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Photometric multi-site campaign on massive B stars in the open cluster χ Persei (NGC 884)

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Abstract. In 2005 a photometric observation campaign started on the open cluster χ Persei, involving 13 telescopes spread over the whole northern hemisphere. After two years we gathered almost 1200 hours of data. We present here preliminary results on the variability search, especially from the 60-cm telescope in Białków (Poland), which show seven confirmed β Cephei stars, four candidate B-type pulsators and other interesting variable stars.

1. Introduction

Recent breakthroughs in the asteroseismic modelling of β Cephei stars have resulted in a better understanding of the interior structure of these stars. After the successful multi-site campaigns on some selected β Cephei stars, like HD 129929 [1], ν Eridani [2] and 12 Lacertae [3], we are now ready to take the next challenging step in this research area, i.e. to try and perform asteroseismology of such stars in clusters. The simultaneous exploitation of oscillation

Figure 1. A world map with the participating observing sites and their characteristics (telescope diameter and filters used).

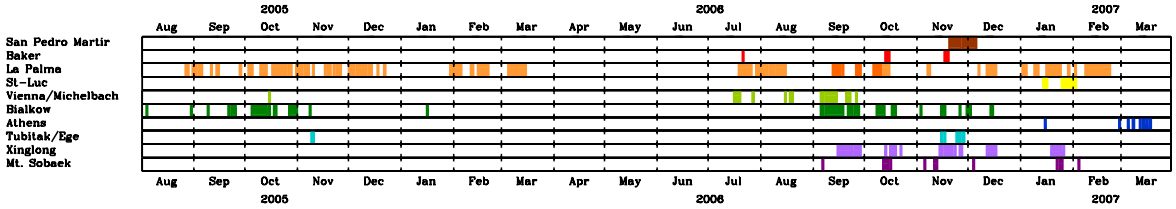

Figure 2. The distribution of the data in time per observing site. All observations were taken with CCD cameras, except at San Pedro Mártir and La Palma (September-October 2006, dark orange) where a photometer was used.

frequencies in stars in the same environment (same age and same chemical composition at birth) obviously has many advantages as it provides us with more severe constraints.

A few young open clusters are known to have β Cephei type variables. We have selected one southern cluster, NGC 3293 [4], with eleven β Cephei stars known before the campaign and two northern clusters, NGC 6910 [5] and NGC 884 (χ Persei) with respectively four and two known variables of this type.

2. Observations

For the project to be successful, we need enough accurate measurements with a long time base. Moreover, we can deduce the oscillation frequencies with high precision and avoid aliasing problems only if the data are collected almost continuously. That is why we set up a large-scale multi-site campaign with 13 telescopes participating, spread over the northern hemisphere. We wanted to obtain differential time-resolved multi-colour CCD photometry of a selected field of χ Persei that contains the two known β Cephei stars. Also some photo-electric data were collected.

A first smaller campaign started end August 2005 and lasted till March 2006 and 250 hours of observations were gathered at 4 sites. The main multi-site campaign occurred from July 2006 till March 2007. In this period, 9 more telescopes joined and we obtained 940 hours of measurements. In total the intensive monitoring of the cluster produced 73650 CCD frames, 92 hours of photo-electric data and involved more than 50 observers. An overview of all the observing sites can be found in Figure 1 and the distribution of the data in time in Figure 2.

Due to the high number of CCD frames, the reduction of our data is still ongoing. We present in section 3 the preliminary results obtained by analysing all Białków images in the V-filter. In

