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New period determinations for variable CP stars (*)

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Summary. — New or improved photometric periods are presented for 29 CP stars.

Key words : CP stars : periods — CP stars : Strömgren photometry.

1. Introduction.

We present new periods or improved periods for 29 CP stars that we observed at La Silla between 1977 and 1982. These results which complete or supersede those published previously (Manfroid and Renson, 1981a, 1981b, 1983a, 1983b; Renson and Manfroid, 1978a, 1978b, 1980, 1981; Renson *et al.*, 1978; Renson *et al.*, 1984) are based on careful reduction of most of the original material, using the PHOT2 programme (Manfroid and Heck, 1983). The use of this algorithm allows to bring together the observations of different observing runs more safely, by an improved reduction of the data to a common standard system. Furthermore, poor quality measurements and the possible variability of some comparison stars can be easily detected in an absolute way, independently of the differential measurements of the variable.

The periods were calculated mainly with the Deeming algorithm (Deeming, 1975) and the Stellingwerf algorithm (Stellingwerf, 1978). As a third method — and a very appropriate one for CP stars — we used a least-squares fit to the lightcurve by a fundamental sine wave and its first harmonic. A periodogram was then constructed by plotting the standard deviation as a function of the fundamental frequency. This method was mainly used to refine periods found in another way.

Table I gives the details about the observing runs. The results are presented in table II. The HD number and another identification of the programme stars are given in the first two columns. The observing runs are listed in col. 3, with the corresponding number of observations N and HD numbers of the comparison stars C_1 and C_2 in cols. 4 to 6. The best value(s) of the frequency f and of the period P are indicated in cols. 7 and 9. The error on the period is given in col. 10, it is a coarse estimate of the accuracy of the determination. When a star has been observed during several runs, it is possible that a few equally spaced frequencies are almost equally probable. When this occurs, col. 8 lists the corresponding frequency shift Δf that can be added or subtracted to find other possible frequencies ($f + n \Delta f$, $n = 0, \pm 1, \pm 2, ...$).

2. Notes on individual stars.

Most of the stars presented in this paper have already been discussed in detail in the references quoted above. Here we just comment on some additional points, which are particularly relevant to the present study.

HD 9484 (A0p Si) was thought by Manfroid and Renson (1983b) not to be variable on a short time scale. However our new, more accurate reduction of the older data leaves little doubt about the existence of short period variations, with peak-to-peak amplitudes of about 0.015 mag in u and of a little less than 0.01 mag in v; in y and b, the star is constant within the degree of accuracy of our measurements. The 0.694 d period appears as more probable than the 0.364 d one, mainly because the latter would be unusually short for a CP star; however, this short period cannot be definitely discarded on the basis of our observations.

HD 27376 (B9p HgMn) has already been discussed by Renson and Manfroid (1981); our new reduction of the data shows that their tentative value of the period, 0.51 d, probably came out because of the presence of spurious observations and was purely coincidental. Nevertheless, the variations are small, and several periods seem almost equally probable. Let us just point out that the fairly low projected rotational velocity, $v \sin i = 15$ km s^{-1} (Uesugi and Fukuda, 1981) slightly favours the largest value, 8.5 d.

HD 42536 (A0p SrCr) has also been discussed by Renson and Manfroid (1981). Their (uncertain) period, 3.65 d, is ruled out after the new reduction of the data. Instead, we find a value of 1.36 d (which is probably an alias of the former); however, this period is still rather uncertain.

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

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HD 61966 (B9p Si) is not very well known; our value of the period, 1.035 d, close to that of Manfroid and Renson (1981b), 1.040 d, seems more likely than its alias 0.962 d, but a much longer period (27 d) cannot be ruled out.

HD 90763 (A1p Sr) has already been discussed by Manfroid and Renson (1983a). We believe that this star is really variable, with small amplitudes, but the proposed periods remain rather uncertain.

