A Statistical investigation of pulsating stars

Ninth paper: *Variables in the Sagittarius cloud.*

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Özet: Sagittarius bulutunda bulunan küme ve Cepheid tipi değişen yıldızlardan bir kısmı tetkik edildi. A (2) değerlerinin log P ye nazaran izdüşümü *c* 1, *c* 2, *c* 3, *a* 1, *a* 2, *d* 1 ve *d* 2 seviyelerinin mevcut olduğunu gösterir. Yalnız bir kaç sistem *c* seviyesine aittir. Sistemlerin ekserisi *a* 1 ve *a* 2 seviyelerindedir. *a* 1 seviyesindeki sistemler Sgt. kümelere nispetle daha fazladır. Diğer bakımlardan da dağılım, küresel kümelerde bulunanlardan belirli bir şekilde ayrılır. *a* seviyesi kümelerde olduğundan çok daha kısa peryodlara kadar uzanır. Sistemler *d* 1 seviyesi boyunca, istisnasız, pozitif istikametteki o seviyedenki sistemlerden ayrılır. Log P civarındaki kesiklik çok aşikâdır, fakat bu limit haricinde sistemin dağılımı pek belirli değildir.

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Abstract: A number of cluster and Cepheid variables in Sagittarius cloud is analysed. A plot of the values A (2) agains log P shows that the levels *c* 1, *c* 2, *c* 3, *a* 1, *a* 2, *d* 1 and *d* 2 are present. Only a very few systems belong to the levels *c*. The majority of the systems are on the levels *a* 1 and *a* 2.

Relatively the systems on the level *a* 1 are much more numerous in Sgt. than in the clusters. Also in other respects the distribution markedly deviates from that found in the globular clusters. The levels *a* extend to far shorter periods than with the clusters. The systems along the level *d* 1, without any exception, daviate from that level in positive direction. The break around log P is very distinct, but beyond that limit the distribution of the systems is not very clear.

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1. Introduction

In the present paper a number of variables in the Sagittarius cloud were analysed, according to the autocorrelation and subsequent power series method. We have proceeded in exactly the same way as in the first paper of this series and throughout the identical notations of the light curves by J. Uitterdijk[1] as prepared for publications by P. T. Oosterhoff. The majority of these stars were discovered by H. Van Gent [2] and in our table 1 the variables are indicated by their number in the list of H. van Gent. Not all stars of the list, prepared by Uitterdijk, have been analysed in the present paper. A number of the systems was selected in such a way, that all periods are well represented. Just as in the previous papers this implies that the distribution of the periods in our table 1 is no longer representative for the actual distribution of the periods in the Sagittarius cloud.

Our table relatively contains too large a number of variables with either a very long or a very short period. Also relatively too many systems with rare periods are considered. In first instance the stars were selected in a rather arbitrary way. It seems desirable more exatly to know the extent of the area of which irregular variables of the R. W. Draconis type occur. Therefore in our table we have included all stars which Uitterdijk indicates as possibly belonging to the R. W. Draconis type and also all systems for which the light curve seemed to deviate more or less from the normal one. It is therefore certain that our table 1 contains too high a percentage of irregular variables.

The material collected by Uitterdijk has the advantage of being very homogeneous. Still it was found desirable slightly to extend the numbers of stars having either a very short or a very long period. Thefore some additional sources were consulted. We have used several of the light curves published by W. C. Martin [3], H. H. Swope [4] and J. G. Ferwerda [5]. Finally we have included a few Cepheids of the list collected by A. H. Joy [6]. Of these latter stars the majority have already been considered in the eighth paper of this series. In our table the symbols U, M, S, F and J as entered in second coulomn, indicate from which author the light curve was barrowed.

In our table, where the systems are arrenged in order of increasing period, all variables are indicated by either their number or their letter in the original lists. In the same way as before for all systems the values π (1), A(2), A(3) and A(4) have been computed and these values have also been entered in our table. If the variable is irregular and of the R. W. Draconis type, this has been indicated in the final column of the table. For reasons which are exposed below, two stars have been indicated as possibly irregular (irr ?) although in the original lists they are not indicated as such.

