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Light variability of some CP Si stars*

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Abstract. — Eight southern chemically peculiar Si stars brighter than the seventh visual magnitude have been observed in the *uvby* system. All the stars are known light variables, yet their periods were not accurate enough to allow to phase the various kinds of observations carried out several years apart. Here we present more refined values of the period for the stars: HD 54118, HD 56455, HD 66255, HD 73340, HD 114365, HD 116890, HD 122532, and HD 144231.

Key words: stars: chemically peculiar — stars: individual: HD 54118, HD 56455, HD 66255, HD 73340, HD 114365, HD 116890, HD 122532, HD 144231 — stars: variables: other

1. Introduction

At present 6684 upper main sequence stars are known (or suspected) to be chemically peculiar (Renson et al. 1991). Among them, 3427 stars (i.e. about 51%) are classified as Am, or CP1 stars according to Preston's (1974) classification. The remaining 3257 stars are classified as Ap and Bp stars, i.e. CP2, CP3, and CP4 stars according to Preston's classification. Since we are interested in the study of the variability we will not consider the CP1 stars and will refer to the 3257 CP2, CP3, and CP4 stars as CP stars in the following.

The light variations of CP stars mainly occur in two time scales:

a) the short one, with periodicities ranging from 4 to 20 minutes, is mainly found in the coolest CP2 stars with amplitudes of the order of a few thousands of a magnitude;

b) the long one, with periodicities ranging from half a day to several years, is ubiquitous among CP2 and CP4 stars and is associated with larger amplitudes, up to one or two tenths of a magnitude in some exceptional cases. For CP3 stars, there is increasing evidence that these stars are variable too, although to a smaller degree.

We are here concerned with the long time scale variability only, which, in the large majority of the cases in currently explained in terms of the oblique rotator model. In the framework of this model, the period of the observed light, spectrum and magnetic field variations is nothing else than the rotation period.

Accurate determination of the period of variability of CP stars is a fundamental requirement to understand their complex behavior, especially as far as it concerns the phase relation between the magnetic, spectral an light variations.

Out of the above 3257 stars only for 335 stars (i.e. ≈ 10%) the variability has been ascertained (Catalano & Renson 1984, 1988; Catalano et al. 1991, 1992). Moreover, of the 335 known variables, a sufficiently accurate value of the period is available for 185 stars (55.2%), while for 102 stars (30.4%) only one period determination is found in the literature. For the remaining 48 stars (14.3%) the value of the period is still uncertain.

Recently Catalano et al. (1991) discovered CP stars to be variable also in the infrared and found that within the accuracy of the known ephemeris, the near infrared light curves seem to be phase related to the magnetic field variations in the sense that magnetic field extrema might coincide in time with infrared light extrema, although strong field regions can apparently coincide as well with infrared (primary or secondary) maxima or minima. Up to now about 80 stars have been checked for variability in the infrared, but upon looking at the data, we soon discovered that for too many stars of the sample the period is not known within the requested accuracy to allow investigation of the above said phase relation. Since multicolor photometric observations are the most convenient way to determine the period, we have started a research

* Based on observations collected at the European Southern Observatory, La Silla, Chile

program aimed to accurately determining periods on the basis of new photometric observations.

In this paper we report the results concerning a group of silicon stars.

2. Observations

The data were collected during one observing run in March 1991. All observations were carried out in *uvby* at the 50 cm Danish photometric telescope at ESO-La Silla, Chile. The program stars were measured relative to closely comparisons, which were chosen to have as similar colors and brightness as possible (Tab. 1).

For the stars HD 54118, HD 56455, HD 66255, HD 73340, and HD 122532 we could combine our data with those available in the literature and thus determined the period best representing all the data by performing for each light curve a least square fit with a function of the type:

$$\Delta m = A_0 + A_1 \times \sin 2\pi \left[(t - t_0) / P + \phi_1 \right] + \\ + A_2 \times \sin 2\pi \left[2 (t - t_0) / P + \phi_2 \right] \quad (1)$$

In this relation Δm is the magnitude difference in each filter between the CP star and the comparison star, t is the JD date, t_0 is the assumed initial epoch, P is the period in days. This procedure is partially justified by the fact that a sine wave and its first harmonic appear to be quite adequate to describe the light curves within the accuracy of the measurements (Mathys & Manfroid 1985). Moreover very often the magnetic field variations appear to be quite well represented by a simple sinusoid (Borra & Landstreet 1980).

However, when taking into account observations of other authors the values of the coefficient A_0, calculated separately for each set of data, did not coincide: in such cases the difference with respect to the A_0 obtained from our observations was calculated and the data obtained by other authors were shifted accordingly, hence the fit was performed again for the whole set and the new paramaters of the fit determined.

In the cases of the stars HD 114365, HD 116890, and HD 144231 the periods available in the literature do represent quite well our observations, although some phase shift was found in the phases of maximum or minimum light. Since the data were not available, we refined the value of the period by computing the change in the period value needed to allow the phase of maximum (or minimum) light to coincide with the one assumed in the literature.

The estimated error in the assumed initial epoch is ± 0.005. In all cases the error in the period value has been evaluated according to the relation given in Horne & Baliunas (1986) and assuming the time gap between our and the oldest data (or epochs). The adopted ephemeris elements for each programme star are summarized in Table 2.

The parameters of the least-squares fit of the light curves are reported in Table 3. In the figures, where the light variations are plotted, filled circles represent our data, while crosses represent the observations of other authors.

HD 54118 = HR 2683 = 27G. Car = V386 Car

The magnetic field of HD 54118 had been discovered by Borra & Landstreet (1975), who found it to vary over a period of 3.2 d with an amplitude of about 2.5 kilogauss peak to peak and reversal of polarity.

