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PHOTOMETRY OF SILICON STARS* II

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Three silicon stars – HD 3580, HD 187473 and HD 212432 – have been reobserved at the European Southern Observatory, La Silla, for various reasons (earlier observations were published by Hensberge *et al.* 1977). In the case of HD 3580, arguments in favour of a single wave variation in a period of 1.4788 days are presented. The period of the large amplitude variable star HD 187473 ($\Delta u > 0^{\mathrm{m}}.2$) is considerably refined ($P = 4^{\mathrm{d}}.718$). Finally the period that has been proposed in the earlier paper for HD 212432 is confirmed and refined ($P = 4^{\mathrm{d}}.689$).

Key words: Ap stars – photometry – variable stars

1. INTRODUCTION

Results of an investigation on the *uvby*-variability of silicon stars, carried out with the Danish telescope at La Silla, Chile (ESO), were published by Hensberge *et al.* (1977; hereafter referred to as Paper I). The period of variability of HD 3580 and HD 212432 could not be derived without ambiguity.

In the case of HD 3580 our set of observations did not permit to distinguish between periods in the vicinity of $1^{\mathrm{d}}.48$ and periods near $2^{\mathrm{d}}.94$. If the period is near 2.94 days, the lightcurves would show pronounced secondary extrema. Obviously, the length of the observation run should be as long as one month to permit observation of a primary and a secondary extremum of the same kind during the same run. Moreover, the low amplitude of the variations ($\simeq 0^{\mathrm{m}}.025$ in u and $< 0^{\mathrm{m}}.01$ in v, b and y) demands for many observations if one should have to distinguish between a single wave lightcurve and a lightcurve with pronounced secondary extrema (cf. also θ^1Mic (Maitzen *et al.* 1974), HD 30466 (Maitzen 1977) and HD 72968 (Maitzen *et al.* 1978)). In practice, it was easier to observe the star frequently during two observing runs, each about two weeks in length and separated by about one hundred days.

The importance of HD 187473 should hardly be emphasized. Since we intend to undertake a spectroscopic study of this star, it seems useful to refine the derived period ($P = 4^{\mathrm{d}}.75 \pm 0^{\mathrm{d}}.04$) in such a way, that epochs of extreme light flux can be predicted precisely. Besides the fact that this will permit to take the spectra at the appropriate phases, it offers the advantage of knowing the phase relations between the photometric and expected spectroscopic variations, even if weather conditions during the spectroscopic run would be too bad to allow simultaneous photometry.

In the case of HD 212432, our earlier observations were spread rather inadequately over the phase diagram: a pronounced secondary maximum should exist, but its existence was only supported by two isolated observations near phase 0.45, leaving a gap of $\simeq 0.2$ in phase on both sides. Although no other value of the period than $P = 4.69$ days could be found to be consistent with this set of 12 observations, we felt that the result remained more or less dubious without further confirmation.

2. OBSERVATIONS AND REDUCTIONS

The observations presented in this paper have been obtained by van der Linden (between August 2 and August 31, 1977) and Sterken (between June 18 and July 3, 1977 for HD 187473 and between December 1 and December 16, 1977 for HD 3580). Both observers used the Danish telescope at La Silla and the Strömgren

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

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photometer of the University of Copenhagen. The techniques used for observation, reduction and period determination are basically as described in paper I and will not be repeated here. The major differences are: 1°) that we only used two comparison stars for each program star, as we had tested their constancy in 1975; 2°) that the differential magnitudes for HD 3580 result from integrations over larger time intervals (a factor 1.5 – 2) than in 1975.

The constancy of the photometric system claimed by Grønbech *et al.* (1977) has been confirmed to some extent by our measurements. The instrumental differential magnitudes between comparison stars, derived from the observing runs of 1975 and 1977, differ by no more than a few thousandths of a magnitude (table 1). Consequently, results obtained during different observing runs have been simply added together to search for periodicity.

3. RESULTS

All new observations are tabulated in table 2. In figures 1, 2 and 3 the 1975 observations are represented by open triangles; open circles denote observations made by van der Linden; open squares represent Sterken's measurements. We refer to paper I for the standard *uvby* colours and indices.

