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On slow rotation of CP stars

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Abstract. The distribution of the relative number of chemically peculiar (CP) stars for the rotational velocity is studied. The lower the velocity of rotation the larger the relative number of Cp stars of the SrCrEu and AM types. The distribution maximum of SrCrEu stars is at $V \sin i \approx 0 - 10$ km/s. This distribution for He-r, He-w, HgMn, Si stars is similar to that for the above mentioned group but the maximum is at $V \sin i \approx 15$ km/s. The derived relations suggest that the slow rotation is the basic cause for diffusion of chemical elements. Apparently, the slow rotation favours the stabilization of the atmospheres of stars at which the conditions appear for the magnetic field to be preserved. The slower the star rotates the higher the probability of preservation of the relic magnetic field and diffusion of chemical elements leading to chemical anomalies.

Key words: stars: magnetic chemically peculiar — stars: rotation

1. Introduction

It has long been known that the chemically peculiar stars have on the average lower rotational velocities than the main sequence normal stars. Stepien (2000) and Stepien, Landstreet (2002) give arguments favouring the assumption that the magnetic chemically peculiar (CP) stars might have lost their angular momentum under the action of magnetic field at the time of the "pre-main sequence" evolution. The loss of the angular momentum must be greater for stars with small masses because of their longer, as compared to more massive CP stars, time of the "pre-main sequence" evolution.

In our paper (Glagolevskij, Chountonov 2001) it is shown that the lower the rotational velocity the larger the relative number of CP stars N/N(norm). It may indicate that the relic magnetic field might be preserved in initially slow rotators. The authors discuss another possible cause of slow rotation of CP stars. The distribution N/N(norm)—$V \sin i$ for stars of various masses is presented in the above mentioned paper. However, low-mass (SrCrEu) and massive (Si, He-w, He-r) stars differ by the fact that among the latter there are practically no stars with large periods ($P > 25^d$). For this reason, it would be of interest to study the relation N/N(norm) versus $V \sin i$ for massive and low-mass stars in more detail.

The variation of the rotation periods $\lg P$ with temperature (mass) for CP stars of all types is displayed in Fig. 1. It has been plotted using the data of Catalano, Renson (1998) and Glagolevskij (2002). Stepien (2000) and Stepien, Landstreet (2002) consider the relation of the rotation period of CP stars and their masses. Since there were no data for masses of CP stars available to us, we studied the dependence upon temperature. It is well seen from the figure that the stars with very large periods are observed only at $T_e < 11000$ K, these are mainly the SrCrEu stars. This is why, in further considerations we divide the stars into massive and low-mass ones using this temperature criterion.

The stars with known rotation periods P are considerably fewer than those with known $V \sin i$, and the use of P leads to unreliable results. So, when plotting relations, we used rotational velocities.

Our task consisted in determination of the relative number of CP stars with respect to normal stars, N/N(norm), for various $V \sin i$. For this purpose, the latest published data on the rotational velocities of CP stars were employed (see Table 1). To construct the distribution of normal stars, the data from the catalogue of Uesugi, Fukuda (1982) were taken. When considering the relationship, the following should be kept in mind.

1. The lists of rotational velocities of stars of V, IV, III luminosity classes are not complete because not for all of them the luminosity classes and rotational velocities are known (we are interested only in the main sequence stars the magnetic CP stars belong to).

2. The lists of CP stars should not be treated as complete either because the border between nor-

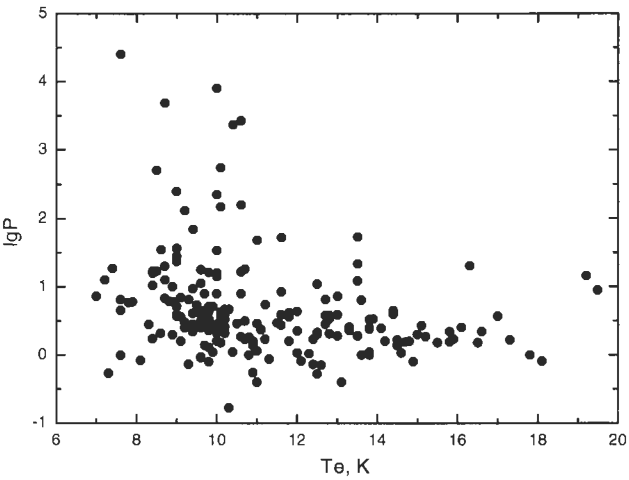

Figure 1: *Variation of the rotation periods (lgP) with temperature (mass) for CP stars.*

mal and peculiar stars is blurred and possibly some of stars are not related to CP stars yet. For many stars $V \sin i$ are not derived. Therefore it is impossible to determine accurately the number of CP stars among all stars having the same temperature and being in the same range of stellar magnitudes. However, we take interest, first of all, in the behaviour of N/N(norm) dependence on $V \sin i$, which can be reliable enough despite the data incompleteness.

