A statistical study of pulsating stars

Eleventh paper : *The variables in and near the constellation Carina*

by E. A. KREIKEN
(Department of Astronomy)

Özet : Bu makalede Carina bulutunda bulunan bir takım değişen yıldızlar tetkik ediliyor. Sönük değişkenler için materyal tam değildir. Küme tipi değişkenler iyi temsil edilmiyorlar, fakat bu materyalın tamam olmayışından ileri gelebilir.

Sagittarius bulutunun umumiyetle populasyon II yıldızlarını, Carina bulutunun populasyon I yıldızlarını ihtiva ettiği düşünülür. Peryodu P 1 gün olan Cepheidler iyi temsil ediliyor ve A (2)—log P düzleminde dağılımın, Sagittarius bulutunda muteber olan dağılımdan katiyetle ayrıldığını işaret etmek enteresandır. Maamafih bu neticeyi umumileştirmek için henüz çok erkendir.

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Abstract : In the present paper a number of variables in the Carina cloud are considered. With the fainter variables the material is incomplete. The cluster type variables are poorly represented, but this may be due to the incompleteness.

While the Sagittarius cloud is usually thought to contain population II stars, the Carina cloud is thought to contain population I stars. The Cepheids of period $P > 1$ day are well represented and it is interesting to notice that their distribution in the A(2)—log P plane definitely deviates from that found in the Sagittarius cloud. As yet it is too early to generalise this result.

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In the present paper I have considered a number of variables in or near the constellation Carina. Many authors think that the Carina cloud is an example of an almost pure population I grouping of stars, while on the other hand Sagittarius represents a population II grouping. It is therefore interesting to analyse a number of variable stars in or near Carina and to compare the results with those obtained in Sagittarius (papers 9 and 10 of this series). The stars considered here were taken from the lists of *L. Plaut* [1], *S. Gaposchkin* [2] and *C. Payne-Gaposchkin* [3].

Altogether 48 variables have been analysed by the method exposed in the first paper of this series. To attain this number it was necessary not to restrict the choice of system to the Carina cloud proper but to include stars situated in the adjacent regions. The variables considered in this paper are collected in table I, in which they are arranged in order of increasing periods.

The first column of this table gives the designation of the star while the second contains the logarithm of the period. In the third column the letter P indicates that the light curve which has been analysed, is one determined by *Plaut* [1]. The letters S. G. and P. G. indicate that the light curve was borrowed from the lists published by *S. Gaposchkin* [2] and *C. Payne-Gaposchkin* respectively. The next four columns give the values of π (1); A (2); A (3) and A (4) which have been computed in the usual way. The final column refers to remarks in the text. As is seen from the table there is a large deficiency of variables with periods $<$ 1 day. Our table only contains three such variables and all three have been taken from the work of *Plaut*.

This certainly does not prove that in the Carina clond the short period variables are extremely rare.

The faintest variables which occur in the surveys of *S. Gaposchkin* and *C. Payne-Gaposchkin* have a mean magnitude of about $m = 11.5$. The list of *Plaut* also contains fainter stars. At maximum light the three cluster type variables have magnitudes of 13.3; 12.51 and 12.94 respectively. So evidently the cluster type variables are too faint to show up in the surveys of *S. Gaposchkin* and *C. Payne-Gaposchkin*. In his work *Plaut* has considered only a very limited area around Carina. This explains why so few cluster type variables appear in our table. Of course ultimately it might turn out that the short period variables actually are scarce among the population I stars in Carina. Such a conclusion however cannot be based on the present material.

Our table contains two systems. R Y Vel and U Y Car (log P = .744 and 1.449 resp.) for each of which two different light curves are available, one by *L. Plaut* and one by *C. Payne-Gaposchkin*. Both sets of light curves have been analysed and the results entered in the table. The close correlation between the two sets of values π (1) and A (f) is very satisfactory.

