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HD 190336 A NEW β Cep STAR

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HD 190336 ($m_V \approx 8\overset{\mathrm{m}}{.}6, \alpha_{2000.0} = 20^{\mathrm{h}}03^{\mathrm{m}}18\overset{\mathrm{s}}{.}68, \delta_{2000.0} = +33^\circ 26' 59\overset{''}{.}7$) was found to be an unsolved new variable with $f = 4.45732\,\mathrm{cd}^{-1}$ frequency and 0.0247 mag amplitude by Koen and Eyer (2002) during the revision of the epoch photometry data of the Hipparcos catalogue. This star lies in the field that was observed by the HAT-5 telescope in June and July 2003 (Hartman et al. 2004). Based on these data the HATNET variability survey classified HD 190336 as a pulsating variable with $P = 0.2244\,\mathrm{d}$ period ($f = 4.45633\,\mathrm{cd}^{-1}$). Although the HAT-5 light curve of HD 190336 shows it definitely that the star is not monoperiodic (Fig. 1), no detailed analysis of the available photometric data of HD 190336 has been performed previously. Photometric time series of HD 190336 was also observed with the Optical Monitoring Camera (OMC, Mas-Hesse et al., 2003) on board the Integral satellite (Winkler et al., 2003). The FITS format OMC data were converted into ASCII tables using the OMC2ASCII program as described in Sokolovsky (2007).

Table 1 summarises the log of the photometric data available for HD 190336.

Table 1. Photometric observations of HD 190336

Source	Observation period [JD]	number of data*	filter
Hipparcos	2 447 894–2 449 046	138	Hip
OMC	2 452 595–2 453 961	296	V
HAT-5	2 452 800–2 452 830	756	I_C

The most deviant data points are omitted

The spectral type of HD 190336 was classified to be B0.7 II-III (Walborn, 1971), its empirical temperature calibrations gave $\log T_{\mathrm{eff}} = 4.37$ (Gulati et al., 1989). Based on its period, amplitude, shape and variability of the light curve, the star can be classified as a new β Cep variable. Although all these data were available previously, HD 190336 was not listed as a candidate β Cep star in the recent catalogue of galactic β Cep stars (Stankov & Handler, 2005).

The Fourier spectrum of the HAT-5 data shows 6 distinct frequencies in the 4–5 cd^{-1} frequency range, forming two equidistant triplets with $\Delta f = 0.135\,\mathrm{cd}^{-1}$ spacing. Three combination frequency components can also be detected. Cleaned spectra of the HAT-5 observations of HD 190336 are shown in Fig. 2. (See Roberts et al., 1987, on the application of the Clean algorithm on Fourier amplitude spectra of variable star time

series.) The positions of the equidistant triplets and their linear combination frequencies are marked in Fig. 2. The detected frequencies and their Fourier amplitudes and phases are listed in Table 2. Frequency triplets and doublets with the same frequency spacing were detected in other β Cep variables also (see e.g. Handler, 2005). A trivial explanation of equidistant triplets is rotational splitting, however e.g., Handler et al. (2006) interpreted the equidistant spacing of the triplet frequencies detected in the spectrum of 12 Lac as accidental because the components were found to belong to different order l modes.

