ON THE CHANGES OF PERIODS OF RR LYRAE VARIABLES IN THE GLOBULAR CLUSTERS M5, M53 AND NGC 5053

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The period of a variable star is very sensitive to extremely minor changes in luminosity, mass, radius, surface temperature, etc. of the star. With new theoretical calculations of the interior structure of stars in the late stages of evolution now available, the investigation of instabilities in the periods of the RR Lyrae variables in globular clusters becomes urgent.

Sufficient material for statistical investigation of the instability of periods of cluster variables has already been accumulated for several clusters. For example, the observations of the RR Lyrae variables in the globular clusters M3 and M5 embrace a time interval of 80 yr, in M53 – 50 yr, in NGC 5053 – 45 yr. Such time intervals afford the possibility of defining the periods of variables more accurately and obtaining information about their changes.

For the majority of variables in three globular clusters studied by us, long time intervals of relative quietness of the periods replaced by brief intervals of spontaneous changes are highly characteristic. Therefore during the intervals of quietness the residuals $O-C$ can be well approximated by linear elements, and the general $O-C$ diagram can be well approximated by discontinuous lines. Of the 51 variables studied in M5 (Kukarkin and Kukarkina, 1971) 85% show sudden changes of period. 93% of period-changing variables in M53 (of the 13 studied) and 75% of the period-changing variables in NGC 5053 (of the 9 studied) changed their periods spontaneously. In exceptional cases the residuals $O-C$ are subject to slight oscillations during the time intervals of quietness. In other cases the considerable dispersion of observations does not permit a conclusion about the character of period changes to be drawn. All the RR Lyrae variables with the Blazhko-effect show very large changes of periods.

Some interesting conceptions on the problem of period changes were published by Detre (1969).

Unfortunately, up to now the investigators of variable stars have supported the tradition of approximating the residuals $O-C$ by a quadratic form as follows:

$$O-C = T_0 + P \cdot E + k \cdot E^2$$

or by a trigonometric equation like

$$O-C = T_0 + P \cdot E + k_1 \cdot \sin\left[\theta \cdot (E - E_0)\right]$$

and to use the quantities k, k_1 and θ as measures of period instability. However, as long as 15 yr ago it was shown (Parenago, 1956) that these equations do not represent the observations if the investigator utilises an array of observations which is sufficiently

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prolonged. Modern theoretical calculations of stellar evolution predict smaller rates of secular period changes; the observed changes of periods must be a kind of noise.

Figure 1 shows several examples of unsuccessful interpretations of the $O-C$ curves by means of quadratic and trigonometric equations (Margoni, 1964, 1967; Wachmann, 1965) for 4 RR Lyrae variables in the globular cluster M53. One can see that usually the more complete array of observations contradicts such an interpretation.

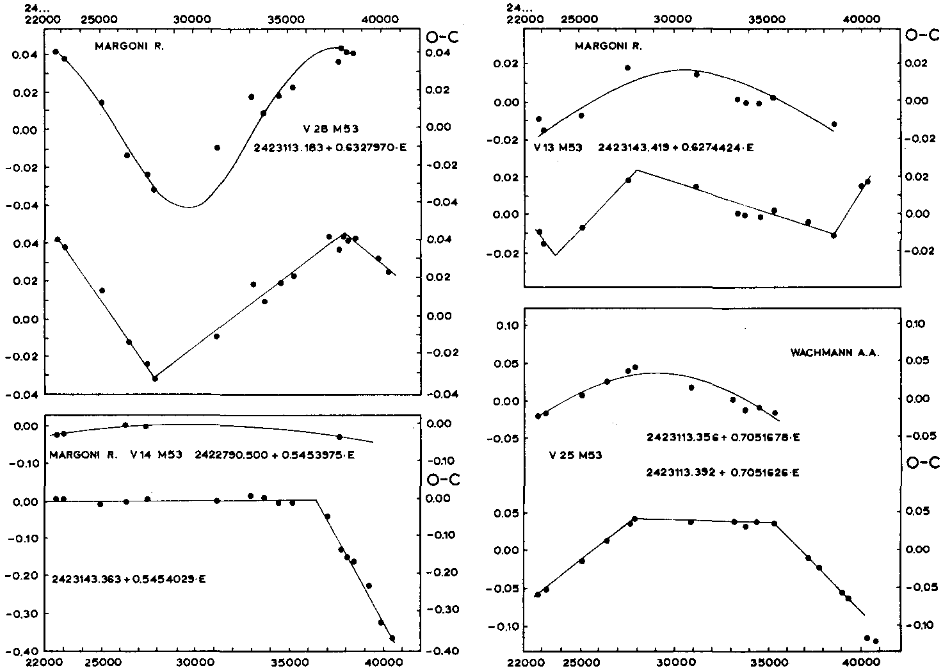

Fig. 1. Typical $O-C$ diagrams for RR Lyrae variables in globular clusters. Note that the discontinuous straight lines generally represent the observations better than the quadratic or sinusoidal curves.

We suppose that the best physical quantities describing the instability of the period of an RR Lyrae variable (and also other pulsating stars) and reflecting the nature of these period variations are the value of the period jump ΔP, the duration of the quiet stage of the period ΔT_1 before and ΔT_2 after the jump. It is very probable that the quantity $\log(\Delta T \cdot \Delta P/P)$ may be a measure of instability (Parenago, 1956). All these quantities should be used for statistical analysis.

References

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DISCUSSION

Schwarschild: I suspect that the question regarding the character of period changes – other than the probably very slow systematic evolutionary changes – is of basic importance to theoretical considerations. It would seem to me, for example, that it would make all the difference for theoreticians to know whether the random period changes are relatively abrupt, as suggested in the paper we just heard, or relatively smooth as implied by β computations.

Coutts: Some of the periodic period changes found by Margoni can be explained if the RR Lyraes are members of binary systems. The variation in radial velocity causes an apparent period change which can be detected if the period of the binary is at least 8 yr.

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