For the system S T Vel. log P = 0.768 no very satisfactory results could be obtained. For A(2) we find the value A(2) = 0.344 which is normal but for A(3) and A(4) imaginary values are obtained which obviously are impossible. But *C. Payne-Gaposchkin* confirms an earlier conclusion by *P. Th. Oosterhoff*[4] that the period of these variables is subject to changes. The light curve given for this system therefore is a certain mean, which might deviate from a true light curve.

In figure 1, the values A(2) of our table are plotted against the corresponding logarithms of the period. The various levels and sublevels which are indicated in the figure are borrowed from the 8th paper of this series, where we have considered the general distribution of the Cepheids.

TABLE 1.

List of variable stars in or near the constellation Carina, analysed in this paper

Design	log P	Ref	π (1)	A (2)	A (3)	A (4)	Remarks
VX Vel	0.707—1	P	0.727	0.537	.324	0.175	
TX Car	.779—1	P	.717	.528	.285	.253	
EE Car	.832—1	P	.749	.467	.277	.155	
RT Mus	.490	S.G	.837	.381	.161	.100	
BK Cen	.501	S.G	.807	.456	.100	.095	
UZ Cen	.522	S.G.	.853	.374	.176	—	
Y Car	.561	PG	.814	.351	.232	.095	
UX Car	.566	PG	.878	.311	.138	.105	
AG Cru	.584	SG	.822	.402	.152	.134	
BB Cen	.602	SG	.944	.164	.114	.084	see text
CY Car	.630	P	.854	.391	.084	.063	
V Vel	.640	SG	.915	.313	.045	—	
GI Car	.646	SG	.967	.077	.114	.045	see text
T Vel	.666	PG	.903	.257	.110	.095	
DY Car	.669	P	.869	.330	.176	.110	
WW Car	.669	SG	.869	.335	.179	.000	
S Cru	.671	SG	.797	.428	.000	.219	
SX Car	.687	SG	.902	.243	.138	.118	
CN Car	.693	P	.779	.431	.210	.063	
UZ Car	.716	SG	.872	.302	.105	.071	
CQ Car	.726	P	.796	.414	.205	.152	
UW Car	.728	PG	.834	.395	.158	.084	

TABLE 1 (continued)

Design	log P	Ref	π (1)	A (2)	A (3)	A (4)	Remarks
UY Car	.744	PG	.862	.390	.114	.045	}
» »	»	P	.829	.404	.178	.063	}
GH Car	.758	SG	.942	.232	.032	.063	
R Cru	.766	SG	.864	.351	.071	.130	
ST Vel	.768	PG	.897	.344	—	—	see text
X Cru	.794	PG	.755	.504	.214	.257	
V 878 Cen	.810	PG	.948	.173	.084	.045	
V Car	.826	PG	.911	.263	.130	—	
T Cru	.828	SG	.901	.315	.063	.095	
XX Vel	.844	P	.899	.249	.173	.100	
R Mus	.876	SG	.909	.259	.155	—	
ER Cer	.888	SG	.878	.324	.077	.100	
SX Vel	.980	PG	.955	.122	.130	.063	
S Mus	.985	SG	.917	.110	.045	.095	
AQ »	.990	PG	.978	.063	.055	.045	
UU Mus	1.066	SG	.972	.173	.063	.063	
XY »	1.093	PG	.952	.184	.055	.077	
SV Vel	1.149	SG	.916	.141	.158	.114	
VW Cen	1.176	SG	.692	.528	.292	.141	see text
XX Car	1.196	SG	.820	.315	.161	.179	
XZ Car	1.220	SG	.828	.286	.170	.138	
YZ Car	1.260	PG	.832	.302	.239	.000	
VY Car	1.279	SG	.927	.251	.077	.045	
WZ Car	1.362	SG	.854	.320	.185	.118	
SW Vel	1.371	PG	.706	.484	.298	.187	
RY Vel	1.449	P	.811	.298	.195	.095	}
» »	1.449	PG	.838	.352	.212	.071	}
U Car	1.588	SG	.771	.452	.187	.130	

The three short period variables are on the sublevel a 2 while in Sagittarius the short period stars mostly are distributed along a 1. However, in this case the available number of systems is so small, that this distribution may be quite accidental. Anyhow, it would be extremely dangerous to conclude from this meagre material that with the short period stars in Carina, the distribution is different from that found in Sagittarius.

