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EFFECTS OF HELIUM ENRICHMENT IN GLOBULAR CLUSTER POPULATIONS

A. A. R. Valcarce,[1] M. Catelan,[1] and A. V. Sweigart[2]

RESUMEN

Recientemente, el entendimiento de cúmulos globulares (CGs) ha cambiado drásticamente debido a la mejora de las observaciones, tanto espectroscópicas como fotométricas, las cuales han revelado que no todos los CGs deben ser considerados poblaciones estelares simples. Mientras estudios espectroscópicos han mostrado diferentes grados de variación en elementos livianos en todos los CGs observados (e.g. anticorrelación entre O-Na, Carretta et al. 2009), estudios fotométricos han mostrado separaciones en algunas fases de los diagramas color-magnitud (DCM), donde la triple secuencia principal de NGC 2808 ha sido atribuida a diferencias en la abundancia de helio (ΔY, Piotto et al. 2007), el cual no puede ser medido con bastante precisión en CGs. En esta contribución mostramos los otros efectos que se deberían observar en DCM de CGs si ΔY es real.

ABSTRACT

Recently, the understanding of globular clusters (GCs) has drastically changed owing to the improvement in spectroscopic and photometric observations, which have shown that not all GCs could be considered simple stellar populations. Whilst spectroscopic studies have shown variations of some light elements in different degrees in all observed GCs (e.g., O-Na anticorrelation, Carretta et al. 2009), photometric studies have shown splits in some phases of color-magnitude diagrams (CMDs), where the triple main sequence (MS) detected in NGC 2808 has been attributed to differences in the helium abundance (ΔY, Piotto et al. 2007), which cannot be measured with enough precision in GCs. In this contribution, we show the other effects that must be observed in CMDs of GCs if ΔY is real.

Key Words: stars: evolution — stars: low mass

1. THEORETICAL EVOLUTIONARY TRACKS

We have computed extensive evolutionary tracks for a wide range of [Fe/H] from −2.25, to −0.25, in steps of 0.25, and initial helium abundances (Y) from 0.245 to 0.370, in steps of 0.025, using PGPUC stellar evolution code (Valcarce, A., 2011, in preparation). Isochrones were created from 7.5 to 15.0 Gyrs, with minimum masses of 0.5 $M_\odot$ which, together with zero age horizontal branch (ZAHB) loci, are used to study the effects of different Y in GCs[3].

2. HELIUM EFFECTS IN ISOCHRONES, AND ZAHBS

Figure 1 shows two sets of isochrones with [Fe/H] values (−2.00 and −1.00)[4], where the main effects are summarized below.

Main Sequence (MS): Here, it is observed a MS split for different Y where MS is hotter and brighter for higher Y which is produced for the lower amount of particles to support the same mass: e.g. stars with 0.5 $M_\odot$ (faintest point in each isochrone) are brighter when Y is higher, because these stars are more compressed, increasing central density, and temperature which increase the thermonuclear reaction rates, and, consequently, the luminosity (L), and effective temperature ($T_{\rm eff}$).

Turn-Off (TO) point: It is the locus where isochrones reach the maximum $T_{\rm eff}$. When isochrones with similar [Fe/H] are compared not only the difference in Y affects the TO point, but also the age is important. While an increase in Y drives a reduction of L, and increase in the $T_{\rm eff}$, an increase in the age of the isochrone decreases both L, and $T_{\rm eff}$. However, this last effect almost does not change the difference in L, and $T_{\rm eff}$ between isochrones with different Y.

Sub Giant Branch (SGB): This loci correspond to the zone between the TO point, and the point where isochrone's slope changes suddenly in favor of greater L. Although SGB loci start at greater

[1]Pontificia Universidad Católica de Chile, Dep. Astronomía y Astrofísica, Av. Vicuña Mackena 4860, 782-0436 Macul, Santiago, Chile (avalcarc, mcatelan@astro.puc.cl).

[2]NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (allen.v.sweigart@nasa.gov).

[3]Isochrones, and ZAHB loci are free available in several set of filters via private communication with A.A.R.V.

[4]See color figures in the electronic version of this article.