2. Discussion of the results.

In figure 1 for all stars in our table the value A (2) has been plotted against the corresponding value of log P. In this figure we have also indicated the provisional levels and sublevels adopted in the first paper of this series and the additional levels obtained in the eighth paper. The sublevel *d* 3 has also been inserted, though this sublevel may have no actual meaning at all. The elongated vertical rectangle in the left hand part of the figure indicates the range of A. R Her while this star moves through its complete secondary cycle. For the irregular variable N 300 Uitterdijk gives two curves valid for different years. In the diagram all irregular stars have been indicated by open circles and variable No. 300 therefore is indicated by two different open circles, which are connected by a dotted a line. A few comments should be made about the distribution of the points in our diagram. Evidently only a few stars belong to the subtype *c*. Partly this may be due to the effect of selection. While in the mean the magnitudes of the stars of Bailey's subtype *c* do not deviate very much from the magnitude of the subtypes *a* and *b*, the amplitude of their light curves is considerably smaller. However, compared with the diagram obtained in W Cen. the deficiency in *c* stars is so striking, that it seems hardly possible that this is entirely due so an effect of selection.

It is interesting to notice that the few *c* stars which are present, all are almost exactly on one of the sublevels *c* 1, *c* 2 or *c* 3 ; intermediate systems do not occur.

In several other respects the distribution of the stars in this diagram also deviates from the distribution found in ω Cen.

In ω Cen. the *a* and *b* systems are evenly distributed over rhe subleves *a* 1 and *a* 2. In the Sagittarius cloud the great majority of these variables are on the sublevel *a* 1. In this respect the distribution in the Sagittarius cloud more closely resembles that found in such globular clusters as M 3, M 5, M 53 and NGC 3201.

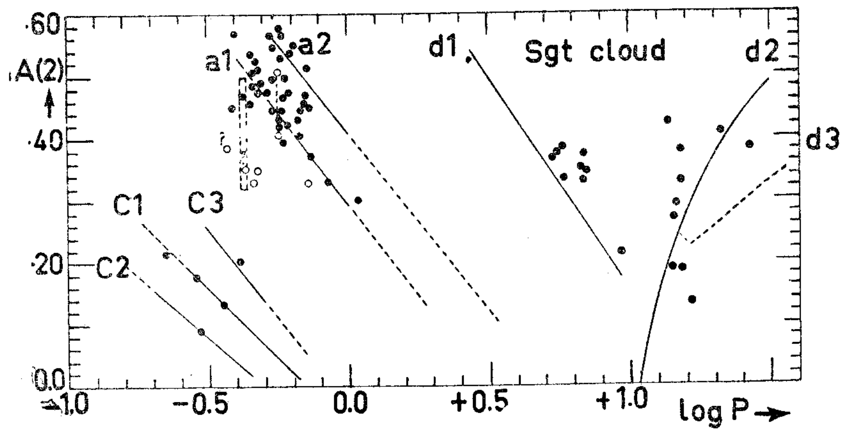

Fig. 1

However, in one recpect the distribution in the Sagittarius cloud deviates from that in all clusters. In the cluster no or hardly any variables of the Bailey subtypes *a* and *b* have a period shorter than log P $\leq$ 0.700 — 1. That is to say, no such variables are found having a period shorter than about the limit of the area occupied by the irregular stars. In the Sagittarius cloud a considerable number of the variables on the levels *a* 1 and *a* 2 have periods which are substantially below this limit. This point is further illustrated by figure 2. In this figure the range in period of the variables on the levels *a* and *b* are indicated by the black horizontal rectangles. The corresponding range of the levels *c* are indicated by the open rectangles.

The ranges valid for the Sagittarius cloud and for the clusters have separately been indicated, but have been shifted in vertical direction. The dotted vertical lines roughly indicate the range in period of the irregular stars. In the figure the difference between the Sagittarius cloud and the clusters is very apparent.