HD 3580

We were able to determine the number of elapsed periods between the 1975 and 1977 observations without ambiguity. In the case that the period is near three days, it turns out that Sterken has observed the minimum already established in 1975, whereas van der Linden has observed the second minimum. If the light curves have really double waves, and the amplitude or shape of both waves are not identical, a plot of the observations in a best fit period near $1\overset{d}{.}5$ should show some systematic differences between the measurements of van der Linden and all other measurements. Figure 1 shows the observations plotted in a period of $1\overset{d}{.}4788$. Since no such systematic differences occur in any of the phase diagrams, there is strong evidence that the photometric period of this star is really $1\overset{d}{.}4788 \pm 0\overset{d}{.}0002$.

HD 187473

The three sets of observations define a unique set of lightcurves (figure 2). There remains a gap – between phase 0.3 and 0.4 – which, unfortunately, seems to contain the primary maximum. However, maximum light in *v* is situated apparently about 0.05 – 0.1 cycle after the time of maximum light in the other channels. It is also in this channel that the secondary maximum is the least distinct and that the amplitude of the variations is smallest. The steep rise in light flux between the primary extrema permits to match the different sets of observations very precisely. This results in a rather high precision for the derived period: $P\ 4\overset{d}{.}718 \pm 0\overset{d}{.}001$.

HD 212432

The 1977 observations clearly confirm the existence of the pronounced secondary extrema which were suggested by the earlier observations (figure 3). The period given in paper I can not be refined without ambiguity, as a consequence of the limited length of both observation runs relative to the length of the time interval between both. The most probable period lies in the interval $P = 4\overset{d}{.}689 \pm 0\overset{d}{.}002$, but the alternative periods $P = 4\overset{d}{.}659 \pm 0\overset{d}{.}002$ and $P = 4\overset{d}{.}719 \pm 0\overset{d}{.}002$ should not be excluded.

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Table 1 Instrumental differential magnitudes between comparison stars measured during the various observing runs

Comparison stars	Observ. run	Δy	Δb	Δv	Δu
HD 3581-HD 4622	Aug.75	1.534	1.816	2.154	1.994
	Aug.77	1.533	1.816	2.154	1.991
	Dec.77	1.532	1.815	2.152	1.989
HD187578-HD190285	Aug.75	0.432	0.422	0.355	0.058
	Jun.77	0.434	0.425	0.355	0.059
	Aug.77	0.433	0.425	0.356	0.059
HD210931-HD214172	Aug.75	-0.020	-0.062	-0.114	-0.120
	Aug.77	-0.020	-0.060	-0.113	-0.121

Table 2 Instrumental differential magnitudes. See Paper I for the 1975 observations (plotted in the instrumental system)

JD 2 443 300+	Δy	Δb	Δv	Δu
	HD 3580 - HD 4622			
68.786	1.156	1.124	1.074	0.549
68.862	1.153	1.120	1.071	0.542
71.794	1.159	1.124	1.069	0.547
71.877	1.157	1.120	1.068	0.536
72.817	1.168	1.136	1.082	0.577
73.712	1.155	1.123	1.067	0.556
73.805	1.159	1.126	1.074	0.559
74.703	1.162	1.128	1.068	0.554
74.810	1.154	1.123	1.066	0.536
76.702	1.156	1.121	1.072	0.558
76.782	1.157	1.125	1.074	0.562
77.665	1.157	1.128	1.074	0.549
79.693	1.158	1.125	1.076	0.559
79.810	1.162	1.127	1.079	0.565
81.718	1.164	1.132	1.082	0.578
81.782	1.166	1.135	1.084	0.578
82.723	1.159	1.124	1.077	0.566
82.787	1.160	1.125	1.077	0.562
83.656	1.152	1.123	1.072	0.543
83.738	1.156	1.120	1.068	0.535
83.820	1.155	1.119	1.069	0.537
86.734	1.152	1.118	1.065	0.537
86.782	1.150	1.117	1.067	0.539
179.567	1.163	1.133	1.084	0.566
180.572	1.160	1.126	1.078	0.572
181.565	1.159	1.125	1.075	0.542
182.570	1.163	1.133	1.080	0.558
183.574	1.164	1.129	1.080	0.569
184.574	1.159	1.122	1.074	0.556
185.574	1.163	1.131	1.079	0.554
186.580	1.166	1.132	1.086	0.572
187.572	1.155	1.121	1.073	0.559
188.576	1.161	1.125	1.075	0.552
189.569	1.168	1.134	1.086	0.573
190.571	1.155	1.125	1.079	0.562
191.586	1.152	1.119	1.073	0.551
192.570	1.166	1.131	1.082	0.573
193.567	1.164	1.131	1.083	0.564

