DUPLICITY AMONG THE CEPHEIDS IN THE NORTHERN HEMISPHERE

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Cepheid variables in binaries are important from various points of view. These objects can in some cases provide direct information about the physical parameters of the system, can be used as tracers of stellar evolution, and the effect of the companions may influence the form of various relations (e.g. P-L-C, P-R) derived for Cepheids. While the first two advantages mentioned concern individual stars, the third involves the question of the frequency of binaries among the Cepheids. Systematic searches for binaries containing this kind of variable resulted in increasingly higher frequency of incidence: 2% (Abt 1959), 15% (Lloyd Evans 1968), >20% (Madore 1977), 25% (Pel 1978), 20%-40% (DeYoreo & Karp 1979), 35% (Madore & Fernie 1980). It was only in the early eighties that this trend ceased. The recent determinations of the incidence of binaries among the Cepheids are: 20%-40% (Gieren 1982), 18% (lower limit, Lloyd Evans 1982), 25% (Russo 1982), 25%-35% (Burki 1984). At the same time we have been going over to a qualitative era from the quantitative one, i.e. very thorough studies are now available on some individual cases of binary Cepheids (e.g. McNamara & Feltz 1981; Coulson 1983; Evans 1983; Böhm-Vitense et al. 1984).

The aim of this paper is not only to give an estimation of the percentage of binaries in a previously unused sample but also to recommend for further analysis more than twenty Cepheids suspected of having a companion.

The sample consists of the classical Cepheids whose O-C diagram has recently been constructed (Szabados 1977, 1980, 1981 & 1983). Altogether 89 northern Cepheids ($\delta > 0^{\circ}$) with B magnitude at light minimum brighter than $12^{m}.5$ were investigated. All kinds of evidence concerning the duplicity of the programme stars were then collected including spectroscopic evidence (radial velocity, IUE spectrum, etc.), photometric evidence (loops and location in two-colour diagrams, phase difference between the light and colour curves), and evidence based on the O-C diagram (periodic variations of the O-C residuals, rejump of the period). Strictly speaking, the rejump of the period ("stepwise" O-C curve) cannot be considered as evidence but rather a phenomenon observable exclusively in those Cepheids which show other signs of duplicity.

Table 1 contains a summary of the data about the duplicity of the northern Cepheids, where both the definite and the possible binaries are

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listed. In column (1) the names in parentheses are Cepheids in possible binaries. Column (2) gives the references of the various studies concerning the duplicity of the given Cepheid. Here, figures in parentheses denote those references where the binary nature of the programme star is not borne out. The key to the second column is in column (3). In addition to the 9 definite cases (10 per cent), 21 other Cepheids are suspected of having a companion (24 per cent). The well known binaries α UMi and CE Cas were not included in the programme. Although this percentage supports the reality of the earlier determinations, no numerical conclusion on the incidence of binaries among the Cepheids can be drawn.

Table 1

(1) Name	(2) References
FF Aql	1,2,(10),11,(12),13,28,29
(FM Aql)	16,28
(FN Aql)	5,28
η Aql	(12),(13),18,(28)
(RT Aur)	2,(8),(10),11,(13)
(SY Aur)	(8),11,17
(YZ Aur)	(8),16,17,32
(AN Aur)	(8),16,17,32
RW Cam	3,8,16,17,22,24
(BY Cas)	12,17
(DD Cas)	16,17,31
(X Cyg)	(7),(8),16,17,32
SU Cyg	16,17,21,22,30,31
(SZ Cyg)	12,13,16,31
(VX Cyg)	16,17
(VY Cyg)	12,13,16,17
(BZ Cyg)	12,17
(DT Cyg)	13,17,30
(V 386 Cyg)	12,16,17
(V 532 Cyg)	16,30
V 1334 Cyg	25,27
(W Gem)	(8),11,17,22,(28)
(RZ Gem)	16,17
T Mon	2,4,(12),(13),17,19,28,32
(CV Mon)	16,28,31
(RS Ori)	16,17,(28),31
SV Per	3,8,14,15,16,17,22,32
AW Per	2,6,13,16,17,20,22,23,26,31
S Sge	2,9,12,13,17,28
(SZ Tau)	16,30

(3) Key to references

1 Abt (1959)
2 Balona (1977)
3 Böhm-Vitense et al. (1984)
4 Coulson (1983)
5 Dean (1977)
6 Evans (1983)
7 Evans (1984)
8 Harris (1981)
9 Herbig & Moore (1952)
10 Hutchinson (1977)
11 Janot-Pacheco (1976)
12 Kurochkin (1966)
13 Lloyd Evans (1968)
14 Lloyd Evans (1982)
15 Lloyd Evans (1984)
16 Madore (1977)
17 Madore & Fernie (1980)
18 Mariska et al. (1980 a)
19 Mariska et al. (1980 b)
20 McNamara & Chapman (1977)
21 McNamara & Feltz (1981)
22 Mianes (1963)
23 Miller & Preston (1964 a)
24 Miller & Preston (1964 b)
25 Millis (1969)
26 Oosterhoff (1960)
27 Parsons (1981)
28 Pel (1978)
29 Plaut (1934)
30 Szabados (1977)
31 Szabados (1980)
32 Szabados (1981)

