

LIGHT VARIATIONS IN SEVERAL BROAD-LINED B STARS

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In our photoelectric searches for the  $\beta$  Cephei variables (JS77, JS79, and J82) several early B stars with nebulous lines were included. A summary of their photometric behaviour is presented in Table 1, columns four to six. Two of the stars, HR 2963 and HR 3476, are

Table 1. The photometric behaviour of a sample of Bn stars.

HD	HR or Name	MK	Range	Time Scale	Type	Ref.
24190	-	B2 Vn	0.015 $\bar{b}$	days?	var?	J82
28446	1 Cam	B0 IIIIn	0.010 $\bar{y}$	hours?	var?	J82
36646	1863	B4 Vn	0.015 $\bar{y}$	unknown	var	J82
45871	2364	B4 Vnp	0.055 $\bar{b}$	~10 hours	var	JS77
61878	2963	B5 Vn	0.010 $\bar{b}$	-	cst	JS77
67341	3179	B3 Vpn	~0.02 $\bar{u}$	unknown	var	JS79
67536	3186	B2.5 Vn	0.040 $\bar{b}$	~10 hours	var	this paper
68324	3213	B1 IVn	0.015 $\bar{u}$	P=0.108 <sup>d</sup>	$\beta$ Cep	JS79
72014	-	B3 Vnnek	0.050 $\bar{b}$	days	var	JS77
74455	3462	B1.5 Vn	0.045 $\bar{b}$	P=0.563 <sup>d</sup>	E11	JS77
74753	3476	B0 IIIIn	0.010 $\bar{b}$	-	cst	JS77
85860	-	B9	0.080 $\bar{b}$	~10 hours	var	JS77
201819	8105	B0.5 IVn	0.020 $\bar{y}$	hours?	var	J82
219634	8854	B0 Vn	~0.10 $\bar{b}$	P=2.3913 <sup>d</sup>	EA	J82

apparently constant in light, HR 3213 is a short-period  $\beta$  Cephei star, HR 3462 shows ellipsoidal variations with a period of 0.563<sup>d</sup>, which implies an orbital period twice that long (cf. also Shobbrook 1981), and HR 8854 is an eclipsing binary with P = 2.3913<sup>d</sup>.

Of the remaining nine cases, in which the type of variability is somewhat less clear, four seem to be related to the topic of this symposium. These are HR 2364, HR 3186, HD 72014, and HD 85860. All were discovered by JS77 from observations carried out in November and

December 1975 at the European Southern Observatory with the four-channel uvby spectrograph-photometer, attached to the Danish National 50-cm reflecting telescope. About 20 observations on four or five nights were obtained of each star. HD 72014, the only star on our list with the emission line MK classification, showed a night-to-night light variation typical of Be stars. For HR 2364, HR 3186, and HD 85860 we found somewhat irregular variations with the time scale of the order of ten hours. In fact, HD 85860 is included in Table 1 not on the basis of its MK class, which is not available, but because it varied in a manner similar to HR 2364 and HR 3186.

The above-mentioned 1975 observations indicated that in the light variation of HR 3186 a strong component with the period of either  $0^d.264$  or  $0^d.359$  may be present. This made the star a candidate for membership in the  $\beta$  Cephei group, and therefore it was re-observed by JS79 along with a few other  $\beta$  Cephei suspects. The observations were carried out on seven nights in November and December 1977 at the same observatory and with the same equipment as in 1975. Neither of the two periods was confirmed. In fact, no periodicity at all was present in the light variation. This is clearly seen from Fig.1, where the b

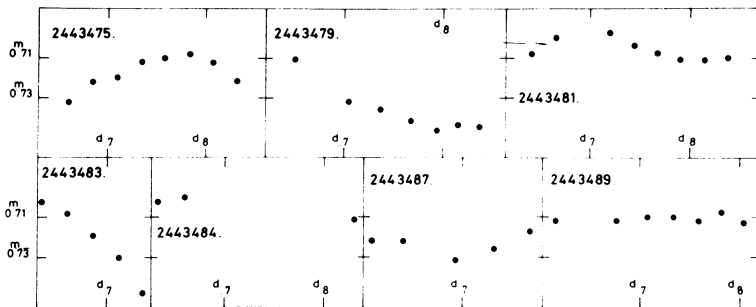


Fig.1. The b light-curves of HR 3186 on seven nights in 1977.

magnitudes of HR 3186, referred to the same comparison stars as in 1975, are plotted as a function of heliocentric Julian date.

