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The RS Canum Venaticorum Binary HD 116204

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Abstract. *BV* photometry of HD 116204 obtained on 57 nights during 1983–84, 1984–85 and 1986–87 observing season is presented. A photometric period of 21.9 ± 0.2 d and a mean $(B-V) = 1.196 \pm 0.010$ are obtained. It is suggested that the binary HD 116204 has a mass ratio close to unity. Attempts are needed to detect the spectrum of secondary.

Key words: *BV* photometry—HD 116204—RS CVn systems

1. Introduction

A preliminary inspection of moderate-dispersion objective prism survey by Bidelman (1983) has shown the K2-type HD 116204 to be a Ca II emission star. In 1984 January we started observations of this star as part of a programme to study the photometric behaviour and chromospheric activity of late-type emission-line binaries. From the *UBV* photometry of this star its variability with a 21.7 day period has since been reported by Boyd, Genet & Hall (1984). Here we report on our *BV* photometric observations of HD 116204.

2. Observations

HD 116204 was observed on a total of 57 nights during the three observing seasons 1983–84 (13 nights), 1984–85 (7 nights), and 1986–87 (37 nights) with the 34-cm reflector of Vainu Bappu Observatory, Kavalur, using standard *B* and *V* filters. The comparison stars were HD 116494 (spectral type G5) and HD 115968 (spectral type K0). All observations were made differentially with respect to HD 116494 and transformed to the *UBV* system. The mean differential magnitudes and colours of the comparison stars, in the sense HD 116494 minus HD 115968, obtained during the three seasons are given in Table 1. Table 2 gives the results for the variable star HD 116204. Each value given in Table 2 is a mean of three to four independent measurements. The probable errors of the differential magnitudes and colours of the variable star for each observing season are also given in Table 2.

3. Results

Using the technique described by Raveendran, Mekkaden & Mohin (1982), we find a mean photometric period of 21.9 ± 0.2 d which agrees well with the value of $21.7 \pm$

Table 1. The mean differential magnitudes and colours of comparison stars, in the sense HD 116494 minus HD 115968.

Season	ΔV	$\Delta(B-V)$
1983–84	−0.512±0.004	+0.005±0.003
1984–85	−0.510±0.004	+0.007±0.003
1986–87	−0.515±0.001	+0.014±0.001

Table 2. The differential magnitudes and colours of HD 116204. The probable errors for each season are also given.

JD (hel.)	ΔV	$\Delta(B-V)$
2440000+		
5726.4105	−0.265±0.017	0.444±0.009
5727.4025	−0.256	0.437
5727.4449	−0.260	0.439
5730.4551	−0.234	
5781.2468	−0.244	0.482
5782.4091	−0.258	0.482
5790.4437	−0.270	
5792.3363	−0.262	
5820.2982	−0.269	0.463
5825.2607	−0.264	0.490
5826.3030	−0.261	0.483
5827.2297	−0.273	0.470
5828.2161	−0.288	
6084.4513	−0.259±0.010	
6086.4721	−0.292	0.474±0.007
6088.4925	−0.301	0.452
6090.4343	−0.303	0.462
6118.3211	−0.210	0.462
6120.3443	−0.194	0.480
6123.3203	−0.208	0.449
6803.4849	−0.201±0.007	0.476±0.006
6819.3930	−0.192	0.454
6820.4114	−0.214	0.456
6823.4156	−0.224	0.458
6823.4498	−0.227	0.458
6823.4847	−0.229	0.462
6824.4292	−0.214	0.452
6825.4224	−0.208	0.467
6825.4403	−0.205	0.464
6828.3993	−0.186	0.470
6830.4128	−0.178	0.473
6830.4373	−0.168	0.467
6831.3981	−0.163	
6832.3750	−0.177	0.460
6833.4560	−0.159	0.461

Table 2. Continued.