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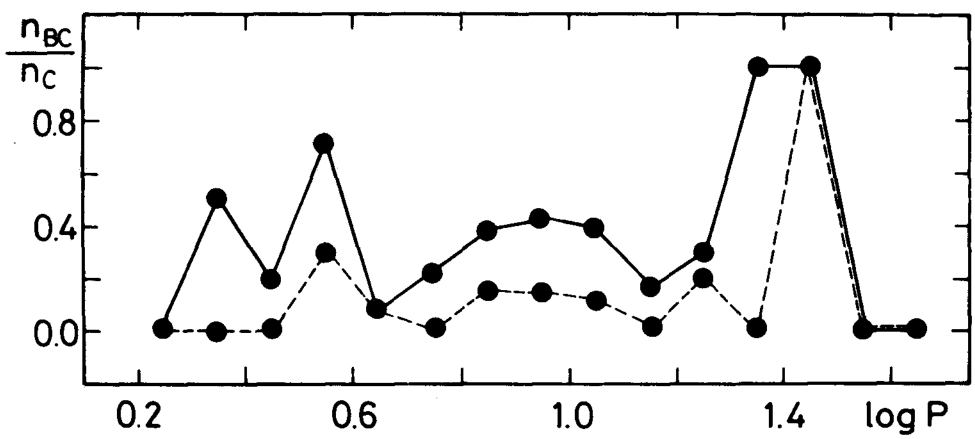
The uncertainty arising from the possible binaries can only be diminished by further observations. In particular, spectroscopic observations are needed to this end since almost all the suspected northern Cepheid binaries lack this kind of observational data.

Figure 1 shows the frequency of binary Cepheids as a function of the logarithm of period (n_{BC} = number of binary Cepheids, n_C = number of Cepheids). The upper (solid) curve is both for the definite and possible binaries, the lower (dashed) curve is based on the definite cases only. The trend towards higher duplicity with longer pulsation period found by Madore & Fernie (1980) cannot be seen in this figure. Similarly, Burki & Mayor (1983) and Burki (1984) could not confirm this trend. Again, many-sided investigations of suspected binaries are needed to reduce the selection effect that may be present.

Figure 1



References:

Abt, H.A. (1959). Astrophys. J., 130, 769.
Balona, L.A. (1977). Mon. Not. R. astr. Soc., 178, 231.
Böhm-Vitense, E., Borutzki, S. & Harris, H. (1984). preprint.
Burki, G. (1984). Astron. Astrophys., 133, 185.
Burki, G. & Mayor, M. (1983). Astron. Astrophys., 124, 256.
Coulson, I.M. (1983). Mon. Not. R. astr. Soc., 203, 925.
Dean, J.F. (1977). MNASSA, 36, No.1, 3.
DeYoreo, J.J. & Karp, A.H. (1979), Astrophys. J., 232, 205.
Evans, N.R. (1983). Astrophys. J., 272, 214.
Evans, N.R. (1984). preprint.
Gieren, W. (1982). Astrophys. J. Suppl., 49, 1.
Harris, H.C. (1981). Astron. J., 86, 707.
Herbig, G.H. & Moore, J.H. (1952). Astrophys. J., 116, 348.
Hutchinson, J. (1977). B.A.A.S., 9, 357.

https://doi.org/10.1017/S0252921100109121 Published online by Cambridge University Press

Janot-Pacheco, E. (1976). Astron. Astrophys. Suppl. Ser., 25, 159.
Kurochkin, N.E. (1966). Perem. Zvezdy, 16, 10.
Lloyd Evans, T. (1968). Mon. Not. R. astr. Soc., 141, 103.
Lloyd Evans, T. (1982). Mon. Not. R. astr. Soc., 199, 925.
Lloyd Evans, T. (1984). Observatory, 104, 26.
Madore, B.F. (1977). Mon. Not. R. astr. Soc., 178, 505.
Madore, B.F. & Fernie, J.D. (1980). P.A.S.P., 92, 315.
Mariska, J.T., Doschek, G.A. & Feldman, U. (1980 a). Astrophys.J., 238, L87.
Mariska, J.T., Doschek, G.A. & Feldman, U. (1980 b). Astrophys.J., 242, 1083.
McNamara, D.H. & Chapman, R. (1977). P.A.S.P., 89, 329.
McNamara, D.H. & Feltz, K.A.Jr. (1981). In: "Effects of Mass Loss on Stellar Evolution". eds. C. Chiosi & R. Stalio, p. 389. D. Reidel. Dordrecht.
Mianes, P. (1963). Ann. d'Astrophys., 26, 1.
Miller, J. & Preston, G.W. (1964 a). Astrophys. J., 139, 1126.
Miller, J. & Preston, G.W. (1964 b). P.A.S.P., 76, 47.
Millis, R.L. (1969). Lowell Obs. Bull., No. 148.
Oosterhoff, P.Th. (1960). P.A.S.P., 72, 313.
Parsons, S.B. (1981). Astrophys. J., 247, 560.
Pel, J.W. (1978). Astron. Astrophys., 62, 75.
Plaut, L. (1934). Bull. astr. Inst. Neth., 7, 181.
Russo, G. (1982). In: "Binary and Multiple Stars as Tracers of Stellar Evolution". eds. Z.Kopal & J. Rahe, p. 23, D. Reidel, Dordrecht.
Szabados, L. (1977). Mitt. Sternw. ung. Akad. Wiss., Budapest, No. 70.
Szabados, L. (1980). Mitt. Sternw. ung. Akad. Wiss., Budapest, No. 76.
Szabados, L. (1981). Commun. Konkoly Obs. Hung. Acad. Sci., Budapest, No. 77.
Szabados, L. (1983). Astrophys. Space Sci., 96, 185.

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