The light variations of HD 54118 have been found by Manfroid & Renson (1981) to have the same period as the magnetic field variation. Recently the value of the period has been refined to 3.27536 d by Mathys & Manfroid (1985).

To refine the period we have used the *uvby* observations collected in the Long-Term Photometry of Variables Project (Manfroid et al. 1991). Using all these data, together with our observations, we found the period 3.2275170 ($\pm$ 0.000015) d best represents all the photometric data.

The light curves of HD 54118 are plotted in Fig. 1 versus tha phase computed by means of the ephemeris elements:

$$JD(b \text{ light min}) = 2448343.532 + 3.275170\ E \quad (2)$$

From Fig. 1 we see that the light curves show quite a peculiar behavior: the amplitude being largest ($\sim$ 0.04 mag peak to peak) in the v and b filters and a slightly smaller ($\sim$ 0.03 mag peak to peak) in the u and y filters. A double wave is clearly present in u, b, and y light curves. The light minimum occurs at the same phase in v and b, instead the maximum light is found at the same phase in the u and y curves.

The magnitude differences HD 54118 minus HD 52622 are listed in Table 4.

HD 56455 = HR 2761 = 77G. Pup = PR Pup

The light variability of the star HD 56455 has been discovered by Renson et al. (1976) who found the period to be 2.24 or 1.72 d. Later on Waelkens (1985) by observing this star in the Geneva system found the period to be 1.9346 d. This value has been confirmed by Heck et al. (1987).

No magnetic field observations are available for HD 56455.

To refine the value of the period of HD 56455 we have combined our observations with those by Heck et al. (1987). We got 2.06370 ($\pm$ 0.00015) d.

The light curves, displayed in Fig. 2, are plotted versus the phase computed by means of ephemeris elements:

$$JD(uvby \text{ minimum}) = 2448341.513 + 2.06370\ E \quad (3)$$

From Fig. 2 we see that the light curves show by far the largest amplitude in the u filter, where it amounts to 0.12 mag peak to peak : in the other filters the amplitude is less than half value, being 0.003 mag in v, and 0.04 mag in b and y. All light curves are in phase with each other.

The magnitude differences HD 56455 minus HD 55892 are listed in Table 5.

HD 66255 = HR 3151 = PY Pup

The light variations of the star HD 66255 have been first studied in *uvby* by Renson & Manfroid (1978) who found a period of 6.82 d. Later on Mathys & Manfroid (1985) refined the value of the period to 6.846 d but could not exclude other nearby values. On the basis of further observations Heck et al. (1987) obtained a value of 6.8178 ($\pm$ 0.0016) d.

Neither magnetic nor spectroscopic observations are available for this star.

Search for periodicity has been performed using the observations by Heck et al. (1987). We got the value: 6.81780 ($\pm$0.00015) d.

Our *uvby* observations of HD 66255 are plotted in Fig. 3 versus the phase computed by means of the ephemeris elements:

$$JD(uvby \text{ maximum}) = 2448343.439 + 6.81780\ E \quad (4)$$

From Fig. 3 we see that HD 66255 shows fairly large variations having amplitudes of the order of 0.08 mag peak to peak in u, 0.05 mag in v, and b, and 0.04 mag in y and all in phase with each other. The maximum is broader than the minimum.

The magnitude differences HD 66255 minus HD 66210 are listed in Table 6.

HD 73340 = HR 3413 = 47G. Vel = HV Vel

The first indication for periodic variability of HD 73340 arose from photometric observations by Hensberge et al. (1976). However since they could not distinguish among several periods, all of which showing unusually large a scatter, Hensberge et al. did not attempt to construct light curves, instead they suggested the period to be of a few days or less since the star changed its brightness from minimum to maximum in one day. At the same time Hube & Walker (1976) found the SiII lines to vary in strength over a period of 2.670 or 1.06 d, the former value being most probable.

The light curves of HD 73340 in the *uvby* photometric system have been first published by Renson et al. (1978). These authors found the period to be 2.6679 d.

Later Manfroid & Mathys (1985) refined the period to 2.66745 d but they could not exclude other nearby values. Some more *uvby* observations led Heck et al. (1987) to determine the period to be 2.66753 ($\pm$0.00025) d.

By combining Heck et al.'s (1987) observations and ours, we got a period of 2.667588 ($\pm$0.000015) d.

The light curves of HD 73340 are shown in Fig. 4, where they are plotted versus the ephemeris elements:

$$JD(uvby \text{ maximum}) = 2448345.545 + 2.667588\ E \quad (5)$$

From the analysis of the light curves we see that all of them are in phase with each other; the amplitudes amounts to 0.06 mag in the u filter, 0.05 mag in v, 0.04 mag in b, and 0.03 mag in y. It is interesting to note that in all light curves the minimum is broader than the maximum, indeed the ascending branch shows a plateau which is best evident in the u variation, where an incipient double-wave seems to be present.

The magnitude differences HD 73340 minus HD 71043 are listed in Table 7.

HD 114365 = HR4965 = 179G. Cen = V824 Cen

The star HD 114365 has been discovered to be variable in light with a period $P = 1.172$ d by Manfroid & Renson (1983). This value of the period was later on confirmed by Mathys & Manfroid (1985) who reanalyzed the same set of data.

Neither spectroscopic study nor magnetic field determination are available for this star.

By plotting our data with the ephemeris by Manfroid & Renson we found that the light curves presented a moderate phase shift but remained unchanged in shape. By forcing the extrema of the light curves to coincide in phase we could improve the period to the value $P = 1.271925$ ($\pm$0.000015) d. The resulting light curves are plotted in Fig. 5 with the following ephemeris elements:

$$JD(v \text{ light maximum}) = 2448347.832 + 1.271925\ E \quad (6)$$

As it is shown in Fig. 5 the light curves of HD 114365 are very peculiar: the u, b and y ones have a double-wave behavior, instead the v curve is single-waved. Also the amplitudes are quite different, ranging from 0.08 in u to 0.05 in v and to about 0.03 mag. in b and y. Another interesting feature is that the primary maximum in u and y occurs at the same phase of the secondary one in b and of the single minimum in v.

