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Distance and age determination of the Galactic clusters NGC 2682 and NGC 6205

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Abstract: We present a multi-band photometric study on the Galactic clusters NGC 2682 and NGC 6205, which was conducted at the University of Athens Observatory. NGC 2682 is relatively close to our Solar System, while there is negligible interstellar absorption towards its direction. It has approximately similar age to our Sun and this makes it a perfect candidate for stellar evolution models. On the other hand NGC 6205 is one of the oldest globular clusters in our Galaxy, setting a good constraint for the lower limit on the age of the Universe. The distance modulus for each cluster was calculated by inspecting characteristic regions on these diagrams, while we estimated their age, utilizing the most recent theoretical isochron models. The photometric properties of the blue stragglers in NGC 2682 were derived and compared with the very few available studies conducted on this cluster in a homogeneous way.

1 Introduction

The present study aims towards the age and distance determination of both clusters, in order to disentangle the disagreement between literature values. It can also constrain the region where Blue Stragglers (BS) and Horizontal Branch (HB) stars appear in these two peculiar rich Galactic clusters.

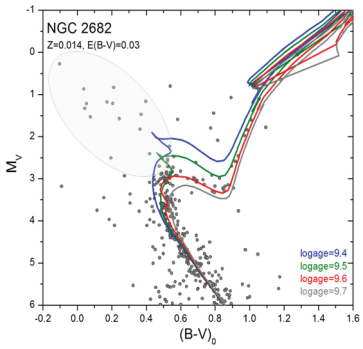
NGC 2682 (M67) is one of the oldest known open Galactic clusters, with a noticeably large number of Blue Stragglers (BS), approximately 30. It has almost no reddening, while its chemical composition is similar to solar [4]. Its age is estimated to be about 4 Gyr, slightly younger than our Sun. Thus, NGC 2682 is a good target for understanding and improving our theories about the solar-type stars and stellar evolution in general.

NGC 6205 (M13) is one of the oldest known clusters, setting a quite accurate lower limit to the age of the Universe [7] Due to its advanced evolutionary state NGC 6205 is one of the most appropriate candidates for the study of Population II stars. NGC 6205 has a rich BS population, while it displays a peculiar and unusually blue horizontal branch with most of its stars belonging to Population I. This is in contrast to the characteristics of the globular cluster NGC 5272 (M3), which shares similar age and metallicity with NGC 6205.

2 Photometric observations and data reduction

Multi-band photometric observations were obtained with the 0.40 m f/8 Cassegrain reflector at the University of Athens Observatory and an SBIG ST10-XME CCD camera, equipped with a set of BVRI (Bessell) filters and an f/6.3 focal reducer, giving a FoV of 17×26 arcminutes. We obtained 584 frames on NGC 2682 in each band within 4 successful observing nights in April 2015. The total exposure times were 17.5 ksec, 5.8 ksec, 3.5 ksec, and 4.7 ksec in BVRI filters respectively. NGC 6205 was observed for 2 nights in February 2015. We obtained 89 frames in each filter band and the total exposure times were 3.6 ksec, 1.8 ksec, 0.9 ksec, and 1.8 ksec in BVRI filters respectively.

The most recent isochron models were used for determining the age of both clusters. These are the PARSEC models, which utilize Padova and Trieste Stellar Evolution Code. ([2]). Fig.1 shows



Cluster ID	Our study		Literature	
	m-M_V (mag)	age (Gyr) logage (age/yr)	m-M_V (mag)	age (Gyr) logage (age/yr)
NGC 2682 (M67)	9.69 ± 0.02	3.98 ± 0.46 Gyr 9.60 ± 0.05	9.70 ± 0.05	4.0 ± 0.5 Gyr 9.6
NGC 6205 (M13)	14.4 ± 0.2	11.22 ± 1.29 Gyr 10.05 ± 0.05	14.4 ± 0.05	12.00 ± 0.38 Gyr 10.09

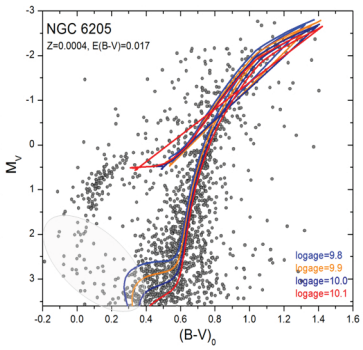


Figure 1: Color-Magnitude diagrams of NGC 2682 (left) and NGC 6205 (right), where several isochron models are over-plotted for Z=0.014 and Z=0.0004 [2] , corresponding to the cluster's metallicity and reddening [6]. Blue stragglers (BS) are indicated in both clusters under the shaded areas. They have color indices between $0 < M_V < 3, -0.2 < (B-V)_0 < 0.5$ for NGC 2682 and $1.5 < M_V < 3.5, -0.2 < (B-V)_0 < 0.4$ for NGC 6205, respectively.

the calculated CMDs for both clusters. NGC 2682 shows clearly MS stars, as well the turnoff point, Red Giant Branch (RGB) and Red Clump (RC). We achieved a reasonably good accuracy on the fit of the isochron models for the cluster's age determination. NGC 6205 is much fainter, so we can only distinguish the Horizontal Branch (HB) and the RGB. HB stars were used in NGC 6205 for the absolute magnitude determination, using the equation $M_V = 0.21[Fe/H] + 0.89$ ([3]), while RC stars were used for estimating the distance of NGC 2682, according to [1]. The resulted measurements for both clusters are given in Table 1, in comparison to the most recent studies, conducted for the same clusters. BS population is rich in both clusters and they are indicated in shaded areas in Fig.1.

3 Discussion

Distance and age are derived for two highly interesting galactic clusters. They are in agreement with the most resent literature values ([2], [8]) despite the fact that we used a relatively small telescope. Vandenberg et al. [8] used HST data and their own theoretical isochron models for NGC 6205, proving that they are in accordance to the latest isochrones (PARSEC). Bressan et al. [2], used the same isochron models on NGC 2682, but they utilized poor quality ground-based photometric data. Our estimation is based on the most accurate evolutionary tracks and better observational data, resulting in highly reliable values on NGC 2682. The number of BS found in this study indicates rich population in both clusters. Their photometric characteristics show strong dependence on metallicity and age. Additionally, the significantly blue HB stars in NGC 6205 may indicate the existence of more than one chemically distinct stellar populations ([5] and references therein).

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