

PHOTOMETRY STUDY OF NGC288 ON UVBY BANDPASS

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ABSTRACT

We present a new photometric study of the globular cluster NGC288 in Strömrgren u , v , b , y , and H_β system. This cluster is known to have an intermediate metallicity but its color-magnitude diagram has a pure blue horizontal branch, which is a signature of metal poor stellar population. We compare our dataset with Bergbusch's (1993) in both field size and CMD to see whether different photometry system would determine the same physical parameters of a cluster. Demarque and Yi's isochrones (1996, private communication) were applied to Bergbusch's dataset, and we obtained distance modulus of $(m - M) = 14.9 \pm 0.2$, color excess of $E(B - V) = 0.03$, and age of 15 ± 3 Gyr. Vandenberg's (1985) isochrones for Strömrgren system were also applied to Bergbusch's and our data. We find that the isochrone fits to different photometric systems give rather inconsistent solutions. The source of this discrepancy may become clear when the Demarque and Yi's isochrones for Johnson system are converted to those of Strömrgren system. We note that Kurucz model atmospheres provide a useful ground for this conversion work as well as theoretical study of Strömrgren characteristics of globular cluster stars.

I. INTRODUCTION

(a) Globular Clusters : an Overview

Globular clusters are the oldest surviving stellar sub-system in galaxies. They provide information on the earliest phases of galactic evolution, and are used as the fossil record to establish a chronology of the formation of the galaxy. In general, there exist a small number of characteristics that are shared by all globular clusters. On the other hand, some family traits of globular clusters are found to vary from galaxy to galaxy (Van den Bergh, 1993).

Globular clusters are particularly useful to stellar evolution studies for three main reasons: (a) they have so many stars in comparison to open clusters; (b) their stars are virtually coeval; and (c) in most cases they are also chemically homogeneous. In other words, globular clusters represent the purest and simplest stellar populations we can find in nature.

(b) Previous Studies of NGC288

The globular cluster NGC288 has been the subject of a number of photometric and spectroscopic studies in the past two decades since first noticed by Cannon (1974). The underlying motivation for many of the studies were to find an explanation for the anomalously blue horizontal branch (hereafter HB) seen in the color-magnitude diagram (hereafter CMD) of this cluster. NGC288 is one of the most extreme examples of an intermediate metallicity ($[Fe/H] \sim -1.3$) globular cluster that has a HB almost completely consisting of stars on the blue side of the instability strip. This is a pathological case of the so-called "second parameter" problem, which requires that a parameter other than overall cluster metallicity, contributes to determining the HB morphology of a cluster. A strong candidate for the second parameter is age, therefore NGC288 has been targeted for several studies designed to determine the cluster's age.

II. DISCUSSION AND CONCLUSION

(a) Color-Magnitude Diagram

The mosaic image of the five cluster fields with all of the 3412 objects that survived the detection/reduction procedures. No restrictions have been imposed for inclusion of stars in the CMD. In contrast to the CMD of Bergbusch(1993, hereafter referred to as B93), there are no obvious gaps exist along the HB ($V \sim 15.7$ and 16.5) using the mosaic field. Moreover, we note that the distribution of stars along the BHB of NGC288 shows an apparent clump at $V \sim 15.7$, which was also noticed by Kaluzny (1996) at $V \sim 16.0$.

The CMD also displays that there are a few stars at $V \sim 15.0$ on the instability strip of the HB. Although the photometry through the turnoff region is highly uncertain, an extension of the main sequence above and blueward of the turnoff consistent with a population of blue stragglers seems to be present. At the bright end, the photometry is apparently good enough to clearly separate the Asymptotic Giant Branch (AGB) from the RGB, although the status of the stars brighter than $y = 13.4$ is uncertain. The thick disk turn-off is clearly visible for stars brighter than 14.0.

(b) Isochrone Considerations

Prof. Pierre Demarque and Dr. Sukeyoung Yi (1996 private communication) have generously provided their new isochrones created for NGC288. These isochrones are ranging from 1 to 25 Gyr with $Y = 0.24$, $Z = 0.00075$ (corresponding to $[Fe/H] = -1.4$), and the new opacity calculation. However, the isochrones present on the observational plane only of the Johnson photometric system, so the application to the present study isn't available and hence only to B93's data.

The calculation results of different estimates of reddening exhibit no significant influences on isochrone fitting, if the value is adopted from 0.00 to 0.03, the common range for $E(B-V)$ derived in the previous studies.

The loci of the minimum χ^2 value suggest a distance modulus of 14.9 ± 0.2 . The χ^2 values of different ages, at two different distance moduli ($m - M = 14.9$ and 15.1) and reddening excess $(B - V) = 0.03$ give an estimate of $age = 15 \pm 3$ Gyr, in agreement with the previous studies.

For the purposes of a comparison of the results of isochrones fitting derived from different photometry system, Vandenberg's $[Fe/H] = -1.27$ and $Y = 0.2$ isochrones (1985), containing the observational plane presented on both Strömgen and Johnson system, were applied to both this study and B93's data.

The fitting results are not readily to compare with each other, so we adopt the distance modulus ($m - M = 14.9$) and reddening excess $E(B - V) = 0.03$ and $E(b - y) = 0.0219$ respectively for B93 and this study, to the isochrones to see the fit results of two datasets. The fitting of this study is still acceptable whereas that of B93 is shifted by -0.03 in (B-V).

(c) Physical Characteristics of NGC288

The fitting of Demarque & Yi's isochrone to B93 dataset suggest a distance modulus of 14.9 ± 0.2 , consistent with the result Bergbusch derived by fitting different isochrones (Vandenberg, 1992). However, using three stars on the instability strip on CMD, we make an estimate of HB luminosity of $V = 15.0 \pm 0.1$ has been found in this study. From synthetic HB models, Lee et al.(1990) predict that the mean absolute magnitude of the RR Lyrae variables and hence we can obtain $M_v = 0.599$ for the HB using $[Fe/H] = -1.3$ and a distance modulus of $(m - M) = 14.4 \pm 0.1$, slightly smaller than that of the isochrone fitting.

The reddening excess is taken as $E(B - V) = 0.03$, $E(b - y) = 0.022$, $E(m_1) = -0.007$, and $E(c_1) = 0.004$ from the isochrone fitting.

An age estimate for NGC288 is 15 ± 3 Gyr or an acceptable range from 13 to 20 Gyr, in consistence with the previous studies.

(d) Perspective

As implied in the isochrone fitting results, the physical parameters of a globular cluster determined by different photometry system would not be consistent. We want to make sure whether this is a universal phenomenon and where the discrepancy results from, the usefulness of Demarque and Yi's isochrones to the CMD of this study is evident. Before this procedure, the first step to carry out this analysis is to use the color-temperature relations to transpose the models from the theoretical to the observational plane. To carry out this analysis, Dr. Kurucz has generously provided his stellar atmospheric model on CD-ROMs and this part of analysis is also to be conducted in the near future.

Another future attempt is to use the metal-sensitive property of the Strömgen system for observing glob-

ular clusters of similar metallicities but different ages, to test the possible existence of the second parameter.

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