The magnitude differences HD 114365 minus HD 113902 are listed in Table 8.

HD 116890 = HR 5066 = EZ Mus

The star HD 116890 was the first one to have been detected by the λ5200 Å depression index photometry alone (Maitzen 1976; Maitzen & Wood 1977).

The single wave light variability of HD 116890 has been found by Maitzen & Wood (1977) to occur with a period of about 4.5 d. Later on Stift (1979) refined the period to the value of 4.3127 ($\pm$ 0.0010) d, although two other closeby values (i.e. 4.3022 and 4.3224 d) are still possible though less probable.

No measurements of the magnetic field are available for HD 116890.

The application of Deeming analysis and Renson's algorithm (Renson 1978, 1980) to our data shows that the variation is well represented by a period close to 4.30 d. Forcing the extrema of our observations to coincide with the light extrema given by Maitzen & Wood (1977) and by Stift (1979) we obtain $P = 4.301176 \pm 0.000012$ d.

The *uvby* observations of HD 116890 are plotted in Fig. 6 versus the phase computed by means of the ephemeris elements:

$$JD(uvby \text{ minimum}) = 2448344.525 + 4.301176\ E \quad (7)$$

From Fig. 6 we see that the *uvby* light curves of HD 116890 are all in phase with each other and show the same behavior. The amplitude steadily decreases from 0.13 mag. peak to peak in u to 0.08 in y.

The magnitude differences HD 116890 minus HD 115967 are listed in Table 9.

HD 122532 = HR 5269 = 307 G. Cen = V828 Cen

The light variability of HD 122532 has been discovered by Manfroid & Renson (1983) who found a period of 1.837 d.

Magnetic field measurements of this star were carried out by Thompson et al. (1987), who found the magnetic variation to occur in 3.6790 or 3.6622 d with with polarity reversal and equal positive and negative extrema. Further magnetic observations have been performed by Mathys (1991), who improved the period found by Thompson et al. to the value 3.68069 d. Mathys confirmed the sinusoidal variation of the magnetic field observed by Thompson et al. and also studied the variations of the equivalent widths of the lines FeIIλ5961 and SiIIλ5978, which were found to behave in antiphase with each other, the Si line varying in phase with the magnetic field.

Combining new observations in the Geneva system with the older *uvby* data by Manfroid & Renson (1983), Lanz & Mathys (1991) derived the value of the period $P = 3.6807$ ($\pm$0.0001) d.

Our *uvby* observations extend by about two years the time basis of the photometric observations, so that we could definitively confirm the value of the period as given by Lanz & Mathys (1991), obtaining the value: 3.68070 ($\pm$0.00005) d.

The light curves of HD 122532 are plotted in Fig. 7 versus the phase computed by means of the ephemeris elements:

$$JD(uvby \text{ maximum}) = 2448339.736 + 3.68070\ E \quad (8)$$

From Fig. 7 we see that the light curves in all filters are in phase with each other and show the same double-wave behavior. The amplitudes of the light variations are 0.07 mag in u, 0.05 mag in v and b, and about 0.04 mag in y.

The magnitude differences HD 122532 minus HD 123445 are listed in Table 10.

HD 144231 = GC 21650 = LL TrA

The star HD 144231 has been discovered to be variable in light by Renson & Manfroid (1980), who derived a period of 4.41 d. From the same set of data Mathys & Manfroid (1985) derived a value of 4.39 d.

Plotting our data with each of these values we found that the observations could be quite satisfactorily represented, although a small phase shift was present with respect to the ephemeris given by Mathys & Manfroid (1985). By imposing the light variation extrema to occur at the same phase we refined the period to the value: 4.39136 ($\pm$ 0.00010) d.

The light curves of HD 144231 are shown in Fig. 8, where they are plotted versus the phase computed by means of the ephemeris elements:

$$JD(uvby \text{ maximum}) = 2448339.179 + 4.39136\ E \quad (9)$$

From Fig. 8 we see that all light variations are single-waved and in phase with each other and the amplitude is of about 0.06 mag peak to peak in u, and of the order of 0.03 mag. in the other filters.

The magnitude differences HD 144231 minus HD 144481 are listed in Table 11.

3. Conclusions

We have presented new photometric observations of the Si stars HD 54118, HD 56455, HD 66255, HD 73340, HD 114365, HD 116890, HD 122532, and HD 144231. To refine the period values for the stars HD 54118, HD 56455, HD 66255, HD 73340, and HD 122532 we have used our observations and those available in the literature from other authors. Since no other observations were available for the stars HD 114365, HD 116890, and HD 144231, we adjusted the value of the period by imposing our epochs of the extrema of the light curves to coincide in phase with those by other authors available in the literature.

From the analysis of the light variations of CP stars it has become evident that as the value of the period is more accurately determined, the behavior of the light curves appears to be more and more complex, in the sense that different behaviors emerge in the different filters, i.e. the shape of the variations and the phases at which their extrema occur do change with the wavelength. However nothing else can be inferred from photometry alone, instead to understand such a complex behavior, spectroscopic and magnetic observations are needed to study the phase relations and the precise cause of the observed variations.

