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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 SYNTHE. 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.

Resumo. As estrelas do Ramo Horizontal Azul (BHB) são estrelas que já passaram por quase todo seu processo evolutivo, perderam parte de sua camada externa, deixando uma fina camada de H e o núcleo queimando He. Isso faz com que elas sejam muito quentes e azuis, porém velhas. Podemos encontrar essas estrelas em muitos sistemas estelares, e sua presença pode induzir a erros na determinação da idade desses objetos. A técnica de análise de populações estelares utilizando espectros integrados é uma ferramenta poderosa no estudo de galáxias, mas modelos de populações estelares não levam em conta as estrelas BHB. Por causa disso, a presença dessas estrelas induz a uma determinação de idades mais jovens do que o esperado para esses sistemas. Neste projeto estamos criando espectros sintéticos para as estrelas do Ramo Horzontal (HB) que poderão ser incorporados aos modelos de populações estelares utilizados em sínteses espectrais. Realizamos uma pesquisa cuidadosa na bibliografia para determinar a cobertura de parâmetros atmosféricos e propriedades químicas necessárias para representar o HB de diversos sistemas estelares. Esses valores baseiam a criação da biblioteca de espectros. Para gerar os espectros sintéticos estamos utilizando modelos de atmosfera do ATLAS9 e o código de síntese espectral SYNTHE. Resultados preliminares mostram que o espectro observado de 14 estrelas do HB, retirados da biblioteca estelar empírica MILES, são melhor representados com espectros ricos em 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 Horizonltal 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. 2013). 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 SYNTHE (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.

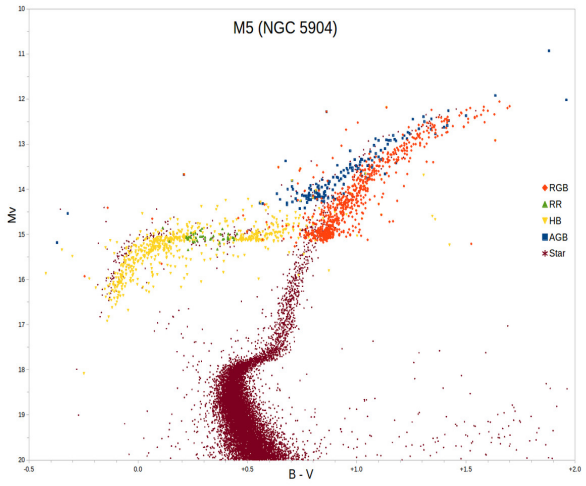

Figure 1. Example HR diagram, representing some stages of stellar evolution. Source:`http://www.wikiwand.com/en/Horizontal_branch`

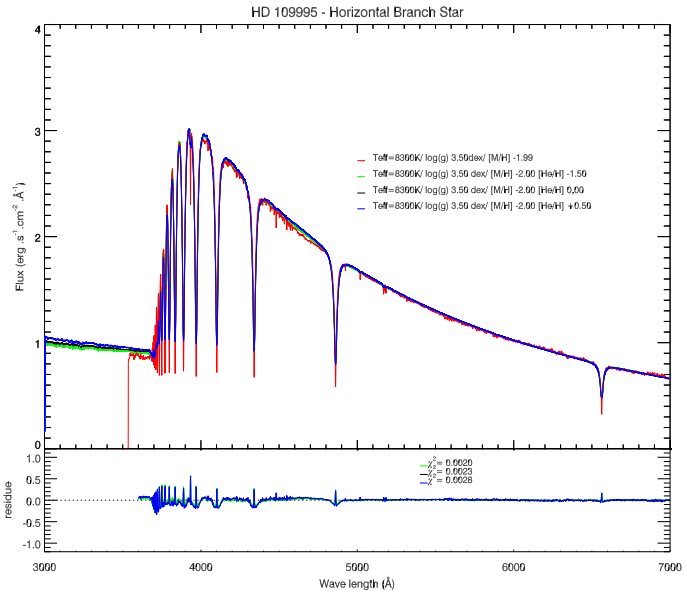

Figure 2. Adjustment of spectra model, to observed spectrum, with best approximation in abundance He sub-solar to HB stars.

Once the generated synthetic spectra have been tested and validated using observed spectra, the full library of synthetic spectra covering the entire range of parameters observed for HB and EHB will be created, forming the library. This library will be made available to the community and can be used to generate future SSPs that more fully consider HB and EHB.

5. Parcial 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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