JD (hel.)	ΔV	$\Delta(B-V)$
2440000+		
6834.3298	−0.171	0.447
6835.3314	−0.154	
6836.3176	−0.164	
6846.3321	−0.215	
6847.3287	−0.212	0.457
2440000+		
6850.4092	−0.192	
6851.3670	−0.178	0.456
6852.3834	−0.173	0.468
6853.3914	−0.160	0.464
6857.3133	−0.161	
6858.3773	−0.162	
6859.4047	−0.167	0.464
6860.3200	−0.158	0.461
6861.3029	−0.173	0.461
6861.3464	−0.170	0.465
6861.3809	−0.172	0.473
6862.3375	−0.172	0.461
6862.3654	−0.174	0.459
6877.3104	−0.172	
6880.4389	−0.169	0.464
6883.3061	−0.192	
6884.3272	−0.196	0.461
6884.3566	−0.203	0.468
6885.4278	−0.210	0.461
6886.4238	−0.219	0.455
6887.2641	−0.212	0.463
6889.4350	−0.230	0.455
6890.4332	−0.226	0.454
6892.3746	−0.238	
6892.4041	−0.223	0.425
6893.3653	−0.228	
6893.3868	−0.217	0.424

0.2 d obtained by Boyd, Genet & Hall (1984). Only the observations obtained during 1986–87 season were used for the period analysis since they provide more data points necessary to have a better phase coverage. The times of minima in Figs 2 and 3 satisfy a 21.67 d period, whereas the time of minimum listed by Boyd, Genet & Hall (1984), together with the minimum in Fig. 3 results in a period of 21.83 d. However, we note that in several late-type Ca II H and K emission-line objects, the phases of light maxima and minima are found to vary arbitrarily (*cf.* Mohin, Raveendran & Mekkaden 1986). The Heliocentric Julian days of observation given in Table 2 are converted to photometric phases using the ephemeris:

$$\text{J.D. (Hel.)} = 2446803.4849 + 21^{d}.9E, \qquad (1)$$

where the initial epoch is arbitrary and the period is the photometric period mentioned above. The differential magnitudes ΔV and colours $\Delta(B-V)$, in the sense HD 116204 minus HD 116494, given in Table 2 are plotted against photometric phases in Figs 1 to 3. During 1986–87 we found that on two nights (JD 2446892.3854 and JD 2446893.3791), HD 116204 was brighter than expected from the mean light curve, presumably due to a long duration flare up similar to that reported in the case of V711 Tau (Parthasarathy, Raveendran & Mekkaden 1981). The $(B-V)$ obtained on JD 2445726.4105 and JD 2445727.4237 (Fig. 1) were brighter compared to the other values, probably due to a similar long-duration flare up. The corresponding variation is not clearly seen in V because of the poor definition of the trend of the light curve. However, it is clear from Figs 1 to 3 that the light curve is highly variable: the mean light level varied from -0.26 mag to -0.19 mag during the three observing seasons. The amplitude of light variation was always small (0.05–0.10 mag). Here we note that the amplitude of 0.05 mag in V obtained during the 1983–84 season is consistent with the observations of Boyd, Genet & Hall (1984) during the same period.

4. Discussion

From the nature and phasing of the light minima it is evident that geometrical eclipses are not the cause of light variation. We obtain a mean $(B-V)=1.196\pm0.010$, comparable to $(B-V)=1.16$ given by Walker (1971) who also gives $(U-B)=1.00$ for HD 116204. Assuming that the interstellar reddening is negligible, the colours to-

