A Statistical study of pulsating stars.

Sixth paper: *Variables in miscellaneous clusters.*

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Özet : Bu makalede yalnız bir kaç değişen yıldızı ihtiva eden yıldız kümeleri tetkik edilmiştir. Bütün hallerde peryotlar ayni derecede iyi tayin edilmemiştir. Bu yıldız kümeleri bir kaç Cephei yıldızlarını ihtiva ettiklerinden tetkike dahil edilmesi değerlidir. Tetkik edilen neticeler tablo halinde verilmiş ve grafikle de şekilde gösterilmiştir. Şeklin esas özellikleri münakaşa edilmiştir.

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Abstract : In this paper clusters are considered, which contain a few variables only. Not in all instances are the periods equally well determined. The inclusion of these clusters is valuable because they contain several δ Cepheï stars. The results of the analysis are tabulated and are graphically represented in a figure. The principal features of this figure are discussed.

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Up till now we have only considered globular clusters containing relatively great numbers of variables. About the clusters containing only a few variables a great deal of work has been done at the David Dunlap Observatory by *Helen B. Sawyer.* I have included one cluster which has been observed by *Frances W. Wright.*

All variables have been collected into table 1. The first column gives the number of the variable and at the same time indicates in what cluster the variable occurs.

The letters S or W in the second column indicate whether the light curve has been determined by *Helen B. Sawyer* or by *Frances W. Wright.* The variables are arranged in order of increasing period and the third column gives the logarithm of the period. The next four columns contain the results of our present analysis, e.g. the values $\pi(1)$; $A(2)$; $A(3)$ and $A(4)$.

These values were derived in exactly the same way as in the previous papers and for details the reader is referred to the first paper in this series.

Not all variables in the different clusters are equally well observed and in a few cases it seems doubtful whether the period which is stated can be correct. It is therefore necessary briefly to discuss the separate clusters.

Messier 9.

The variables in this cluster have been investigated by *Helen B. Sawyer*[1], which author states: "Because of limited hour angle of the plates, considerable difficulty was experienced in determining the periods".

The variable 13 possibly is a non cluster star and has been rejected. Also rejected were the variables 2, 6, 5 and 10, for which in the figures given by *H. B. Sawyer*, the scatter of the points representing the individual observations is so large, that I have not found it possible to draw an unobjectionable mean light curve.

For six of the variables in this cluster the results of the analysis are given in our table. In the correlation plane where A(2) is plotted against log P (see figure) the variable 12 M9 gives a point which widely deviates from any other point found up till now. The point indicating the variable is situated halfway between the sublevels $c \cdot 3$ and $a \cdot 1$ and so far to the right that it is outside the area occupied by the irregular variables. The star might still represent an irregular variable with extreme period. However, with a view to the remark quoted above, it seems possible that the period needs revision. For this variable a period of nearly one half day is given and under these circumstances it must be difficult to fix the period with great accuracy. I have seen no definite reasons to reject this variable, but I cannot place great confidence on the results of the analysis.

Messier 22.

The variables in M 22 have been studies by *Helen B. Sawyer*[2] who also gives normal light curves. However, in some cases the mean light curves are drawn sooner from a general knowledge of the light variations of this type of stars than

from the distribution of the observed points. I do not doubt that the mean curves have correctly been drawn, but on the other hand I do not think that they can wholly be considered as observed curves. Therefore, for an analysis they should be rejected.

For this reason from the light curves drawn by *H. B. Sawyer* I have rejected the Nos. 3, 23, 15, 24, 20, 7 and 4. The curves for variable 22 is based on few points only and the results of the analysis are indicated as uncertain.

N. G. C. 6218 and 6254.

In each of these two clusters *Helen B. Sawyer*[3] has studied one δ Cepheï star. The variable 1 N. G. C. 6218 is a double star and *Sawyer* states that the measurements were difficult. Therefore in our table the results of the analysis are indicated as uncertain.

TABLE 1

Variables in different globular clusters.

