Boletim da Sociedade Astronômica Brasileira, **34**, no. 1, 115-116
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Studying the (in)compatibility of spectroscopic ages in globular clusters

Lídia Ascon[1], Paula Coelho[2], & Geraldo Gonçalves[2]

[1] Instituto de Física da USP, e-mail: lgfabri@usp.br
[2] Instituto de Astronomia, Geofísica e Ciências Atmosféricas da USP
e-mail: pcoelho@iag.usp.br, geraldo.goncalves.santos@usp.br

Abstract. The study of globular clusters is relevant to understand stellar populations, as they are relics of the first phases of galactic formation. It is known in literature that there are problems with the determination of spectroscopic ages of globular clusters. To understand this problem, we studied clusters in Gonçalves et al. (2020) that show an age difference $\Delta t = t_{\text{spectroscopic}} - t_{\text{isochrone}}$ larger than 3 billion years. The objective is to search for possible correlations between observational parameters such as reddening, galactocentric, heliocentric distances and Δt. We compared the observed, synthetic and the simple stellar population model spectra to classify the clusters in two groups, compatible and incompatible, based on the expected single-age and single-metallicity model being similar or not to the observed spectrum . There was no correlation between Δt and cluster core radius (kpc), half light radius (kpc), heliocentric and galactocentric distances (kpc). However, the compatible group tends to concentrate at distances smaller than 15 kpc. The group of clusters classified as incompatible are concentrated in higher values of redenning.

Resumo. O estudo de aglomerados globulares é relevante para entender as populações estelares, pois são relíquias das primeiras fases da formação galáctica. Sabe-se na literatura que existem problemas com a determinação de idades espectroscópicas de aglomerados globulares, como visto em Gonçalves et al. (2020). Para entender este problema, estudamos os aglomerados em Gonçalves et al. (2020) que mostram uma diferença de idade $\Delta t = t_{\text{espectroscpica}} - t_{\text{iscrona}}$ maior que 3 bilhões de anos. O objetivo é buscar possíveis correlações entre parâmetros observacionais como avermelhamento, distância galactocêntrica, distância heliocêntrica e Δt. Comparamos os espectros observados e sintéticos com o modelo de população estelar simples para classificar os aglomerados em grupos de compatíveis e incompatíveis, quando o modelo esperado de uma idade e de uma metalicidade é semelhante ou não ao espectro observado. Não houve correlação entre Δt e raio do núcleo do cluster (kpc), raio de meia luz (kpc), distância heliocêntrica (kpc), distância galactocêntrica (kpc), entre outros. No entanto, o grupo compatível tende a se concentrar em distâncias menores que 15 kpc. O grupo de clusters classificados como incompatíveis concentra-se em valores mais elevados de avermelhamento.

Keywords. globular cluster – metallicity – spectroscopic

1. Introduction

Deriving chemical abundances and ages of globular clusters is important for understanding stellar evolution and the evolution of more complex stellar systems such as galaxies. Gonçalves et al. (2020) has shown that, in the case of low metallicity clusters, ages derived from integrated spectroscopy can be different from isochrone ages by several Gyr. It is possible that part of this discrepancy is explained by the presence of stars in the hot horizontal branch (HB), altering the spectral and photometric integrated data of the clusters in a way of mimicking younger ages (Cabrera-Ziri et al. 2022). Here we study a sample of clusters to try to identify common characteristics among the clusters with deviant ages, beyond the low metallicity.

2. Methodology

For this analysis, we used the parameters compiled in Usher et al. (2017), and cross-correlate with the clusters and the results by Gonçalves et al. (2020). This work inferred ages t, metallicities [Fe/H] and redenning A_V with the Starlight software by Cid Fernandes et al. (2005).

First, from the sample in Gonçalves et al. (2020), we defined $\Delta t = t_{\text{spectroscopy}} - t_{\text{isochrone}}$. Clusters with $\Delta t > 3$ Gyrs were selected for analysis. This sub-sample resulted in 29 clusters from an initial sample of 61 objects.

For this sub-sample, we obtained the cluster parameters: cluster core radius (kpc), half-light radius (kpc), metallicity (dex), heliocentric distance (kpc), galactocentric distance (kpc) and reddening (mag).

From the isochrone ages (see Table 2.2 in Goncalves et al. 2020) and their metallicities we obtained simple stellar population models from Vazdekis et al. (2015).

After separating the clusters with $\Delta t \geq 3$ Gyr and comparing the observed and SSP spectra, we classified visually each cluster as either compatible or incompatible. An example is shown in Figure 1

Finally, we compare the groups with the observational parameters listed above.

3. Results

In Figure 2, it is possible to observe that the clusters with $\Delta t \geq 3$ Gyr are preferably of low metallicity, which is in agreement with the results of Gonçalves et al. (2020).

This also reinforces the hypothesis that the morphology of the HB, as seen in Cabrera-Ziri et al. (2022), has an impact.

We plotted Δt with all parameters collected from Usher et al. (2017), namely: cluster core radius (kpc), half light radius (kpc), heliocentric distance (kpc), galactocentric distance (kpc), reddening (mag) and metallicity (Fe/H). Most parameters showed no obvious correlation with Δt or our visual classification, with the exception of metallicity [Fe/H] and reddening (mag), as seen in Figure 2 and Figure 4.

We also made a histogram that shows the galactocentric distance and the stellar extinction distributions, as seen in Figure 3 and Figure 4, respectively.