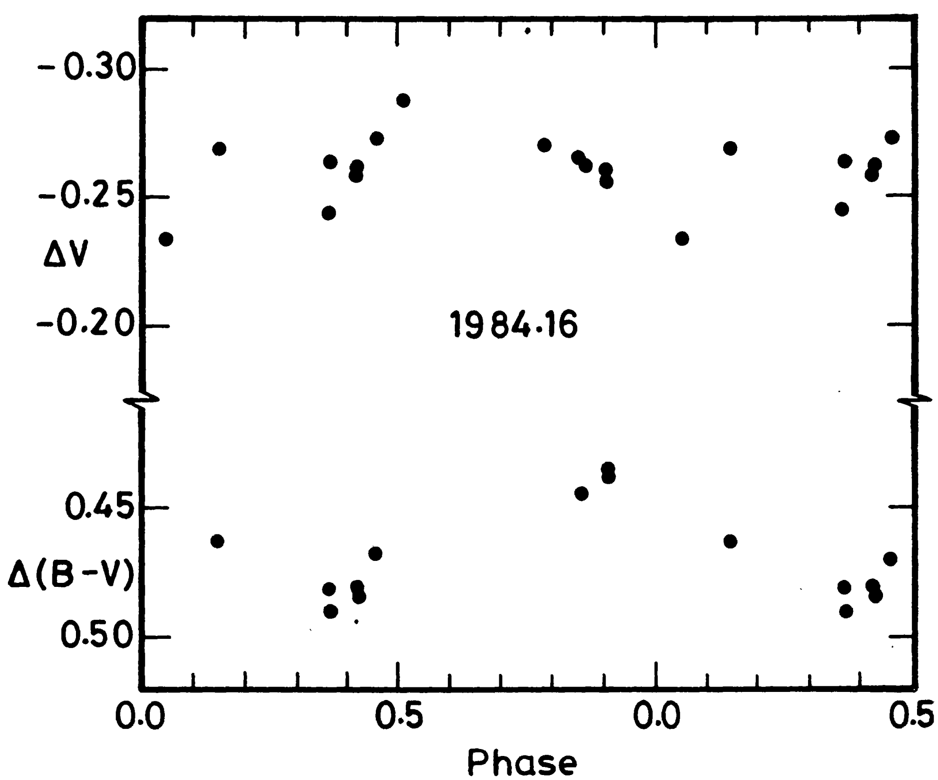

Figure 1. V and $(B-V)$ light curves of HD 116204 during 1983–84 season. Phases are reckoned from HJD 2446803.4849 and the photometric period 21.9 d.

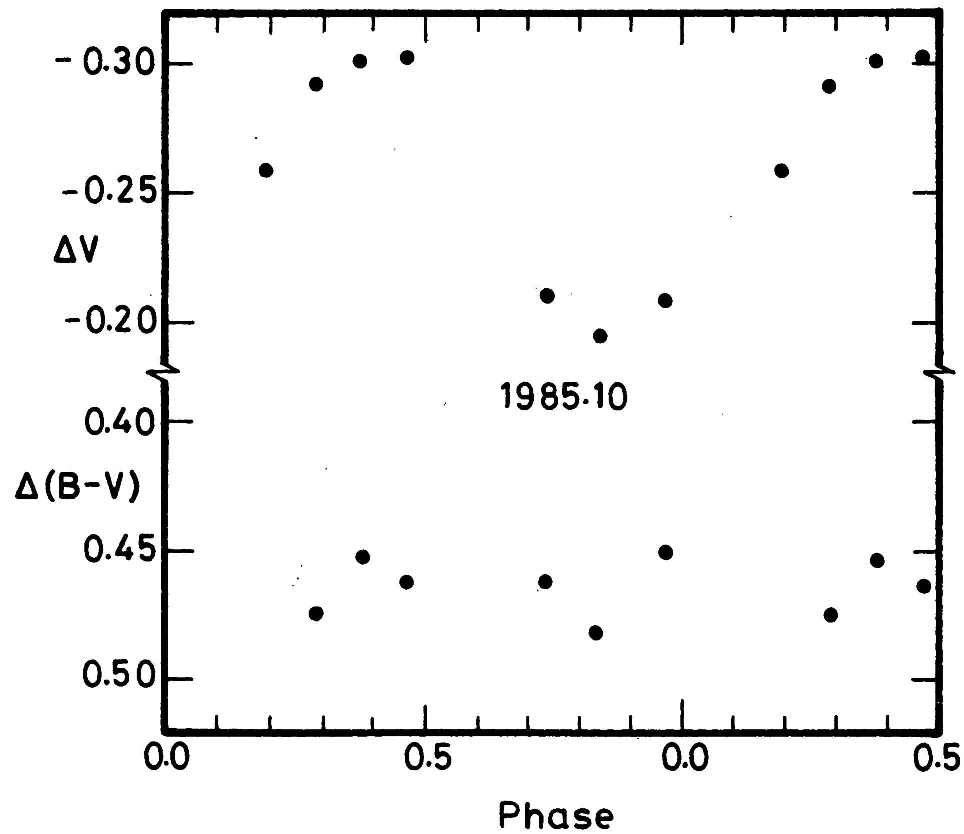

Figure 2. V and $(B-V)$ light curves of HD 116204 during 1984–85 season. Phases are reckoned as in Fig. 1.

