A synthetic spectral stellar library of blue horizontal branch stars

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Abstract. Blue Horizontal Branch (BHB) stars are stars that have gone through most of their evolutionary process, lost part of their outer layers, leaving a thin layer of H and the core burning He. This makes them very warm and blue, but old. We can find these stars in many stellar systems, and their presence may induce errors in determining the age of these objects. The technique of analysis of stellar populations using integrated spectra is a powerful tool in the study of galaxies, but models of stellar populations do not take into account BHB stars. Because of this, the presence of these stars induces a determination of younger ages than expected for these systems. In this project we are creating synthetic spectra for the stars of the Horizontal Branch (HB) that can be incorporated to the models of stellar populations used in spectral synthesis. We performed a careful research in the literature to determine the coverage of atmospheric parameters and chemical properties required to represent the HB of various stellar systems. These values are the base of the creation of the library. To generate the synthetic spectra we are using ATLAS9 atmosphere models and the spectral synthesis code SYNTH. As a preliminary result, we noticed that the spectra of 14 observed HB stars, extracted from the MILES empirical spectral library, are better represented by spectra rich in He.

Keywords. Stars: horizontal-branch, abundances, atmospheres

1. Introduction

Models of single stellar population have quickly become a fundamental tool in the study of both galactic and extragalactic populations (e.g. Percival & Salaris 2009, Kotulla et al. 2009, Coelho et al. 2007, Maraston 2005, Bruzual & Charlot 2003). Despite the increasing sophistication of the models used, there are still areas where models and methods could be improved and expanded. A key area in which simplifications are usually made is related to the Horizontal Branch (HB). The presence of Extreme Horizontal Branch (EHB) stars in a stellar population directly affects the age inferred through spectroscopic adjustments with synthetic models of stellar populations (Schwartz 2004).

2. Objective

The main objective of this work is to construct a library of HB synthetic spectra, which can be created with any variation of atmospheric parameters desired for these stars so that they can later be included in the analyzes of the stellar populations.

3. The Horizontal Branch

After undergoing deep changes in its structure, in RGB, the star eventually re-balances and reaches the HB of the HR diagram. HB is populated as follows: if the star loses a lot of mass, only a thin layer of hydrogen will remain around the nucleus that is burning helium, resulting in a bluish coloration and higher temperature. This star will be further to the left in the HR diagram. A star that loses little mass will have a thick outer layer, resulting in a red coloration and a lower temperature. This star will be further to the right in the HR diagram. Figure 1 shows an example of HR diagram for the cluster M5, where many phases of stellar evolution are represented, including the HB.

Some chemical peculiarities may be related to the formation of these stars, in particular related to the abundance of He (D'Antona et al. 2002, D'Antona 2005, Lee et al. 2005).

4. Material and methods

The study of the distribution of atmospheric parameters and chemical peculiarities of the stars of HB and EHB can lead to a better understanding of the formation and evolution of these stars and the clusters that have them (Salgado et al. 2015). Through careful research in the literature we determined the coverage of atmospheric parameters and chemical properties necessary to represent the HB and EHB of various stellar systems.

To generate the synthetic spectra, ATLAS9 atmosphere models were used (Castelli & Kurucz 2004). The spectral synthesis code used to generate the spectra was SYNTH (Kurucz & Avrett 1981).

To test the validity of the generated synthetic spectra and to evaluate their limitations, it was necessary to compare them with observed spectra of HB stars.
5. Partial Results

We looked in the MILES empirical stellar library for stars classified as HB to test our spectra. We found 14 out of about 1000 stars. Of the stars analyzed 10 were better fit with subsolar He abundance, 2 with super solar He abundance and 2 with solar. That means 85.72% of them are better adjusted by non-conventional He abundances. Figure 2 shows, as an example, the comparison between the observed spectra of HD109995 and models with different He abundances. Our library, therefore, will have different He abundances.

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References

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Figure 1. Example HR diagram, representing some stages of stellar evolution. Source: http://www.wikiwand.com/en/Horizontal_branch

Figure 2. Adjustment of spectra model, to observed spectrum, with best approximation in abundance He sub-solar to HB stars.