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FIVE NEW β CEPHEI STARS REVEALED IN ASAS PHOTOMETRY

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The β Cephei stars are a group of massive early B-type pulsators that oscillate in radial and/or nonradial modes of low radial order. Some 110 galactic representatives of this group are known (e.g. Stankov & Handler 2005, Pigulski 2005) to date, but some open questions concerning their group behaviour still remain.

For instance, the theoretical boundaries of the β Cephei instability strip comprise all known pulsators, but some regions are not populated. In particular, theory predicts the existence of O-type β Cephei stars which are not observed to date. Another interesting aspect is the apparent existence of a few rapidly rotating stars with high photometric pulsation amplitude (Stankov & Handler 2005, Aerts et al. 2005). It is also not known whether post-main sequence β Cephei stars exist or not. Therefore, but also for unravelling interesting asteroseismic targets, the discovery of new β Cephei stars is important.

During the preparation of an observing programme, we noticed that the ASAS-2 (see Pojmański 1997 for a description of this project) periodic variable ASAS J113318-6306.2, so far deemed to be a δ Scuti candidate (Pojmański 1998), had virtually the same coordinates as the B1III star HD 100495. Published Strömgren photometry (Kaltcheva et al. 2000) puts the star into the β Cephei instability strip. We therefore concluded that ASAS J113318-6306.2 and HD 100495 are the same star, which is a β Cephei pulsator.

Consequently, we searched the ASAS-2 data base of periodic variables for similar objects, i.e. stars of O and (early) B spectral type that show short-period variability indicative of β Cephei pulsation, and we performed frequency analyses for these data. Indeed, we found a total of four previously unrecognised β Cephei stars among these variables. As three of these were initially classified as eclipsing variables, we also searched the ASAS-3 data base for OB type variables classified as contact or semi-detached binaries, which resulted in the discovery of another new β Cephei pulsator. In the following, we briefly report our findings for the individual new pulsating stars.

ASAS J113318-6306.2 = HD 100495

We performed a frequency analysis of the ASAS-2 photometry of this star, after adjusting the zeropoints of the individual subsets of data, with the program `Period98` (Sperl 1998), applying both single-frequency power spectrum analysis and simultaneous multi-frequency sine-wave fitting. The Fourier amplitude spectrum of the data and some prewhitening thereof is shown in Fig. 1. We find the same main period as Pojmański (1998), but we also see evidence for a secondary period in the residual amplitude spectrum. Its value is however uncertain due to aliasing.

We estimated the luminosity, effective temperature and mass of the star from the published Strömgren photometry (Kaltcheva et al. 2000) following the procedure described by Stankov & Handler (2005), resulting in $T_{\rm eff} = 27000 \pm 1500$ K, $\log L = 4.34 \pm 0.16$ and $M \approx 14$ M$_\odot$. With these parameters we obtain a pulsation constant $Q = 0.036 \pm 0.011$, perfectly consistent with the values for other β Cephei stars (cf. Stankov & Handler 2005).

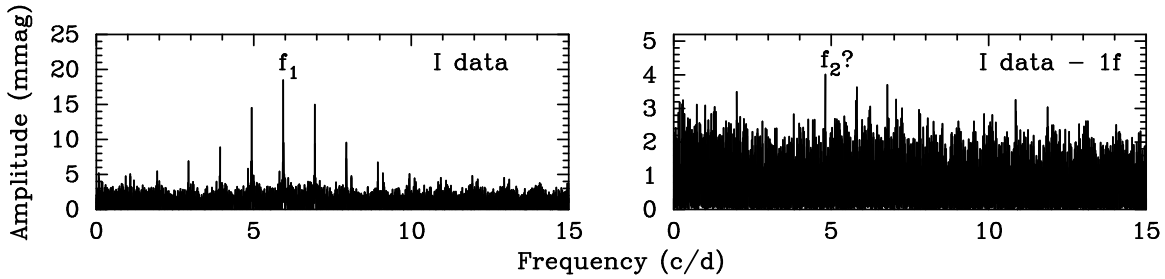

Figure 1. Left panel: amplitude spectrum of the ASAS-2 photometry of HD 100495. Right panel: amplitude spectrum after prewhitening the strongest signal. A possible second periodicity is indicated.