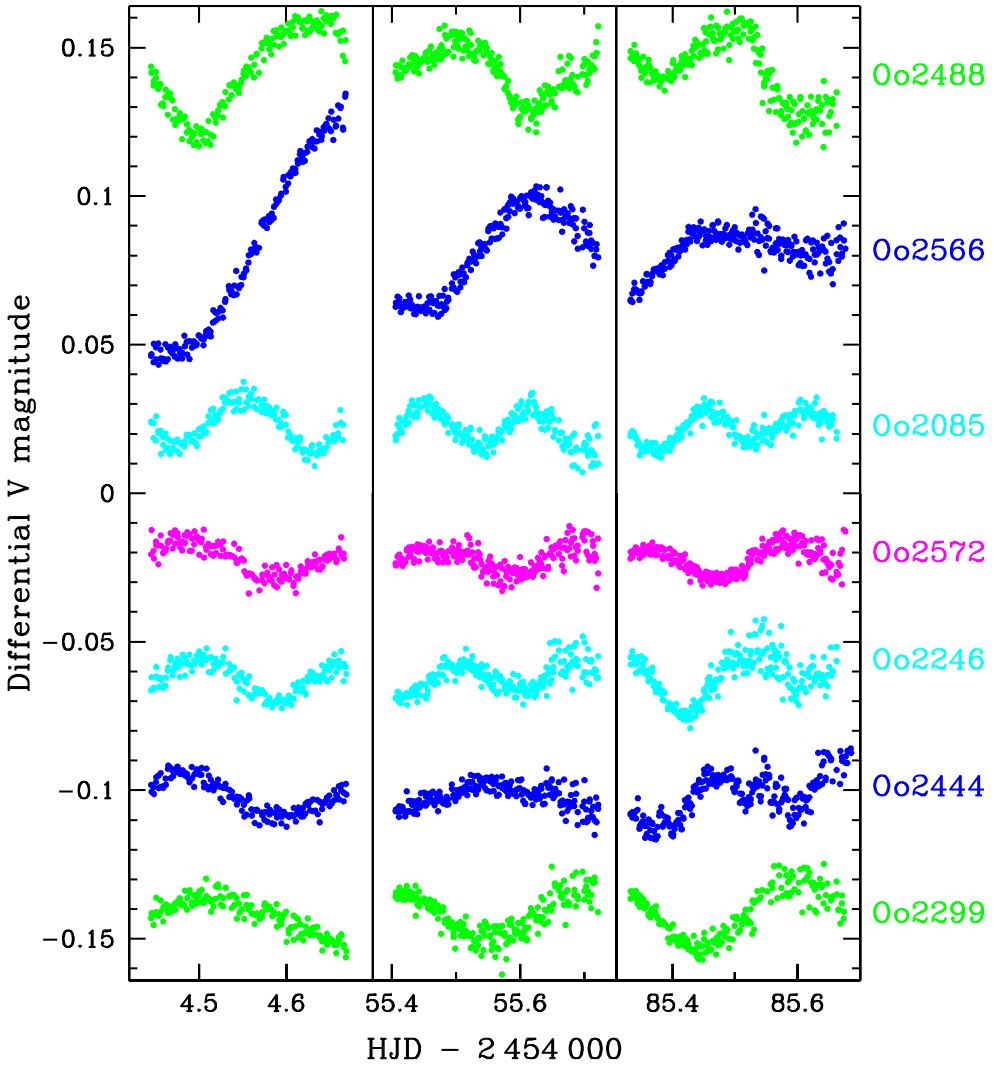

Figure 3. The differential light-curves in the V-filter of the seven confirmed β Cephei stars during three selected nights of Białków data.

total we have 11720 CCD frames taken over two observation seasons which were mainly from September 2005 till October 2005 and September 2006 till December 2006. An accuracy better than 3 mmag is achieved for the brightest stars.

3. Preliminary results

The analysis of the first season of Białków data [5] confirms the pulsations of the two β Cephei stars Oo 2246 and Oo 2299 [6] discovered by Krzesiński & Pigulski [7]. Moreover, five more variables of this type were found: Oo 2085, Oo 2444, Oo 2488, Oo 2566 and Oo 2572. An extract of the light-curves of the second season of these stars is shown in Figure 3. Furthermore, the whole Białków dataset permitted us to detect two candidate β Cephei/SPB stars: Oo 1977 and Oo 2579, and two candidate SPB stars: Oo 2191 and Oo 2455. In addition, the observed field of χ Persei contains several eclipsing binaries and other variable stars.