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Table 1. Program Stars and their comparisons. The spectral types of program stars are from the "General Catalogue of CP stars" (Renson et al. 1991), those of comparison stars are from the Bright Star Catalogue (Hoffleit & Jaschek 1982)

Program Stars					Comparison Stars			
HD	HR	Name	Sp. type	m_V	HD	HR	Sp. type	m_V
54118	2683	27G. Car	A0 Si	5.30	52622	2638	F2	6.44
56455	2761	77G. Pup	A0 Si	5.82	55892	2740	F0 IV	4.49
66255	3151	PY Pup	A0 Si	6.12	66210	3148	A2 V	6.02
73340	3413	47G. Vel	B9 Si	4.86	71043	3300	A0 V	5.85
114365	4965	179G. Cen	A0 Si	6.06	113902	4951	B8 V	5.71
116890	5066	EZ Mus	B9 Si	6.20	115967	5030	B6 V	6.05
122532	5269	307G. Cen	A0 Si	6.1	123445	5294	B9 V	6.17
144231	—	LL TrA	B9 Si	6.89	144481	—	Am	6.48

Table 2. The adopted ephemeris elements for the programme stars

HD	Var. name	Sp.	JD($\phi = 0$)	Instant of	P(days)
54118	V386 Car	A0 Si	2448343.532	*b* light min.	3.275170
56455	PR Pup	A0 Si	2448340.480	*uvby* min.	2.06370
66255	PY Pup	A0 Si	2448343.439	*uvby* max.	6.81780
73340	HV Vel	B9 Si	2448345.545	*uvby* max.	2.667588
114365	V824 Cen	A0 Si	2448347.832	*v* light max.	1.271925
116890	EZ Mus	B9 Si	2448344.525	*uvby* min.	4.301176
122532	V828 Cen	B9 Si	2448340.718	*uvby* max.	3.68070
144231	LL TrA	B9 Si	2448345.798	*uvby* max.	4.39136

Table 3. Parameters of the least-square fit of the light curves according to formula (1) in the text and their relative errors

HD	filter	A_0	A_1	φ_1	A_2	φ_2
54118	u	−2.019±0.004	−0.012±0.006	−0.005±0.008	0.006±0.006	0.215±0.017
	v	−1.819±0.004	0.016±0.006	0.217±0.006	−0.001±0.006	−0.147±0.090
	b	−1.557±0.004	0.014±0.006	0.308±0.007	0.008±0.006	−0.747±0.012
	y	−1.284±0.004	0.008±0.006	0.469±0.001	0.006±0.006	−0.756±0.017
56455	u	0.358±0.008	0.049±0.008	−0.758±0.004	0.007±0.001	0.261±0.002
	v	0.675±0.008	0.014±0.009	−0.706±0.014	0.005±0.001	0.069±0.001
	b	0.976±0.008	0.018±0.008	0.223±0.011	−0.003±0.001	−0.076±0.058
	y	1.235±0.008	0.018±0.008	0.224±0.010	−0.002±0.001	−0.060±0.092
66255	u	−0.769±0.008	−0.036±0.001	0.261±0.005	−0.001±0.001	−0.741±0.170
	v	−0.028±0.008	−0.020±0.001	0.286±0.009	−0.005±0.001	0.360±0.038
	b	0.093±0.008	−0.018±0.001	0.258±0.011	−0.002±0.001	0.295±0.107
	y	1.076±0.008	−0.018±0.001	0.254±0.011	−0.002±0.001	0.292±0.099
73340	u	−0.953±0.001	0.019±0.001	−0.175±0.008	−0.012±0.001	−0.821±0.015
	v	−0.260±0.001	0.018±0.001	−0.223±0.009	−0.007±0.001	−0.813±0.026
	b	−0.156±0.001	0.013±0.001	−0.232±0.013	−0.004±0.001	−0.727±0.044
	y	−0.105±0.001	0.011±0.001	−0.218±0.015	−0.004±0.001	−0.737±0.047
114365	u	0.158±0.001	0.016±0.001	0.213±0.016	0.037±0.002	−0.231±0.051
	v	0.331±0.001	−0.022±0.001	0.238±0.012	0.006±0.002	−0.144±0.040
	b	0.316±0.001	−0.003±0.001	0.334±0.085	0.012±0.002	−0.195±0.018
	y	0.345±0.001	−0.011±0.001	−0.270±0.024	0.013±0.002	−0.220±0.016
116890	u	−0.022±0.002	0.057±0.002	−0.759±0.006	0.013±0.003	0.229±0.028
	v	0.057±0.002	0.042±0.002	−0.762±0.008	0.007±0.003	0.262±0.042
	b	0.089±0.002	0.040±0.002	−0.764±0.009	0.007±0.003	0.260±0.044
	y	0.134±0.002	0.032±0.002	−0.755±0.011	0.008±0.003	0.274±0.039
122532	u	−0.256±0.002	0.010±0.003	−0.256±0.035	0.026±0.002	0.752±0.014
	v	−0.136±0.002	0.008±0.003	−0.270±0.044	0.019±0.002	0.750±0.019
	b	−0.132±0.002	0.010±0.003	−0.273±0.035	0.020±0.002	0.755±0.018
	y	−0.093±0.001	0.005±0.001	0.742±0.030	0.018±0.001	−0.229±0.008
144231	u	−0.453±0.002	−0.028±0.002	−0.235±0.016	0.002±0.002	−0.226±0.189
	v	0.008±0.002	0.015±0.002	−0.226±0.028	−0.001±0.004	−0.308±0.582
	b	0.256±0.002	0.014±0.002	−0.236±0.030	−0.001±0.002	−0.405±0.430
	y	0.392±0.002	0.016±0.002	−0.229±0.028	−0.002±0.003	−0.745±0.216

Table 4. Observations of HD 54118. The magnitude differences are in the sense HD 54118 minus HD 52622