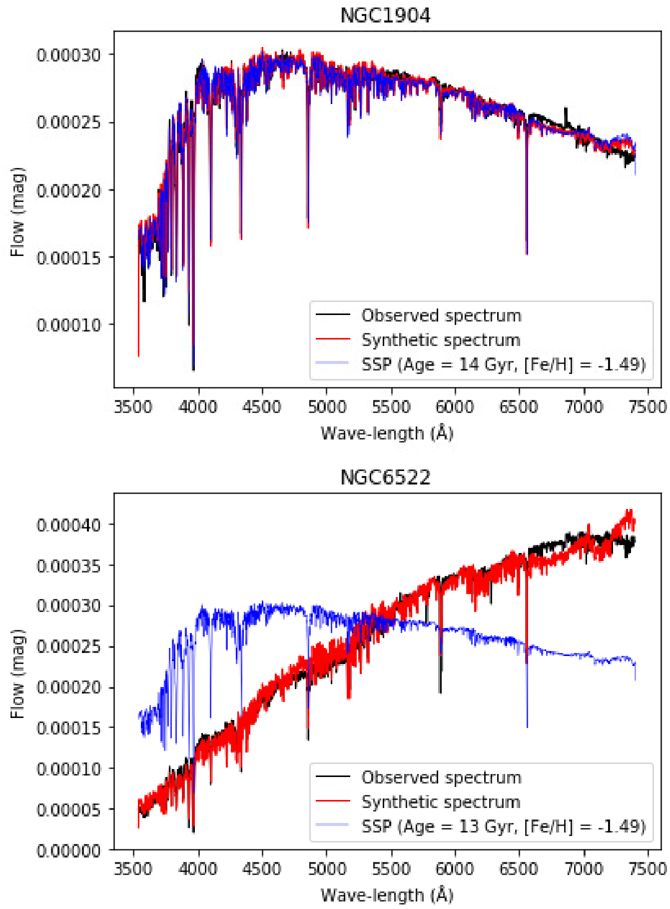

Figure 1. Example of synthetic (red, fit by Starlight) and observed (black) spectra, compared to the SSP model with closest parameters (blue). The top and bottom clusters were classified as compatible and incompatible, respectively.

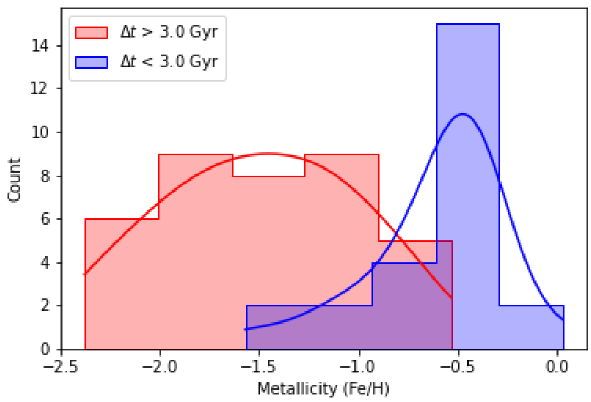

Figure 2. Metallicity histogram separated by differences between $\Delta t > 3$Gyr and $\Delta t < 3$Gyr.

The distribution of reddening in Figure 4 illustrates that our visual classification is likely biased by the reddening. Including the effect of reddening on the SSPs would be needed for further analysis.

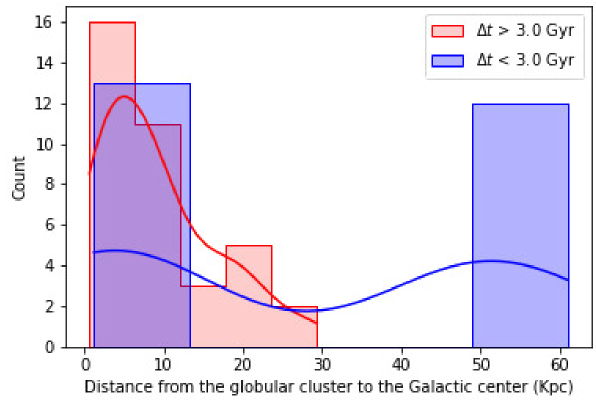

Figure 3. Distribution of galactocentric distance for the clusters with $\Delta t > 3$Gyr and $\Delta t < 3$Gyr.

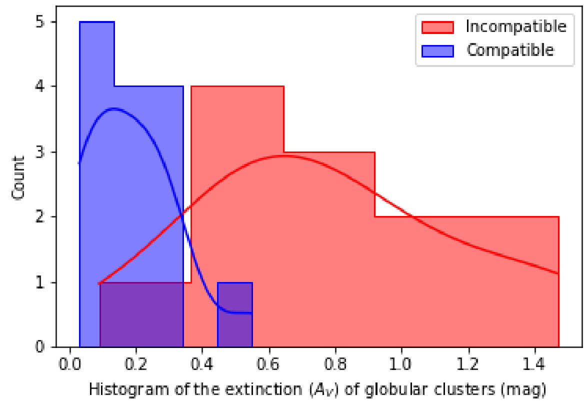

Figure 4. Stellar extinction distributions for clusters with $\Delta t > 3$Gyr and $\Delta t < 3$Gyr.

4. Conclusion

The clusters with $\Delta t > 3$ Gyr are preferably those with lower metallicity [Fe/H]. This confirms the results of Gonçalves et al. (2020) that the greatest differences between photometric and spectroscopic ages are found in metal-poor objects. Regarding the sub-sample classified between compatible and incompatible, we identified that the incompatibles are the objects with larger reddening. This result indicates that a correction of the reddening of the spectrum is necessary before proceeding with the analysis.

References

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