

A statistical study of pulsating stars

Fifth paper: *The variable stars in M 53 and N.G.C. 3201*

by E. A. KREIKEN
(Department of Astronomy)

Özet: M 53 deki değişen yıldızlar ve N.G.C. 3201 deki değişen yıldızların ekseriyeti tetkik edilmiştir. Neticeler tablo 1 ve 2 de verilmiştir. Değişkenlerin korelasyon düzleminde $\log P$ ve $A(2)$ arasında dağılımı şekil 1 ve 2 de görülmektedir.

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Abstract: The variable stars in M 53 and the majority of the variables in N. G. C. 3201 are analysed. The results are given in the tables 1 and 2. The distribution of the variables in the correlation plane between $\log P$ and $A(2)$ appears in the figures 1 and 2.

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In the present paper the variable stars in the globular clusters M 53 and N. G. C. 3201 are analysed. The method of analysis is the same as the one used in the first paper of this series and the same symbols have been used throughout. Therefore neither the method nor the symbols are discussed here.

The variable stars in M 53 have been studied by E. Grosse who gives the periods and the light curves of 32 variables^[1]. Those which he indicates as being uncertain have been excluded from the present analysis. Also excluded were the variables No. 15 and No. 40, for which Grosse finds exceedingly short periods. It has been emphasized by P. Th. Oosterhoff that such very short periods must be treated with great caution^[2]. In several instances he has been able to show that different periods fitted better to the observed light curve.

In the particular instance Oosterhoff has made a further study of the variables No. 15 and No. 40 in M 53^[3]. His improved periods are slightly longer than those given by Grosse. The results of the present analysis show that the improved periods must be correct. The values $A(2)$ derived from the light curves given by Grosse are highly improbable. In the correlation plane of $\log P$ and $A(2)$ these two points would be situated well below and to the left of the level c_2 (see figure 1). If the light curves given by Oosterhoff are analysed, we find values of $A(2)$ which indicate that the two variables are quite normal and very nearly on the level c_1 . For the present I have thought it better to leave these two systems out of consideration. This leaves us 22 systems which are enumerated in Table 1. As indicated in the last column of the table even now for the two variables $N = 32$ and 19 the numerical values which could be obtained are uncertain. In the table the variables are arranged in order of increasing period.

The numbers in the first column refer to the table given by Grosse^[1].

The next columns contain the logarithm of the period the Bailey type if given by Grosse and the numerical values of $\pi(1)$, $A(2)$, $A(3)$ and $A(4)$ respectively. The final column contains some remarks concerning the individual variables. Variable No. 30 has been indicated as irregular.

It is classified by Grosse as being of intermediate type ab , while he remarks the successive maxima of the light curve are of unequal light and have unequal shape.

The plot of the individual values $A(2)$ against the corresponding values of the logarithms of the period appears in fig. 1. With the exception of the irregular variables, all stars are indicated by black disks. For the irregular variables open circles are used. In M 53 only one irregular variable occurs, viz. the system $N = 30$, and from figure 1 it is evident that it is situated exactly in the region which in the other clusters was found to be occupied by the irregular systems.

The majority of the c type stars are on the sublevel c_1 , while only a few occupy the level c_2 . The sublevel c_3 is not represented. The variables of Bailey type a and b fall along the levels a_1 and a_2 , but the two levels are not well separated.

The eighty six variable stars in N. G. C. 3201, as listed by

Helen B. Sawyer^[4] have been studied by Frances W. Wright^[5]. In her catalogue she gives the elements of 55 light curves.

In the present paper of these light curves twenty eight were analysed by the autocorrelation and subsequent power analysis method.

These twenty eight variables are enumerated in table 2, which also gives the values $\log P$, $\pi(1)$ A(2), A(3) and A(4).

The arrangement is by period, while the numbers in the first column refer to the catalogues of Miss Sawyer^[4] and Miss Wright. The variables were selected at random but in such a way that all periods are represented.

Also a few additional systems were inserted which have either a very long or very short period, or a period near the transition from the Bailey subtype *c* to *a* and *b*.

Finally a few systems were added, which judging from the light curve given by Miss Wright (1. c. figure 1) seem more or less to deviate from the normal type.

Consequently the distribution of the periods of the variables enumerated in table 2 is no longer representative for the true distribution of the periods of the variables in N. G. C. 3201.

The plot of the values A(2) against $\log P$ in figure 2 reveals some interesting features. The sublevels c_1 , c_2 and c_3 are

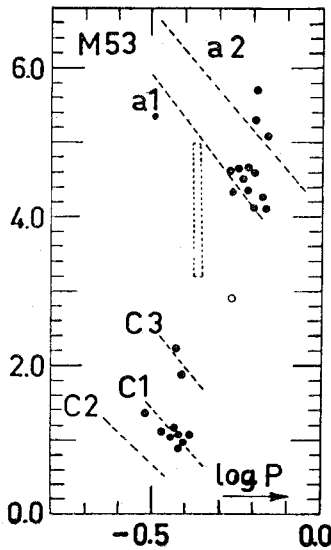


Fig. 1.

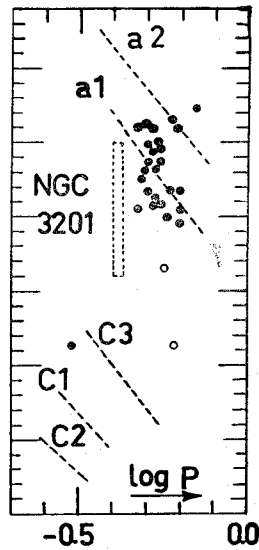


Fig. 2

conspicuously absent. There is only one variable (No. 11) which seems to be on the c_3 level. All cluster type variables being of nearly the same absolute magnitude, it seems that the absence of the c levels is real. The black disks indicating the individual stars are mainly concentrated along the level a_1 . Only relatively few are on or near the level a_2 . In the diagram two stars have an abnormal position viz. the nos. 21 and 44. The point indicating the system 21 is in the area of the irregular variables. Miss Wright^[5] does not state whether the system is irregular or not, but from her figure 1 it might be inferred that the successive maxima are of unequal height. I have therefore tentatively indicated this system as being irr.

The point indicating the system 44 is near, but slightly to the right and below the area which previously was found to be occupied by the irregular systems.

Consequently the system 44 may also be an irregular variable, but it may also be that the period needs revision.

The apparent magnitude of the system 28 seems to be larger than that of the other variables, but its $A(2)$ value is quite normal.

In the diagram 2, the point indicating this system compares well with the other systems and nearly coincides with the a_1 level.

Altogether there are marked differences between the distribution in the correlation plane of the variables in ω Cent. M 3, M 5, M 53 and N. G. C. 3201.

As yet it is not quite evident what the explanation of these differences should be. It may be that they are related to the ages of the clusters. However, before any conclusions can be drawn, an analysis of additional clusters is needed.

Literature :

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E. A. Kreiken

Department of Astronomy of
Ankara University.

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