THE DEVELOPMENT OF A RED-GIANT BRANCH IN LOW TO INTERMEDIATE MASS STARS

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ABSTRACT: A new grid of evolutionary sequences has been computed for the main sequence and first red-giant branch (RGB) phases of low to intermediate mass stars. From these sequences we have obtained new intermediate age isochrones.

1. MOTIVATION

The evolution of low to intermediate mass stars is of theoretical and observational interest for a number of reasons, including:

a) The study of the phase transition from degenerate to nondegenerate helium-core ignition.

Low mass stars develop a degenerate helium core following the main sequence phase and, as a result, have an extended RGB phase prior to helium ignition, as found in galactic globular clusters. In contrast, intermediate mass stars do not develop a degenerate helium core and therefore do not have an extended RGB phase prior to helium ignition. Thus the transition between low and intermediate mass stars represents a transition in both the interior structure and observable morphology in the HR diagram.

b) The need for intermediate age isochrones covering the evolutionary phases up to helium-core ignition.

Such isochrones are necessary, for example, in order to understand the HR diagrams of intermediate age globular clusters in the Magellanic Clouds (cf. Poster 210 by Renzini et al. in this symposium).

c) The interpretation of the integrated properties of stellar populations.

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The Harlow-Shapley Symposium on Globular Cluster Systems in Galaxies, 483–484.

Intermediate age theoretical sequences are needed to determine the contributions of the different evolutionary phases to the integrated luminosities and colors as well as to determine the dependence of the integrated properties on chemical composition and age.

2. COMPUTATIONS

One hundred canonical evolutionary sequences consisting in total of $\sim 10^5$ models have been constructed for the evolution of low to intermediate mass stars from the zero-age main sequence to helium-core ignition. These sequences, obtained with a modified version of the evolution code described in Sweigart and Gross (1978), have been computed for each combination of the following main sequence helium and heavy element abundances: Y_{MS} = 0.20 and 0.30 and Z = 0.004, 0.01 and 0.04, and for stellar masses between 1.4 and 3.4 $M_\odot$. A small mass spacing of only 0.05 $M_\odot$ was used around the RGB phase transition in order to map this transition very precisely.

The present sequences have been used to construct isochrones for ages ranging from 0.3 to 1.75 Gyr. These isochrones, which include the first RGB phase, have been transformed into the observational M_V versus B-V plane for comparison with the HR diagrams of the intermediate age globular clusters in the Magellanic Clouds. These isochrones can also be used to construct model stellar populations for high red-shift galaxies, when the dominant stellar population consists of $\sim$1 Gyr old stars.

3. RESULTS

The objective of the present work has been to study the phase transition between low mass stars with degenerate helium cores and prominent RGB's and intermediate mass stars without these evolutionary characteristics. From our results we conclude:

a) The phase transition occurs abruptly with increasing mass. Typically this transition covers a mass range of $\sim 0.4\ M_\odot$.

b) The mass at the phase transition varies from ~ 2 to $\sim 3\ M_\odot$, depending on the composition. The transition mass increases with either decreasing Y_{MS} or increasing Z.

c) During the phase transition the luminosity at the tip of the RGB changes by $\sim$2.5 mag.

d) The average age at the phase transition is 6×10^8 yr. Most importantly, this age varies by only $\pm 10^8$ yr for $0.20 \leq Y_{MS} \leq 0.30$ and $0.004 \leq Z \leq 0.04$ and thus is insensitive to the composition.

REFERENCE

Sweigart, A, V, and Gross, P. G. 1978 Astrophys. J. Suppl. 36, 405.

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