ASAS J123748-6219.4 = CD-61 3543

This B star was originally classified as an eclipsing binary of the W UMa type (Pojmański 1998) with a period near 10 hr. However, our frequency analysis reveals it to be a multiperiodic variable (see Fig. 2). We find four independent variations with periods near 5 hr and one combination frequency (with evidence for more combinations). Three of the independent frequencies form an (almost) equally spaced triplet. The multiperiodicity of the star and its periods make it clear that it is a β Cephei pulsator.

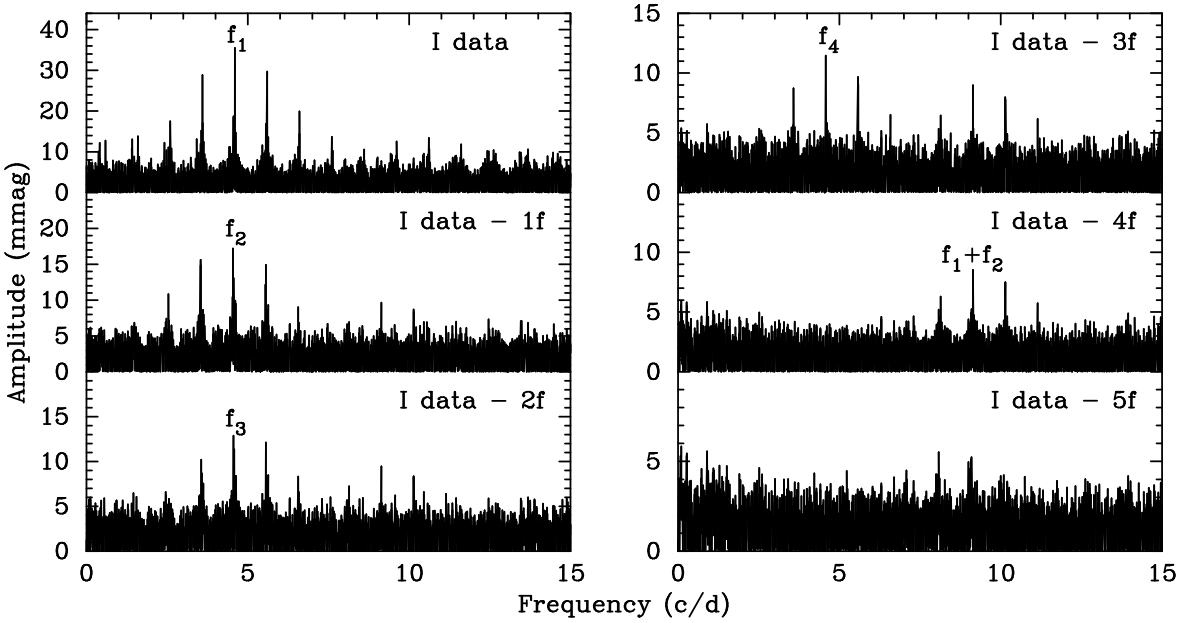

Figure 2. Original and prewhitened amplitude spectra of the ASAS-2 photometry of CD-61 3543.

ASAS J125319-6401.4 = ALS 2798

The B type star ALS 2798 was also originally classified as a W UMa binary with a period near 10 hr (Pojmański 1998). Again, we find multiperiodic variability with periods near half this value (see Fig. 3). The length of the periods and the fact that there are several also imply that we are dealing with a new β Cephei star. Interestingly, the four signals we find are arranged in two close doublets that have the same frequency spacing.