2. List of $V \sin i$

The list of the $V \sin i$ values for the CP stars is presented in Table 1. The sources of the initial data are the papers by Klochkova, Kopylov (1985), Abt, Morrell (1995), and Uesugi, Fukuda (1982), hereafter designated as (KK), (AM) and (UF). The mean value of $V \sin i$ is computed with a weight equal to the number of determinations. So, for the first and second sources the weight is equal to 1, while for the data of the catalogue (UF) the weight is equal to the number of sources from which the mean value was derived. The weighted mean values of $V \sin i$ are listed in the sixth column of Table 1, the seventh column shows the peculiarity type. The fifth column of the table gives $V \sin i < 10$ km/s. We adopted this value for the stars which have the rotation period $P > 25^d$. When using the known formula for the rotational velocity at the star's equator, $v = 50.6 \cdot R/P$, then for the stars with the radius $R < 5R_\odot$ (i.e. for the majority of CP stars) $V \sin i$ is < 10 km/s at any angle i. Because of measurement errors, $V \sin i > 10$ km/s is frequently ascribed to such stars, as can be seen from Table 1. For stars with $P > 25^d$, we have always taken the mean value $V \sin i = 0$.

3. The number of SrCrEu stars among normal stars

The range of masses of the SrCrEu type stars is of interest because practically all the slowest rotators ($P > 25^d$), which assumingly (Stepien, Landstreet 2002) underwent "magnetic" braking at the stage of the "pre-main sequence" evolution, are concentrated in it. So, we may assume that the relation between the number of CP stars among all stars and $V \sin i$ found in the paper by Glagolevskij, Chountonov (2001) can be violated due to the strong effect of the magnetic field if the loss of the angular momentum occurred under the action of the magnetic field. First of all, we are interested in the part played by the magnetic field in the braking of CP stars.

First the relationship between the number of normal stars N(norm) and $V \sin i$ was plotted from the data of Uesugi, Fucuda (1982). A total of 827 normal main sequence stars was involved. Then the number of CP stars (62 stars) with various $V \sin i$ was derived. Fig. 2A shows the variation of the relative number of SrCrEu stars N/N(norm) with variation of $V \sin i$ plotted from the data of Table 1. The solid line shows the mean relationship in the form of a second-degree polynomial, which was plotted by the least squares method. It is well seen that the lower the rotational velocity the greater the number of CP stars among the normal stars. This result is completely consistent with the results of the paper by Glagolevskij, Chountonov (2001). Each point in Fig. 2 and further is the mean value within narrow $V \sin i$ intervals.

4. The number of metallic-line stars among normal stars

It is interesting to study the distribution of metallic-line stars without magnetic field which could affect the rotational velocity. The distribution for the rotational velocities for the normal stars is taken the same as that taken for the SrCrEu stars because the metallic-line stars are in the same range of temperatures. The rotational velocities for 147 Am stars are taken from the catalogue of Uesugi, Fukuda (1982), they are lacking in Table. 1. The variation of the relative number of Am stars depending on $V \sin i$ is shown in Fig. 2B from which it follows that the relation derived is basically the same as in the case of the SrCrEu stars. A rise towards low rotational velocities is seen. The difference is only in that the relationship for the SrCrEu stars is shifted towards lower velocities as compared to the metallic-line stars, their mean velocity is twice as low. The fact that the relative number N/N(norm) grows with decreasing rotational velocity is common to both types, the difference is that there is no magnetic field in the latter.

