THE EXPECTED MORPHOLOGY OF ZERO AGE HORIZONTAL BRANCHES

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On the basis of available theoretical evaluations of the H-burning evolutionary phases of Population II stars, it is at present quite simple to predict the expected location of Zero-Age Horizontal-Branch (ZAHB) stars for assumed values of the age and original chemical composition. A result of such a computation is disclosed in Fig. 1, for the labelled values of the assumed evolutionary parameters.

From a qualitative point of view, the HR diagram behavior is the one well known from the numerous ZAHB's computed since the first work by Rood (1973) appeared. Here it might be worth discussing some quantitative details.

The effect of the increase in surface helium, connected with the sinking down of the external convection during the red giant phase is shown in Fig. 2. If one choses Y=0.20, the ZAHB luminosity at the RR Lyrae gap increases, roughly as $\Delta \log L \sim 0.04$. Such a difference is obviously not a dramatic one. Nevertheless one has to realize that, if interpreted in terms of variation in the original He-content, a similar discrepancy would imply $\Delta Y \sim 0.03$ which can be a not negligeable value, when quantitative interpretations are attempted. As a matter of fact, increasing the original helium abundance decreases the size of the helium core at the beginning of H.B. evolution which counteracts the increased efficiency of the H-burning shell. As a result the ZAHB location is less sensitive to variations in the original helium abundance than in the "external helium". In this way it is easy to understand the above quoted results.

A. G. Davis Philip and D. S. Hayes (eds.), The HR Diagram, 221-224. *All Rights Reserved. Copyright © 1978 by the IAU.*

https://doi.org/10.1017/S0074180900145553 Published online by Cambridge University Press

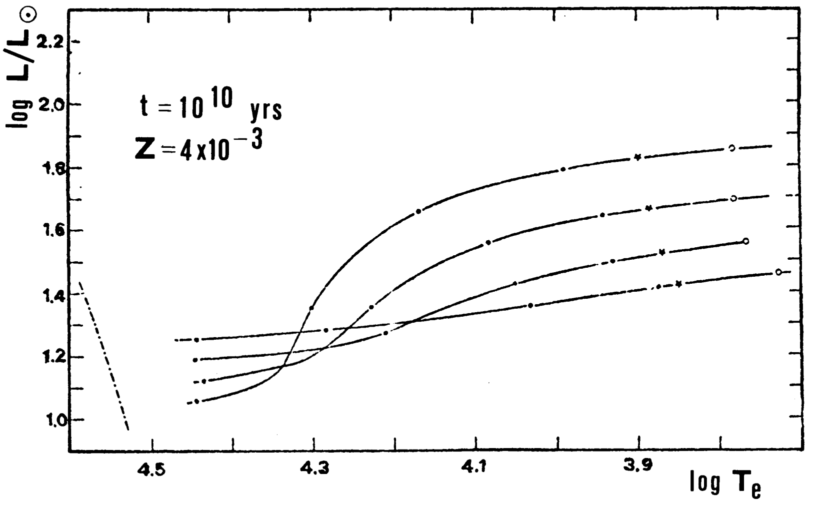

Fig. 1. ZAHB loci for Z=$4x10^{-3}$ and original Y= .40, 0.30, 0.20 and 0.10 (top to bottom in the red region). Stars indicate on each sequence the blue boundary for pulsational instability. (From Caloi et al. 1977.)

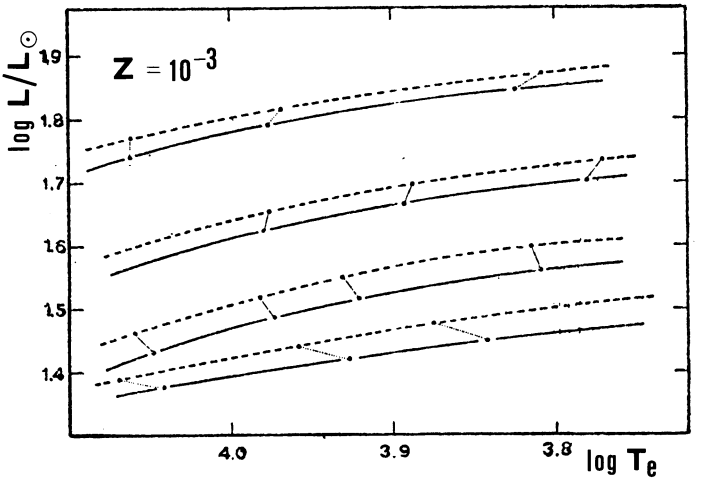

Fig. 2. ZAHB sequences showing the effect of the evolutionary increase in surface helium. Full lines: original helium, dashed lines: evolutionary helium.