Returning to our inspecıion of figure 1 we see that the area occupied by the irregular stars seems to coinside with the corresponding area obtained from the clusters. One of the irregular stars is farther to the right than any of those previously fonnd, but as yet the limits of the area occupied by the irregular stars have not definitely been fixed.

Of the variables in Sagittarius 162 U and V 414 Sgr U are in te area occupied by the irregular stars, but Uitterdijk does not indicate that these systems might be irregular. However,

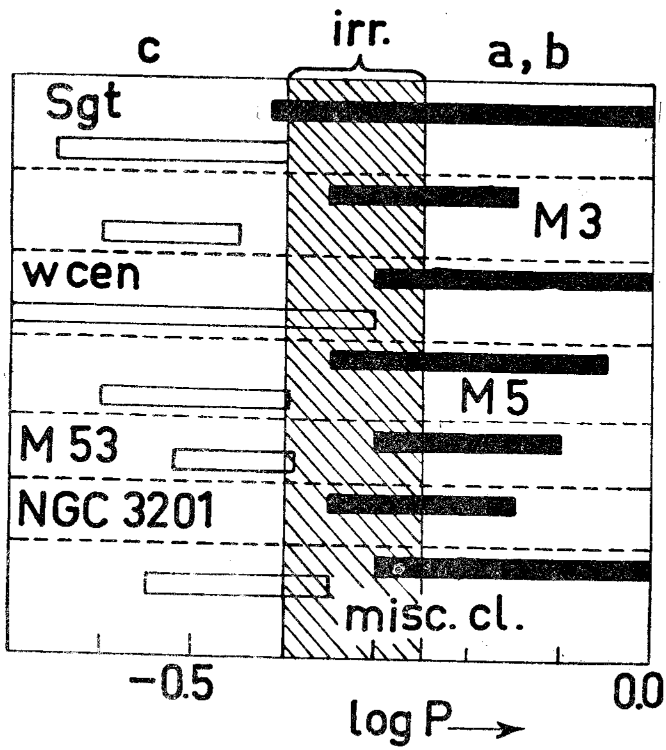

Fig. 2.

regular variables in this region are so extremely rare, that we suspect that on closer inspection they still might appear to belong to the R. W. Draconis subtype. Therefore in table 1 we have indicated these stars as being possibly irregular.

In this part of the Sagittarius cloud no pulsating variables seem to occur in the interval $0.1 \leq \log P \leq 0.7$. The Cepheid

TABLE 1.

Pulsating stars in the Sagittarius cloud which have been analysed in the present paper.

U = light curve, determined by J. Uitterdijk [1];
M = » » » » W. C. Martin [3];
S = » » » » H. H. Scoope [4];
F = » » » » J. G. Ferwarda [5];
J = variable from the list of A. H. Joy;

Design	Ref	Log P	π (1)	A (2)	A (3)	A (4)	Remarks
238	U	0.348—1	0.897	0.217	0.032	0.032	
96	U	.456—1	.871	.179	.130	.152	
a	F	.478—1	.979	.094	.061	.080	
b	M	.531—1	.955	.134	.055	.089	
162	U	.575—1	.882	.386	.282	.033	irr ?
38	U	.588—1	.797	.443	.155	.114	
b	M	.599—1	.707	.567	.228	.055	
144	U	.610—1	.946	.202	.084	.033	
190	U	.619—1	.717	.468	.321	.141	
142	U	.627—1	.613	.536	.435	.288	
V414 Sgr	U	.637—1	.845	.356	.195	.138	irr ?
147	U	.651—1	.722	.460	.346	.176	
221	U	.657—1	.871	.332	.167	.045	irr ?
107	U	.658—1	.689	.482	.310	.170	
HV 9148	S	.666—1	.737	.505	.217	.164	
157	U	.668—1	.662	.528	.339	.187	
119	U	.678—1	.685	.472	.270	.148	
80	U	.680—1	.862	.348	.118	.045	irr ?
100 b	U	.682—1	.762	.511	.205	.084	
192	U	.691—1	.653	.486	.403	.224	
302	U	.701—1	.762	.472	.214	.167	
111	U	.703—1	.700	.565	.270	.210	
273	U	.719—1	.670	.542	.312	.173	
HV 10281	S	.719—1	.768	.440	.217	.164	
211	U	.728—1	.680	.494	.318	.210	
257	U	.736—1	.765	.440	.251	.158	
245	U	.740—1	.696	.418	.303	.200	} irr.
300 I	U	.740—1	.823	.410	.145	.071	} irr.
300 II	U		.752	.512	.141	.045	
118	U	.751—1	.721	.429	.323	.190	