gether with the spectral classification K2 imply that HD 116204 is a giant or a subgiant. Additional support for a giant classification comes from the $V \sin i$ measurements by Fekel, Moffett & Henry (1986), who arrive at a radius of 6 $R_\odot$ or more for HD 116204. The observed changes in the mean light level and amplitude of light variation are similar to the photometric characteristics of RS Canum Venaticorum systems, wherein the photometric variations are attributed to the presence of large-scale starspots on the giant/subgiant component which rotationally modulate the observed flux (Eaton & Hall 1979). If HD 116204 behaves similarly to the active component of RS CVn systems, then its photometric period is the rotation period of the star. The rotation period of 22 days, and the orbital period of 21 days found by Griffin (Fekel, Moffett & Henry 1986) suggest that the star is a member of a nearly-synchronous binary with the mass ratio close to unity (*cf.* Zahn 1977, Equation 6.1). A single K2 subgiant is expected to have a rotation period much larger than 22 d, which would also be the case of a K2 subgiant in a binary unaffected by the companion. Here we note that in the case of λ And (G8III–IV + ?) the rotation period is 56 d while the orbital period is 20.5 d (Hall 1976). As far as we know the orbital elements are not available in the literature except for a mention of the binary period (Fekel, Moffett & Henry 1986). Also it is not known whether HD 116204 is a single-lined spectroscopic binary or not. If the mass-ratio is close to unity the secondary must be detectable spectroscopically.

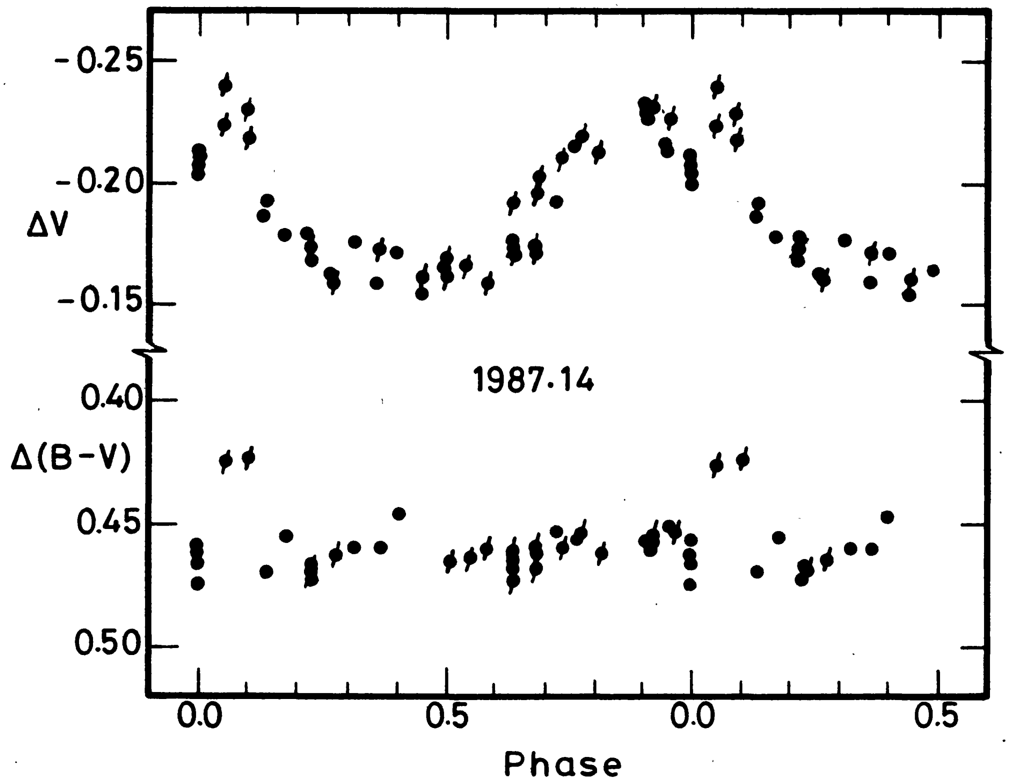

Figure 3. V and $(B-V)$ light curves of HD 116204 during 1986–87 season. Phases are reckoned as in Fig. 1. Note that the observations obtained during the last two rotations (ϕ), of the five included in 1987.14 light curve, are systematically brighter, suggesting noticeable changes in the spot number and surface distribution.

An inspection of Fig. 3 shows that the observations obtained during the last two rotations, of the nearly five covered by our 1986–87 observations, are systematically brighter than the previous ones. This suggests a vertical shift of the entire light curve towards brighter magnitudes, as would occur due to a decrease of the spot covering factor and changes in their surface distribution. The low amplitude of light variations and the change in the mean light level of HD 116204 imply that the distribution of the spots is such that a major fraction of them is always presented on the star's hemisphere facing the observer. This suggests a low inclination of the rotation axis.

We did not attempt any quantitative modelling of the observed light curve and of its variation, since the large number of free parameters involved would render such a model ambiguous.

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