Desing. of var.	Auth.	log P	π (1)	A (2)	A (3)	A (4)	Remarks
6 N.G.C. 5053	S	0.465—1	0.943	.178	.141	.063	
12 N.G.C. 5466	S	.468—1	.975	.084	.063	.122	
16 N.G.C. 5466	S	.473—1	.985	.077	.000	.063	
10 N.G.C. 5053	S	.483—1	.963	.168	.095	—	
9 M 9	S	.509—1	.933	.241	.071	.032	
16 M 22	S	.510—1	.914	.224	.084	.095	
18 M 22	S	.512—1	.912	.248	.117	.054	uncertain
21 M 22	S	.515—1	.955	.200	.095	.084	
13 N.G.C. 5466	S	.534—1	.976	.217	.153	.000	
7 N.G.C. 5053	S	.547—1	.980	.114	.095	.100	
8 N.G.C. 5053	S	.560—1	.949	.210	.055	.063	
17 N.G.C. 5466	S	.573—1	.933	.226	.114	.063	
11 N.G.C. 5466	S	.578—1	.797	.449	.190	.118	irr ?
2 N.G.C. 5053	S	.579—1	.930	.207	.000	.000	uncertain
19 M 22	S	.584—1	.954	.210	.063	—	
4 N G.C. 5053	S	.603—1	.943	.230	.071	.032	
25 M 22	S	.604—1	.934	.237	.100	.032	
5 N.G.C. 5053	S	.620—1	.895	.224	.187	.045	
12 M 9	S	.757—1	.915	.207	.145	.084	
1 N.G.C. 5466	S	·761—1	.818	.387	.226	.106	

Table 1 (continued)

Design. of var.	Auth.	log P	π (1)	A (2)	A (3)	A (4)	Remarks
3 N.G.C. 5466	S	.762—1	.747	.458	.288	.141	
1 M 9	S	.768—1	.802	.404	.217	.138	
2 N.G C. 5466	S	.770—1	.831	.375	.155	.063	
3 N.G.C. 5053	S	.773—1	.846	.346	.182	.106	
3 M 9	S	.782—1	.866	.342	.176	.077	
12 M 9	S	.787—1	.915	.207	.145	.084	irr ?
1 M 22	S	.789—1	.818	.415	.170	.000	
6 N.G.C. 5466	S	.793—1	.747	.461	.222	.176	
22 M 22	S	.796—1	.661	.530	.387	.187	uncertain
7 M 9	S	.798—1	.796	.410	.235	.138	
8 N.G.C. 5466	S	.799—1	.769	.460	.255	.100	
10777 N.G.C. 4830	W	.799—1	.674	.472	.230	.161	
6 M 22	S	.806—1	.670	.567	.292	.184	
2 M 22	S	.808—1	.772	.455	.251	.148	
10 M 22	S	.810—1	.784	.439	.212	.095	
1 N.G.C. 5053	S	.811—1	.817	.369	.241	.145	
10778 N.G.C. 4830	W	.816—1	.583	.659	.428	.295	uncertain
10776 N.G.C. 4830	W	.817—1	.657	.591	.346	.200	
10779 N.G.C. 4830	W	.825—1	.719	.507	.247	.138	
4 M 9	S	.826—1	.847	.381	.122	.071	
13 M 22	S	.828—1	.832	.365	.219	.118	
9 N.G.C. 5466	S	.836—1	.678	.542	.338	.000	
7 N.G.C. 5466	S	.847—1	.727	.561	.241	.161	
10 N.G.C. 5466	S	.851—1	.786	.467	.205	.055	
9 N.G.C. 5053	S	.871—1	.670	.536	.423	.205	
3692 N.G.C. 4830	W	.875—1	.670	.553	.344	.192	
1 M 13	S	.134	.919	.247	.100	.141	
11 M 22	S	.228	.793	.272	.089	.032	
6 M 13	S	.324	.953	.224	.055	.063	
2 M 13	S	.708	.955	.221	.221	.000	
1 N G.C 6218	S	1.191	.999	.089	.000	.055	uncertain
1 M 80	S	1.204	.979	.100	.118	.032	
2 N.G.C. 6254	S	1.270	1.000	.148	.148	.045	

Messier 13.

In this cluster *H. B. Sawyer*[4] gives the light curves of four of its variables. Of these four I have rejected the light curve of No. 8, because the scatter of the individual points is rather large.

