	1.00	1.00	0.89	0.75	0.75	0.70
	Errors:		0.07	0.09	0.09	0.08	0.07	0.07	0.07
f_4	1.14247	0.87530	0.0077	0.0097	0.0092	0.0085	0.0071	0.0073	0.0067
Errors	0.00008	0.00006							
	Amplitude ratios:		0.79	1.00	0.95	0.88	0.73	0.75	0.69
	Errors:		0.11	0.13	0.13	0.12	0.11	0.11	0.11
f_5	1.00138	0.99862	0.0160	0.0202	0.0191	0.0207	0.0218	0.0191	0.0218
Errors	0.00004	0.00004							
	Amplitude ratios:		0.74	0.93	0.88	0.95	1.00	0.88	1.00
	Errors:		0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 14. HD 100215.

HD 100215			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		8.7886	8.3636	7.4040	8.8074	8.6996	7.9816	9.0866
	Errors:		0.0007	0.0008	0.0008	0.0008	0.0007	0.0006	0.0006
	Amplitude errors:		0.0010	0.0012	0.0011	0.0011	0.0010	0.0009	0.0009
HD 100215	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.32188	0.75650	0.0143	0.0229	0.0222	0.0206	0.0167	0.0163	0.0147
Errors	0.00005	0.00003							
	Amplitude ratios:		0.63	1.00	0.97	0.90	0.73	0.71	0.64
	Errors:		0.05	0.07	0.07	0.07	0.06	0.05	0.05
f_2	1.42205	0.70321	0.0097	0.0148	0.0142	0.0126	0.0102	0.0100	0.0090
Errors	0.00007	0.00003							
	Amplitude ratios:		0.66	1.00	0.95	0.85	0.69	0.67	0.61
	Errors:		0.09	0.11	0.10	0.10	0.09	0.08	0.08
f_3	1.27908	0.78181	0.0058	0.0084	0.0085	0.0080	0.0067	0.0069	0.0065
Errors	0.00011	0.00007							
	Amplitude ratios:		0.68	1.00	1.00	0.94	0.79	0.82	0.77
	Errors:		0.15	0.19	0.18	0.18	0.16	0.15	0.15
f_4	1.61592	0.61884	0.0036	0.0065	0.0056	0.0055	0.0039	0.0042	0.0042
Errors	0.00018	0.00007							
	Amplitude ratios:		0.55	1.00	0.87	0.85	0.60	0.64	0.65
	Errors:		0.18	0.25	0.23	0.23	0.19	0.18	0.19
f_5	1.54452	0.64745	0.0052	0.0072	0.0070	0.0070	0.0053	0.0050	0.0057
Errors	0.00013	0.00005							
	Amplitude ratios:		0.72	1.00	0.97	0.98	0.73	0.70	0.79
	Errors:		0.18	0.23	0.22	0.22	0.18	0.17	0.18

Table 15. HD 105458.

HD 105458			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		8.5229	8.1213	7.1688	8.5793	8.4753	7.7584	8.8683
	Errors:		0.0009	0.0012	0.0011	0.0011	0.0010	0.0009	0.0008
	Amplitude errors:		0.0011	0.0014	0.0013	0.0013	0.0011	0.0011	0.0010
HD 105458	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.32084	0.75709	0.0196	0.0309	0.0292	0.0288	0.0223	0.0218	0.0205
Errors	0.00003	0.00002							
	Amplitude ratios:		0.63	1.00	0.94	0.93	0.72	0.71	0.67
	Errors:		0.05	0.06	0.06	0.06	0.05	0.05	0.04
f_2	1.09007	0.91737	0.0117	0.0154	0.0151	0.0155	0.0125	0.0120	0.0106
Errors	0.00006	0.00005							
	Amplitude ratios:		0.76	0.99	0.98	1.00	0.80	0.77	0.69
	Errors:		0.10	0.12	0.12	0.12	0.10	0.09	0.09
f_3	1.25034	0.79978	0.0103	0.0151	0.0146	0.0139	0.0108	0.0109	0.0105
Errors	0.00006	0.00004							
	Amplitude ratios:		0.68	1.00	0.97	0.92	0.72	0.72	0.70
	Errors:		0.10	0.13	0.12	0.12	0.10	0.10	0.09
f_4	1.40906	0.70969	0.0083	0.0120	0.0114	0.0113	0.0088	0.0088	0.0080
Errors	0.00007	0.00004							
	Amplitude ratios:		0.70	1.00	0.95	0.94	0.74	0.73	0.67
	Errors:		0.12	0.16	0.15	0.15	0.13	0.12	0.12
f_5	0.94631	1.05674	0.0085	0.0114	0.0114	0.0097	0.0083	0.0081	0.0073
Errors	0.00008	0.00009							
	Amplitude ratios:		0.75	1.00	1.00	0.85	0.73	0.71	0.64
	Errors:		0.13	0.17	0.16	0.15	0.13	0.12	0.12
f_6	1.55279	0.64400	0.0066	0.0097	0.0095	0.0090	0.0078	0.0074	0.0065
Errors	0.00010	0.00004							
	Amplitude ratios:		0.68	1.00	0.98	0.93	0.80	0.76	0.67
	Errors:		0.15	0.20	0.19	0.19	0.16	0.15	0.14

