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ON THE REALITY OF A GROUP OF CARBON STARS IN AURIGA

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ABSTRACT

The properties of a group of seven carbon stars whose projected positions make them appear clumped together are examined. It is concluded that the seven do not form a physically real group. The possibility is discussed that there are two pairs of carbon stars within this group.

I. INTRODUCTION AND OBSERVATIONS

At Case Institute, Nassau and Blanco (1954, 1957*a*, *b*) carried out objective-prism surveys of the Northern Milky Way and discovered large numbers of carbon stars. One of the interesting sidelights of these surveys was the observation that many carbon stars appeared in small clumps of about six or seven stars in an area of several square degrees. This is highly reminiscent of OB associations. If these groups are physically real, then the carbon stars in them must be very young objects as the shearing effects of differential galactic rotation tend to break up such associations on a timescale of the order of 10^7 years.

With these thoughts in mind, we have made observations of one of these groups (consisting of seven stars) with a view toward establishing whether or not it is a real association. The observations consist of spectra taken for purposes of classification and radial velocity measurements together with *VR* photometry. The spectra were secured in the yellow-red region at a dispersion of 106 Å mm^{-1} at the Cassegrain focus of the Kitt Peak 84-inch (213-cm) telescope, while the photometry was obtained with the No. 2 36-inch (91-cm) and the Steward Observatory 90-inch (229-cm) telescopes.

II. RADIAL-VELOCITY REDUCTIONS

Along with the program stars, spectra were obtained of a total of 33 standard carbon stars so that the velocities could be tied to Sanford's (1944) system. The standard stars were chosen only from those for which Sanford listed a class *a* velocity (error $\pm$ 1 km s^{-1}). All spectra were measured on the Grant comparator of the Physics Department at the University of British Columbia.

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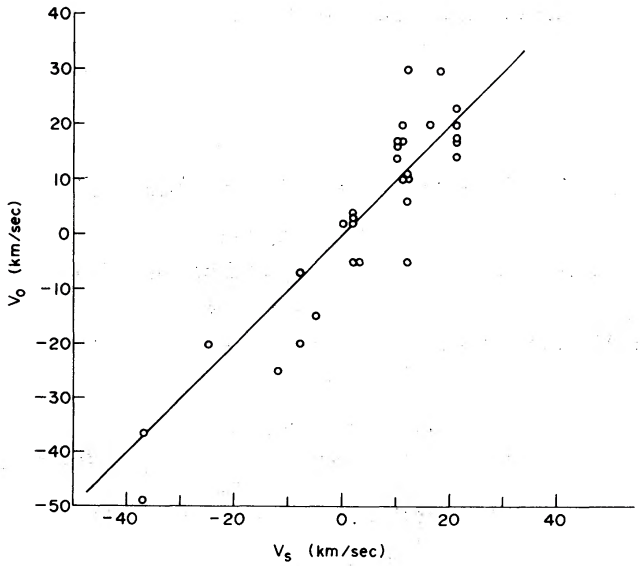

FIG. 1.—Our measured radial velocity (V_0) plotted against Sanford's (V_S) velocity for carbon stars. A systematic correction of +4 km s^{-1} has been applied to our velocities, and a 45° line has been included.

An internally consistent set of wavelengths was derived, and after reduction a systematic correction of +4 km s^{-1} was required to reduce our velocities to Sanford's system. Figure 1 plots our velocities (V_0) versus Sanford's (V_S) after this correction was applied. A 45° line has been included in the diagram. The agreement between the two systems must be considered quite good considering that all of Sanford's velocities were obtained from high dispersion plates (5.9, 10 or 20 Å mm^{-1}). Our external probable error is ± 5.2 km s^{-1}.

III. SPECTRAL CLASSIFICATION

The strength of the sodium D-lines has been estimated for each carbon star in the group on a scale of 1–9 as used by Sanford (1944). The one exception is Case 372 for which no spectrogram was obtained. Further, the intensity of the $^{12}C^{13}C$ band at λ6168 was estimated and the appearance of Hα was noted. These data are collected in table 1, where column (1) gives the Case number of the star, and column (2) the strength of the D-lines. Column (3) gives the intensity of the band head at λ6168 from a visual estimate and the last column the appearance of Hα. If there is no entry in the last column, Hα was not apparent at the dispersion used.

TABLE 1

SPECIAL CHARACTERISTICS OF STARS IN THE GROUP

Star Number (1)	D-Line Strength (2)	λ6168 (3)	Hα (4)
363	4	Strong	Weak emission?
366	4	Strong	...
368	5	Weak	...
+33°1194	1	Very weak	Absorption
370	6	Moderate	...
371	4	Moderate	...

TABLE 2

DATA ON CARBON-STAR GROUP

Case No. (1)	Other (2)	$\alpha_{(1900)}$ (3)	$\delta_{(1900)}$ (4)	V_0 (km s^{-1}) (5)	V (6)	$(V-R)$ (7)
363	...	$5^h48.^m5$	+34°02′	−1	11.40	1.78
366	...	5 49.5	+33 51	1	11.15	2.53
368	...	5 51.8	+28 27	+24	12.02	3.66
.....	+33°1194	5 55.0	+33 52	−84	10.07	0.77
370	BQ Aur	5 55.4	+29 27	+17	11.44	3.27
371	...	5 55.9	+27 31	+46	10.10	2.35
372	BR Aur	5 56.4	+29 39	...	11.77	2.58

IV. DISCUSSION

Table 2 contains the velocity and photometry data pertinent to the group of carbon stars studied. Column (1) contains the star number from the Case lists while column (2) lists some other designation. Columns (3) and (4) list the stellar coordinates, column (5) the observed radial velocity, and columns (6) and (7) the photometry.

The data of this table argue strongly against the reality of this group of stars. First, one must exclude BD + 33°1194 as a possible member. It is clearly a much earlier carbon star than the others in this group. Since there is much evidence that the hotter carbon stars are intrinsically less luminous than the later ones (Gordon 1968), we can exclude it as a member on the basis of its V-magnitude and spectral type. Further, its radial velocity indicates that it is probably a Population II object. As regards the remaining six stars, the velocity spread seems too large to allow for physical reality of the group. The dispersion in velocity about the mean for the five other carbon stars for which radial velocities were determined is 17 km s^{-1}. An OB association typically has a velocity dispersion of about 1 km s^{-1} (Blaauw 1964).

The question of the existence of pairs of carbon stars is almost as interesting as the possibility of groups of carbon stars. The surveys of Nassau and Blanco (1954, 1957*a*, *b*) and Westerlund (1964, 1971) have suggested that carbon stars appear frequently in pairs separated by a few minutes of arc. Among these many, possibly physical systems, only HD 58337 and HD 58364 (separation 97″) have known radial velocities (Sanford 1944). Their velocities are similar (+4 and −3 km s^{-1}) and suggest the intriguing possibility that they are coeval.

Among the seven stars in this group there seem to be two possible pairs; Case 363 and 366, and BQ and BR Aur. The magnitudes, spectral characteristics, and velocities of 363 and 366 are similar and they lie close together. BQ and BR Aurigae have similar magnitudes and are separated by about 15′.

It is interesting to note that among all the carbon stars suspected of being in binary systems, the carbon star is always the primary and is always at least 2 mag brighter than the secondary (Gordon 1968; Richer 1972). This holds true even for W CMa and its B2 V companion. Only if both stars are carbon stars do they have similar magnitudes.

In conclusion, then, it seems highly unlikely that these seven stars form a physically real group of stars (even excluding BD + 33°1194), but the possibility exists that there are two pairs of carbon stars in this sample.

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