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# AGE AND TEMPERATURE OF GLOBULAR-OPEN STAR CLUSTERS CASE STUDY : M3 M35 AND M67

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***Abstract***

*In this work, the age and the temperature of the globular cluster M3 and the open clusters M37 and M67 were observed by CCD Photometer via a 0.5-meter Rithchey-Chertien Reflecting Telescope at Regional Observatory for the Public Nakhon Ratchasima, Thailand ; images were obtained of the cluster stars in B and V photometric filter. The magnitude of the cluster stars were analyzed by Iris and Aperture Photometry Tool (ATP) program. The age and temperature of M3, M35 and M67 clusters were calculated by the apparent magnitude and color index (B-V) of the Hertzsprung-Russell diagram . Our results shown that the both open cluster M35 and M67 were found to lie at a distance of 2,700 light years (832pc) from the Earth. In addition, the M35 is approximately 110 million years old and the temperature in range of 7,000 -13,000K. Meanwhile M67 is roughly 3.11 billion years old, the temperature is about 4,400K to 6,400K. However, we determined that the globular cluster M3 is approximately 11.1 billion years old and located 34,000 light years (10,420pc) away from the Earth, while temperature is around 3,600 -6,800K.*

*Keywords: Globular-Open, Temperature, M3, M35, M67 .*

## Introduction

Star clusters are objects of great interest to astronomers. The stars in a given open or globular cluster are considered to have been created at the same time and same composition. Globular clusters are often quite old and dim star cluster and exist in the halo of the galaxy. Over decades many many researchers has shown that the star in globular clusters are among the oldest stars in our galxy.Whereas the open star clusters, which revolve within or close to the disk of galxy, are bright and easily observed. Open cluster is a group of gravitationally-bound stars that formed in a single gas cloud. They contain from 100 to 10,000 stars, formed at nearly same time and same materials compositon. In this work, we observe both the globular cluster M3 and open cluster M35 and M67.

Messier 3 (M3 or NGC 5272) is a globular cluster in the northern constellation of Canes Venatici, was discovered by Charles Messier in1764 [1]. This cluster is one of the largest and brightest, containing an estimated 500,000 stars. It's located at a distance of about 33,900 light-years away from Earth [2], is further away than the center of our Milky Way glaxy. M3 has an apparent magnitude of 6.2 [3], as its absolute magnitude is about -8.93, corresponding to a luminosity of about 300,000 times of our sun, and an estimated age of 11.39 Gyr [4].

Young Open star cluster M35 or Messier 35 or also designated NGC 2168 that is located in constellation, Gemini, is consisted of several hundred stars scattered over the area covered by the full Moon. M35 lies at an estimated distance of 2,800 light-years from earth. It has an apparent magnitude of 5.3. It contains 2,700 stars and its estimated age is 150 million years [5]. It is of intermediate age and contains some post-main sequence star including several yellow and orange giants of spectral type late G to early K. Its hottest main sequence star is given as spectral class B3. The cluster M67 (NGC 2682) in Cancer is one of the oldest open cluster in our Galxy with and age of 3.5-4.5 Gyr [10], that is close to the age of the sun and is nowere near as bright.

In this research, we report on the pioneered study focusing on an age and an effective temperature of the globular cluster M3 and the open clusters M35 and M67. To find the age of a cluster, one must simply create an Hertzsprung-Russell (HR) diagram. We

obtained B and V band images of the star clusters and used absolute and relative photometry to determine their magnitudes in each filter and we use this imformation to construced an HR diagram.

**Observation And Analyzation**

In this work, photometry of a star clusters M3 M35 and M67 obverved with the CCD photometer via Rithch-Chertien Reflecting 0.5 m Telescope, at Regional Observatory for the Public Nakhon Ratchasima, Thaioland in Decemver 2015. Exposures time of cluster star were taken in B and V filter is 60 seconds. These images were calibrationed and stacked using IRIS in order to increase the signal to noise ratio of our data. The apparent magnitude of all stars in ware analyzed by Aperture Photometry Tool (APT)program. Finding the age and effective temperature of a star cluster, we must creat an HR diagram with the absolute V- magnitude on the y-axis and the color-mgnitude index,which determined by subtracting the V-magnitude from the B-magnitud or (B-V) on x-axisey. Figure 1 shows the observed color-magnitude, apparent magnitude v vs (B-V), diagram for our clusters M3, M35 and M67.