residuals. As a consequence, the errors are the same for each frequency in a multifrequency solution. Since these values are larger than the formal values obtained from a harmonic least-squares fit, they can be considered as a reliable upper limit. The relative errors will increase and this is reflected in the increase of errors on the amplitude ratios from the dominant to the lower amplitude modes (see Fig. 2).

The mean values of the magnitudes in each filter as obtained from the fit (with errors) are given in each table as well. The values were used for the calibration of effective temperature, gravity

Table 16. HD 108100.

HD 108100			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		7.9628	7.5625	6.5931	7.9882	7.8371	7.1152	8.2101
	Errors:		0.0007	0.0008	0.0008	0.0007	0.0006	0.0006	0.0006
	Amplitude errors:		0.0010	0.0011	0.0011	0.0010	0.0009	0.0009	0.0009
HD 108100	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.40134	0.71360	0.0076	0.0124	0.0118	0.0109	0.0084	0.0085	0.0074
Errors	0.00007	0.00004							
	Amplitude ratios:		0.61	1.00	0.95	0.88	0.68	0.69	0.60
	Errors:		0.09	0.13	0.12	0.12	0.10	0.09	0.09
f_2	1.32572	0.75431	0.0064	0.0104	0.0098	0.0091	0.0072	0.0065	0.0061
Errors	0.00008	0.00005							
	Amplitude ratios:		0.61	1.00	0.94	0.88	0.69	0.63	0.59
	Errors:		0.11	0.15	0.14	0.14	0.12	0.11	0.11
f_3	1.36559	0.73228	0.0039	0.0047	0.0045	0.0049	0.0036	0.0032	0.0029
Errors	0.00017	0.00009							
	Amplitude ratios:		0.81	0.96	0.93	1.00	0.74	0.65	0.60
	Errors:		0.26	0.30	0.29	0.30	0.25	0.23	0.22

Table 17. HD 113867.

HD 113867			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		7.6159	7.1823	6.2260	7.6367	7.5425	6.8253	7.9382
	Errors:		0.0007	0.0007	0.0006	0.0006	0.0006	0.0005	0.0006
	Amplitude errors:		0.0010	0.0010	0.0009	0.0009	0.0008	0.0007	0.0008
HD 113867	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	0.88841	1.12561	0.0332	0.0429	0.0426	0.0400	0.0320	0.0312	0.0282
Errors	0.00002	0.00002							
	Amplitude ratios:		0.77	1.00	0.99	0.93	0.75	0.73	0.66
	Errors:		0.03	0.03	0.03	0.03	0.02	0.02	0.02
f_2	1.00553	0.99450	0.0189	0.0223	0.0224	0.0212	0.0190	0.0192	0.0165
Errors	0.00003	0.00003							
	Amplitude ratios:		0.84	0.99	1.00	0.94	0.85	0.86	0.74
	Errors:		0.06	0.06	0.06	0.05	0.05	0.05	0.04
f_3	1.89101	0.52882	0.0189	0.0214	0.0225	0.0211	0.0162	0.0146	0.0144
Errors	0.00003	0.00001							
	Amplitude ratios:		0.84	0.95	1.00	0.94	0.72	0.65	0.64
	Errors:		0.06	0.06	0.06	0.05	0.04	0.04	0.04
f_4	1.77613	0.56302	0.0099	0.0123	0.0120	0.0120	0.0090	0.0089	0.0080
Errors	0.00006	0.00002							
	Amplitude ratios:		0.80	1.00	0.97	0.97	0.73	0.72	0.65
	Errors:		0.10	0.11	0.11	0.10	0.08	0.08	0.08
f_5	0.88340	1.13199	0.0035	0.0058	0.0047	0.0055	0.0037	0.0030	0.0032
Errors	0.00017	0.00021							
	Amplitude ratios:		0.61	1.00	0.81	0.96	0.65	0.51	0.55
	Errors:		0.20	0.24	0.21	0.22	0.17	0.16	0.16
f_6	1.42185	0.70331	0.0054	0.0068	0.0070	0.0065	0.0061	0.0061	0.0057
Errors	0.00011	0.00005							
	Amplitude ratios:		0.77	0.97	1.00	0.93	0.86	0.87	0.81
	Errors:		0.18	0.18	0.18	0.17	0.16	0.15	0.15

