COLLAPSED STARS IN BINARIES

The collapsed stars, whose existence is forecast by general relativity, should be observable solely by their gravitational field (see, e.g., Harrison, Thorne, Wakano, and Wheeler (1965) or Zeldovich and Novikov [1964, 1965] for survey and references).

All estimates of the number of collapsed stars are very unreliable. The possibility is not excluded that stars lose mass in some stages of evolution—not because they "wish" to be white dwarfs or "fear" to be collapsed, but by the natural course of nuclear processes (Cameron 1960), which may be assisted by rotation.

It would be of greatest importance to find even one example of a collapsed star. The catalogue (Moore and Neubauer 1948; Becvar 1959) of spectroscopic binaries with unobserved satellites yields the suspect cases listed in Table 1. The mass of the ordinary star, $\mathfrak{M}_1$, is evaluated on the basis of its spectral index. Taking $\sin i = 1$, we obtain $\mathfrak{M}_2$. As an alternative, $\mathfrak{M}_2'$ is calculated for the most probable value $\sin^3 i$, namely, $\frac{2}{3}$.

In most pairs $\mathfrak{M}_2 > \mathfrak{M}_1$. The hypothesis is put forward that the second unobserved star is a collapsed star, or, as in case 7, an old neutron star.

TABLE 1

N	Star	α_{1950}	δ_{1950}	m_1	Sp	Period (days)	K_1 (km/sec)	$a_1 \sin i$ (10^6 km)	MF	$\mathfrak{M}_1$	$\mathfrak{M}_2$	$\mathfrak{M}_2'$	π	m_2	Ref.*
1.	HD 187399	19ʰ46ᵐ6	+29°17′	7 7	Bge	27 97	104 5	37 6	2 72	4 5	7 1	9″6			(1)
2†	+40°1196	05 03 7	+40 53	8 1	B3e	3710	31 5	1528	10 4	10	22	29			(2)
3.	HD 30353	04 45 2	+43 12	7 7	cA5p	359 7	51 3	244	4 5	12 6	15 1	19			(3)
4†	HD 193928	20 17 8	+36 36	9 7	WN6	21 64	130	...	4 94	10	14 2	18	...	. .	(4)
5	π Cep A	23 06 3	+75 07	4 56	gG1	556 2	23 02	169	0 623	3	2 76	3 4	011	6 1	(5)
6	PaV	18 18 6	−61 31	4 25	gM1	2214	17 92	526	1 188	7	5 9	7 2	015	3	(6)
7	α Her B	17 12 4	+14 27	5 39	F8	51 58	36 12	25 62	0 258	1 4	1 22	1 48	006	10 2	(7)

* References: (1) Merrill (1949); (2) McCuskey (1959); Schmidt-Haler (1964); Merrill (1934); (3) Heard and Boshko (1955); Heard (1962); (4) Hiltner (1945); (5) Harper (1924); (6) Bateson, Jones, and Philpott (1960); (7) Bouigne (1957).

† The coordinates of the stars refer to the year 1900.

Of course this hypothesis is not the only one that can be made. In cases 5 and 7 where the parallax is known, one can evaluate m_2, the visual magnitude of a star with mass $\mathfrak{M}_2$ on the main sequence. In cases 5 and 7, $m_2 > m_1$, and possibly the second star is unobserved by contrast with the brighter first star. In case 6, $m_2 < m_1$, but it is suspected that the parallax is erroneous because the proper motion of the ordinary star was underestimated.

As pointed out to us by L. Snejko, in binaries the star with the smaller mass is often brighter (see also Sahade 1960) than its heavier companion as a consequence of more rapid evolution due to mass exchange. I. Novikov has pointed out another possibility—namely, that the second star can give enough light but without sharp spectral lines. In this instance it should not be identified as a companion of the first star.

The main purpose of this Letter is to draw attention to the particular objects to which we have referred. It is important to obtain parallaxes, to observe the proper motion, and to study the binaries using interferometric techniques. The motion of the gas in the gravitational field of a collapsed star can give X-rays or other unusual spectral features.

An unambiguous proof of the existence of a collapsed star would naturally be of the greatest interest. But even a negative result will be of some value: a comparison with the number of binaries with larger masses could provide some support to the conclusion that stars escape from collapsing. As noted by Auer and Woolf (1965), the occurrence of white dwarfs as binaries in young clusters already argues for a possibility of large mass loss during a period of 10^4–10^5 years.

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ON THE EXACT SPLITTING OF THE PULSATION MODES IN CONNECTION WITH THE BETA CANIS MAJORIS STARS

The beat phenomenon of the β Canis Majoris stars has been interpreted (Chandrasekhar and Lebovitz 1962) as an effect of rotation on the modes of oscillation responsible for the observed variations in light and radial velocity. It is supposed that the physical conditions prevalent in these stars (in particular, the ratio of specific heats) are such that a degeneracy occurs between the fundamental characteristic frequencies of the radial and the $l = 2$ modes of oscillation. Rotation, according to the theory, removes this degeneracy and gives rise to two non-radial, normal modes characterized by slightly different frequencies, the difference (or splitting) being proportional to the square of the angular velocity.

However, on the basis of the foregoing hypothesis, various treatments of this problem have indicated that the splitting of the two modes is too small to explain satisfactorily the observations. Clement (1965*b;* hereinafter referred to as "Paper II") has applied to the β Canis Majoris stars the results of some variational calculations on the rotationally distorted polytropes. On the assumption that these variable stars can be approximated by polytropic distributions, it was found that the variational theory involving approximate trial functions (cf. Clement 1965*a;* hereinafter referred to as "Paper I") predicts, for a given splitting, rotational velocities which are generally larger than those obtained from radial velocity measurements. That is, the splitting of the two periods is too small according to the approximate theory. It was stated in Paper II that more accurate trial functions would probably increase the splitting but not by a sufficient amount to remove