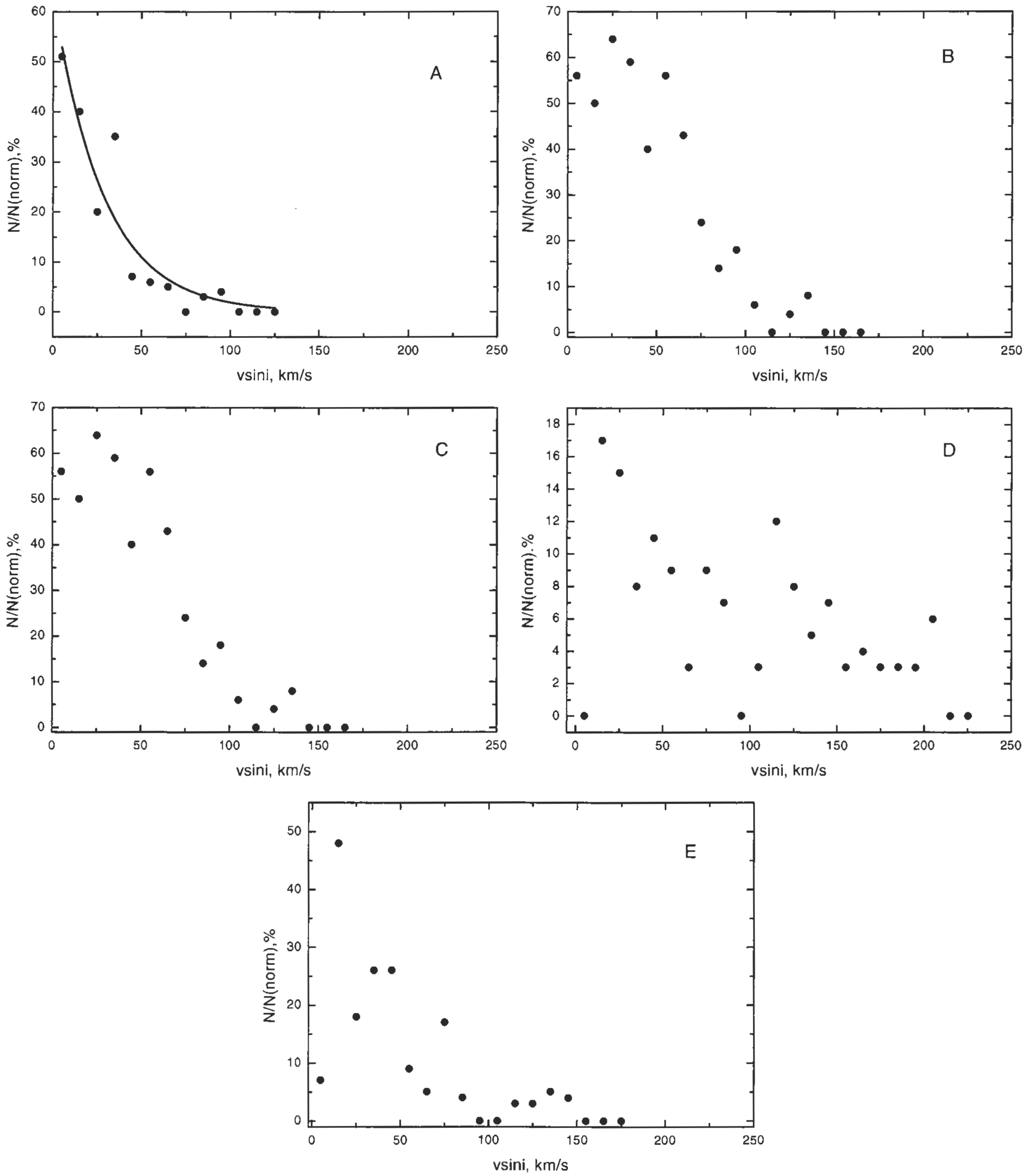

Figure 2: *Variation of the number of CP stars among the main sequence stars with rotational velocity V sini.*
A — SrCrEu stars,
B — Am stars,
C — Si stars,
D — He-rich and He-weak stars,
E — HgMn stars.

5. The number of Si stars among normal stars

Stepien and Landsreet (2002) showed that the magnetic braking is effective only in low-mass stars (mainly of the SrCrEu type) because of their long stay at the "pre-main sequence" stage. We care for a numerous group of CP stars with Si anomalies which borders on the SrCrEu group as for their masses and

