ON THE DUPLICITY OF CP3 STARS

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Abstract : Out of 111 CP3 stars 56.7 percent are binaries and further 15.3 percent are probable binaries. The distribution of the periods shows a maximum around 7 days and the deficit of periods <3 days is remarkable. Systems with periods <15 days seem to rotate synchronously, while wider binaries do not. Photometric observations confirm these, and, in addition, point to an occurance of slow pulsation.

I. Introduction

The catalogue of Hg-Mn (CP3) stars [1] contains 127 stars of which 102 are certain members of this group. The remaining stars are called 'suspected' (only one or different classification). During the last years it turned out that 16 stars from the latter subgroup are certainly CP3 stars, while 3 stars should be put back in the subgroup 'suspected', so I get 111 definite CP3 stars (literature updated until 1984), on which the following investigation will be concentrated.

II. Frequency of binaries

From the 111 stars 17 are SB2 systems (including the eclipsing binary AR Aur), 24 are SB1, and 14 have variable radial velocity or remarks about SB character in the literature. These 55 stars represent 49.5% of the sample. If I include the stars which occur in visual binary systems (7.2%) I get a value of 56.7%, which is slightly higher than the frequency of binaries among normal stars within the same spectral range.

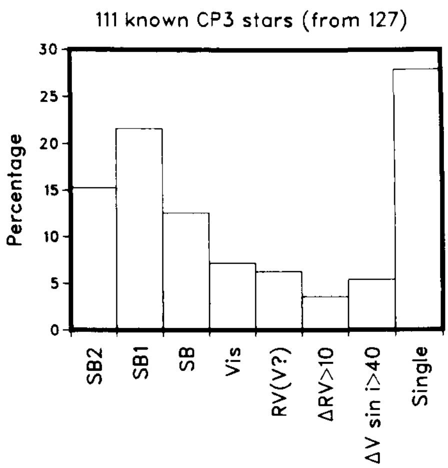

Fig. 1 : Distribution of CP3 stars of the groups as described in the text.

In general spectroscopic binaries will be detected by variable radial velocity (RV) or double-line patterns. If the double-line structure can not be separated, it results in variable projected rotational velocity (V sin i). During the compilation and updating of the catalogue many hints about probably vari-

C. R. Cowley et al (eds.), Upper Main Sequence Stars with Anomalous Abundances, 205–208.

able RV and differences in the published RV and V sin i data (more than 2 sources) were found for the single stars : 7 stars have remarks about probably variable RV, 4 show differences in the published RV data (>10Km/s), and 6 in the published V sin i data (>40Km/s). All together this yields 15.3%, and if one believes that all of these stars are binaries only 27.9% of the 111 CP3 stars remain to be single (many of these stars, especially cluster stars, do not have published RV and/or V sin i data). Figure 1 shows the distribution of the different groups.

From 8 stars the spectral type of both components are known : in 4 systems both show CP3 character, in one the other is a normal A5V star, while in the remaining systems the other component is classified as a metallic-line (CP1) star. This, the lack of a measurable magnetic field, and the high frequency of binaries points to a close relationship of the two groups.

III. Distribution of periods

Figure 2 presents the distribution of the periods. In comparison with the normal stars from Batten's [2] catalogue (B5-A0, III-V, without known CP and emission-line stars) the deficit of

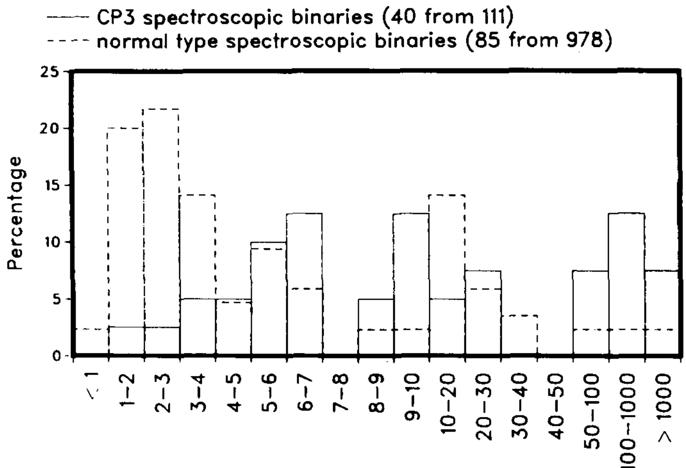

Fig. 2 : Distribution of periods [days] of the CP3 stars.

periods <3 days is remarkable (only 2 systems), while the enhancement of periods >50 days may be due to a selection effect.

If one assumes that in close systems the stars rotate synchronously and takes 90Km/s for the maximum rotational velocity (where diffusion can work), a calculation with $R=3.5R_{\odot}$ yields a period of approximately 2 days. This may explain the absence of systems with shorter periods.

