Estimating Age of The Open Cluster M34 Using Turn - Off Point of The Stars on The Main Sequence

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Abstract

In this work I observed the open cluster M34 using 16 inch reflecting telescope to estimate the age of the cluster using turn–off point of a star from the main sequence stars on the B – V color magnitude diagram. This can be done by plotting the stars in a so-called Hertzsprung-Russell (HR) diagram, revealing the nature of the stars. Since the hot and bright (high-mass) stars have much shorter lives than the colder and fainter (low-mass) stars, we can find the cluster age by finding the hottest stars still remaining in the cluster (the turn off point). In order to obtain images of stars at different wavelengths for photometric study. one might use images taken through the B- and V-band filters to determine B-V color of the stars.

To avoid a worse seeing or the high brightness of the saturating stars in the cluster one can limit the field of view of the telescope so that only part of the cluster can be imaged at once, so, I used four parts of the image at lower left, lower right, upper left, and upper right.

On the other hand there are many faint stars in our cluster. So, several images will be need in each B, and V- filters, at different exposure time. I used 30 s and 300 s. The long exposure for measuring the fainter stars, and the short exposure for measuring the bright stars, and it is important for our aim of this work that the bright stars are included in the selection, to determine the turn–off point of the cluster.

By using aperture photometry on 232 stars, the age of the cluster has been estimated to be between 100-260 Myr. To estimate the seeing, ten stars have been examined to give the value of 3.03 arcsec in B-filter and 2.7 arcsec in V-filter.

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Introduction

To understand the various flux measurements we make with our telescope setting, we have to clarify first which quantities exactly we measure and how we can derive physical quantities out of them.

The apparent magnitude, m, is a measure of a star's brightness as seen by an observer on Earth. In other words, it is the integrated radiation flux, f, measured in W/m^2 contained in a particular frequency range Δv. Measuring fluxes of celestial bodies in different frequency ranges is called astronomical photometry which is the main objective of this work.

Based on a magnitude system, the apparent magnitude is a comparative scale in which brighter stars are given smaller magnitudes than fainter stars[1], such that

$$m_2 - m_1 = -2.5\, log_{10}\left(\frac{f_2}{f_1}\right)$$

Where the indices denote the magnitudes and fluxes of two distinct stars.

But there is extinction of radiation through intergalactic gas, interstellar gas and, of course, through the earth's atmosphere. In addition, there's also flux getting lost in our telescope. Thus, the flux which reaches the solar system is not the flux which was emitted by the source and the flux received by our detector, *f*, is not the flux *f* that reaches the solar system. So, many images such as bias, dark image, and flat field images we need to take here other than the selected cluster in order to improve the image quality, and thus the measurements.

The observed flux *f* of an object depends not only on its intrinsic brightness but also on its distance. In order to compare the brightness of different astronomical objects with each other we need a distance independent flux measurement. In this context we used absolute magnitudes, which is a measure of how bright an object such as a star would look if it was placed at a standard distance of 10 pc [2].

In order to calculate the absolute magnitudes from our measured apparent magnitudes, a distance modulus of our cluster which is equal to 8.38(475pc) used here.

Image reduction

For reducing the data and extracting a catalogue of sources out of the images, a number of steps are necessary for creating a color-magnitude diagram.

The reduction was carried out with the IRAF environment, using standard procedures [4].

The reduction steps includes reducing the cluster images and then calculating photometry of the stars in the cluster.

Reducing the cluster images

The following steps have been done to reduce our cluster images.

BIAS subtraction

In this work we used a single bias frame for all other exposure; so, it will be a master bias, which has to be subtracted from every image including the dark current frame and the two flats frames using imarith command, as a first step of data reduction.

Dark current subtraction

Dark current is one of the main sources for noise in image sensors such as a CCD. The pattern of different dark currents in the pixels across the CCD can result in a fixed-pattern noise.

Taking DARK frames and subtract them from the science (and FLAT) frames can remove an estimate of the mean fixed pattern.

Normalize the flat fields

Since our obtained image will be far from uniform. You need to take two flat frames, one for B- filter and one for V- filter by making exposures towards a uniformly illuminated background. This is done using statistics mean of the more flat region in the image, and then divide the flat field with the mean value. The exposure time for the FLAT frames should be determined also. And for each filter used for science exposures, a new FLAT frame should be made. During data reduction a FLAT frame will be normalized to an average value of 1 and used to divide the science image.

Calculating photometry of the stars

To obtain accurate color magnitude diagram it is required that the image be calibrated to standard scale. To measure the photometry of the stars we will do the following steps.

• Estimate the seeing from the radial profile.

• Measure the magnitude of all stars in the image. Then apply the following formula to calculate the flux ratio *F* for these stars: $F = 10^{-0.4(m+11.22)}$

Where m is the apparent magnitude of the star.

