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PG1618+563: A NEW BRIGHT PULSATING sdB STAR

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Abstract. Recent observations at the NOT telescope clearly show that PG 1618+563 (hereafter PG 1618) is a new member of the EC 14026 class of sdB pulsating stars (Kilkenny et al. 1997, O'Donoghue et al. 1999). The very good quality of the non-filtered data allows to detect an amplitude modulation effect with a beat period of about 1.2 hours, which is consistent with the presence in the temporal spectrum of two close frequencies at 6.95 and 7.14 mHz ($\sim$ 144 and 140 s). The amplitudes are very low: between 1 and 2 mma. Moreover, from *UBV* data we find amplitude (and phase) differences, that could be useful for mode identification.

Key words: stars: hot subdwarfs, oscillations, individual: PG 1618+563

1. INTRODUCTION, OBSERVATIONS AND REDUCTIONS

PG 1618 is a double star having Strömgren b magnitude of 12.7 (Wesemael et al. 1992), composed from a hot B subdwarf (sdB) and a close G companion. It is not clear whether the two stars form a binary system or not (Moehler et al. 1990). PG 1618 was selected for our photometric monitoring program from an ongoing spectroscopic study of hot subluminous stars drawn from the Palomar Green (Green et al. 1986) and Hamburg Schmidt surveys (Heber et al. 1999a). The quantitative spectral analysis of PG 1618 resulted in $T_{\rm eff}$ = 33500 K, log g = 5.75 and log(He/H)=−1.5. This places PG 1618 well within the temperature range where other pulsating sdB stars have been found (Koen et al. 1999).

PG 1618 has been observed with the NOT 2.5 m telescope + Tromsø-Texas three channel photometer in July 20, 21 and 22, 1999 without filter using an integration time of 5 s. Moreover quasi-contemporary *UBV* data have been registered on July 20, with 9, 3 and 8 s integrations, respectively (the sampling time being of 20 s). All the observations have been carried out without using ch.2, because of some focusing problems due to recent modifications of the telescope. Thanks to high stability of the sky, the lack of comparison stars has not significantly affected the quality of the results. The presence of the close G type star, at about 3.5 arcsec in the SW direction (the identification has been confirmed by spectroscopy), has forced us to use medium size apertures (10.3 and 14.7 arcsec), in order to include both stars in the diaphragm. Some attempts to exclude the G star using a 5.1 arcsec aperture did not give good results.

The data were reduced on-line using the standard WET software and then were reduced again with a more accurate procedure (smoothing of the sky measurements, compensation of long timescale trends). The data were then analyzed calculating the amplitude spectrum of the single observations and the spectrum of all the three non-filtered runs together. The results, are shown in Fig. 1, are briefly discussed in the next section.

2. PRELIMINARY ANALYSIS AND POSSIBLE INTERPRETATIONS

2.1. Beat phenomenon

The best non-filtered data of July 20 show the presence of a doublet of close frequencies with a period difference $\Delta P \simeq 4.1$ s. On the other hand, we can see a beat period of about 4250 s (the total duration of the run corresponds almost exactly to two beat periods), which is not far from the expected value of $P_{\rm beat} \simeq P^2/\Delta P \simeq 4900$ s. The doublet of frequencies is also visible in the July 22 observation, but not in the July 21 run because of lower quality and lower frequency resolution. Using the three runs together, we obtain $\Delta P \simeq 3.8$ s, implying $P_{\rm beat} \simeq 5300$ s.

2.2. Why the doublet?

Taking into account some recent models of pulsating sdB stars (O'Donoghue et al. 1998 and references therein), the observed modes of PG 1618 might have low radial index ($n = 1$ or 2). The two peaks could have different spherical harmonic index (ℓ) and maybe different radial index too. Another possibility is that their separation is due to the frequency (rotational) splitting, with the other components of the multiplet which are not excited or just hidden in the noise. In this case, considering an $l = 1$ degree and $\mid \Delta m \mid= 1$ (and ignoring second order terms), we would obtain a rotation period of the star of about 2500 s (~ 4200 s in the $l = 2$ case). Considering $M = 0.5\,M_{\odot}$ and $\log g = 5.75$, the rotation (unprojected) velocity of PG 1618 should be of about 270 km/s (or $\sim$ 160 km/s if l=2), which is about two times (or little more than one time if $l = 2$) the velocity of 130 km/s, obtained for PG 1605+072, comparing its pulsational modes with theoretical models (Kawaler 1999). Indeed, PG 1605+072 was spectroscopically confirmed to be rotating at v sin i = 39 km/s (Heber et al. 1999b).