and a metallicity indicator according to Kunzli et al. (1997), of which a summary is given in Table 4.

7. Conclusions

Almost all frequencies of known γ Dor stars presented in this paper are confirmed and one candidate (HD 74504) can now be considered as an additional member of this class. By combining the Mercator data with data available from the literature (including Hipparcos data), sets of frequencies were enlarged, confirmed and/or more precisely determined. Many γ Dor stars have frequencies that are very stable over a long period (1989−2004). Only in a few cases did the frequencies found in the Hipparcos data (1989−1993) deviate from the values found in more recent data. Differences are only a few hundredths of a cycle per day in some cases and yearly aliasing could be the cause, but in a few other stars there was no agreement at all. This may be caused by the coarse sampling of the Hipparcos data, but it could also be an indication of some more hidden frequencies, complex beating patterns and/or changing frequencies.

For the large majority of the γ Dor stars the behaviour of the amplitude ratios as a function of the wavelength is very similar. We will explore these observational results in future modelling of their oscillations, with the goal to check if we can constrain the input physics of the models for F-type stars. Our study is the only consistent long-term multicolour photometric database of

Table 18. HD 167858.

HD 167858			*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
	Mean magnitudes:		7.4093	6.9926	6.0277	7.4350	7.3337	6.6143	7.7259
	Errors:		0.0011	0.0014	0.0014	0.0013	0.0011	0.0011	0.0011
	Amplitude errors:		0.0016	0.0020	0.0020	0.0019	0.0015	0.0015	0.0015
HD 167858	Frequency (d^{-1})	Period(*d*)	*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
f_1	0.76504	1.30712	0.0295	0.0412	0.0394	0.0363	0.0281	0.0288	0.0255
Errors	0.00008	0.00013							
	Amplitude ratios:		0.72	1.00	0.96	0.88	0.68	0.70	0.62
	Errors:		0.05	0.07	0.07	0.06	0.05	0.05	0.05
f_2	0.69543	1.43796	0.0217	0.0300	0.0283	0.0264	0.0207	0.0212	0.0181
Errors	0.00011	0.00023							
	Amplitude ratios:		0.72	1.00	0.94	0.88	0.69	0.70	0.60
	Errors:		0.07	0.10	0.09	0.09	0.07	0.07	0.06
f_3	1.07613	0.92926	0.0142	0.0189	0.0183	0.0174	0.0134	0.0133	0.0131
Errors	0.00016	0.00014							
	Amplitude ratios:		0.75	1.00	0.97	0.92	0.71	0.70	0.69
	Errors:		0.12	0.15	0.15	0.14	0.11	0.11	0.11
f_4	1.30172	0.76821	0.0101	0.0143	0.0138	0.0130	0.0106	0.0101	0.0097
Errors	0.00022	0.00013							
	Amplitude ratios:		0.70	1.00	0.97	0.91	0.74	0.71	0.68
	Errors:		0.15	0.20	0.20	0.19	0.15	0.15	0.14
f_5	1.60489	0.62310	0.0053	0.0074	0.0074	0.0058	0.0049	0.0058	0.0042
Errors	0.00047	0.00018							
	Amplitude ratios:		0.71	1.00	1.00	0.79	0.66	0.78	0.57
	Errors:		0.29	0.38	0.38	0.34	0.27	0.30	0.25

Table 19. HD 175337.