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A few further details may be worth discussing. The first one is the expected location of hot HB stars in the HR diagram. The occurrence of a very blue tail of HB stars has been observed (or suggested) in some "M 13 like" galactic globular clusters. From data reported in Fig. 1 we obtained the V, (B-V) loci reported in Fig. 3, adopting B.C.'s and C-T_{eff} relations as given by L. Rossi (1977) on the basis of detailed atmospheric computations. As a result, we find that the location of hot HB stars in the HR diagram is largely independent of the original chemical composition. Thus, the assumption made by Cannon (1974) in comparing the HR diagrams of globular clusters by superimposing the blue HB stars is supported. The observed differences in the location of red giant branches in the HR diagram remains (quantitatively) an open question.

A comparison with observations, as given in the same Fig. 3, seems to be in good agreement with the theoretical results, supporting the previous conclusions.

Of course, ZAHB structures depend on the assumption on the relative abundance of CNO elements. Fortunately, theoretical computations (Castellani and Tornambe 1977) indicate that varying CNO doesn't sensitively change the ZAHB locus, and the pulsational characteristics of RR Lyrae variables are expected to remain essentially correlated with He abundance, even if a "reasonable" fluctuation in CNO abundances is assumed. In this context, it might be worth noticing that in Population II systems there is not (yet) any clear indication about a discrepancy between "pulsational" and "evolutionary" masses, in the sense that "evolutionary" HB models can fit very well the observed period-frequency histograms of RR Lyrae pulsators, when suitable values of the evolutionary parameters are assumed.

In conclusion, one finds that "realistic" HB stars largely support the belief in a quantitative understanding of HB evolution. At the same time one is facing some new problems. Among these, I wish to mention the case of the Draco dwarf galaxy: if we believe for this system a value of Z as low as $Z \approx 3 \times 10^{-5}$ (Canterna 1975), evolutionary HB stars cannot reach the red side of the instability strip if $Y \gtrsim 0.20$. On the contrary, Draco is a well known red-HB cluster. Why?

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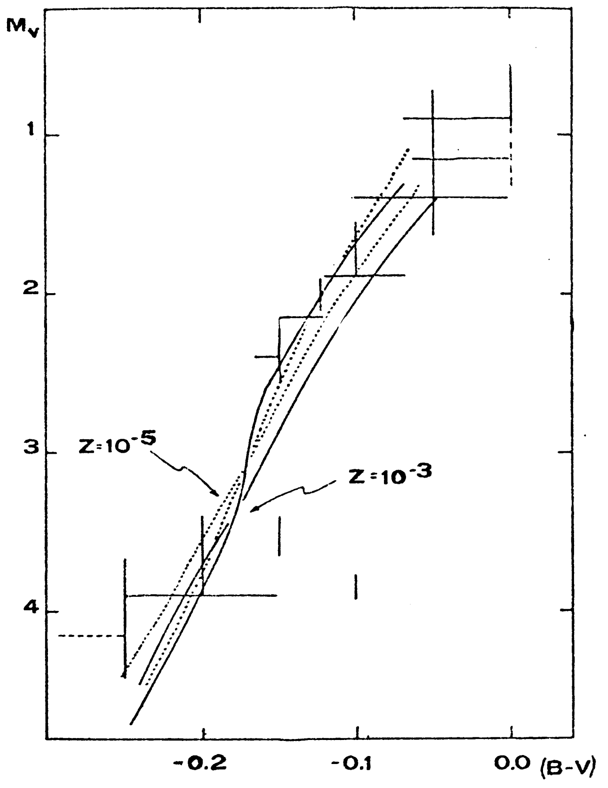

Fig. 3. The expected location in the C-M diagram of hot ZAHB stars for two different assumptions on Z and for Y=0.30 or 0.20 (top to bottom at the lower temperatures). Bars roughly indicate the locations of hot HB stars observed in NGC 6752 (Cannon and Lee 1973).

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