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8339.571	−2.0148	−1.8183	−1.5602	−1.2794
8339.571	−2.0106	−1.8219	−1.5631	−1.2800
8340.512	−2.0113	−1.8069	−1.5323	−1.2759
8340.528	−2.0196	−1.8027	−1.5375	−1.2779
8341.510	−2.0336	−1.8315	−1.5732	−1.2954
8342.512	−2.0073	−1.8298	−1.5643	−1.2803
8343.532	−2.0164	−1.8050	−1.5360	−1.2796
8344.516	−2.0338	−1.8198	−1.5722	−1.2995
8345.534	−2.0071	−1.8332	−1.5616	−1.2737
8347.525	−2.0334	−1.8132	−1.5679	−1.2968

Table 5. Observations of HD 56455. The magnitude differences are in the sense HD 56455 minus HD 55892

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8339.573	0.3300	0.6609	0.9590	1.2157
8339.573	0.3285	0.6600	0.9576	1.2255
8340.512	0.4068	0.6818	0.9915	1.2504
8340.530	0.4050	0.6883	0.9903	1.2524
8340.609	0.4041	0.6919	0.9955	1.2565
8341.512	0.3201	0.6575	0.9623	1.2181
8342.513	0.4169	0.6965	0.9967	1.2609
8343.538	0.3168	0.6696	0.9667	1.2214
8344.522	0.4205	0.6946	0.9992	1.2560
8345.536	0.3112	0.6649	0.9644	1.2195
8347.526	0.3218	0.6671	0.9676	1.2219

Table 6. Observations of HD 66255. The magnitude differences are in the sense HD 66255 minus HD 66210

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8340.541	−0.7383	−0.0110	0.1091	0.1232
8341.514	−0.7685	−0.0283	0.0895	0.1062
8342.516	−0.7884	−0.0412	0.0773	0.0961
8343.539	−0.8081	−0.0524	0.0712	0.0852
8344.526	−0.7881	−0.0297	0.0890	0.1051
8345.545	−0.7496	−0.0182	0.1033	0.1147
8347.534	−0.7456	−0.0140	0.1067	0.1208

Table 7. Observations of HD 73340. The magnitude differences are in the sense HD 73340 minus HD 71043

JB (2440000.0 +)	Δu	Δv	Δb	Δy
8339.554	−0.9428	−0.2515	−0.1509	−0.1038
8339.554	−0.9497	−0.2563	−0.1537	−0.0983
8339.583	−0.9548	−0.2645	−0.1565	−0.1085
8339.583	−0.9524	−0.2605	−0.1524	−0.1058
8340.551	−0.9549	−0.2673	−0.1643	−0.1041
8341.525	−0.9422	−0.2447	−0.1424	−0.0995
8342.519	−0.9579	−0.2641	−0.1644	−0.1083
8343.537	−0.9388	−0.2509	−0.1508	−0.0988
8344.528	−0.9557	−0.2540	−0.1459	−0.0999
8345.545	−0.9784	−0.2852	−0.1807	−0.1197
8347.532	−0.9479	−0.2575	−0.1541	−0.1014

Table 8. Observations of HD 114365. The magnitude differences are in the sense HD 114365 minus HD 113902

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8339.664	0.1252	0.3493	0.3133	0.3277
8339.686	0.1362	0.3530	0.3169	0.3348
8339.699	0.1404	0.3511	0.3170	0.3340
8340.618	0.1667	0.3404	0.3207	0.3464
8340.622	0.1683	0.3412	0.3219	0.3437
8340.657	0.1516	0.3416	0.3154	0.3366
8340.702	0.1362	0.3445	0.3120	0.3346
8341.597	0.1763	0.3224	0.3228	0.3594
8341.678	0.1887	0.3260	0.3250	0.3616
8342.707	0.1318	0.2996	0.2987	0.3367
8342.726	0.1333	0.3038	0.2995	0.3452
8343.711	0.1946	0.3349	0.3249	0.3592
8344.708	0.1142	0.3513	0.3133	0.3278
8345.725	0.1579	0.3385	0.3170	0.3423
8346.807	0.1958	0.3224	0.3218	0.3570
8347.628	0.1726	0.3196	0.3148	0.3519
8347.709	0.1522	0.3107	0.3072	0.3512
8347.800	0.1412	0.3053	0.3034	0.3452
8347.832	0.1350	0.3003	0.3001	0.3396
8347.867	0.1426	0.3050	0.3042	0.3456

Table 9. Observations of HD 116890. The magnitude differences are in the sense HD 116890 minus HD 115967

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8339.684	0.0187	0.0910	0.1188	0.1604
8339.726	0.0195	0.0871	0.1193	0.1596
8340.664	0.0335	0.0970	0.1275	0.1636
8341.724	−0.0556	0.0330	0.0668	0.1145
8342.752	−0.0608	0.0241	0.0579	0.1104
8343.732	−0.0146	0.0652	0.0956	0.1397
8344.740	0.0374	0.0974	0.1297	0.1615
8345.735	−0.0437	0.0449	0.0786	0.1212
8346.816	−0.0677	0.0210	0.0550	0.1087
8347.716	−0.0412	0.0426	0.0758	0.1220

Table 10. Observations of HD 122532. The magnitude differences are in the sense HD 122532 minus HD 123445

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8339.736	−0.2277	−0.1146	−0.1094	−0.0752
8339.784	−0.2298	−0.1159	−0.1111	−0.0775
8340.718	−0.2976	−0.1683	−0.1642	−0.1236
8340.719	−0.2925	−0.1621	−0.1636	−0.1201
8341.686	−0.2373	−0.1239	−0.1174	−0.0782
8342.765	−0.2675	−0.1461	−0.1379	−0.0969
8343.752	−0.2487	−0.1304	−0.1265	−0.0903
8344.761	−0.2665	−0.1440	−0.1416	−0.1006
8345.763	−0.2441	−0.1250	−0.1232	−0.0851
8346.828	−0.2378	−0.1204	−0.1152	−0.0802
8347.729	−0.2734	−0.1492	−0.1457	−0.1085