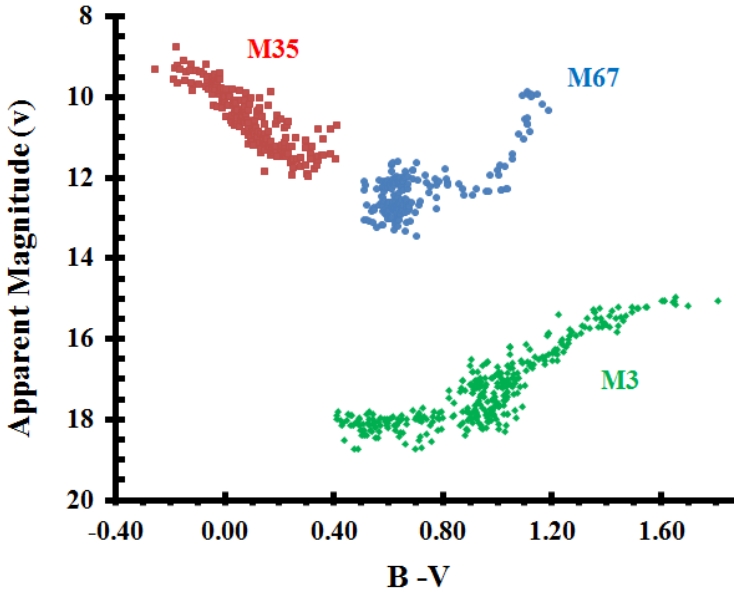


Figure 1 The apparent magnitude and color-magnitude diagram of M3, M35 and M67

To determine the absolutes of the our clusters, M3 ,M35 and M67, The ALADIN site was used as a reference in both filter The HR diagram's main sequence turnoff point enabled us to determine the ages of star cluster. So the age of a cluster can be calculated using the equation

$$t = 10^{10}\left[\frac{M_{sun}}{M}\right]^{2.5} \quad (1)$$

When $v\text{-}V_{sun} = -2.5\log\left[\left(\frac{L}{L_{sun}}\right)\left(\frac{d_{sun}}{d}\right)^2\right]$ , $\frac{L}{L_{sun}} = \left[\frac{M}{M_{sun}}\right]^{3.5}$ and $d = 10^{\frac{v\text{-}V+5}{5}}$ in parsec

Where v and V is a apparent and absolute magnitude a star cluster at turn off point.

$V_{sun}$ is a apparent magnitude of the sun (about -26.5)

$d$ is a distance of cluster away from Earth (parsec)

$d_{sun}$ is a distance of sun away from Earth ($4.848132\times10^{-6}$ parsec)

Using our data to determine $L/L_{sun}$ and $M/M_{sun}$ based on B-V values, We found that the $M/M_{sun}$ ratio of M3, M35 and M67 is about 2.62, 4.44 and 1.55, respectively.

In addition, the offset from the color (B-V) enables us to determine the temperature of star cluster. However, temperature is investigrated using equation [6].

$$T_{eff} = 4600\left(\frac{1}{0.92(B-V)+1.7}+\frac{1}{0.92(B-V)+0.62}\right) \quad (2)$$

**Results And Discussion**

Figure 2 presents our phometric color-magnitude diagram, The green triangles indicate the positions of the main sequence of globular cluster M3 extending from (B-V) in range of 0.4 to 1.0 and turn off point is located at color (B-V) magnitude=0.8. The both apparent and absolute magnitude is approximately 18.5 and 3.4, respectively[8].Our calculated result indicates that an age of M3 is 11.1Gyr. The calculated result of age obtained by this work and by Porbes Duncan and et al[4]. The blue circles HR diagram as shown in Fig 2. The region of the main sequence of open clusters M35 and M67 extending from (B-V) around -0.2 to 0.4 and 0.5 to 0.8, respectively. Turn off point of M67 is located at (B-V)=0.7 is agreement with Shim on Naim[7]. While the apparent and absolute magnitude is approximately 13 and 3.4, respectively. The age of M67 is roughly 3.11 billion years old. Meanwhile, the color index (B-V) of M35 is 9.6, which corresponding to Surrazine et al [9]. the age of M35 is estimately 110 million year old [5], as shown in Table 1.