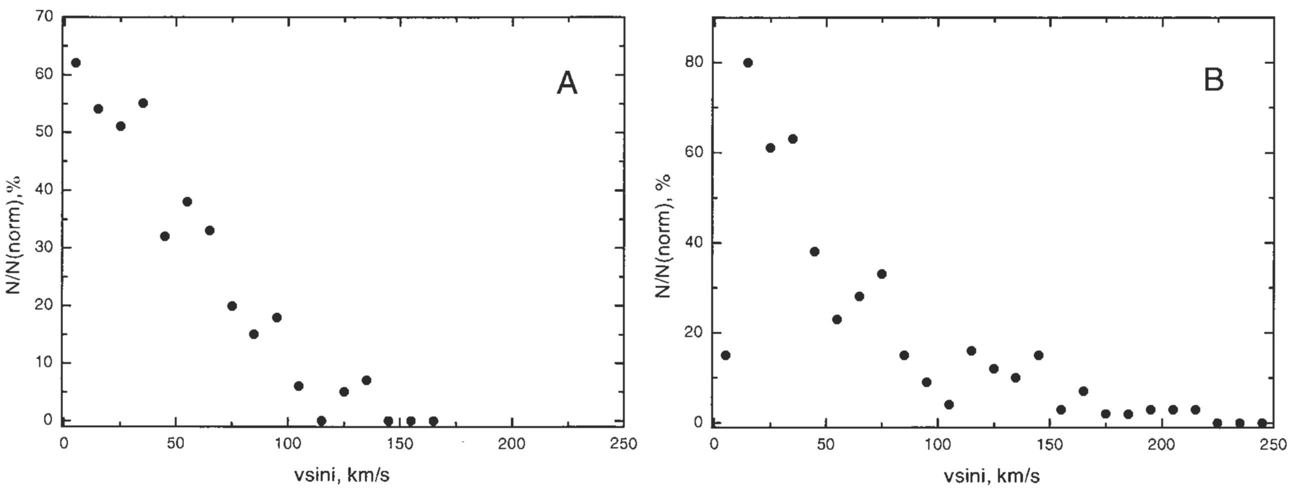

Figure 3: *Variation of the number of low massive (T_e < 11000 K) (A) and massive (T_e > 11000 K) (B) CP stars with V sini.*

does not contain very slow rotators. These stars lie in the region of spectral classes B5–A2. The relationship N—$V \sin i$ for normal main sequence stars of this type was plotted from the data of the catalogue (Uesugi, Fukuda 1982). A total of 990 normal main sequence stars and 80 CP stars was involved. Fig. 2C shows a diagram of the relative number of Si stars N/N(norm) as a function of rotational velocity $V \sin i$. The same as for the SrCrEu and Am stars the number of Si stars is well seen to increase with decreasing rotational velocity. However, in contrast to them the maximum is at $V \sin i \approx 25$ km/s but not at $V \sin i = 0 - 10$ km/s.

Thus in the case of Si stars a typical growth of their number is observed with decreasing rotational velocity. This is the basic conclusion.

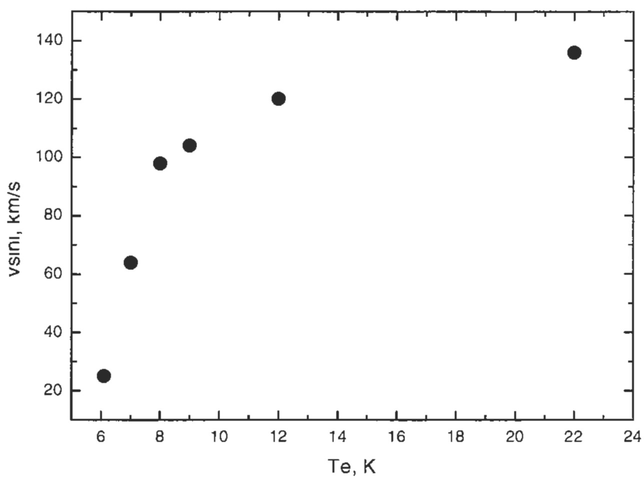

Figure 4: *Variation of the mean rotational velocity of the main sequence normal stars versus the star temperature (mass).*

6. The number of He-rich and He-weak stars

We have plotted in a similar manner the relationship N/N(norm) vrs $V \sin i$ for the He-rich and He-weak stars. These stars occupy the region of spectral classes B0–B8. Over 850 normal main sequence stars are collected in the catalogue (Uesugi, Fukuda 1982). The number of CP stars is very small, 45, because of this, the relationship proved to have a considerable scatter of points (Fig. 2D). Nevertheless, a rise towards small $V \sin i$ is well seen, the same as in the case of the stars of the peculiarity types discussed above. The maximum of the relation falls on $V \sin i \approx 15$ km/s.

