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HIGH-SPEED ULTRACAM COLORIMETRY OF THE SUBDWARF B STAR SDSS J171722.08+58055.8

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Abstract. We present high-speed multicolour photometry of the faint subdwarf B star SDSS J171722.08+58055.8 ($m_B = 16.7$mag), which was recently discovered to be pulsating. The data were obtained during two consecutive nights in 2004 August using the three-channel photometer ULTRACAM attached to the 4.2 m William Herschel Telescope. We confirm the star to be oscillating and we refine the dominant frequency to 6.960 mHz. A second new frequency of 7.267 mHz was discovered. Both frequencies are significant in all three colors at level $> 5\sigma$ and vary in phase in the three colors. We attempted mode identification for the strongest mode from its amplitude ratios but did not succeed.

Key words: stars: subdwarfs – stars: variables – stars: oscillations – stars: individual (SDSS J171722.08+58055.8)

1. INTRODUCTION

Of the 33 sdB stars with p-mode oscillations known to date, few have been modelled seismically so far (Charpinet et al. 2006). These modeling efforts result in mode identification based on frequency matching from the theoretical predictions, by means of a procedure that gives equal probability to spherical degrees $\ell = 0, 1, 2, 3$. It is therefore clear that a great need for empirical mode identification, i.e., identification obtained independently of the details of the theoretical models, emerges. The easiest way to achieve such empirical identification is from multicolor high-precision photometry (Jeffery et al. 2006).

In this poster, we present ULTRACAM multicolor photometry of the sdB star SDSS J171722.08+58055.8 (hereafter abbreviated as SDSS 1717). This is an sdB star of B magnitude 16.7 in which Solheim et al. (2004) discovered oscillations from white-light data gathered with the Nordic Optical Telescope (NOT). The NOT data revealed a frequency of 7.03 mHz and a variable amplitude ranging

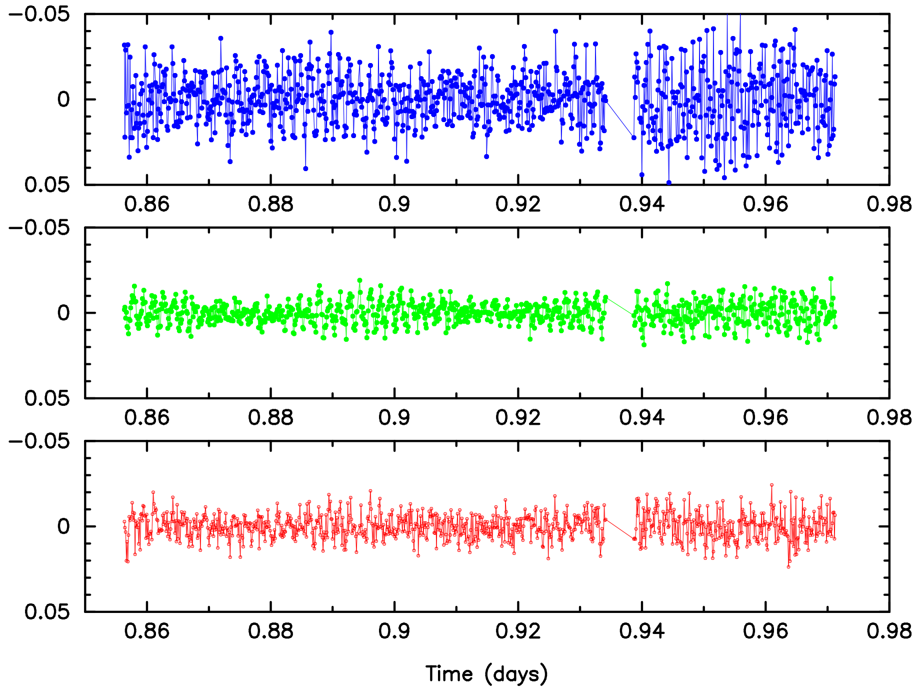

Fig. 1. ULTRACAM light curves for SDSS 1717 on 2004 August 24.

from 4.4 to 6.2 mmag, most likely due to multimode beating. Our data confirm this result and prove the multiperiodicity.

2. DATA DESCRIPTION

Jeffery et al. (2005) recently reported on the outcome of a six nights ULTRACAM run with the 4.2 m William Herschel Telescope dedicated to the sdB star PG 0014+067 performed in 2004 August. The main target was not yet visible during the first 2.5 hours of each of these nights. Two such blocks of 2.5 h on two consecutive nights were devoted to SDSS 1717 ($\alpha_{2000} = 17{:}17{:}22.0$, $\delta_{2000} = +58{:}05{:}59$) together with several comparison stars. We adopted an integration time of 10 s which samples the dominant 140 s pulsation well.

The reduction of the data frames was performed in the same manner as for PG 0014+067, which was already described in much detail in Jeffery et al. (2005). We hence refer the reader to that paper for information. Different comparison stars were considered to compute the differential magnitudes in the three channels (u', g', r'). The final results of the frequency analysis is independent of the different choices of the comparison stars. The details of the light curve computation will be presented elsewhere (Aerts et al., in preparation), but the final result for one night is shown in Figure 1. A beat pattern is readily seen in the g' light curve, pointing towards multiperiodicity as already suspected by Solheim et al. (2004).