Table 11. Observations of HD 144231. The magnitude differences are in the sense HD 144231 minus HD 144481

JD (2440000.0 +)	Δu	Δv	Δb	Δy
8339.801	−0.4390	0.0151	0.2653	0.4005
8340.765	−0.4736	−0.0590	0.2445	0.3802
8340.766	−0.4697	−0.0360	0.2460	0.3826
8341.805	−0.4699	−0.0500	0.2473	0.3803
8343.794	−0.4272	0.0222	0.2696	0.4054
8344.873	−0.4567	0.0480	0.2522	0.3871
8345.805	−0.4867	−0.0700	0.2422	0.3730
8346.843	−0.4528	0.0730	0.2549	0.3935
8347.786	−0.4256	0.0249	0.2709	0.4049

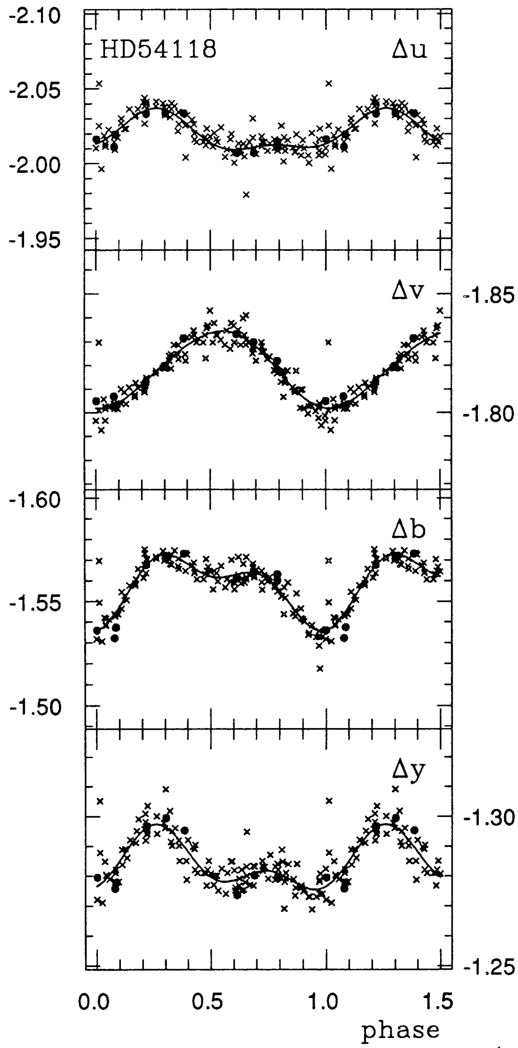

Fig. 1. Lightcurves of HD 54118. The phases are computed according to the ephemeris elements (2). The solid line is a least-square fit of the observations by formula (1). Filled circles represent our observations, crosses Manfroid et al.'s (1991) ones (see text)

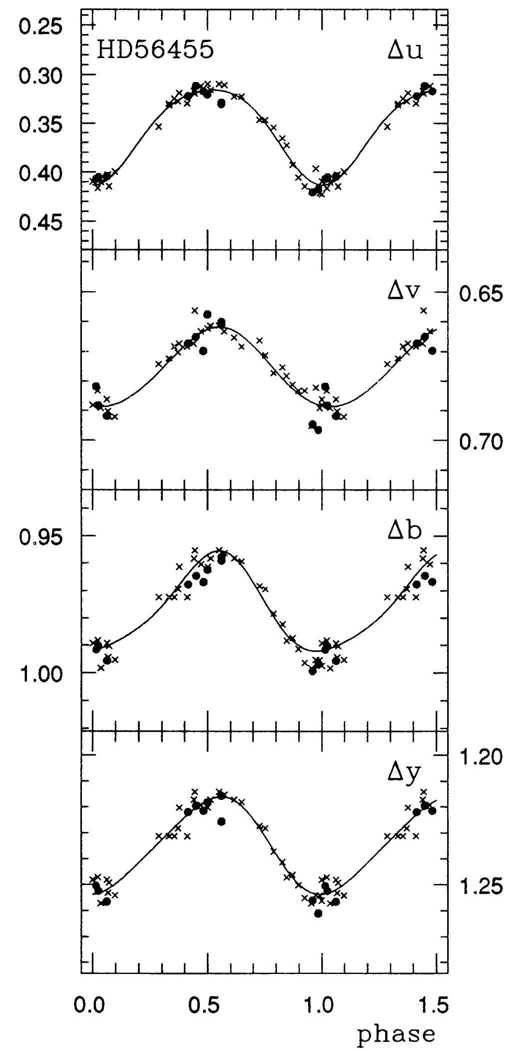

Fig. 2. Lightcurves of HD 56455. The phases are computed according to the ephemeris elements (3). The solid line is a least-square fit of the observations by formula (1). Filled circles represent our observations, crosses Heck et al.'s (1987) ones (see text)

