B V PHOTOMETRY OF RR LYRAE VARIABLES IN M15

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New BV photographic photometry for 56 RR Lyrae variables in M15, combined with original measures by Sandage, Katem and Sandage (1981), yield data of improved precision which enable a rediscussion of the RR Lyrae characteristics and Oosterhoff problem.

Pulsation theory is used to derive a mass-luminosity ratio: Log L = 1.92 (±0.03) + 0.81 + Log M, which gives $M_V(RR) = 0.40$ assuming a mean mass of 0.65 $M_\odot$ obtained by Cox, Hodson and Clancy (1983) for the multimode variables. This luminosity implies an age a few billion less than the current estimates, but such a derivation is still affected by many uncertainties.

The observed distribution of stars in the HR diagram (Fig. 1) is in good agreement with the morphology of the appropriate evolutionary tracks of Sweigart and Gross (1976). However, the mass-luminosity ratios derived from evolutionary models are consistent with those derived by pulsation theory only if the helium abundance is $Y \gtrsim 0.30$. If $Y \lesssim 0.25$ as might be

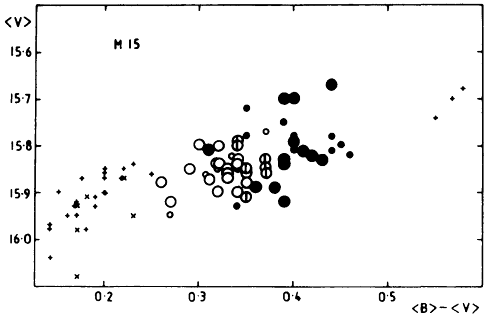

Fig. 1 RR Lyrae variables in the c-m diagram. Non variable stars are also plotted (+,×). c-type variables are plotted as open circles or open circles with bar (multimode behaviour), ab-types as filled circles. The blue edge of the instability strip is clearly demarcated.

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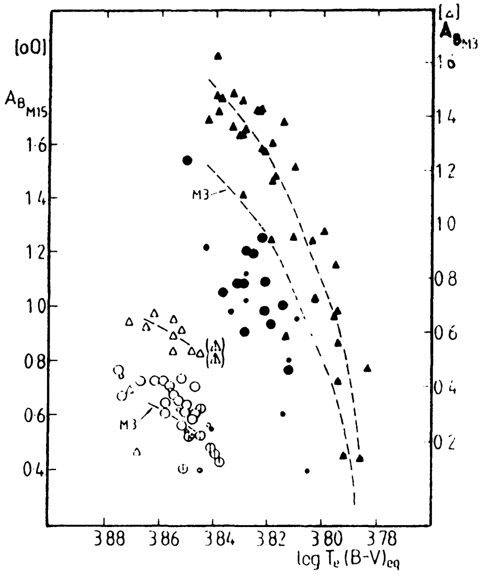

Fig. 2 Blue amplitude as a function of Log Teff for RR Lyraes in M15 (circles) and M3 (triangles).
The thick dashed line shows the position of the mean M3 relations referred to the left hand ordinate.
Effective temperatures are derived using temperature scales from BDE and reddenings of E(B-V) = 0.00 (M3) and 0.10 (M15).

expected from independent evidence, the evolutionary models predict a lower luminosity (ΔLog L $\simeq$ 0.1) than obtained from pulsation theory. This discrepancy can be removed if the effects of stellar rotation and CNO enhancement are taken into account.

Comparison with the RR Lyraes in M3 shows that the Osterhoff effect between these two clusters cannot be simply described in terms of a period shift, since the distribution of amplitude and number with period and temperature differ in detail, in particular a unique amplitude-temperature relation for both c- and ab-type variables is not possible (Fig. 2). The present analysis confirms Sandage's result that the correlation of period shift with metal abundance over many clusters requires an anticorrelation of metal abundance with helium abundance within the current frame of evolutionary models.

Comparison with the morphology of the appropriate theoretical tracks reveals that many of the RR Lyraes in M15 begin their HB evolution within the instability strip, spending much longer in the center of the strip than variables in M3-like clusters which evolve more rapidly bluewards across the strip. The distribution in M15 peaks just bluewards of the transition temperature giving rise to the many c-type variables found there. The multimode variables occur precisely at the transition temperature (the same in M15 and M3) and appear to be a "stable" mode of pulsation.

REFERENCES

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DISCUSSION

Cox: The brightness of the horizontal branch in M15 gives a rather high luminosity. That is $M_{bol} = 0.3$. This corresponds to a small age of only 10^{10} years. Can you comment?

Cacciari: This value of luminosity for the horizontal branch comes from pulsation theory, assuming a mass 0.65 $M_{\odot}$. It certainly leads to an estimated age smaller than 15 billion years. On the other hand, this larger value of age is based on the assumption that the luminosity of RR Lyrae stars in M3 is $M_v = 0.80$ mag, which is probably too faint by approximately 0.1-0.2 mag, as suggested by a number of independent estimates.