HD 175337			*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
	Mean magnitudes:		8.2102	7.8103	6.8335	8.2302	8.1012	7.3784	8.4828
	Errors:		0.0011	0.0011	0.0011	0.0009	0.0009	0.0008	0.0010
	Amplitude errors:		0.0016	0.0016	0.0016	0.0013	0.0013	0.0011	0.0014
HD 175337	Frequency (d^{-1})	Period(*d*)	*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
f_1	1.27109	0.78673	0.0154	0.0215	0.0206	0.0195	0.0153	0.0143	0.0145
Errors	0.00007	0.00005							
	Amplitude ratios:		0.72	1.00	0.96	0.91	0.71	0.67	0.68
	Errors:		0.09	0.11	0.10	0.09	0.08	0.07	0.08

Table 20. HD 195068.

HD 195068			*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
	Mean magnitudes:		6.5117	6.0955	5.1233	6.5300	6.4220	5.6994	6.8119
	Errors:		0.0008	0.0011	0.0011	0.0011	0.0008	0.0008	0.0008
	Amplitude errors:		0.0011	0.0016	0.0015	0.0015	0.0012	0.0012	0.0011
HD 195068	Frequency (d^{-1})	Period(*d*)	*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
f_1	1.25054	0.79965	0.0415	0.0603	0.0576	0.0546	0.0428	0.0413	0.0382
Errors	0.00002	0.00001							
	Amplitude ratios:		0.69	1.00	0.95	0.90	0.71	0.69	0.63
	Errors:		0.03	0.04	0.04	0.03	0.03	0.03	0.02
f_2	1.29843	0.77016	0.0199	0.0285	0.0272	0.0262	0.0206	0.0202	0.0182
Errors	0.00005	0.00003							
	Amplitude ratios:		0.70	1.00	0.95	0.92	0.72	0.71	0.64
	Errors:		0.06	0.08	0.07	0.07	0.06	0.06	0.05
f_3	0.96553	1.03570	0.0163	0.0221	0.0216	0.0205	0.0164	0.0158	0.0148
Errors	0.00006	0.00006							
	Amplitude ratios:		0.73	1.00	0.97	0.93	0.74	0.71	0.67
	Errors:		0.07	0.10	0.10	0.09	0.07	0.07	0.07
f_4	0.28517	3.50668	0.0120	0.0160	0.0157	0.0145	0.0120	0.0115	0.0108
Errors	0.00007	0.00092							
	Amplitude ratios:		0.75	1.00	0.98	0.91	0.75	0.72	0.68
	Errors:		0.10	0.14	0.13	0.13	0.10	0.10	0.10

Table 21. HD 206043.

HD 206043			*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
	Mean magnitudes:		6.5605	6.1317	5.1674	6.5809	6.4790	5.7572	6.8713
	Errors:		0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
	Amplitude errors:		0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
HD 206043	Frequency (d^{-1})	Period(*d*)	*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
f_1	2.35951	0.42382	0.0114	0.0172	0.0166	0.0156	0.0129	0.0126	0.0118
Errors	0.00004	0.00001							
	Amplitude ratios:		0.66	1.00	0.97	0.91	0.75	0.73	0.69
	Errors:		0.07	0.08	0.08	0.08	0.07	0.07	0.07
f_2	2.43246	0.41111	0.0124	0.0177	0.0167	0.0158	0.0134	0.0130	0.0119
Errors	0.00004	0.00001							
	Amplitude ratios:		0.70	1.00	0.94	0.89	0.76	0.74	0.67
	Errors:		0.07	0.08	0.08	0.08	0.07	0.07	0.07
f_3	2.52428	0.39615	0.0075	0.0110	0.0104	0.0103	0.0078	0.0077	0.0069
Errors	0.00007	0.00001							
	Amplitude ratios:		0.68	1.00	0.94	0.94	0.71	0.70	0.63
	Errors:		0.11	0.13	0.13	0.13	0.11	0.11	0.11
f_4	2.26550	0.44140	0.0020	0.0036	0.0034	0.0030	0.0027	0.0024	0.0022
Errors	0.00022	0.00004							
	Amplitude ratios:		0.58	1.00	0.96	0.86	0.76	0.67	0.61
	Errors:		0.32	0.41	0.39	0.38	0.36	0.33	0.34
f_5	2.59928	0.38472	0.0028	0.0044	0.0040	0.0039	0.0027	0.0024	0.0024
Errors	0.00020	0.00003							
	Amplitude ratios:		0.64	1.00	0.90	0.90	0.61	0.55	0.54
	Errors:		0.27	0.33	0.31	0.32	0.27	0.26	0.27
f_6	2.46060	0.40640	0.0029	0.0039	0.0040	0.0039	0.0029	0.0028	0.0026
Errors	0.00019	0.00003							
	Amplitude ratios:		0.72	0.97	1.00	0.96	0.71	0.68	0.63
	Errors:		0.30	0.35	0.35	0.35	0.30	0.29	0.30