HD 148898 (A7p Sr) has been studied by Renson and Maitzen (1978) on the basis of *UBV* measurements; these authors proposed several possible values of the period. These values appear in our periodograms (built from our newly reduced data) as much less likely than those that we give in table II. One can also notice that the 0.58 d period, attributed by Catalano and Renson (1984) to Borra and Landstreet (1980) and therefore regarded as relying on magnetic observations, has in fact been derived from photometric observations by Winzer (1974, quoted by Borra and Landstreet); as a matter of fact, the presence of a magnetic field in this star cannot be firmly established from the measurements of Borra and Landstreet. As to Winzer's 0.58 d period, it definitely does not appear in our observations.

HD 164258 (A3p SrCrEu). The new reduction allowed the elimination of some spurious measurements; as a result, we derive a short period (0.719 d) with a high degree of confidence and in good agreement with the large projected rotational velocity, $v \sin i = 65$ km s^{-1} (Uesugi and Fukuda, 1981). As for HD 9484, we preferred the double-waved lightcurve to the single-waved one ($P = 0.359$ d) mainly in view of the range of periods usually encountered in CP stars.

HD 177517 (B9p HgSi) was thought by Renson and Manfroid (1978a), to have a long period. The high value of the projected rotational velocity ($v \sin i = 95$ km s^{-1}, Uesugi and Fukuda, 1981) rules out this possibility. In fact, our new reduction clearly shows that the star varies on a short timescale. Unfortunately, the very small number of measurements that we have and the resulting difficulty to bring together the observations of both runs make the choice of the period rather questionable. The 0.33772 d value seems excellent, but this may be purely coincidental. If it eventually proved to vary with that period, HD 177517 would become the CP star with the shortest known period. (Borra and Landstreet, 1980, failed to establish the presence of a magnetic field in this star, which is not surprising in view of the important rotational broadening of the lines.)

HD 183806 (A0p CrEuSr). Our analysis, where we have added measurements of July 1978 to those of July 1977 used by Renson and Manfroid (1978a) confirms and improves the value of the period derived by these authors.

HD 189832 (A6p SrCrEu) has a period (18.89 d) slightly longer than previously estimated by Manfroid and Renson (1983b; see also Catalano and Renson, 1984); however, an unusually large number of equidistant, close frequencies, almost equally probable, appear in the periodogram and there remains some ambiguity about the choice of the best value of the period.

HD 212385 (A3p Sr), Renson and Manfroid's (1978a) 2.48 d period, which was rather uncertain, is confirmed and the accuracy of its determination is improved.

HD 216494 (B9p HgMn). The variations that we observe in this star are small (which is not surprising for a MgMn star) and a period could not be unambiguously derived. The small projected rotational velocity, $v \sin i = 10$ km s^{-1} (Uesugi and Fukuda, 1981) may favour the largest value of the period (3.40 d).

3. Conclusion.

To conclude, let us emphasize that, although a significant improvement over the previously published data has been achieved, there remains considerable uncertainty about the choice of the best periods for most CP stars. In many instances, magnetic observations would be needed to solve annoying ambiguities, especially the possible presence of quasi-symmetric double waves. An important observational effort is obviously requested.

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TABLE I. — *The observing runs.*

Run	Date	Number of nights	Telescope
1	February 1977	25	Danish 0.5 m
2	July 1977	14	Danish 0.5 m
3	November 1977	20	Danish 0.5 m
4	July 1978	17	Bochum 0.61 m
5	December 1978	20	ESO 0.5 m
6	June 1979	24	Danish 0.5 m
7	March 1980	23	Danish 0.5 m
8	December 1980	24	Danish 0.5 m
9	September 1981	17	Danish 0.5 m
10	January 1982	13	Danish 0.5 m

