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LIMITS ON PULSATIONS IN TWO ECLIPSING BINARIES: AY Cam AND RW CrB

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In the recent years, the interest in δ Scuti stars in eclipsing binary systems has been constantly increasing. There are a few ongoing surveys (e.g., Mkrtichian et al., 2002; Kim et al., 2003) aiming the identification of pulsating components in Algol systems of A-F spectral types. Our group has already published results of a similar survey (Kiss, 2002; Székely, 2003) and this paper presents an analysis for two other stars. The target objects were AY Camelopardalis (BD+77°328, sp. type A5–F5 (Lacy, 1987), m_V = 9.69 – 10.26 mag, $P \approx 2.735$d) and RW Coronae Borealis (HD 139815, sp. type F2V, m_V = 10.22 – 10.78 mag, $P \approx 0.726$d). The spectral types of these stars suggested there might be δ Scuti-like pulsations and these are the subjects of the present paper (RW CrB has already been investigated by Kim et al. (2003) with negative result).

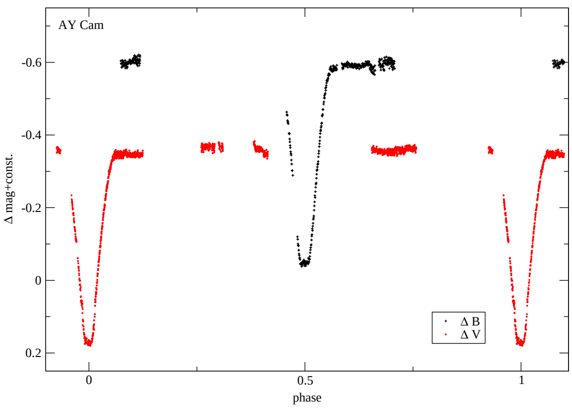

Figure 1. The phase diagrams of AY Cam in B and V. Note the very similar depths of the primary and the secondary minimum.

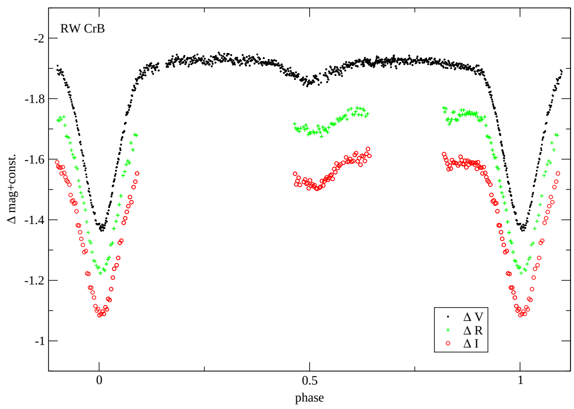

Figure 2. The phase diagrams of RW CrB in V(RI)$_C$ filters.

Our observations have been carried out at two observatories, on 15 nights in total. AY Cam was observed on nine nights between July 26 and December 31, 2001, while RW CrB on six nights between May 15 and June 21, 2002. The data of AY Cam were obtained at the Piszkéstető Station of the Konkoly Observatory using the 0.6m Schmidt-telescope

Table 1: Details of the observations and new times of minimum.

obs. date	hours	filter	HJD_{min}	obs. date	hours	filter	HJD_{min}
AY Cam				31/12/2001	2.93	B	–
26/07/2001	2.04	V	–	RW CrB			
28/07/2001	5.84	V	2452119.5240	15/05/2002	6.95	V	–
29/07/2001	0.65	V	–	16/05/2002	7.43	V	2452411.3455
30/07/2001	6.75	V	–	17/05/2002	7.31	V	2452412.4290
31/07/2001	7.25	V	–	18/05/2002	7.15	V	2452413.5231
01/08/2001	2.16	V	–	20/07/2002	3.14	V,R,I	–
27/12/2001	12.79	B	2452271.3097	21/07/2002	4.70	V,R,I	2452477.4488*
30/12/2001	10.00	B	–				

* mean epoch in three filters

equipped with a Photometrics AT200 CCD camera (1536×1024 pixels) and standard BV filters. The $V(RI)_C$ photometry of RW CrB was taken at the Szeged Observatory with the 0.4m Cassegrain telescope using an SBIG ST−9E CCD camera (512×512 pixels). The exposure times largely varied between 10 s and 60 s, depending on the filter, telescope, star and weather conditions. The journal of the observations is listed in Table 1.