With the stars having periods between 1 and 10 days, the situation is different.

With the Sagittarius cloud it was noticed that the points representing these stars were almost entirely confined to a small area, which in figure 1 has been indicated by the dotted square. With the variables in Sagittarius the values A (2) which were obtained were such, that without any exception they all deviated in positive sense from the provisional level *d* 1. In the Carina cloud the situation is quite different.

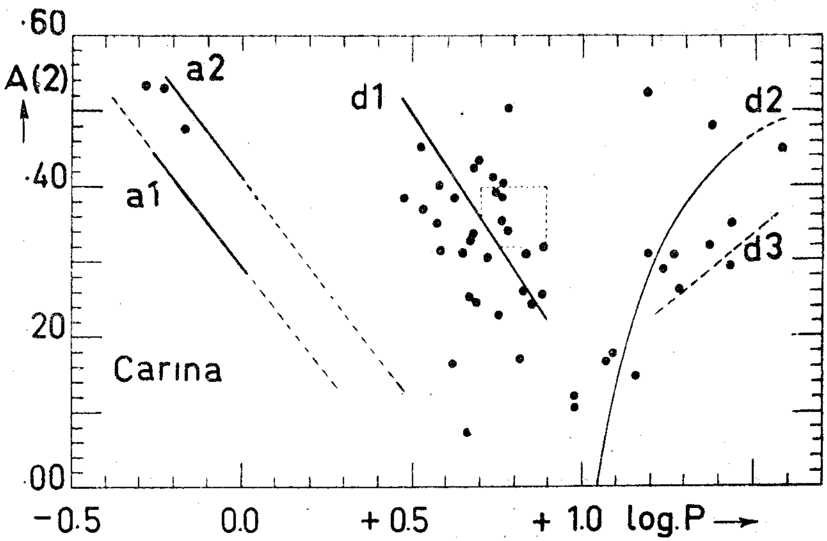

Fig. 1

The points representing the variables are scattered on both sides along the *d* 1 level, but the majority is below this level. The ratio is about 2 : 1. Two systems are so far below this level that they might be identified with the extension of the level *a* 2. This would indicate that these stars are R R Lyrae stars of very long periods. This is by no means impossible. In previous cases several similar systems were found (cumf. paper 8 of this series). In this case the two stars in question are G I Car log P = 0.646 and B B Cen (log P = 0,602).

Anyhow, with these periods there seems to be a real difference between the distribution of the stars in Carina and that in Sagittarius. Further evidence must be awaited before this conclusion can be generalised into a difference between the distribution of the population I and population II Cepheids.

Beyond the limit $P = 10$ days the beginning of the level $d\ 2$ is well indicated. It would, however, be very difficult definitely to say whether the three points near $\log P = 1.000$ representing very small values of $A(2)$ belong to the level $d\ 2$ or are on the extension of $d\ 1$.

Due to the gap between $d\ 1$ and $d\ 2$, which is also present in the stars in Sagittarius and with the Cepheids in general, I am inclined to identify these systems with the $d\ 2$ level. At the upper end the level $d\ 2$ is sparsely populated and one star (VW Cen $\log P = 1.176$) hasa very large positive deviation. The difference with the Sagittarius cloud however is that while in Sagittarius the provisional sublevel $d\ 3$ does not show up at all, in Carina the majority of the long period Cepheids appear to be arranged along $d\ 3$.

In this case also before generalising this conclusion, I would prefer to consider additional material.

Literature

[1] Plaut, L.: B.A.N. **7**, 273, 1935
[2] Gaposchkin, S.: H.A., **115**, **5**, 1946
[3] Payne-Gaposchkin, C.: H.A. 115, 6, 1946
[4] Oosterhoff, P, Th.: B.A.N. **8**, 80, 1936

Ankara, February 1956.
E.A. Kreiken