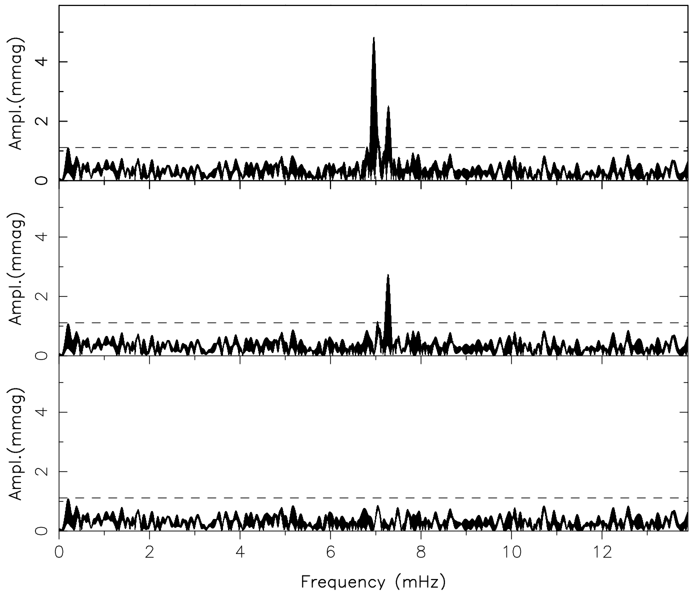

Fig. 2. Lomb-Scargle periodograms at subsequent stages of prewhitening for the g' light curve. The dashed line indicates the 4σ level after prewhitening with f_1 and f_2 determined within the interval 17–23 mHz.

3. FREQUENCY ANALYSIS

As in Jeffery et al. (2005), we computed Lomb-Scargle periodograms (Scargle 1982) over the frequency range $[0 \div 14]$ mHz in steps of 0.1 μHz for each of the light curves and adopted a prewhitening procedure. The results for the g' filter are shown in Figure 2. We find one dominant frequency of $f_1 = 6.960(2)$ mHz with amplitudes of 5.8(8), 5.0(3) and 3.7(4) mmag for respectively u', g' and r'. This result is entirely compatible with the one of Solheim et al. (2004). After prewhitening with f_1, we find a second very significant frequency in all three residual light curves (middle panel of Fig. 2): $f_2 = 7.267(3)$ mHz. This new second frequency has amplitudes 3.8(7), 2.8(3) and 2.0(3) mmag in respectively u', g' and r'. The periodograms following the second prewhitening stage reveal no further significant frequencies (see bottom panel in Fig. 2). The dashed lines in Fig. 2 indicate the 4σ level which we adopted as a stop criterion. In conclusion, we have found two independent oscillation frequencies in SDSS 1717, of which the second one was not known so far. All three light curves are in phase with each other for both f_1 and f_2.

4. MODE IDENTIFICATION

We show the amplitude ratios with respect to the g' filter for f_1 and f_2 in Figure 3. The 1σ confidence interval is shown only for f_1. The theoretical predictions in the adiabatic approximation are taken from Ramachandran et al. (2004, their Fig.4 top panel) for the temperature and gravity of SDSS 1717 (Solheim et al. 2004). It is impossible to identify the modes from this plot. For f_1, the ratio u$'$/g$'$ behaves according to $\ell \neq 3$, while the r'/g' ratio is only compatible with

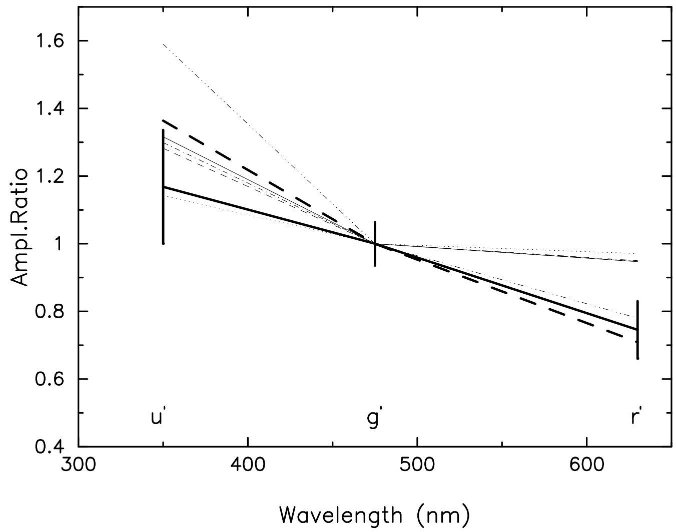

Fig. 3. Observed amplitude ratios for f_1 (thick full line) and f_2 (thick dashed line). The 1σ confidence interval is shown only for f_1. The thin lines are theoretical predictions taken from Ramachandran et al. (2004): dashed-dot-dot-dot: $\ell = 3$, full: $\ell = 0$, dashed-dot: $\ell = 1$, dashed: $\ell = 2$, dotted: $\ell = 4$.

$\ell = 3$. We are currently investigating whether the non-adiabatic approximation (Fontaine 2006) leads to better results. It may also be that unresolved beating affects the observed amplitude ratios and makes them deviate from the theoretical predictions. The error bars for f_2 (not shown) are too large to draw conclusions.

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