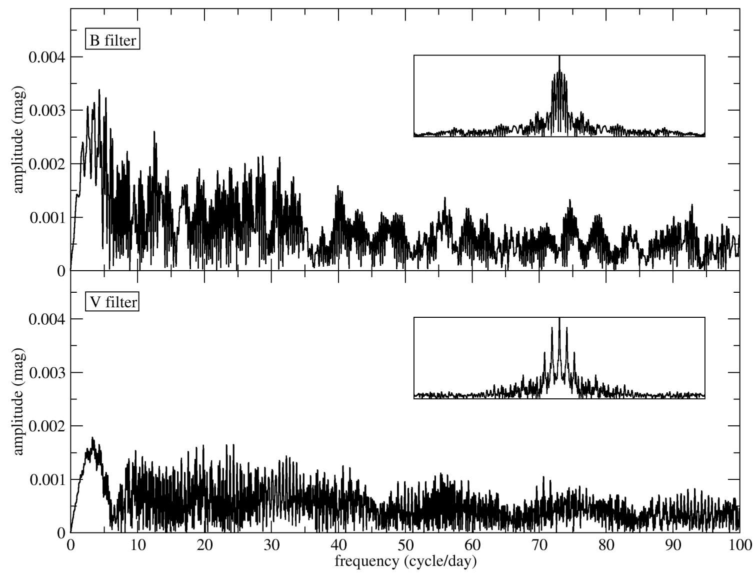

Figure 3. The amplitude spectra of AY Cam (top panel: B-filtered data, bottom panel: V-filtered data). Small panels show the window function on the same frequency scale.

The images were reduced with aperture photometry using IRAF[1]/digiphot. We chose close GSC stars as comparisons which did not show any significant brightness variations within ±0.02 mag (as judged from the comp−check scatter). To decrease the observational noise, we averaged all points taken within 60 s. All data were phased (Figs. 1-2) using the following ephemerides: AY Cam — $HJD_{\rm min} = 2452119.5240 + 2.7349658 \cdot E$; RW CrB — $HJD_{\rm min} = 2452411.3455 + 0.7264114 \cdot E$ (periods were taken from the GCVS).

We determined new times of minimum for both stars (Table 1). The epochs for AY Cam were adopted as the middle point of the flat minima, while for RW CrB, they were

[1]IRAF is distributed by the National Optical Astronomy Observatories,which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

calculated by fitting low-order (4-5) polynomials to the light curves around minima.

Since none of the individual light curves showed the absence of oscillations unambiguously, we examined the data with standard Fourier-analysis. For this, it was necessary to remove slow trends from the light curves caused by the variations outside eclipses. We fitted the lowest order polynomials to the light curves which reflected the trend but did not any of the faster and smaller variations (typically from linear to third-order). For the eclipses, polynomials were fitted separately to the ascending and the descending branches. After the trend subtraction, a period analysis of the residual light curve data was performed using Period98 of Sperl (1998). Fourier-spectra were calculated for the B and V (Figure 3) and the V (Figure 4) filtered data for AY Cam and RW CrB, respectively. The signal-to-noise ratios (S/N) of the highest peaks in the Fourier-spectra were determined and compared to the proposed limit of significance ($S/N > 4$) suggested by Breger et al. (1993).

The results are as follows. We could not detect any significant periodic signal in AY Cam with amplitudes greater than 3 mmag in B and 2 mmag in V. Similarly, we confirm the result by Kim et al. (2003) on the absence of oscillations in RW CrB by putting an upper limit of 2 mmag in V. We have also checked the noise effects on amplitude determination by injecting pure sine waves into the data with amplitudes close to the given limits. The calculated spectra revealed them with amplitudes smaller by about 10%. Therefore, the real upper limits might be larger by ∼10%.

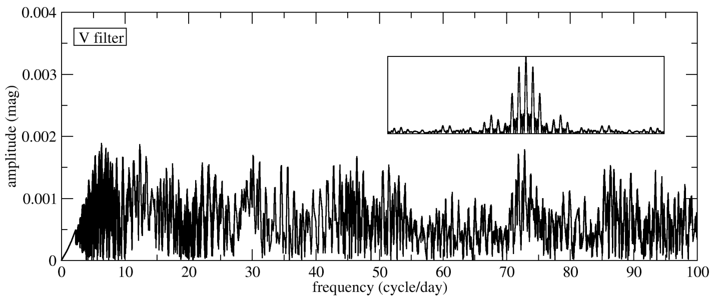

Figure 4. The amplitude spectrum of RW CrB in V. The small panel shows the window function on the same frequency scale.

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