IV. Rotational velocity

The distribution of the V sin i data of the systems shows a significant difference : the SB2 systems have values mainly <30Km/s while the data for the SB1 systems were more or less equally distributed. If I divide the binaries in systems with periods <15 and >15 days I find that the first group has a maximum for values <10Km/s, while the other group has one for 20-30Km/s

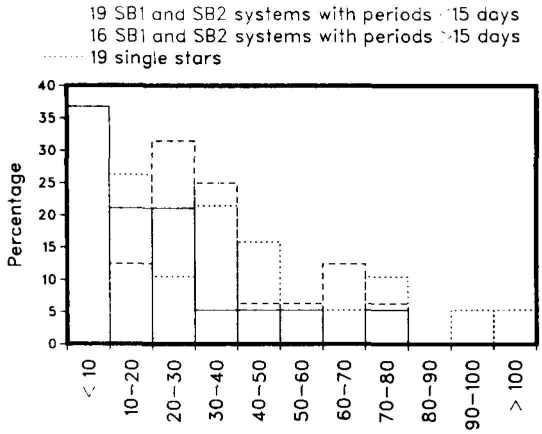

Fig. 3 : Distribution of V sin i [Km/s] of the three groups as described in the text.

(Fig. 3). Assuming random distribution for the axes I find average values for the rotational velocity of 30Km/s and 53Km/s, respectively, and for the single stars (no remarks about variable RV or V sin i) 61Km/s. Of course, one can argue that the axes are not randomly distributed, but more concentrated to smaller orbital inclinations. Checking the literature for published i data I find no evidence for the latter case : the values are more or less equally distributed with a slight peak around i=40°-50°. The low average value for the systems with periods <15 days stands in opposite to the assumption of random distribution : synchronous rotation for a star with a period of 7 days yields 37Km/s for V sin i, while from Figure 3 it is easily seen that most of the values are clearly smaller. This implies that the anomalies are more concentrated towards the pole, or that an unknown mechanism prevents synchronous rotation so that the stars really rotate more slowly.

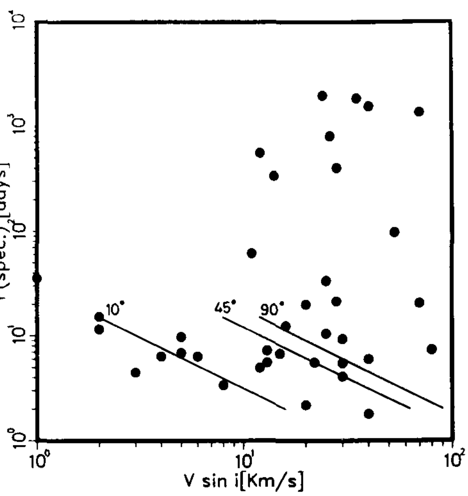

Fig.4 : Orbital periods vs. projected rotational velocity. The straight lines indicate synchronous rotation.

In Figure 4 the spectroscopic (orbital) periods are plotted versus V sin i. Assuming synchronous rotation for systems with periods <15 days (drawn in as straight lines in Figure 4, calculated with $R=3.5R_\odot$ and V=90Km/s) I find that the majority of these stars have orbital inclinations <45°, but some stars rotate with higher than synchronous velocity (see also chapter V).

The lack of long-period systems having smaller V sin i values may be due to a selection effect : the longer the periods the smaller the changes in RV and therewith the probability of discovery.

V. Photometric variability

About photometric variability of CP3 stars only little is known. Nevertheless, 17 stars are reported as variable, but because of small amplitudes (in the order of .01 mag.) the obtained periods are normally uncertain.

From 10 stars spectroscopic as well as photometric periods are known. Table I lists the periods.

Table I

HD	P(spec) [days]	P(phot) [days]	P(phot)/P(spec) =P(rot)/P(orb)
7374	~800	2.8	~211
145389	~560	7.8	~71
207857	~338	20.7	~16
143807	35.4	20-30(25)	~1.5
89822	11.6	11.5	~1
27295	4.4	4.4	1
129174	2.2	2.2	1
358	96.7	.96	~100
33647	21.4	.56	~38
27376	5.1	.51	~10

Comparing the spectroscopic (orbital) with the photometric (rotational) periods (Figure 5) I find the following : 4 systems with short orbital periods (<15 days) rotate synchronously, while 3 with long periods (>200 days) do not. Nevertheless the two groups do not show differences in rotational velocity. This means that duplicity can not be the reason for the low velocity.

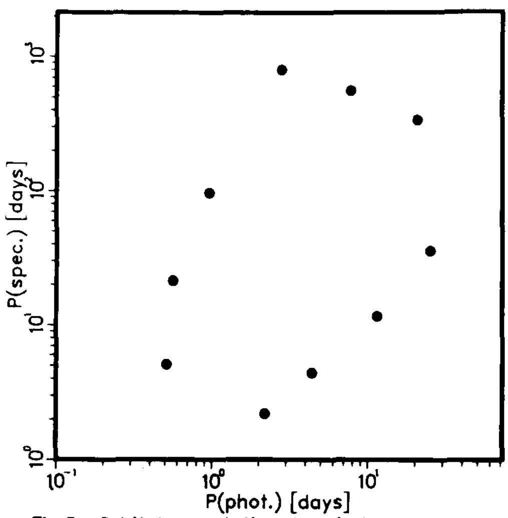

Fig.5 : Orbital vs. rotational periods.

Three systems do not fit in this picture. A straight forward estimation of their rotational velocities yields values over 150Km/s which stands in opposite to the diffusion theory. If one can trust the published periods the only explanation for this variations would be slow pulsation with periods between 12 and 24 hours decreasing with the orbital period.

References :

[1] Schneider,H. Astron.Astrophys. Suppl. 44,137 (1981)
[2] Batten,A.H.,Fletcher,J.M.,Mann,P.J. Publ. DAO **15**,121 (1978)

https://doi.org/10.1017/S0252921100091533 Published online by Cambridge University Press