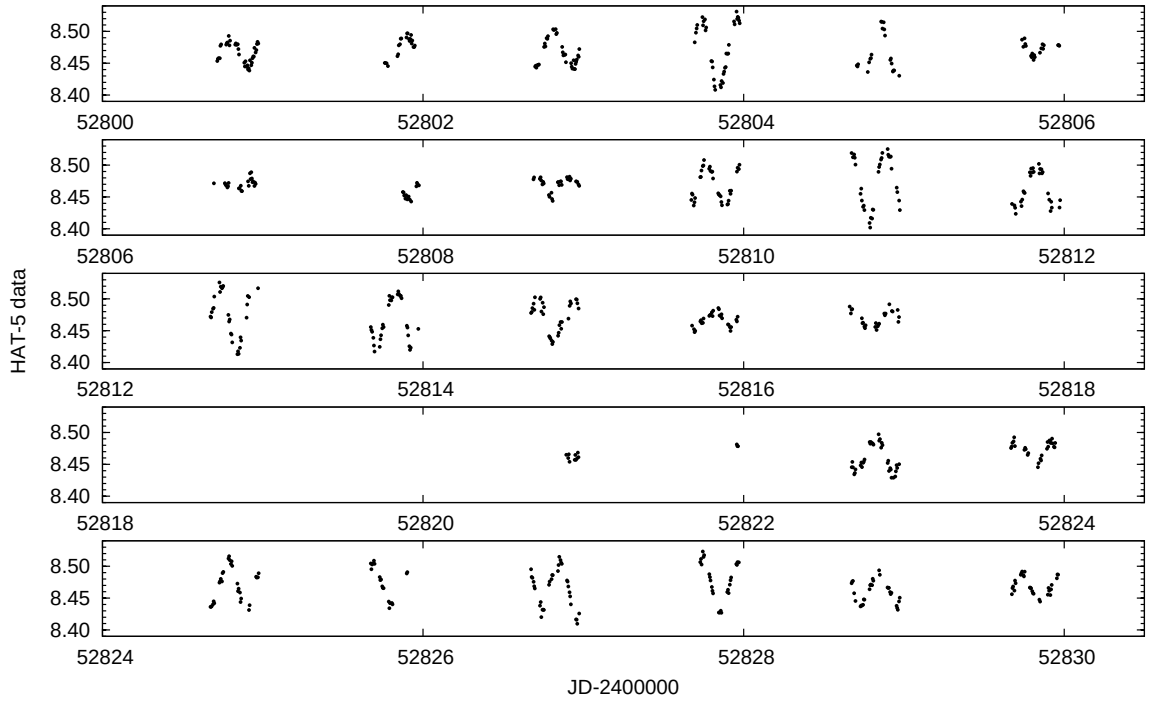

Figure 1. HAT-5 light curve of HD 190336.

Table 2. Frequencies detected in the HAT-5 data of HD 190336

	frequency	amplitude / error		phase* / error	
	cd^{-1}	mag		rad	
$f_1 \approx f_2 - \Delta f$	4.1894	0.0083	0.0003	4.04	0.08
f_2	4.3269	0.0134	0.0003	0.93	0.05
$f_3 \approx f_2 + \Delta f$	4.4576	0.0245	0.0003	3.94	0.03
$f_4 \approx f_5 - \Delta f$	4.5347	0.0064	0.0003	3.89	0.10
f_5	4.6665	0.0125	0.0003	4.37	0.05
$f_6 \approx f_5 + \Delta f$	4.8074	0.0054	0.0003	6.17	0.12
$f_7 \approx f_1 + f_6 = f_2 + f_5 = f_3 + f_4$	8.9908	0.0028	0.0004	3.50	0.24
$f_8 \approx f_3 + f_5 = f_2 + f_6$	9.1361	0.0017	0.0004	3.37	0.39
$f_9 \approx f_4 + f_5$	9.2040	0.0018	0.0004	3.44	0.36

* Initial epoch $T_0 = 2\,452\,800.0$

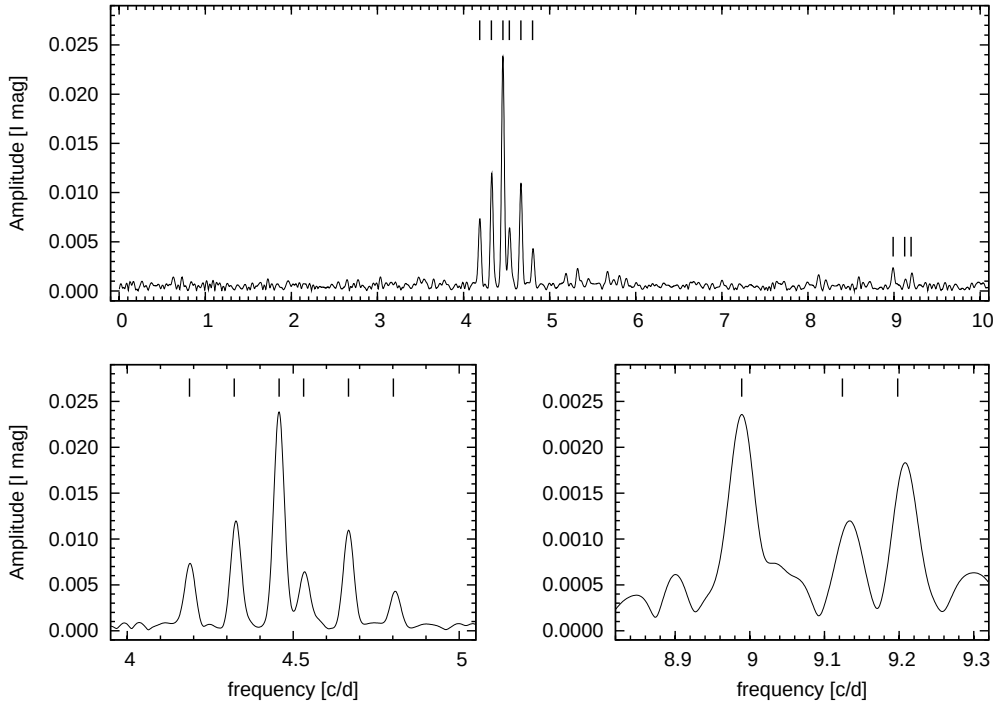

Figure 2. Clean spectra of the HAT-5 observations of HD 190336. Marks show the positions of equidistant triplets with $0.135\,\mathrm{cd}^{-1}$ spacing, and the exact positions of the linear combination frequencies.