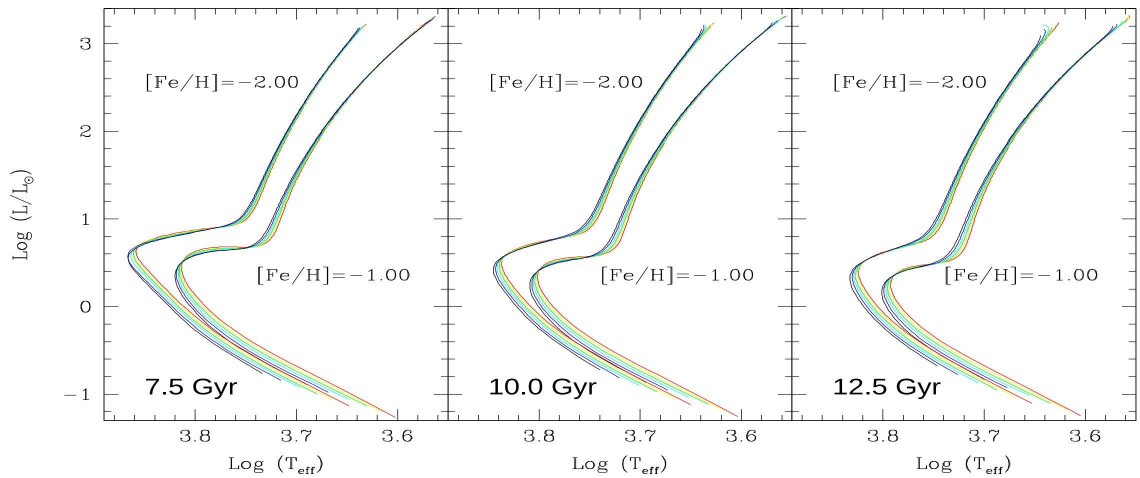

Fig. 1. Isochrones for 7.5, 10.0, and 12.5 Gyrs with [Fe/H]=−2.00, and −1.00. Colors represent different initial helium abundances: 0.245 (red), 0.270 (yellow), 0.295 (green), 0.320 (cyan), 0.345 (blue), and 0.370 (black).

$T_{\rm eff}$ when Y is higher, the difference in L between them at the medium $T_{\rm eff}$ is small. This difference is more prominent for low ages, or for high metallicities.

Low Red Giant Branch (RGB): In the low RGB there are three important effects to be considered when Y is increased: (i) the minimum luminosity almost does not depend on Y, but depends on [Fe/H], and the age; (ii) $T_{\rm eff}$ on the base of the RGB increases with Y and age. However, the $T_{\rm eff}$ difference between isochrones with different Y increases for higher ages; (iii) the absolute value of the low RGB slope is affected by the increase in Y being greater for low helium abundances. Second, and third effects are more prominent for higher metallicities.

High RGB: Above the RGB Bump, the difference in helium does not induce any great difference in the RGB slope being the only observable effect the luminosity of the RGB Tip which decreases for high helium abundances. Although this reduction on the RGB Tip luminosity should be very difficult to observe in CMD of GCs due to the small amount of stars in this point, it could be used to constrain the minimum initial helium abundance of GCs stars if its compared with other zones of CMDs.

ZAHB: Effects of different Y in ZAHB loci have been previously studied by (Sweigart 1987) which, although several input physics have been updated, the main effects are similar (see Figure 2). When Z is constant is observed that ZAHB luminosities for high helium abundances are greater for cooler HB stars (more massive), while luminosities are lower for hotter stars (less massive). Moreover, the L difference between ZAHB with different Y depends on the metallicity which for lower Z this difference is also lower for reddest HB stars, while for bluest HB stars it is greater.

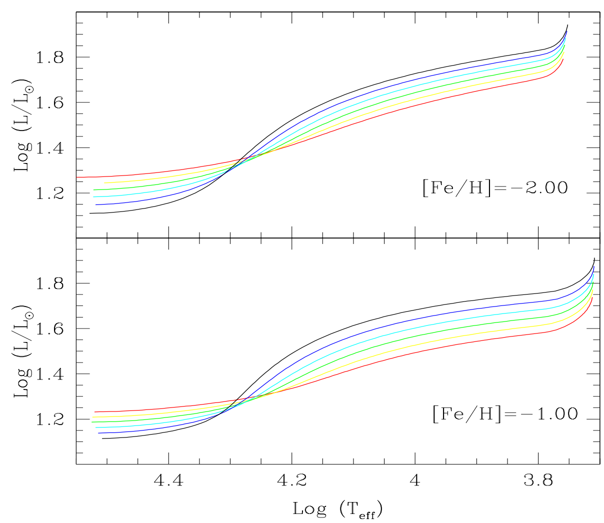

Fig. 2. ZAHB loci for [Fe/H]=−2.00 (upper panel), and −1.00 (lower panel). Colors represent the same Y value than in Figure 1.

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