7. HgMn stars

The HgMn stars are located in the same temperature range as the He-rich and He-weak stars. For this reason, when deriving N/N(norm), the same distribution N(norm) — $V \sin i$ was used. Our list contains 61 HgMn stars. This is why, the scatter of points in the relation N/N(norm) vrs $V \sin i$ (Fig. 2E) is rather great. Attention is attracted by the fact that in the region 0–10 km/s the number of stars is relatively small, whereas in the region 15 km/s a maximum is observed, as in the case of the He-rich and He-weak types. For low-mass SrCrEu and Am stars the maximum falls within 0–10 km/s.

8. Conclusions

Based on the data presented above, it is quite clear that a common relationship is observed for stars of all peculiarity types — the lower the rotational velocity the higher the probability of formation of magnetic chemically peculiar stars. It is shown in the papers by

Glagolevskij, Chountonov (2002), Glagolevskij (2003) that there is no evidence that the magnetic field was involved in the process of braking the CP stars. Therefore, the magnetic field had no effect on the relationship considered. Note, the metallic-line and HgMn stars also have reduced rotational velocities and chemical anomalies, although there is no magnetic field in them. Apparently, the originally low rotational velocity of stars favours both the appearance of chemical anomalies and preserving of the relic magnetic field. Abt, Morrell (1995) have also concluded that the stellar rotation is the only parameter which determines whether the star will have a normal or abnormal spectrum. It is evident that in the case of slow rotation the effects of mixing are weakened. This is why, favourable conditions arise for diffusion of chemical elements. The absence of the mixing effect (meridional circulation and, first of all, differential rotation) enables also the relic magnetic field to be preserved. Then, the difference between the magnetic and nonmagnetic peculiar stars is still open to question.

Considering the common relation between N/N(norm) and $V \sin i$ in Fig. 3A for the SrCrEu and Am stars, it is seen that with $V \sin i = 0 - 10$ km/s their fraction among the normal stars is 60 %, that is, a considerable part of slow rotators becomes chemically anomalous. It should be taken into account that the objects in which anomalies are strong enough are usually referred to chemically peculiar stars. However, there exist objects with relatively weak anomalies, which were not related to the CP class because of difficulties of their detection. When these stars are taken into account, the relative number of normal stars will become even smaller. The relation N/N(norm)—$V \sin i$ for the magnetic and nonmagnetic peculiar stars is the same, therefore, the main cause of chemical anomalies is the same, namely, the rotation.

The problem of absence of extremely slow rotators among stars more massive than the SrCrEu stars still exists. The extremely slow rotation of low-mass stars is likely to be associated with the initial conditions of the origin of stars. Unfortunately, it is impossible to estimate the periods of rotation of normal stars in the same temperature range. However, Fig. 4 shows that the rotational velocities of normal stars with $T_e < 11000$ K decrease sharply in comparison with more massive stars and there is no need for additional "magnetic" braking of late type CP stars.

Fig. 3A, B presents the mean relations N/N(norm)—$V \sin i$ for low-mass and massive stars. These relations show reliably the growth of the number of CP stars towards decreasing rotational velocities. However, one can notice violation of this regularity consisting in the fact that stars with $V \sin i = 0 - 10$ km/s are lacking in the latter. That is, the regularity "the lower the rotational velocity the higher the probability of preservation of the magnetic field and appearance of diffusion of chemical elements" is violated in this narrow range. This presents a difficulty of the hypothesis of formation of CP stars from slow rotators. It can be seen from Fig. 4 that the relative number of low-mass CP stars with $V \sin i = 0 - 10$ km/s accounts for 62 %, while the number of those with $V \sin i = 10 - 20$ km/s makes 54 %. At the same time the relative number of massive stars in the same ranges is equal to 18 % and 80 %. The cause of violation may be both physical and methodological. In the range 0–10 km/s there appear great errors in estimations of rotational velocities, this is well seen in Table 1. For low-mass stars the estimates are more reliable because the periods of rotation are known. And one more note can be done: the lack of CP stars with values $V \sin i \sim 0 - 10$ km/s may happen as a result of the magnetic intensification of the spectral lines.

Acknowledgements. This work was financially supported by grant "Astronomy", RAS.