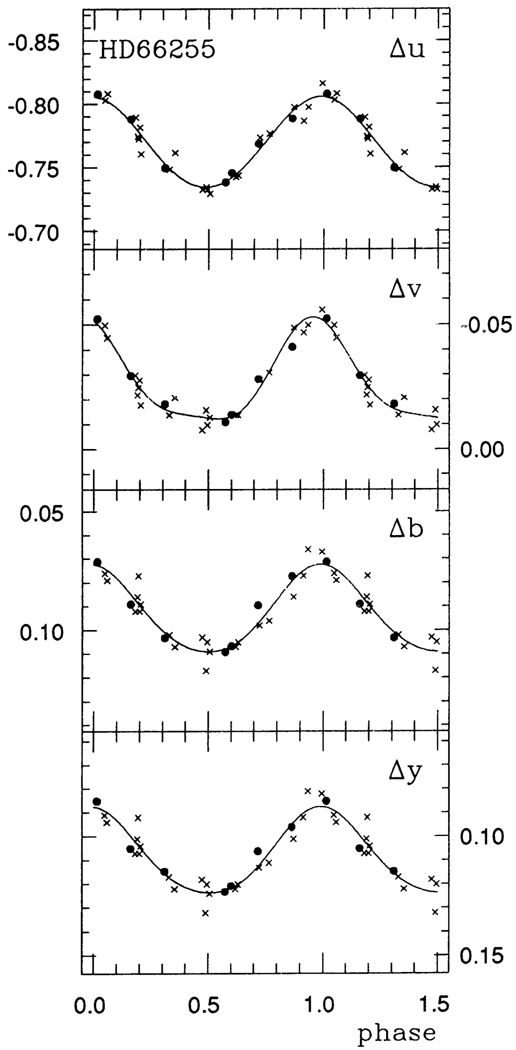

Fig. 3. Lightcurves of HD 66255. The phases are computed according to the ephemeris elements (4). The solid line is a least-square fit of the observations by formula (1). Filled circles represent our observations, crosses Heck et al.'s (1987) ones (see text)

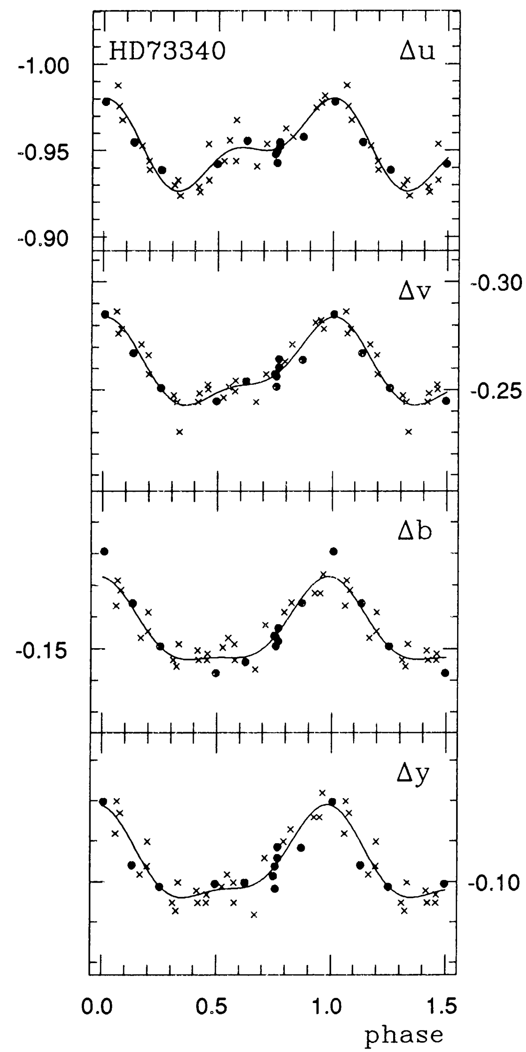

Fig. 4. Lightcurves of HD 73340. The phases are computed according to the ephemeris elements (5). The solid line is a least-square fit of the observations by formula (1). Filled circles represent our observations, crosses Heck et al.'s (1987) ones (see text)

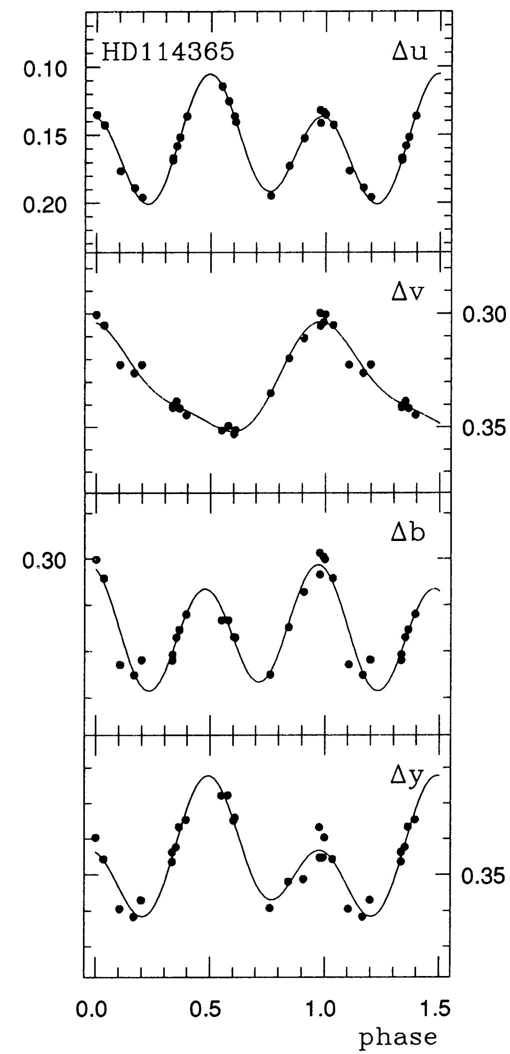

Fig. 5. Lightcurves of HD 114365. The phases are computed according to the ephemeris elements (6). The solid line is a least-square fit of the observations by formula (1)