JD 2 443 300+	Δy	Δb	Δv	Δu
	HD 187473 - HD 187578			
13.803	-0.330	-0.388	-0.394	-0.565
15.906	-0.366	-0.425	-0.435	-0.611
18.916	-0.366	-0.418	-0.410	-0.632
21.898	-0.343	-0.405	-0.408	-0.611
22.846	-0.318	-0.382	-0.394	-0.545
25.837	-0.335	-0.408	-0.419	-0.585
27.823	-0.313	-0.378	-0.394	-0.546
63.573	-0.341	-0.407	-0.415	-0.583
68.675	-0.338	-0.406	-0.413	-0.600
71.732	-0.433	-0.470	-0.449	-0.741
72.756	-0.360	-0.421	-0.430	-0.591
73.727	-0.340	-0.405	-0.410	-0.607
74.597	-0.317	-0.382	-0.398	-0.555
75.713	-0.390	-0.434	-0.420	-0.673
76.632	-0.417	-0.464	-0.452	-0.722
77.628	-0.340	-0.413	-0.423	-0.587
79.634	-0.317	-0.376	-0.388	-0.544
83.620	-0.333	-0.399	-0.405	-0.595
86.609	-0.369	-0.436	-0.440	-0.627
	HD 212432 - HD 210931			
63.704	0.103	0.044	-0.087	-0.562
68.727	0.105	0.042	-0.089	-0.568
71.782	0.107	0.036	-0.086	-0.564
72.802	0.103	0.038	-0.086	-0.561
74.699	0.093	0.030	-0.102	-0.610
75.729	0.117	0.056	-0.070	-0.543
76.649	0.096	0.029	-0.097	-0.584
77.648	0.099	0.039	-0.091	-0.559
79.664	0.108	0.037	-0.092	-0.587
81.625	0.095	0.030	-0.097	-0.578
82.613	0.110	0.043	-0.084	-0.559
86.637	0.100	0.036	-0.093	-0.571

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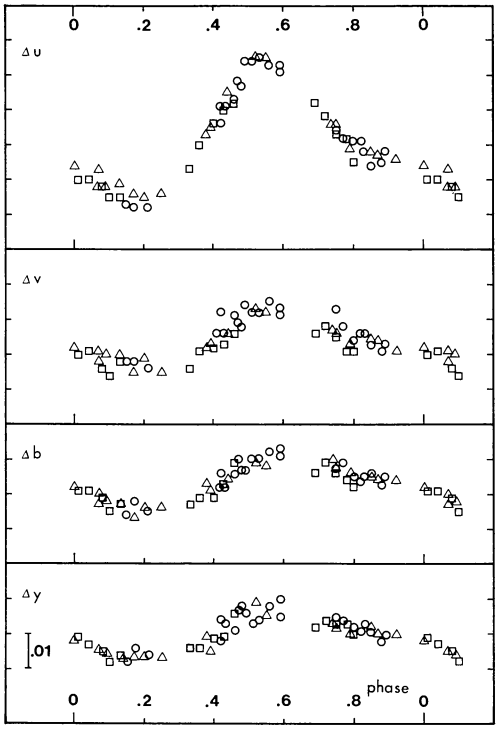

Figure 1 Phase diagram of the variations of HD 3580 in the instrumental system of the Danish telescope at La Silla, constructed with a period of $1^{d}.4788$. Phase zero corresponds to JD 2442619.890. The meaning of the symbols is explained in the text.