TABLE 1 (Continued)

Desing	Ref	log P	π (4)	A (2)	A (3)	A (4)	Remarks
92	U	0.756—1	0.637	0.562	0.322	0.164	
d	M	.760—1	.772	.464	.226	.089	
151	U	.763—1	.789	.396	.155	.207	
164	U	.766—1	.700	.575	.230	.145	
320	U	.769—1	.643	.524	.332	.265	
i	M	.774—1	.788	.420	.044	.045	irr.
V398 Sgr.	U	.774—1	.708	.534	.310	—	
197	U	.783—1	.739	.496	.277	—	
140	U	.790—1	.794	.472	.212	.105	irr.
170	U	.800—1	.708	.545	.235	.155	
262	U	.804—1	.757	.431	.230	.179	
227	U	.816—1	.775	.447	.394	.063	
322	U	.831—1	.701	.455	.318	.182	
305	U	.836—1	.720	.466	.237	.195	
251	U	.843—1	.824	.406	.184	.055	
166	U	.846—1	.709	.515	.286	.141	
228	U	.849—1	.764	.451	.173	.148	
79	U	.857—1	.861	.333	.184	.045	irr.
282	U	.878—1	.801	.387	.224	.155	
h	M	.916—1	.725	.313	.205	.268	
138	U	.042	.715	.401	.332	.195	
AP Sgr	J	.704	.871	.366	.084	.033	
V350 Sgr	J	.712	.841	.379	.055	.089	
HV 10302	S	.760	.838	.385	.158	.089	
Y Sgr	M	.761	.893	.335	.089	.000	
XX Sgr	J	.807	.837	.352	.145	.126	
AY Sgr	J	.818	.904	.332	.000	.055	
BB Sgr	J	.822	.858	.379	.055	.089	
U Sgr	J	.829	.878	.349	.000	.055	
YZ Sgr	J	.980	.862	.212	.170	.110	
112	U	1.127	.836	.427	.000	.071	abnormal
VY Sgr	J	1.132	.916	.270	.100	.055	
i	M	1.139	.935	.185	.180	.045	
99	U	1.139	.901	.298	.032	.105	
HV 10302	S	1.172	.880	.381	.095	.100	
AV Sgr	S	1.188	.840	.332	.210	.134	
12	M	1.192	.942	.185	.089	.071	
95	U	1.209	.959	.138	.063	.100	
WZ Sgr	J	1.339	.767	.407	.228	.207	
HV 10246	S	1.470	.847	.378	.130	.071	

variables start near $\log P = 0.7$ and those with period shorter than 10 days all are near the level d 1. It is somewhat curious that without any exception they all show a positive deviation from this level. It is to early to say whether this significant or not. In the Sagittarius cloud also the discontinuity at $P = 10$ days is very conspicuous. Apart from this however as yet not much definite can be said about the distribution of the systems beyond the limit $P = 10$ days.

The majority of these variables roughly are along the level d 2. Variable 112 U is rather abnormal and has a large positive deviation from d 2. On the other hand variable 95 U has a large negative deviation. This latter negative deviation is so large that the variable is in the region occupied by the Cepheids in globular clusters.

Litterature

[1] Uitterdijk, J: Annalen Leiden **20**, 2, 1949
[2] van Gent, H: B.A.N. **6**, 227, 1932
[3] Martin, W. C.: B.A.N. **6**, 235, 1932
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