The uvby light-curves of HR 3186 on JD 2443479 and JD 2443483, the two nights in 1977 on which the star showed the largest variation, are displayed in Fig.2. On both nights the light range was independent of wavelength to within a few  $0^m.001$ .

On JD 2443475, concurrently with the photometry, a series of eight coude spectrograms was taken of HR 3186 with the ESO 152-cm telescope at the dispersion of  $12.3 \text{ \AA}/\text{mm}$ . As have already been mentioned by JS79, on these spectrograms the  $H\beta$  line appeared with a central absorption feature flanked by blue and red emission components. The other lines,  $\lambda\lambda$  3819, 4026, 4143, and 4471 of He I, as well as the higher members of the Balmer series, were broad and shallow. The

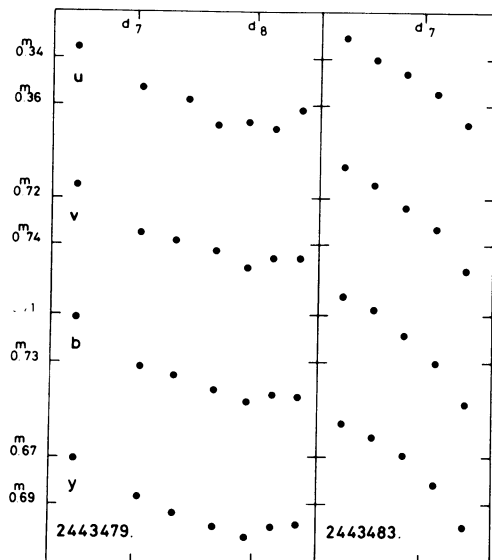


Fig.2. The uvby light variation of HR 3186 on two nights in 1977.

radial velocity showed considerable amount of scatter around a mean value of  $35.4 \pm 3.1$  km/s, due mainly to errors of measurement. The interstellar Ca II K line had a mean velocity equal to  $15.4 \pm 1.0$  km/s.

These results show that variability of HR 3186 may be due to photospheric and/or shell activity. Fast rotation and large-scale surface motions may also play a role. It is possible that HR 2364 and HD 85860 are variables of the same kind. In fact, such stars may be quite common. Other examples are HD 34626 (Percy 1974), HR 9070 (Percy 1979), HR 3593 (Burki et al. 1980), and  $\lambda$  Crucis (Shobbrook 1981). Whether some of these objects are related to the  $\beta$  Cephei stars, as suggested by Percy (1979) and by Burki et al. (1980), is not known.

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## DISCUSSION

Bolton: John Percy has been observing a number of northern hemisphere Be stars. He has observed these in a single colour (Strömgren b) several times per night for up to 10 nights at a time. He has characterized the variations to me as follows.  $\gamma$  Cas and 59 Cyg: variations  $< 0.1$  on time scales of hours up to 10 days measured on two different runs. HR2142: short period variation with amplitude  $> 0.3$  almost certain. 28 Cygni: the amplitude of the variation has been steadily increasing,  $P \approx 0.7$  and the amplitude is now  $0.6$ . EW Lac: noticeable variations with range  $0.05$  and  $P \approx 0.7$ . HR9070: very variable with well-defined  $P \approx 0.3$ , probably a  $\beta$  Cephei star.

Jerzykiewicz:  $P = 0.7$  is certainly too large for a  $\beta$  Cephei star and  $0.3$  would be the longest period known for this type of variability. Of course, in order to prove that HR9070 is a  $\beta$  Cephei star one would have to find out whether its radial velocity also varies with the  $0.3$  period.

Sareyan: Apart from its spectral type, which is quite different, HR3186 seems to show a behaviour similar to V986 Oph. Especially the impossibility to define a stable period. Can you comment this.

Jerzykiewicz: The MK type of V986 Oph is B0 II-III<sub>n</sub> and the period is probably  $0.2907$ . However, it is not certain, that the star is a  $\beta$  Cephei variable, as has been pointed out by Pike and Lloyd (Comm. 27 IAU Inf. Bull. Var. stars, No. 1716). Still, the U amplitude in the case of V986 Oph is considerably greater than the B and V amplitudes, while HR3186 shows no wavelength dependence of amplitude.

Slettebak: Are rotational velocities of your stars known, so that a check could be made as to whether the time scales of the variations you find are consistent with rotational modulation of a bright or dark area on the star?

Jerzykiewicz: Some are. The problem is that the periods are not well defined, so that it is difficult to answer your question. However, rotational modulation alone, won't account for the light variation of these stars.