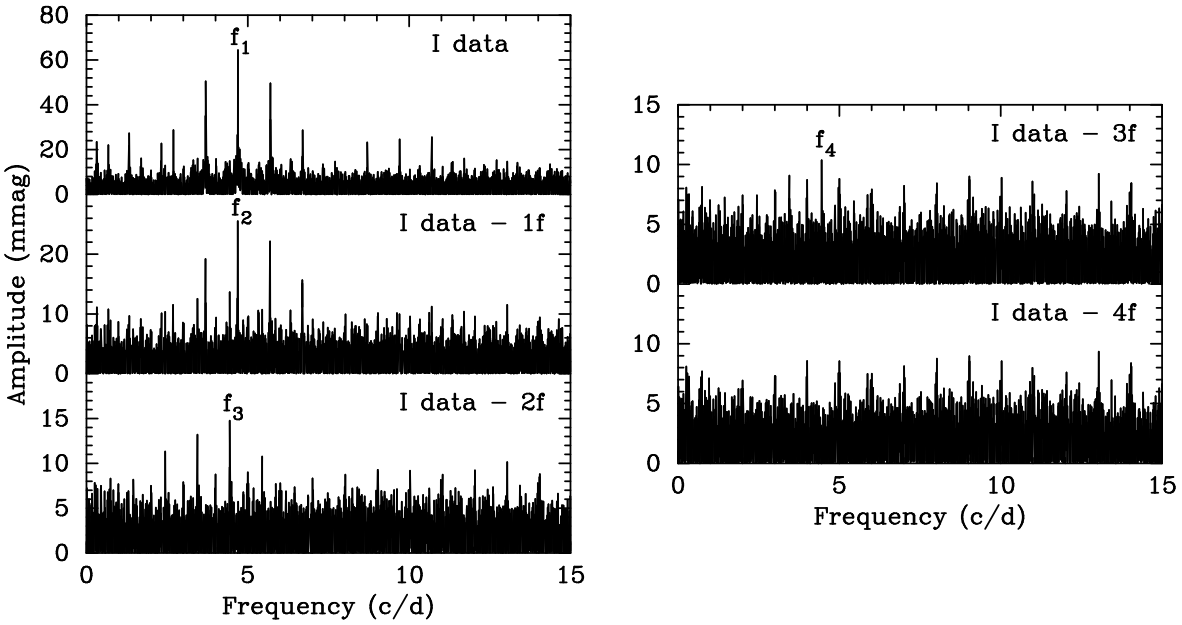

Figure 3. Original and prewhitened amplitude spectra of the ASAS-2 photometry of ALS 2798. The series of peaks discernible in the lower panel of the right-hand side are integer multiples of 1 cycle per sidereal day and are therefore unlikely to be intrinsic to the star.

ASAS J130221-6328.4 = ALS 2877

This B star was also classified as a W UMa binary, but with a period near 9 hr (Pojmański 1998). Once more, multiperiodic variability with periods near half this value is in fact present. This is shown in Fig. 4, where we only used the first two seasons of ASAS measurements since the third was of considerably lower quality. We find three frequencies in the light variations of the star that are (almost) equally spaced.

ASAS J200939+2104.8 = HD 191531

The variability of this B0.5III-IV star (sometimes also mentioned as a Be star) has already been suggested by Koen & Eyer (2002) on the basis of an analysis of its Hipparcos photometry. We find the same frequency as these authors in the ASAS-3 data, and detect a secondary periodicity as well (Fig. 5). The latter is also present in the residual Hipparcos photometry amplitude spectrum, as our re-analysis shows.

Table 1 summarises our findings on the new β Cephei stars. HD 100495 is a new pulsator because of the time scale of its variability and because of its position in the HR diagram. All others are revealed to be pulsators because of their multiperiodicity. The three stars with the most periods appear very attractive for asteroseismology because of their frequency multiplets. Most notably, ALS 2798 seems suitable for a search for differential interior rotation.