Table 22. HD 207223.

HD 207223			*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
	Mean magnitudes:		6.9961	6.6026	5.6300	7.0305	6.8966	6.1730	7.2762
	Errors:		0.0008	0.0010	0.0009	0.0010	0.0009	0.0009	0.0010
	Amplitude errors:		0.0012	0.0014	0.0013	0.0014	0.0013	0.0013	0.0014
HD 207223	Frequency (d^{-1})	Period(*d*)	*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
f_1	0.38542	2.59457	0.0072	0.0108	0.0095	0.0095	0.0074	0.0074	0.0066
Errors	0.00010	0.00065							
	Amplitude ratios:		0.66	1.00	0.88	0.87	0.68	0.68	0.61
	Errors:		0.14	0.19	0.17	0.17	0.15	0.15	0.15

Table 23. HD 211699.

HD 211699			*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
	Mean magnitudes:		9.9568	9.5352	8.5691	9.9679	9.8425	9.1226	10.2255
	Errors:		0.0012	0.0016	0.0014	0.0014	0.0012	0.0011	0.0012
	Amplitude errors:		0.0017	0.0022	0.0020	0.0020	0.0017	0.0016	0.0017
HD 211699	Frequency (d^{-1})	Period(*d*)	*U*	*B*1	*B*	*B*2	*V*1	*V*	*G*
f_1	0.93280	1.07204	0.0307	0.0451	0.0423	0.0413	0.0321	0.0311	0.0284
Errors	0.00003	0.00003							
	Amplitude ratios:		0.68	1.00	0.94	0.92	0.71	0.69	0.63
	Errors:		0.05	0.07	0.06	0.06	0.05	0.05	0.05
f_2	1.12637	0.88781	0.0043	0.0094	0.0095	0.0094	0.0046	0.0070	0.0073
Errors	0.00019	0.00015							
	Amplitude ratios:		0.46	0.99	1.00	0.99	0.49	0.73	0.77
	Errors:		0.21	0.32	0.30	0.30	0.21	0.23	0.24
f_3	1.16331	0.85962	0.0110	0.0145	0.0141	0.0129	0.0116	0.0111	0.0104
Errors	0.00008	0.00006							
	Amplitude ratios:		0.76	1.00	0.97	0.89	0.80	0.77	0.72
	Errors:		0.17	0.22	0.20	0.20	0.17	0.16	0.16
f_4	0.19363	5.16449	0.0126	0.0175	0.0165	0.0155	0.0129	0.0123	0.0118
Errors	0.00007	0.00187							
	Amplitude ratios:		0.72	1.00	0.95	0.89	0.74	0.70	0.68
	Errors:		0.13	0.18	0.17	0.16	0.13	0.13	0.13

Table 24. HD 218396.

HD 218396			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		6.6524	6.2587	5.3186	6.7531	6.6774	5.9601	7.0853
	Errors:		0.0008	0.0011	0.0011	0.0011	0.0009	0.0008	0.0008
	Amplitude errors:		0.0012	0.0015	0.0015	0.0015	0.0013	0.0012	0.0012
HD 218396	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	1.98054	0.50491	0.0137	0.0221	0.0220	0.0222	0.0175	0.0161	0.0154
Errors	0.00004	0.00001							
	Amplitude ratios:		0.62	0.99	0.99	1.00	0.79	0.73	0.69
	Errors:		0.07	0.10	0.09	0.10	0.08	0.07	0.07
f_2	1.73261	0.57716	0.0134	0.0210	0.0204	0.0205	0.0166	0.0158	0.0144
Errors	0.00004	0.00001							
	Amplitude ratios:		0.64	1.00	0.97	0.98	0.79	0.75	0.68
	Errors:		0.07	0.10	0.10	0.10	0.08	0.08	0.07
f_3	0.76762	1.30273	0.0075	0.0121	0.0116	0.0116	0.0099	0.0093	0.0083
Errors	0.00007	0.00013							
	Amplitude ratios:		0.62	1.00	0.95	0.96	0.81	0.77	0.68
	Errors:		0.12	0.18	0.17	0.17	0.15	0.14	0.13

Table 25. HD 221866.