Messier 80.

The light curve of the one δ Cepheï variable has been given by *H. B Sawyer*[5].

N. G. C. 5053.

The shape of the light curve for 10 variables in this cluster is given by *H. B. Sawyer*[6]. All ten were analysed in the present paper and the results are entered in our table. For the variable 2, the results of the analysis are uncertain.

N. G. C. 5466.

From the light curves which in this cluster are given by *H. B. Sawyer*[7] I have found it advisable to reject the Nos. 4, 5 and 14.

With each of these three variables in the figures given by *Sawyer*, the scatter of the individual points is so large, that I do not find it possible to draw a normal curve which is wholly satisfactory.

Of the remaining ones the analysis of variable 11 gives values which are quite abnormal. In the correlation plane A(2)-log P (see figure) the variable is indicated by a point slightly to the left of the area where the irregular variables are situated. Perhaps 11 itself is of the irregular type. Still the position of the star in the diagram is rather unusual and the results can only be accepted with caution. Additional observations are desirable.

N. G. C. 4833.

Of the six light curves which for the variables in this cluster were determined by *Frances W. Wright*[8] the light curve of H. V. 10775 was rejected, as the scatter of the individual points is large.

For the remaining five the resulta of our analysis are given in the table.

The numerical values of the table are graphically represented in figure 1, where the values A(2) are plotted against the corresponding values log P. For indicating the variables of the different clusters different symbols were used. The key to these symbols is indicated in the figure itself.

The inclusisn of the clusters poor in variables greatly extends our knowledge about the relation between A(2) and log P for the longer periods. Up till now our only information about the relation in this part of the correlation plane was based on a few Cepheïds in ω Centauri.

The distribution of the points representing the isolated variables in different clusters is the same as the one found for ω Cen. In the diagram two abnormal points occur, which are situated between the levels *c*. 3 and *a*. 1. These two cases have

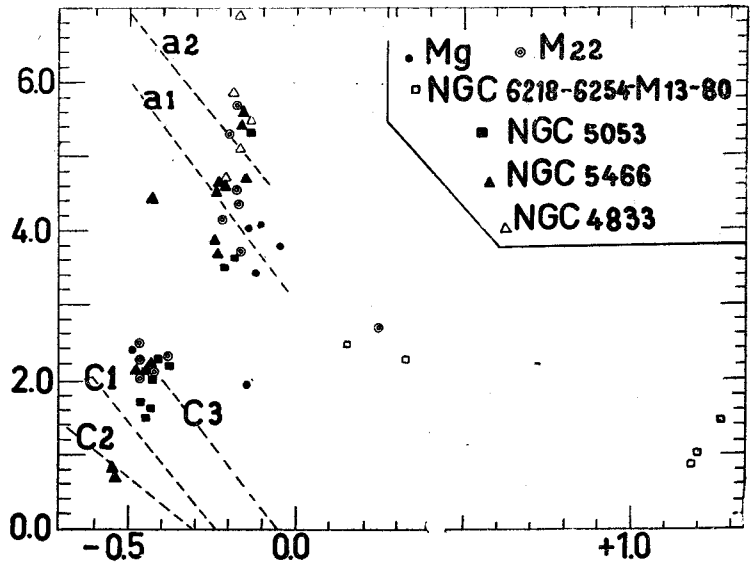

Fig. 1

already been discussed when we considered the separate clusters (N. G. C. 5466 and M 9). Perhaps the most interesting feature of the diagram is the clustering of the individual points representing the *c* type variables along the sublevel *c*. 3.

With the clusters, rich in variables, the *c* stars were mainly on the sublevel *c*. 1 and relatively few on the sublevels *c*. 2 and *c*. 3. In the present case only a very few variables can be ascribed to the sublevels *c*. 1 and *c*. 3. This therefore is a very real difference. As previously already remarked by *H. B Sawyer*, on the levels *a*. 1 and *a*. 2 variables with short periods,

e. g. periods immediately adjoining the area of the irregular stars, are conspicuously absent. An exception to this is only the dubious point given by the variable 11 N. G. C. 5466.

Literature

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