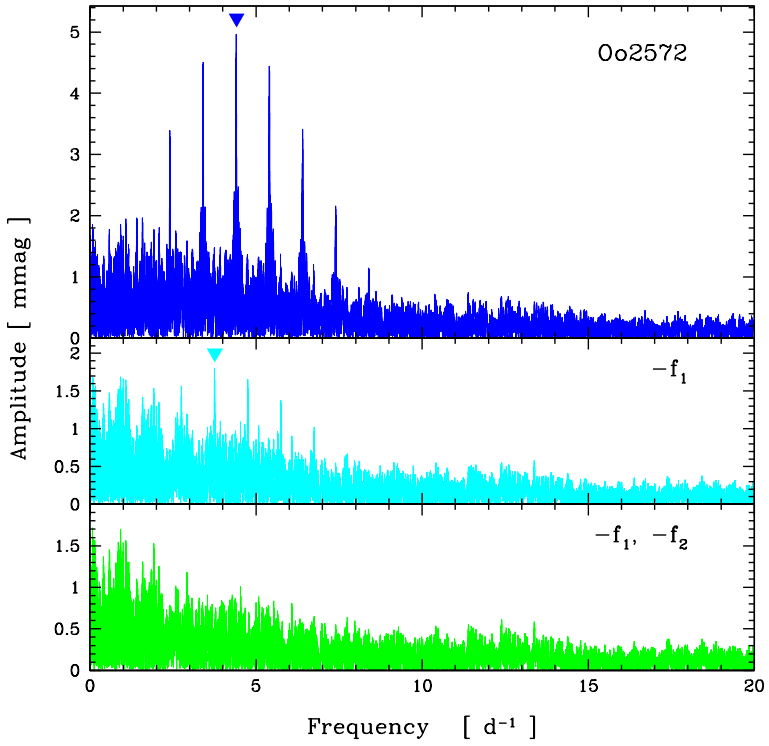

Figure 4. The periodograms in subsequent stages of prewhitening of the β Cephei star Oo 2572. We detect two frequencies: $f_1 = 4.414(7)$ d^{-1} and $f_2 = 3.76(1)$ d^{-1} with amplitudes $A_1 = 5.1$ mmag and $A_2 = 1.7$ mmag.

An initial frequency analysis reveals the multi-periodic character of at least four of the seven confirmed β Cephei stars. Figures 4 and 5 show periodograms in the subsequent phases of prewhitening of respectively Oo 2572 and Oo 2488 as calculated by Period04 [8]. In Oo 2572 we find the frequencies $f_1 = 4.414(7)$ d^{-1} and $f_2 = 3.76(1)$ d^{-1} with respective amplitudes $A_1 = 5.1$ mmag and $A_2 = 1.7$ mmag. In Oo 2488 we also find two frequencies $f_1 = 6.168(0)$ d^{-1} and $f_2 = 6.97(5)$ d^{-1} with larger amplitudes $A_1 = 7.4$ mmag and $A_2 = 2.1$ mmag.

These first results are very promising for our future analysis of all campaign data. We hope to confirm the oscillating character of the candidate pulsators and the existence of other variable stars.

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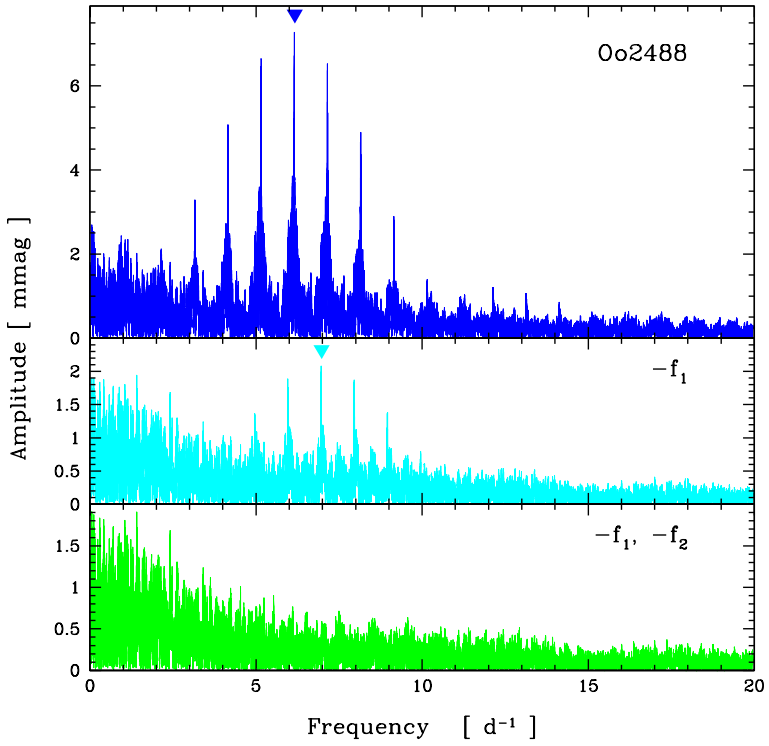

Figure 5. The periodograms in subsequent stages of prewhitening of the β Cephei star Oo 2488. We detect two frequencies: $f_1 = 6.168(0)$ d^{-1} and $f_2 = 6.97(5)$ d^{-1} with amplitudes $A_1 = 7.4$ mmag and $A_2 = 2.1$ mmag.