Table 1: *$V \sin i$ for Cp stars*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
225289	-	-	55	-	55-	HgMn
315	-	- 70	-	-	70	Si
358 7 53	-	55	-	55	HgMn	
952	-	65	-	-	65	Si
1048	-	20	-	-	20	Si
1909	-	-	0	-	0	HgMn
2453	-	-	<5	0	0	SrCrEu
3322	-	-	40	-	40	HgMn
3326	-	98	-	-	98	SrCrEu
4335	-	-	30	-	30	HgMn

Table 1: *V sin i for Cp stars (continued)*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
4778	-	- 33	-	-	33	SrCrEu
5737	-	-	10	-	10	He-w
5797	-	-	<5	0	0	SrCrEu
7374	-	-	30	-	30	HgMn
8441	-	-	<5	0	0	SrCrEu
9298	-	-	70	-	70	HgMn
9484	-	15	-	-	15	Si
9996	-	23	50	0	0	SrCrEu
10221	-	10	25	-	21	Si+
11291	-	-	35	-	35	HgMn
11415	37	-	15	-	19	He-w
11503	62	185?	60	-	60	Si+
11529	16	-	55	-	45	He-w
11905	-	-	10	-	10	HgMn
12288	-	-	<5	0	0	SrCrEu
12447	-	70	70	-	70	Si+
12767	-	35	95	-	65	Si
14392	91	70	80	-	80	Si
14437	-	-	-	0	0	SrCrEu
15089	-	40	50	-	49	SrCrEu
15144	20	23	15	-	17	SrCrEu
16004	-	-	45	-	45	HgMn
16605	13	-	-	-	13	SrCrEu
16693	22	-	25	-	24	HgMn
16705	75	-	100	10	88	He-w
16728	84	-	80	-	81	He-w
18296	-	10	25	-	22	Si+
19400	-	-	75	-	75	He-w
19805	15	-	<20	-	18	He-w
19832	-	85	115	-	105	Si
20135	27	-	35	-	31	Ap
20283	-	215:	-	-	215:	Si
21699	37	-	100	-	112	HgMn
22114	75	-	-	-	75	He-w
22136	27	-	25	-	26	He-w
22327	75	-	-	-	75	He-w
22401	37	-	35	-	36	SrCrEu
22470	-	65	80	-	75	He-w
23387	27	-	18	-	21	He-w
23408	-	-	38	-	38	He-w
23950	75	-	145	-	133	HgMn
23964	18	-	60	-	54	He-w
24321	180	-	-	-	180	He-w
24712	-	<10	<5	-	<10 SrCrEu	
25267	-	20	34	-	31	Si
25823	23	15	21	-	20	Si
26961	-	70	95	-	90	Si
27297	-	-	10	-	10	HgMn

Table 1: V *sin* i *for Cp stars (continued)*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
27309	43	35	46	-	44	Si+
27376	-	-	15	-	15	HgMn
28929	-	-	85	-	85	HgMn
29589	-	-	70	-	70	HgMn
32549	43	30	30	-	33	Si
32650	-	15	30	-	26	Si
33647	-	-	40	-	40	HgMn
33654	-	50	55	-	54	Si
33904	21	-	20	-	20	HgMn
34452	-	40	44	-	43	Si
34719	57	-	-	-	57	Si
34880	-	-	60	-	60	HgMn
35298	-	-	260	-	260	He-w
35502	-	-	290	-	290	He-w
35912	-	-	45	-	45	He-r
36629	-	-	25	-	25	He-w
36881	-	-	25	-	25	HgMn
36982	-	-	135	-	135	He-r
37043	-	-	125	-	125	He-w
37017	-	-	110	-	110	He-r
37058	-	-	25	-	25	He-w
37129	-	-	65	-	65	He-w
37235	-	-	300	-	300	He-w
37321	-	-	100	-	100	He-r
37519	-	-	255	-	255	HgMn
37776	-	-	135	-	135	He-r
38104	37	21	30	-	30	SrCrEu
38478	-	-	70	-	70	HgMn
39317	-	30	30	-	30	Si+
40394	-	10	-	-	10	Si+
42536	-	25	-	-	25	SrCrEu
42657	-	-	75	-	75	HgMn
43812	-	10	165	-	88:	Si
47152	-	25	110	-	89	SrCrEu
49606	-	-	45	-	45	He-w
49976	-	23	-	-	23	SrCrEu
51684	-	-	-	0	0	SrCrEu
51688	-	-	55	-	55	HgMn?
54118	-	-	50	-	50	Si
55719	-	-	95	0	0	SrCrEu
57219	-	-	165	-	165	He-r
58260	-	-	100	-	100	He-r
58661	-	-	35	-	35	HgMn
59256	-	75	-	-	75	SrCrEu
61468	-	-	-	0	0	SrCrEu
62140	-	18	-	-	18	SrCrEu
62510	-	110	90	-	97	Si
64740	-	-	355	-	355	He-r