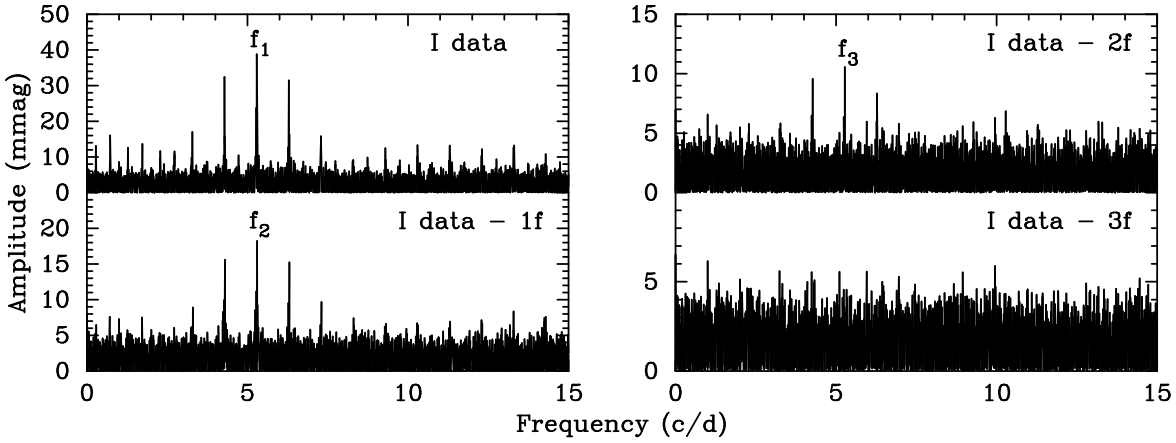

Figure 4. Original and prewhitened amplitude spectra of the ASAS-2 photometry of ALS 2877.

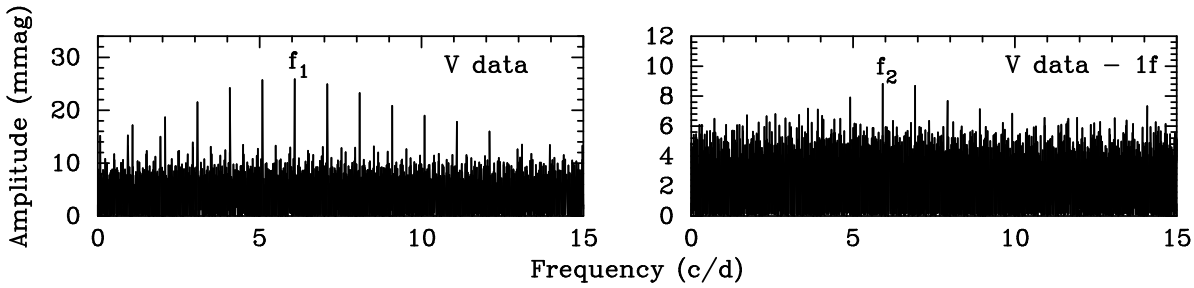

Figure 5. Original and prewhitened amplitude spectra of the ASAS-3 photometry of HD 191531.

Table 1: Pulsation frequencies and amplitudes of the new β Cephei stars

Star	Frequency [c/d]	Amplitude [mmag]
HD 100495	5.9353 ± 0.0004	18.6 ± 0.7 (I)
CD-61 3543	4.598600 ± 0.000014	41.6 ± 1.1 (I)
	4.54019 ± 0.00004	16.9 ± 1.1 (I)
	4.55647 ± 0.00003	17.9 ± 1.1 (I)
	4.57811 ± 0.00004	13.5 ± 1.1 (I)
	9.13879	8.2 ± 1.1 (I)
ALS 2798	4.69541 ± 0.00002	56.3 ± 1.7 (I)
	4.68776 ± 0.00003	31.4 ± 1.7 (I)
	4.44148 ± 0.00006	15.9 ± 1.7 (I)
	4.44909 ± 0.00008	10.8 ± 1.7 (I)
ALS 2877	5.28745 ± 0.00002	42.8 ± 1.3 (I)
	5.30263 ± 0.00004	20.3 ± 1.3 (I)
	5.27222 ± 0.00007	12.2 ± 1.3 (I)
HD 191531	6.08589 ± 0.00004	26.1 ± 1.5 (V)
	5.91437 ± 0.00011	8.7 ± 1.5 (V)

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