A statistical study of pulsating stars

Third paper: *The variable stars in Messier 5*

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Özet: Bu yazıda küresel yıldız kümesi Messier 5 deki değişen yıldızlar tetkik edilmiştir. $\pi(1)$; A(2); A(3) ve A(4) ün nümerik değerleri tablo halinde gösterilmiştir.

Şekilde A(2) değerleri mütekabil log P değerlerine göre izdüşürülmüştür. Noktaların dağılımında ω Cent. için cari olan dağılımdan çok bariz farklar bulunmuştur.

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Abstract: In this paper the variable stars in the globular cluster Messier 5 are analysed. The numerical values of $\pi(1)$; A(2); A(3) and A(4) are tabulated.

In the figure the values A(2) are plotted against the corresponding values of log P. In the distribution of the individual points some striking differences from that valid for ω Cent. are found.

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In this paper the results are given of the autocorrelation and power series analysis of the variable stars in the globular cluster Messier 5. The method used in the present paper is identical to that exposed far ω Cent. (first paper of this series) and also the same symbols and designations have been used.

Consequently concerning the method and the meaning of the symbols, the reader is referred to the first paper and no further explanation is given here.

The variable stars in Messier 5 have extensively been studied by P. Th. Oosterhoff [1] and the normal curves derived by him were used for this analysis.

In order to avoid too extensive computations, just as with ω Cent. not all variable systems were analysed. The variables to be analysed were chosen in such a way, that the different periods seem equally well represented.

From the list, selected in this way, the true distribution of the frequencies of the different periods can no longer be derived. Relatively too many systems with either very short or with long periods have been included.

This very short or long refers to the periods occurring in the cluster. Even when the selection is carried out in this way there remains in this case a lack of systems with a period between that of the longest of the *c* type stars and the shortest of the *a* type ones. In the list of stars to be analysed I have also included all systems of which the light curve seems more or less to deviate from the normal one and as far as possible all systems which Oosterhoff indicates as being irregular. For several of the irregular systems Oosterhoff has evidently not thought it prudent to give normal light curves, so that only 4 irregular systems are available. From those one was excluded, e.g. variable N 14 in the list of Oosterhoff. Of the normal curve given for variable N 14, over a considerable interval the normal points are based on one observation only.

The analysis of the light curve leads to values which are quite unacceptable ($\pi(1) = 0.634$; $A(2) = 0.600$; $A(3) = 0.417$ and $A(4) = 0.261$).

On the other hand on the basis of the values given by the analysis the variable 29 was considered as being irregular and this is not in contradiction with the remarks which Oosterhoff makes concerning this system (l. c. page 18).

The final list of systems which were analysed appears in table 1. The numbers in the first column refer to the numbers in the catalogue of Oosterhoff. The second column gives the logarithm of his period and the third the type which he assigns to the star.

Oosterhoff does not subdivide the type *c* in the systems *c* and *c'*, but as we will see later on, the Martin's subtype *c'* (2) does not occur in Messier 5. In the columns under $\pi(1)$; $A(2)$; $A(3)$ and $A(4)$ the results of the autocorrelation and power series analyses are given.

For the meaning of the symbols see the first paper of this series.

TABLE 1.