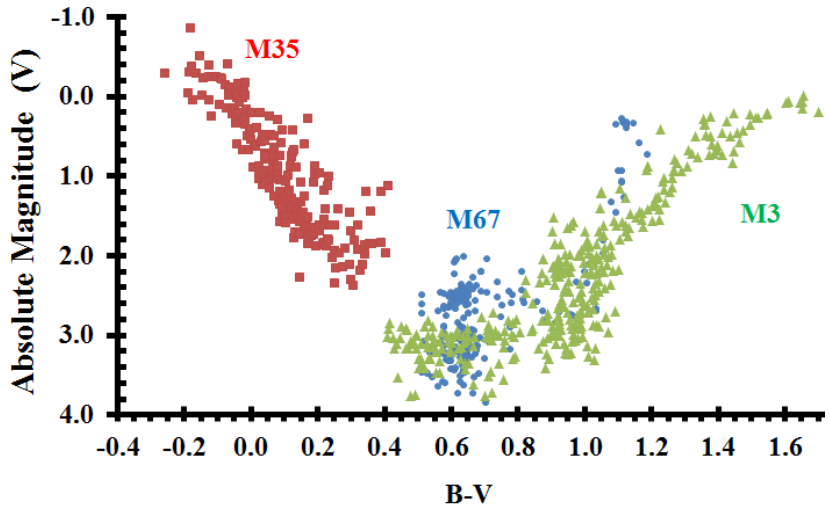


**Figure 2** The absolute magnirude and color-magnitude diagram of M3, M35 and M67

**Table 1.** Our calculated results composing age, distanceand temperature of M3, M35 and M67

| Star Clusters | Age (MYr) | Distance(ly) | Temperature (K) |
|---|---|---|---|
| Globular Cluster M3 | 11,100 | 34,000 | 3,600 – 6,800 |
| Open Cluster M35 | 110 | 2,700 | 7,000 -13,000 |
| Open Cluster M67 | 3,110 | 2,700 | 4,400 – 6,400 |

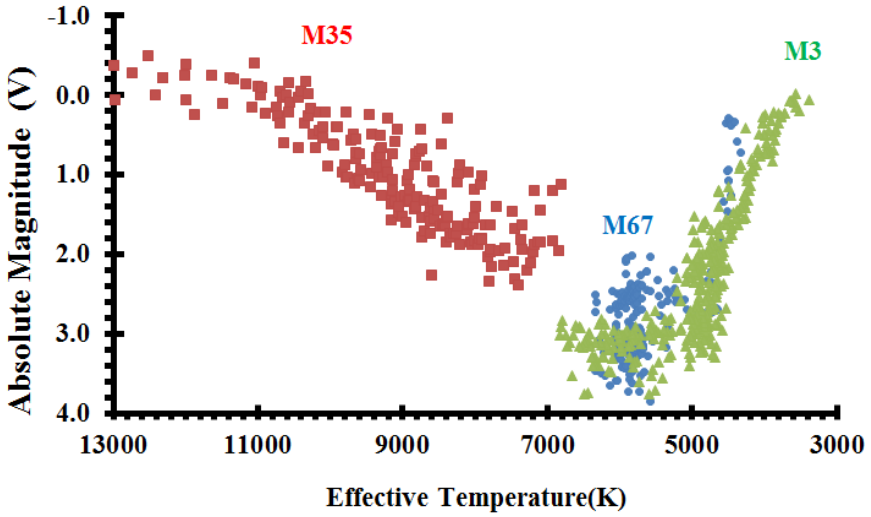


**Figure 3** The absolute magnitude and effective temperature of M3, M35 and M67

The relationship between B-V and temperature is illustrated in Figure 3. It shows the effective temperature of star clusters, which were obtained using equation (2) [6]. Temperature of globular star cluster is estimated in range of 3,600 to 6,800K. Whereas, youg open star cluster M3 and oldest open cluster M67, which lie at an estimated distance of 2,700ly. Its effective temperature of each open cluster extremely differ. That is the M35 temperature is approximely 7,000 to 13,000 K, while the temperature of M67 is in range of 4,400 – 6,400K, as shown in Table 1.

## Conclusion

Summarizing, from our observational data, we built the HR diagram of the globular cluster M3 and both open clusters M35 and M67. The age and an effective temperature of star clusters were investigated. Our calculated results indicated that the age of open star cluster M67, (~ 3.11 Gyr) is a quite older than M35 (~110 Myr). On the contrary its temperature is rather lower than M35. The temperature of M35 and M67 clusters in range of 7,000-13,000K and 4,400 -6,400K respectively. Whereas M3, which is globular cluster, has a estimate age of around 11.1Gyr, and the its temperature in range of 3.600-6,800K.

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