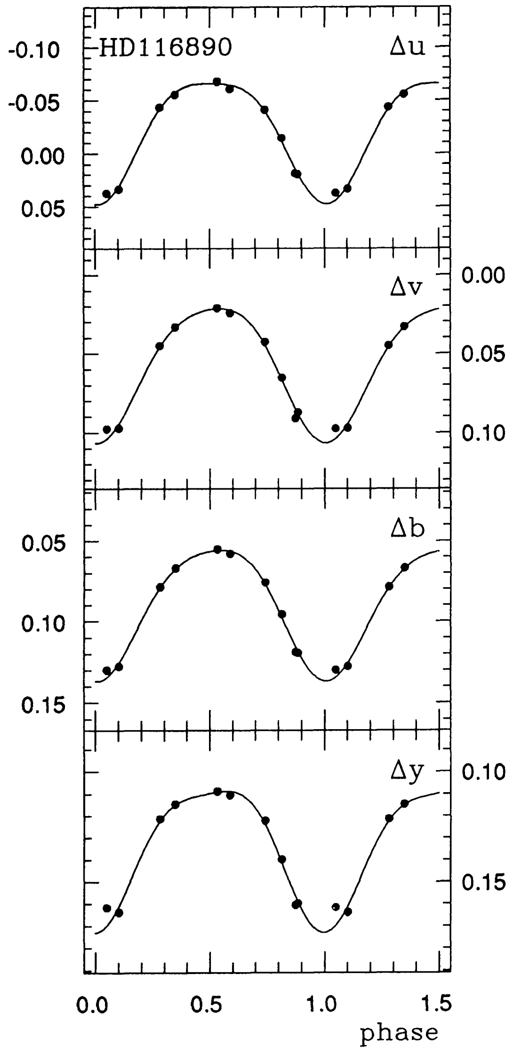

Fig. 6. Lightcurves of HD 116890. The phases are computed according to the ephemeris elements (7). The solid line is a least-square fit of the observations by formula (1)

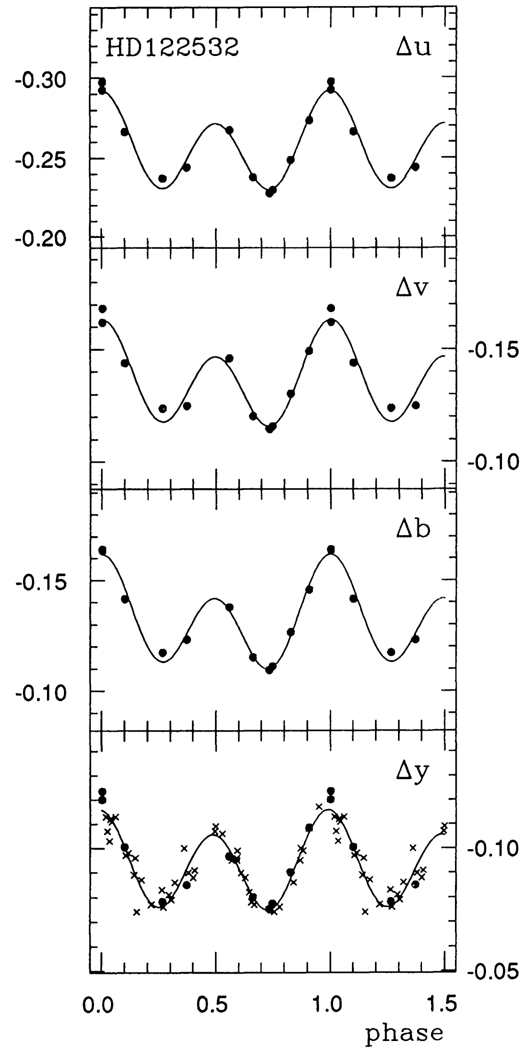

Fig. 7. Lightcurves of HD 122532. The phases are computed according to the ephemeris elements (8). The solid line is a least-square fit of the observations by formula (1). Filled circles represent our observations, crosses Lanz & Mathy's (1991) Geneva V band ones (see text)

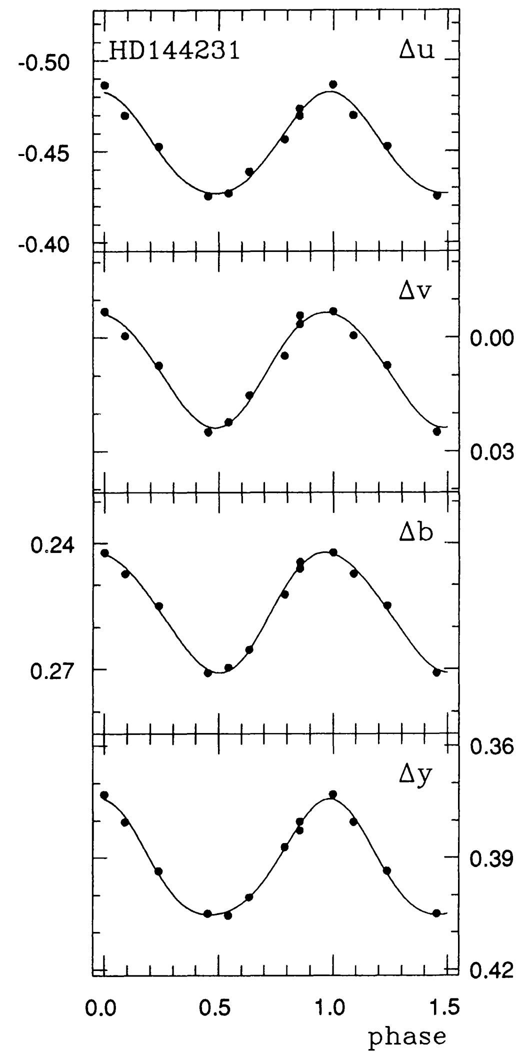

Fig. 8. Lightcurves of HD 144231. The phases are computed according to the ephemeris elements (9). The solid line is a least-square fit of the observations by formula (1)