Table 1: *V sin i for Cp stars (continued)*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
65949	-	-	20	-	20	HgMn
65950	-	-	30	-	30	HgMn
68351	-	25	30	-	29	Si+
70340	-	25	-	-	25	SrCrEu
72208	-	15	-	-	15	HgMn
72968	-	10	15	-	13	SrCrEu
74196	-	-	235	-	235	He-w
74521	27	10	20	-	19	SrCrEu
75333	27	-	30	-	29	HgMn
77350	22	<10	20	-	19	Si
78316	-	-	15	-	15	HgMn
78702	-	205:	-	-	205:	SrCrEu
79447	-	-	10	-	10	He-r
79158	-	40	25	-	33	HgMn
79752	-	245:	200	-	215	SrCrEu
81009	-	10	<10	0	0	SrCrEu
82984	-	-	120	-	120	He-w
83373	-	20	<30	-	27	SrCrEu
90044	-	15	-	-	15	Si+
90264	-	-	110:	-	110:	He-w
90569	-	<10	30	-	27	SrCrEu
89822	-	<10	15	-	14	Si+
90763	-	30	-	-	30	SrCrEu
92938	-	-	145	-	145	He-r
93507	-	-	-	0	0	Si+
94334	-	35	25	-	27	Si
94660	-	-	-	0	0	Si+
96707	-	33	45	-	39	SrCrEu
97411	-	25	45	-	38	Si
98088	-	31	25	-	28	SrCrEu
34°755	84	-	-	-	84	Si+?
101189	-	-	15	-	15	HgMn
106625	-	-	40	-	40	HgMn
106661	-	175	175	-	175	Si
107612	37	-	-	-	37	SrCrEu
108662	16	10	20	-	18	SrCrEu
108945	62	65	60	-	61	SrCrEu
109026	-	-	205	-	205	He-w
109860	-	60	30	-	40	Si
110066	-	21	-	0	0	SrCrEu
110073	-	-	30	-	30	HgMn
111133	-	10	10	-	10	SrCrEu
112185	32	25	35	-	34	SrCrEu
112413	-	-	30	-	30	SrCrEu
116114	-	-	-	0	0	SrCrEu
116458	-	-	<45	0	0	He-w?
118022	27	13	15	-	16	SrCrEu
118054	58	50	-	-	54	SrCrEu

Table 1: *V sin i for Cp stars (continued)*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
119213	-	25	-	-	25	SrCrEu
120198	-	45	30	-	35	SrCrEu
120640	-	-	85	-	85	He-r
120709	-	-	20	-	20	He-w
124224	-	115	115	-	115	Si
125248	-	10	15	-	14	SrCrEu
125823	-	-	304	-	304	He-w
126515	-	-	<5	0	0	SrCrEu
129174	-	-	20	-	20	HgMn
130158	60	55	50	-	55	Si
130557	50	55	80	-	62	Si+
130559A	22	45	20	-	25	SrCrEu
130559B	32	-	-	-	32	SrCrEu
130652	33	-	-	-	33	Si
133029	-	30	<20	-	25	Si+
133518	-	-	110	-	110	He-r
134214	-	-	-	0	0	SrCrEu
134759	58	45	50	-	50	Si
137909	-	18	20	-	20	SrCrEu
138764	27	-	20	-	21	Si?
139160	15	-	170	-	131	He-w
140160	-	65	60	-	62	SrCrEu
140728	-	65	65	-	65	Si+
142250	27	-	60	-	53	He-w
142301	66	-	50	-	55	He-w
142884	130	-	180	-	168	He-w
142990	-	-	185	-	185	He-w
143699	-	-	195	-	195	He-w
143807	22	-	10	-	12	HgMn
144206	-	-	10	-	10	HgMn
144334	53	-	45	-	48	He-w
144661	58	-	55	-	58	He-w
144844	20	25	115	-	78	He-w
144897	-	-	-	0	0	SrCrEu
145102	20	-	40	-	33	Si
145389	-	10	15	-	14	HgMn
145501	-	-	70	-	70	He-w
145788	-	10	<30	-	20	Si
146001	-	-	205	-	205	He-w
146254	-	140	-	-	140	Si
147010	28	-	25	-	26	Si+
145792	22	-	25	-	24	He-w
147869	-	55	-	-	55	SrCrEu
147890	65	-	30	-	39	Si
148112	52	35	25	-	31	SrCrEu
148199	15	-	20	-	19	Si
148330	-	10	-	-	10	Si+
148579	160	-	185	-	177	He-w