The variable stars in Messier 5 considered in this paper

No.	log P	type	π(1)	A(2)	A(3)	A(4)	$\frac{M_1+m}{2}$	Remards
78	0.423—1	*c*	0.958	0.161	0.071	0.055	15.07	
62	.449—1	*c*	.937	.192	.138	.000	15.06	
95	.464—1	*c*	.960	.197	.063	.000	15.46	
31	.479—1	*c*	.974	.161	.032	.071	15.08	
35	.489—1	*c*	924	.230	.100	.055	14.92	
40	.501—1	*c*	.914	.247	.063	.000	15.04	
55	.509—1	*c*	.952	.126	.105	.000	15.06	
68	.528—1	*c*	.986	.077	—	—	15.06	
73	.535—1	*c*	.973	.105	.084	.045	14.97	
67	.543—1	*c*	.921	.237	.176	.000	15.06	
76	.636—1	*c*	.961	.155	.110	.063	14.96	
29	.654—1	*ab*	.900	.313	.077	.045	15.04	irr. (see text)
74	.657—1	*a*	.721	.373	.354	.230	14.82	
32	.661—1	*a*	.792	.381	.288	.192	14.74	
18	.666—1	*ab*	.850	.359	.148	.182	15.11	irr.
12	.670—1	*a*	.661	.483	363	.293	15.06	
58	.691—1	*a*	843	.406	.100	.077	15.14	irr ?
69	.695—1	*a*	.692	.514	.272	.247	15.26	
71	.701—1	*a*	.750	.394	.302	.202	15.08	
52	.701—1	*a*	.819	.392	.230	.141	15.03	irr.
1	.718—1	*a*	.773	.429	.265	.126	14.86	
94	.725—1	*a*	.649	.541	324	.071	15.68	
59	.734—1	*a*	663	.502	.353	.205	14.88	
97	.736—1	*a*	.782	.400	.245	.192	14.90	
8	.737—1	*a*	.774	.414	.290	.179	15.06	
83	.743—1	*a*	.780	.462	.138	.187	15.23	
81	.746—1	*a*	.758	.374	.358	.179	15.08	
70	.747—1	*a*	.732	.410	.322	.205	15.09	
61	.755—1	*a*	.726	.462	.336	.197	15.12	
39	.770—1	*a*	.696	.486	.292	.237	14.92	
30	.772—1	*b*	.839	.369	.210	.000	15.14	
11	.775—1	*a*	.656	536	.365	.230	15.00	
3	.778—1	*a*	.767	.394	.300	.141	14.98	
21	.782—1	*a*	.724	.447	.351	.179	14.99	
20	.785—1	*b*	.724	.492	.311	.182	14.90	
36	.798—1	*b*	.846	.371	.173	.063	15.44	
16	.812—1	*a*	.794	.396	.270	.077	14.91	
43	.820—1	*b*	.792	.434	.167	.122	15.15	
75	.836—1	*b*	.726	.559	.171	.077	15.04	
9	.846—1	*b*	.769	.401	.255	.190	15.09	
87	868—1	*b*	.916	.272	.100	.000	15.02	
77	.927—1	*b*	.828	.430	.077	.045	15.05	

The results combined in the table are graphically represented in figure 1, where for the individual stars the values A(2) are plotted against the corresponding value log P.

Neither from the investigations by Martin[2] and Oosterhoff[1] nor from our analysis has there appeared to be any conspicuous difference between the distribution of the *a* and *b* types in the various correlation planes. On the other hand the difference between the distribution of the *c* systems and that of the *a* and *b* ones is conspicuous. Therefore, except for the irregular systems, all systems are indicated by black dots. For the irregular systems open circles are used.

The dotted lines in the figure indicated the provisionally adopted sublevels c_1, c_2, c_3, a_1 and a_2. The elongated vertical rectangle indicates the course described by A. R. Her. during a complete secular cycle.

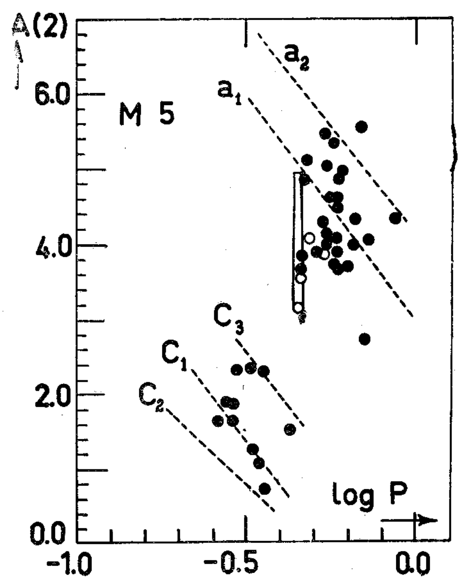

Fig. 1.

From the figure it appears that with Messier 5 the *c* type variables are confined to the sublevels c_1 and c_3.

One variable falls between c_1 and c_2 and its position therefore is slightly dubious. The sublevel c_2 is the one which was preferred by the systems in ω Cent. which Martin has classified as being of the subtype *c'*. Apparently this subtype does not occur in M 5.

In the correlation plane the distribution of the points representing the *a* and *b* systems is such, that there is no trace of a splitting up into two subtypes. The points are scattered around the curve a_1 with the majority below this curve. With ω Cent. the levels a_1 and a_2 were about equally populated but in Messier 5 the stars on the level a_2 are conspicuously scarce. It seems therefore that there are marked differences in the distribution of the variables in the A(2) — log P correlation plane between Messier 5 and ω Cent.

The irregular systems of Messier 5 are situated in exactly the same part of the correlation plane as those of ω Cent. However, with ω Cent. Almost so regular variables seemed to occur in the area occupied by the irregular systems, while with Messier 5 there are several regular variables in this area.

Finally it should be remarked that at least three of the regular a or b systems strongly deviate from the level a_1, falling almost halfway between the levels a_1 and c_3

References:

[1] Oosterhoff, P. Th.: Annalen Leiden, **17**, 4, 1941.
[2] Martin, W. Chr.: Annalen Leiden, **17**, 2, 1938.