2.3. Other frequencies?

Looking at Fig. 1, we can see some power near 6.25 and 7.73 mHz, which is not due to windowing effects (as we checked prewhitening the two main frequencies). The same structures, even if less evident, are present in the July 22 run. A more thorough analysis (and possibly additional data) is needed to confirm these and other possible signals.

2.4. Color effect

Thanks to the brightness of the target, we were able to measure the pulsation amplitudes from *UBV* quasi-contemporary data. The different amplitudes that we found in the *UBV* bands and the phase differences that will be calculated might give precious information for the mode identification, as it has been done for β Cephei stars (see, for example, Cugier, Dziembowski & Pamyatnykh 1994). For sdB stars this point can be particularly important as the present models of EC 14026 stars predict that both radial and nonradial modes should have about the same frequencies (Charpinet et al. 1997, O'Donoghue et al. 1998, Kawaler 1999). The amplitude ratios and phase differences of PG 1618 are not treated in this paper because we need more time (and may be more data) for excluding the contribution of the G star.

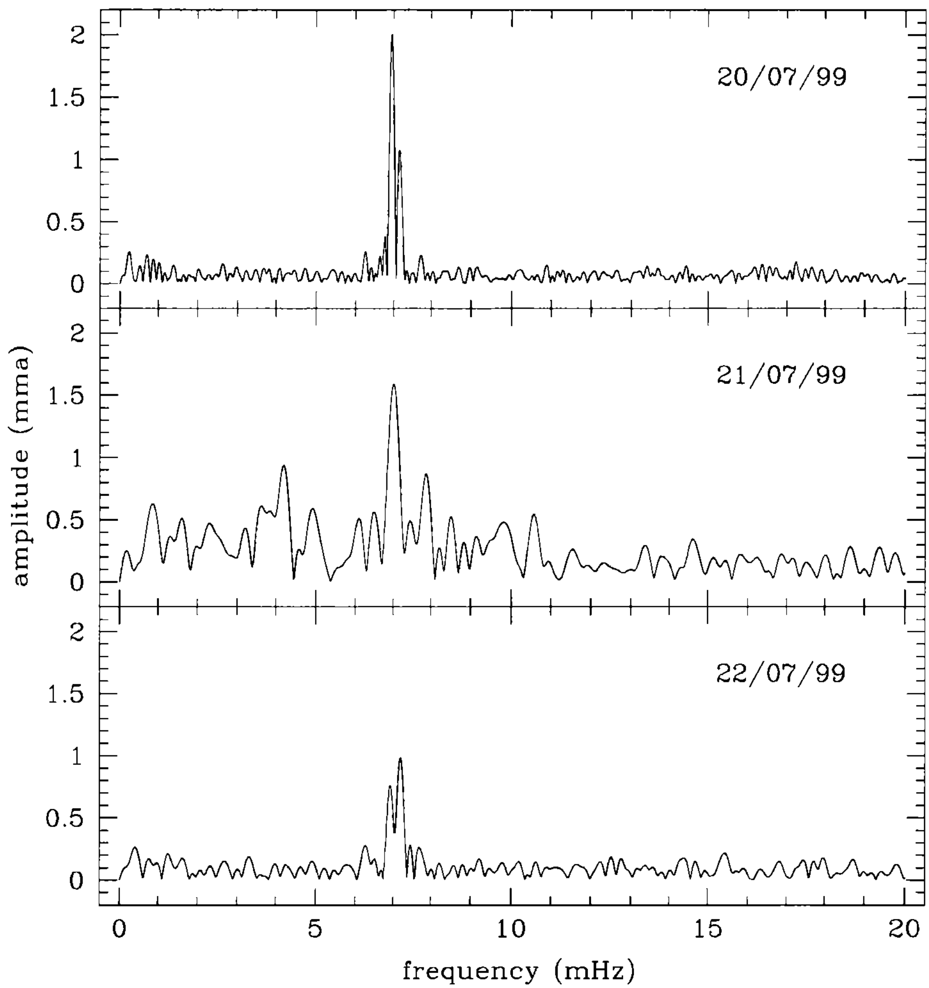

Fig. 1. Power spectra of the non-filtered data.

3. TEMPORARY CONCLUSIONS AND FUTURE

PG 1618 is a new bright pulsating sdB star. Its non-filtered light curves clearly indicate a beating effect which might be due to a high rotation velocity; high resolution spectroscopy is required to test this hypothesis. From the *UBV* time series data it is possible to get an important information on amplitudes and phase differences, which could help the mode identification. A relatively simple temporal spectrum of PG 1618 together with its brightness make this star one of the best candidates for detailed seismological studies, particularly for measuring the secular variation of the pulsation period in EC 14026 stars, in close connection with their evolutionary changes.

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