Table 1: *V sin i for Cp stars (continued)*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
148898	-	51	35	-	40	SrCrEu
149822	-	55	95	-	75	Si+
149911	-	45	-	-	45	SrCrEu
151199	-	48	115	-	81	SrCrEu
151346	46	-	<20	-	33	He-w
151525	-	35	-	-	35	SrCrEu
152107	22	35	30	-	27	SrCrEu
152308	-	95	-	-	95	SrCrEu
153882	-	15	25	-	20	SrCrEu
155102	-	30	45	-	38	Si
157779	-	65	85	-	81	Si
158704	10	-	-	-	10	SrCrEu?
159376	15	35	-	-	25	Si
159973	-	-	135	-	135	HgMn
318107	-	-	-	0	0	SrCrEu
161701	15	-	25	-	20	HgMn
162374	-	-	40	-	40	He-w
164258	-	50	65	-	58	SrCrEu
164429	-	85	210:	-	148	Si+
165474	-	18	15	-	16	SrCrEu
166469	-	15	-	-	15	Si
166473	-	-	-	0	0	SrCrEu
169467	-	-	20	-	20	He-r
170000	-	65	85	-	82	Si
170397	-	30	40	-	35	Si
170973	-	10	20	-	17	Si+
171247	-	65	-	-	65	Si
172044	-	-	45	-	45	HgMn
172883	-	-	70	-	70	HgMn
173524A	16	-	15	-	15	HgMn
173524B	10	-	-	-	10	Si
173650	-	25	20	-	22	Si+
174933	16	-	20	-	19	He-w?
175156	-	-	15	-	15	He-r
175744	50	-	70	-	60	Si
175869	145	-	120	-	128	HgMn
176232	-	10	10	-	10	SrCrEu
177003	-	-	15	-	15	He-r
177517	-	90	95	-	94	Si
179527	-	20	35	-	30	Si
182568	-	-	155	-	155	He-w
183056	-	20	35	-	31	Si
183339	37	-	-	-	37	He-w
184927	-	-	140	-	140	He-r
184961	28	-	45	-	39	SrCrEu
186205	-	-	170	-	170	He-r
187474	-	-	10	0	0	Si+
188041	-	40	5	0	0	SrCrEu

Table 1: *V sin i for Cp stars (continued)*

HD	$V \sin i$ (KK)	$V \sin i$ (AM)	$V \sin i$ (UF)	$V \sin i$ ($P > 25^d$)	$V \sin i$ (mean)	type
189832	-	-	-	0	0	SrCrEu
190229	10	-	30	-	33	HgMn
191980	-	-	80	-	80	He-w
191984	-	150	-	-	150	SrCrEu
196502	-	10	10	-	10	SrCrEu
199728	-	60	-	-	60	Si
200311	-	-	-	0	0	He-w?
201834	-	15	-	-	15	Si
202149	-	-	40	-	40	HgMn
202671	-	-	35	-	35	He-w
204131	50	35	-	-	43	Si+
204411	-	15	10	-	11	Si
205087	-	15	35	-	25	Si+
205116	32	-	95	-	74	He-w
206088	-	31	25	-	26	SrCrEu
207538	-	-	50	-	50	He-r
207857	-	-	15	-	15	HgMn
208266	-	-	140	-	140	HgMn
209339	-	-	220	-	220	HgMn
209515	63	-	85	-	80	SrCrEu
210071	-	75	-	-	75	Si
210873	37	-	45	-	41	HgMn
211838	-	-	65	-	65	HgMn
213236	-	-	30	-	30	HgMn
216494	-	-	10	-	10	HgMn
215907	-	120	80	-	93	Si
217477	-	-	40	-	40	HgMn
217919	-	-	265	-	265	He-w
219749	-	65	85	-	78	Si
221394	-	35	-	-	35	SrCrEu
220575	-	-	35	-	35	HgMn
220825	35	30	40	-	38	SrCrEu
220933	-	-	45	-	45	HgMn
221507	-	-	10	-	10	HgMn
223358	-	68	-	-	68	SrCrEu
223640	-	20	30	-	28	Si
224801	-	25	45	-	38	Si+
224906	-	-	50	-	50	HgMn
224926	-	-	75	-	75	HgM

Notes:
(KK) - Klochkova, Kopylov, 1985; (AM) - Abt, Morrell, 1995; (UF) - Uesugi, Fukuda, 1982.

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