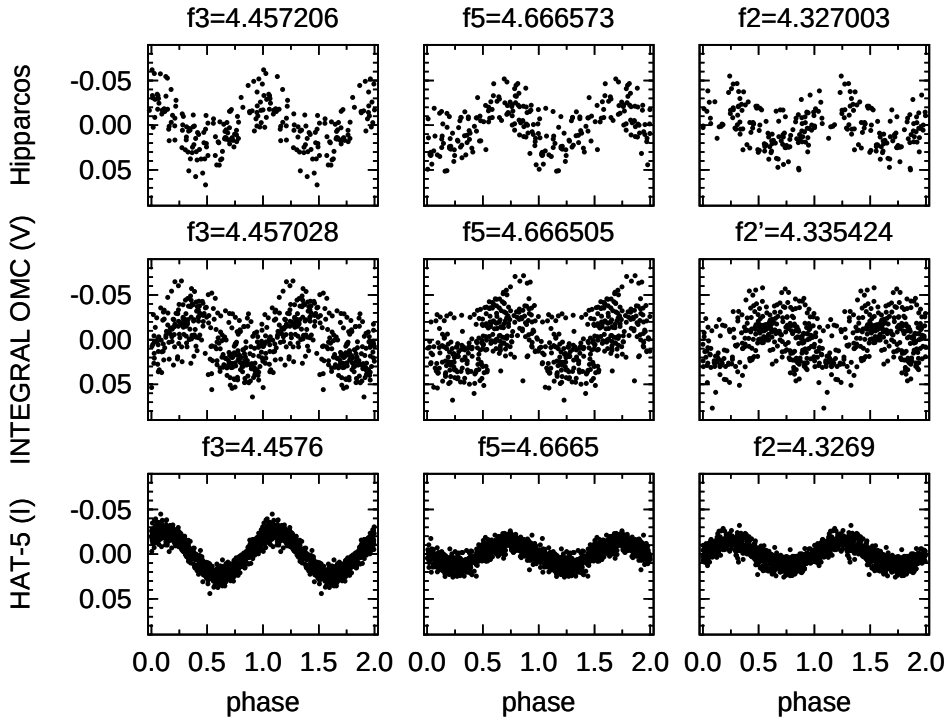

Figure 3. Hipparcos, Integral OMC and HAT-5 light curves of HD 190336 folded with the three main frequencies found in the data. In each plot the the signals belonging to the other frequencies has been removed.

The Hipparcos and OMC data of HD 190336 make it also possible to investigate the stability of the detected frequencies on longer time scale. Pigulski & Pojmanski (2008) detected both period and amplitude changes of the frequencies of multiperiodic β Cep variables using ASAS-3 observations spanning over 6 years.

Hipparcos, OMC and HAT-5 light curves of HD 190336 folded with the three main frequencies found in the data are plotted in Fig. 3. In each panel of this figure, the the signals belonging to the other frequencies has been removed.

In the Hipparcos data the three largest amplitude signals, f_3, f_5 and f_2 also appear. Their amplitudes are 0.026, 0.022 and 0.019 mag, respectively, indicating either that the amplitudes of these frequencies are changing, or that there are significant differences between their amplitude ratios in different bands. The frequencies of the three signals found in the Hipparcos data agree within the error ranges with the frequencies of the three largest amplitude frequencies detected in the HAT-5 data.

The OMC V band data span over four years, overlapping with the 30 days interval of the HAT-5 observations. Although both systematic and random noise are the largest in this data set, f_3 and f_5 can be detected in the OMC data too. Their amplitudes are close the same; 0.021 mag. For comparison, the amplitudes of these frequencies are 0.025 and 0.013 mag in the HAT-5 data (I band). Removing f_3 and f_5 from the Integral data, the residual shows a frequency at $4.3354\,\mathrm{cd}^{-1}$, close to the frequency of f_2 detected in the HAT-5 and Hipparcos data. The difference between the position of this frequency and f_2 is, however, much larger than it could be explained by the uncertainties of the frequencies. Therefore, most probably it is a different frequency.

The available photometric observations of HD 190336 do not allow to perform a more detailed asteroseismic study of the star and mode identification of the detected frequencies. They show, however, that HD 190336 is an ideal, interesting asteroseismic target which definitely deserves further attention. Both observational and theoretical efforts are needed in order to interpret its frequencies and their spacings.

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