CURRENT PROBLEMS ON HORIZONTAL BRANCH STARS

1: H.B.-Topology

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Abstract. After a short historical survey (Section 1), present available informations on the location of H.B. stars in the colour-magnitude diagram are collected. A general agreement is found between observations and theoretical predictions as deduced from the available B.C.- and (B–V)-log$T_e$ relations. It is shown that some peculiarities or differences in the shapes of the blue branch – if real – can be ascribed to differences in the He content and/or in the efficiency of gravitational sedimentation, whereas the discrepancies in the maximum colour index of red H.B. stars is perhaps related with present indeterminacy of the treatment of superadiabacity (Section 2). Finally (Section 3) a comparison among presently available evaluations of the B.C.-log$T_e$ and (B–V)-log$T_e$ relations is made in order to derive informations about the range of reliability, as well as in order to emphasize some possible peculiarities.

1. Introduction and Historical Survey

This is the first part of a work in which we purpose to examine in details some general problems of the actual status of Horizontal Branch stars in Galactic Globular Clusters.

In this first paper we are essentially dealing with the problem of the H.B. topology – i.e. of the analysis of expected locations of H.B. stars in the HR diagram, from both the theoretical and observational points of view; in the second paper we will be devoted to the whole frame of evolution and to the analysis of H.B. stars population.

As an historical survey we can remember that the first theory of H.B. evolution was developed by Hoyle and Schwarzschild in 1955; in that they were the first in identify H.B. stars with He-core burning stars. It follows a series of very important and careful investigations (Nishida 1960; Osaki 1963; Cox and Salpeter, 1961; Hayashi et al., 1962) that was partially neglected only because at that time the evolutionary background was not yet sufficiently well developed.

Further advances have been made by Iben and his coworkers (see, in particular, Iben and Faulkner, 1968; Iben and Rood, 1970; Rood, 1970; Simoda and Iben, 1970), after the group of Göttingen (Kippenhahn and coworkers) and Iben himself had developed a remarkable picture of basic stellar evolution. In those works the fundamental ideas were stated of the interpretation trend which we shall now use as a basis of our work.

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Since 1968 it was suggested (Castellani, Giannone, and Renzini) to take into consideration the occurrence of an appreciable mass loss in the H.B. star generation in order to attain consistency between theoretical and observational features, proposing also a topological approach for the location of the 'remnants' in the HR diagram. Iben and Rood (1970) confirmed this belief, furnishing an extensive set of theoretical data extremely useful to approach a quantitative explanation.

At the present time our knowledge of the Galactic Globular Clusters is rapidly increasing from both the theoretical and observational points of view. Many works have been recently been undertaken to investigate the evolutionary features of G.C.'s stars, as well as in order to take into account the observed discrepancies among various clusters. As a matter of fact the first approach, i.e. the hypothesis of a 'mean' globular cluster, is now progressively being abandoned in the analysis of the stellar populations in the various clusters, in the interpretation of the RR Lyrae variables, etc.

In what follows we shall refer to works trying to collate different kind of available data that can be connected with the basic evolutionary parameters; but in so restricted a review many important contributions have been omitted in order to place in relief only a schematic picture.

Both the theoretical and observational results generally suffer from different kind of indeterminacy and incompleteness. Nevertheless, one can realize that the greatest difficulty in interpreting globular star clusters is, at present, that of relating the observational data with the theoretical results by the temperature-colour and magnitude-luminosity relations. This is the reason why, in our opinion, the interpretation seems to be confined on explanations of the pulsational properties of the RR Lyrae variables, because the pulsational characteristics are essentially unaffected by observational indeterminacy.

Nevertheless, in what follows we shall confine our attention to the possibility of collecting quantitative informations on the Horizontal Branches, in order to investigate the range of similarity among selected classes of Globular Clusters, as well as in order to verify the current hypothesis on the 'status' of presently evolving Horizontal Branch stars.

2. The Observed Horizontal Branch Topology

In Figure 1 we collected a selected sample of the present available informations on the location of H.B. stars in the colour-magnitude diagram. The observed H.B. are arranged following the integrated spectral types of the clusters (van den Bergh, 1967). By a visual inspection of this figure one can realize the wide variety of shapes which occur in the H.B. loci. In Table I some basic parameters are also reported. As is well known, a general trend is easily recognizable: Oosterhoff II type clusters are characterized by essentially blue horizontal branches; high metallicity clusters have red horizontal branches, etc. It is quite difficult to systematize this trend in a monometric family of clusters, so that one is driven to a more or less complicated bi-dimensional classification (Hartwick, 1960; Castellani et al., 1971). One must also emphasize the very peculiar behaviour of NGC 7006, which could support the belief