TABLE II. — *Possible values of the periods.*

HD	Other id.	Run	N	C_1	C_2	f (d^{-1})	Δf (d^{-1})	P (d)	Error (d)	Rem.
9484	HR 444	9	14	10009	8556	1.44(/2.89)		0.694(/0.346)	0.005(/.001)	
22470	HR 1100	3	42	23055	22203	0.51581	0.00260	1.9387	0.0004	
		5	8	23055	22203					
27376	HR 1347	5	18	27490	24626	1.0425		0.959	0.006	
						0.5175		1.93	0.02	
						0.117		8.5	0.7	
						1.121/0.561		0.891/1.78	0.008/0.03	
29305	HR 1465	3	40	27604		0.33975		2.9433	0.0004	
		5	9	27604						
		9	9	27604						
		10	6	27604						
36916	BD−4° 1173	3	36	37077	37410	0.638896		1.5652	0.0001	
		5	7	37077	37410					
		9	6	37077						
		10	8	37077						
37808	HR 1957	3	33	37507	37635	0.91241	0.00257	1.0960	0.0001	
		5	8	37507	37635					
41089	CoD−42° 2282	8	33	42303	41742	0.72539	0.00094	1.37857	0.00008	a
42536	HR 2195	5	21	42690	41794	0.735		1.36	0.02	
54118	HR 2683	8	33	52622	57969	0.30531	0.00091	3.2754	0.0005	b
61966	HR 2971	8	26	62400	61435	0.037		27.0	3.5	
						0.966		1.035	0.005	
						1.039		0.962	0.005	
66255	HR 3151	1	41	66210	66192	0.14671	0.00149	6.816	0.005	
		5	8	66210	66192					
66605	CoD−44° 3980	1	33	65211		0.44835	0.00148	2.2304	0.0005	
		5	8	65211						
66624	HR 3162	8	27	65925	66358	0.49795	0.00256	2.0082	0.0004	
		10	7	65925	66358					
73340	HR 3413	1	33	73127	71043	0.37489	0.00148	2.66745	0.0007	
		5	8	73127	71043					
83625	CpD−53° 2664	1	30	82856	84228	0.92435	0.00148	1.08184	0.00015	
		5	8	82856	84228					

Table II *(continued)*.

90044	HR 4082	7	28	90882		0.228		4.39	0.06	c
90763	HR 4109	7	24	90430	90882	0.280(/0.560)		3.57(/1.786)	0.02(/0.005)	
						1.57		0.637	0.004	
96616	HR 4327	1	13	98176	95370	0.40994	0.000883	2.4394	0.0003	
		7	30	98176	95370					
148898	HR 6153	6	20	147084	150453	0.559		1.79	0.02	
						0.215(/0.43)		4.67(/2.33)	0.08(/0.02)	
164258	HR 6709	6	15	161868	164259	1.39(/2.78)		0.719(/0.359)	0.005(/0.001)	
166469	HR 6802	2	18	167666	168646	0.34656	0.00269	2.8855	0.0008	
		4	13	167666	168646					
170397	HR 6932	2	14	170902	171130	0.45637	0.00265	2.1912	0.0005	
		4	11	170902	171130					
		9	9	171130						
177517	HR 7230	2	12	177817		2.96103	0.00269	0.33772	0.00002	
		4	4	177817		2.05033	0.00270	0.48773	0.00002	
183806	HR 7416	2	20	181623	183007	0.34231	0.00267	2.9213	0.0008	
		4	13	181623	183007					
189832	CoD−39° 13583	2	17	189388	191889	0.05295	0.00066	18.89	0.04	d
		4	8	189388	191889					
		9	14	189388	191889					
199728	HR 8033	2	14	200761	201184	0.44626	0.00269	2.24085	0.0005	
		4	16	200761	201184					
212385	CoD−39° 14697	2	14	214085	214150	0.3958	0.0027	2.5265	0.0015	
		4	15	214085	214150					
216494	HR 8704	9	17	217376		1.3805		0.724	0.005	
						0.79		1.27	0.02	
						0.295(/0.588)		3.40(/1.70)	0.1(/0.03)	
221006	HR 8919	2	12	224392	218631	0.43200	0.00264	2.3148	0.0004	
		4	11	224392	218631					
		9	11	219571	224686					

Remarks to table II.

(a) The sample has been augmented by inclusion of 17 measurements obtained between September and December 1983, within the frame of the ESO Long Term Photometric Programme (with the same comparison stars). (b) The sample has been augmented by inclusion of 9 measurements obtained in December 1983 within the frame of the ESO Long Term Photometric Programme (with the same comparison stars). (c) The sample has been augmented by the inclusion of 13 measurements obtained between December 1982 and December 1983 in the frame of the ESO Long Term Photometric Programme (with the same comparison star); the poor quality of these data, mainly due to the use of various instrumental configurations, is responsible for the pretty large uncertainty on the period. (d) Frequencies $f + 4n\Delta f$ are the most probable ones.