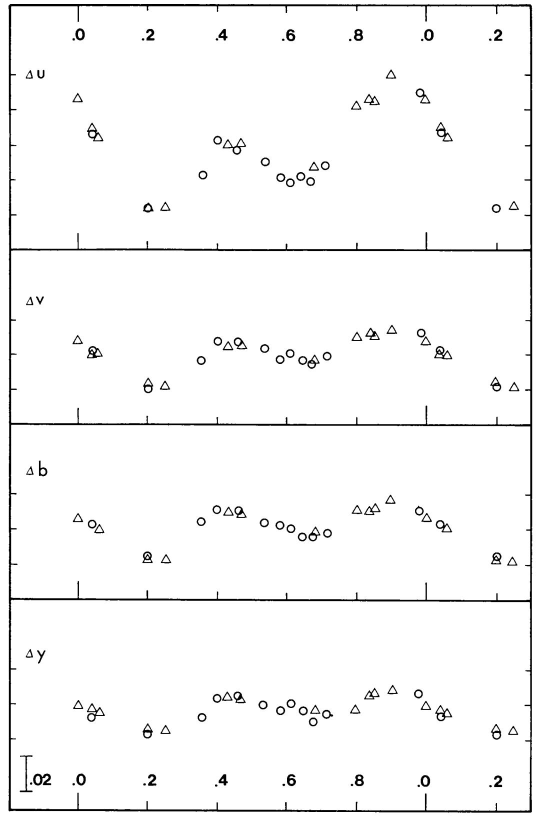

Figure 3 Phase diagram of the variations of HD 212432 constructed with $P = 4^{d}.689$. Phase 0 corresponds to JD 2442619.861.

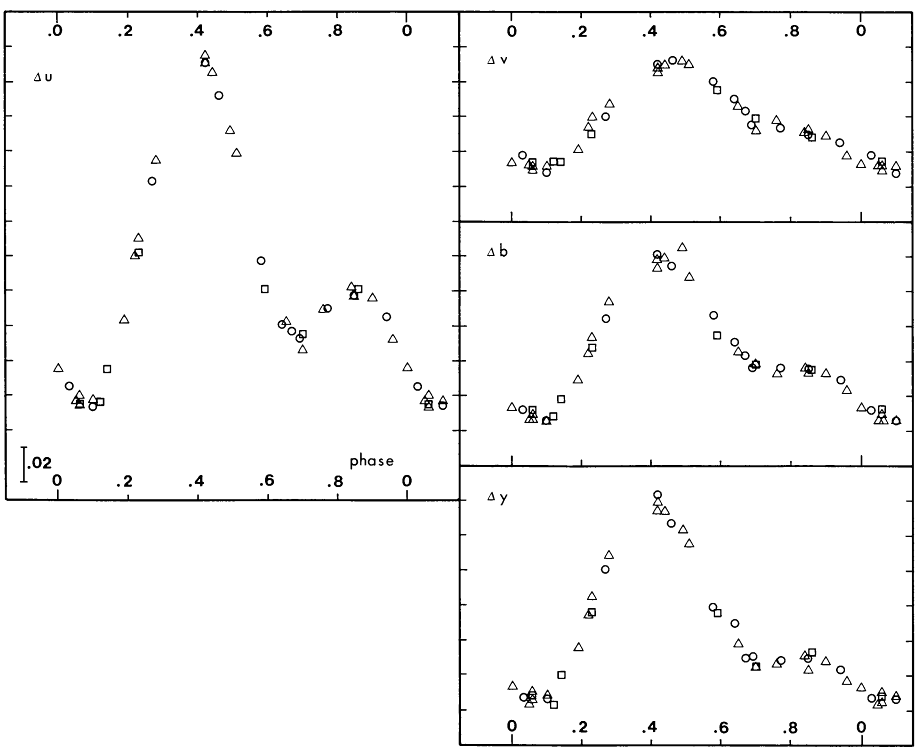

Figure 2 Phase diagram of the variations of HD 187473 constructed with $P = 4^{d}.718$. Phase 0 corresponds to JD 2442619.578.

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