HD 221866			U	$B1$	B	$B2$	$V1$	V	G
	Mean magnitudes:		8.2668	7.7669	6.8081	8.2177	8.1670	7.4528	8.5775
	Errors:		0.0008	0.0010	0.0009	0.0009	0.0008	0.0008	0.0008
	Amplitude errors:		0.0011	0.0014	0.0013	0.0013	0.0011	0.0011	0.0011
HD 221866	Frequency (d^{-1})	Period(d)	U	$B1$	B	$B2$	$V1$	V	G
f_1	0.83843	1.19271	0.0193	0.0257	0.0247	0.0228	0.0184	0.0186	0.0176
Errors	0.00003	0.00004							
	Amplitude ratios:		0.75	1.00	0.96	0.88	0.71	0.72	0.69
	Errors:		0.06	0.08	0.07	0.07	0.06	0.06	0.06
f_2	0.87722	1.13996	0.0201	0.0276	0.0260	0.0237	0.0191	0.0195	0.0174
Errors	0.00003	0.00004							
	Amplitude ratios:		0.73	1.00	0.94	0.86	0.69	0.71	0.63
	Errors:		0.06	0.07	0.07	0.07	0.05	0.05	0.05
f_3	1.71562	0.58288	0.0069	0.0090	0.0084	0.0091	0.0071	0.0069	0.0074
Errors	0.00008	0.00003							
	Amplitude ratios:		0.76	0.99	0.93	1.00	0.79	0.76	0.81
	Errors:		0.16	0.21	0.20	0.21	0.17	0.16	0.17

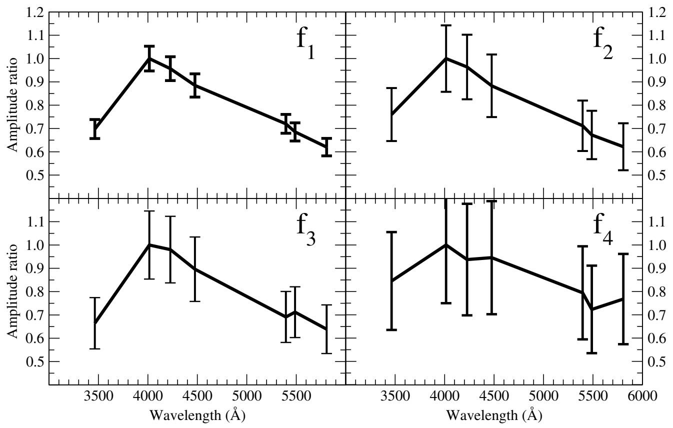

Fig. 2. The ratios of the amplitudes in the Geneva colours (with reference to the highest amplitude) of the four frequencies found for the star HD 277

g-mode pulsations in an extended sample of γ Dor stars so far, and it constitutes a useful reference for future interpretations of the oscillatory behaviour of such pulsators.

Acknowledgements. This research was made possible thanks to the financial support from the Fund for Scientific Research – Flanders (FWO), under projects G.0178.02 and G.0332.06. The Leuven authors additionally are supported by the Research Council of K.U. Leuven under grant GOA/2008/04. The research leading to these results has received funding from the European Research Council under the European Community's Seventh Framework Programme (FP7/2007–2013)/ERC grant agreement No. 227224 (PROSPERITY). We are indebted to our colleagues of the Geneva Observatory who reduced the MERCATOR data. This research has made use of the NASA's Astrophysics Data System and the SIMBAD astronomical database operated at the CDS in Strasbourg, France.

References

Aerts, C., & Kaye, A. B. 2001, ApJ, 553, 814
Aerts, C., Eyer, L., & Kestens, E. 1998, A&A, 337, 790
Aerts, C., Cuypers, J., De Cat, P., et al. 2004, A&A, 415, 1079
Balona, L. A., & Stobie, R. S. 1979, MNRAS, 189, 649
Breger, M., Handler, G., Garrido, R., et al. 1997, A&A, 324, 566
Breger, M., Handler, G., Garrido, R., et al. 1999, A&A, 349, 225
Cuypers, J., & Minarini, R. 1998, in A Half Century of Stellar Pulsation Interpretation, ed. P. A. Bradley, & J. A. Guzik, ASP Conf. Ser., 135, 218
Cuypers, J., Goossens, K., Schoenaers, C., De Cat, P., & Aerts, C. 2006, Commun. Asteroseismol., 147, 52
De Cat, P., Eyer, L., Cuypers, J., et al. 2006, A&A, 449, 281
De Cat, P., Briquet, M., Aerts, C., et al. 2007, A&A, 463, 243

De Ridder, J., Cuypers, J., De Cat, P., et al. 2004, in IAU Colloq., 193, Variable Stars in the Local Group, ed. D. W. Kurtz, & K. R. Pollard, ASP Conf. Ser., 310, 263
Dupret, M.-A., Grigahcène, A., Garrido, R., et al. 2005, MNRAS, 360, 1143
Fekel, F. C., Warner, P. B., & Kaye, A. B. 2003, AJ, 125, 2196
Golay, M. 1966, in Spectral Classification and Multicolour Photometry, ed. K. Loden, L. O. Loden, & U. Sinnerstad, IAU Symp., 24, 262
Griffin, R. F. 2006, The Observatory, 126, 119
Guinan, E. F., Bochanski, J. J., Depasquale, J. M., Ribas, I., & McCook, G. P. 2001, Information Bulletin on Variable Stars, 5062, 1
Guzik, J. A., Kaye, A. B., Bradley, P. A., Cox, A. N., & Neuforge, C. 2000, ApJ, 542, L57
Handler, G. 1999, MNRAS, 309, L19
Henry, G. W., & Fekel, F. C. 2002, PASP, 114, 988
Henry, G. W., & Fekel, F. C. 2003, AJ, 126, 3058
Henry, G. W., Fekel, F. C., Kaye, A. B., & Kaul, A. 2001, AJ, 122, 3383
Henry, G. W., Fekel, F. C., & Henry, S. M. 2005, AJ, 129, 2815
Henry, G. W., Fekel, F. C., & Henry, S. M. 2007, AJ, 133, 1421
Jankov, S., Mathias, P., Chapellier, E., Le Contel, J.-M., & Sareyan, J.-P. 2006, A&A, 453, 1041
Kaye, A. B. 1998, Information Bulletin on Variable Stars, 4596, 1
Kaye, A. B., Handler, G., Krisciunas, K., Poretti, E., & Zerbi, F. M. 1999, PASP, 111, 840
Kaye, A. B., Gray, R. O., & Griffin, R. F. 2004, PASP, 116, 558
Koen, C., & Eyer, L. 2002, MNRAS, 331, 45
Kunzli, M., North, P., Kurucz, R. L., & Nicolet, B. 1997, A&AS, 122, 51
Lomb, N. R. 1976, Ap&SS, 39, 447
Martín, S., Bossi, M., & Zerbi, F. M. 2003, A&A, 401, 1077
Mathias, P., Le Contel, J.-M., Chapellier, E., et al. 2004, A&A, 417, 189
Michel, E., Baglin, A., Auvergne, M., et al. 2008, Science, 322, 558
Montgomery, M. H., & O'Donoghue, D. 1999, Delta Scuti Star Newsletter, 13, 28
Rufener, F. 1989, A&AS, 78, 469
Rufener, F., & Nicolet, B. 1988, A&A, 206, 357
Scargle, J. D. 1982, ApJ, 263, 835
Schoenaers, C., & Cuypers, J. 2004, in IAU Colloq., 193, Variable Stars in the Local Group, ed. D. W. Kurtz, & K. R. Pollard, ASP Conf. Ser., 310, 283
Stellingwerf, R. F. 1978, ApJ, 224, 953
Watson, R. D. 1988, Ap&SS, 140, 255
Zerbi, F. M., Rodríguez, E., Garrido, R., et al. 1999, MNRAS, 303, 275