• Calculate photometry for all the stars in our reducing cluster and for both B, and V filter including a calibration star [3].

Results

The original observed image with B-filter at 300s exposure time shown in figure 1.

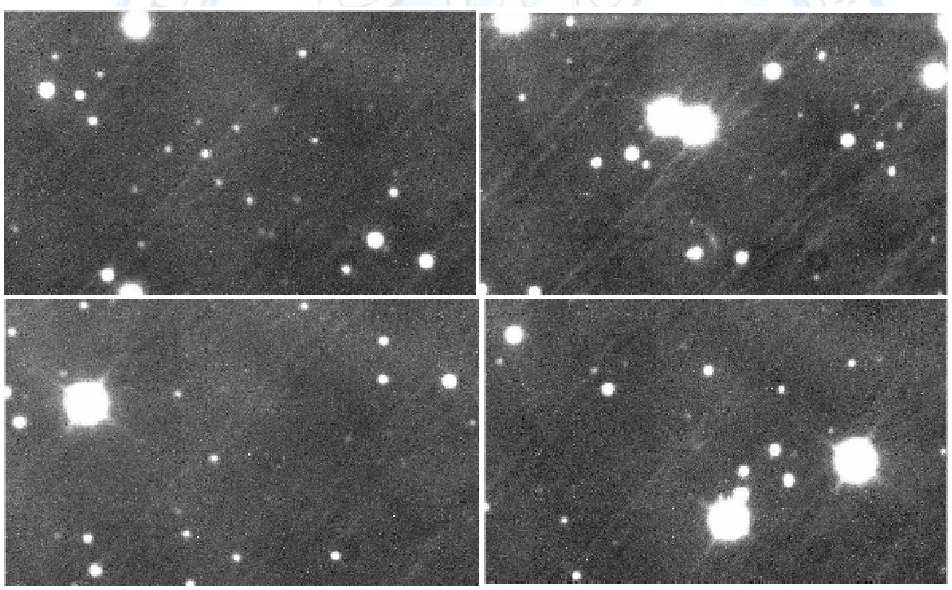

Figure 1: The stars in the open cluster M34 (NGC 1039). The four images corresponding to upper left and upper right in the upper side. Lower left, lower right in the lower side This image observed at September 28th 2010.

The new image after the reduction process illustrates in figure 2.

For all the reduction images, many procedures will be done to estimating the seeing and produce the colour magnitude diagram.

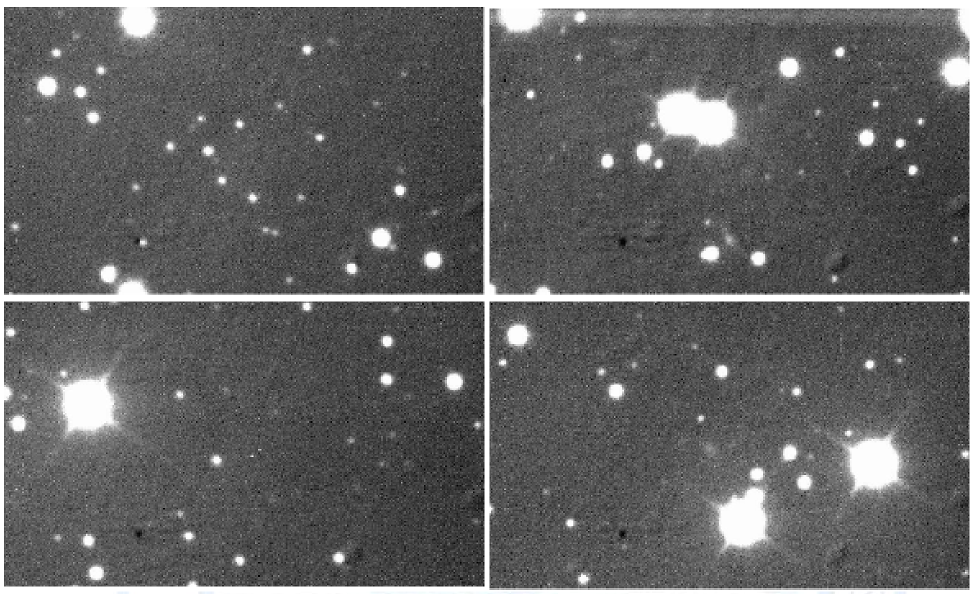

Figure 2: Image of open cluster M34 after the reduction process.

Estimating the seeing using the Full Width at Half Maximum of the light of the star FWHM, by Pyraf using the radial profile 'r' over the star, and then do this for 10 stars in both the V- and B- filter and take an average for each one.

The following table shows FHWM of 10 stars were used to estimate average seeing at each B-filter, and V-filter.

FHWM in pixels at B-filter	FHWM in pixels at V-filter
7.12	5.17
7.20	5.73
6.29	6.69
6.40	6.81
7.55	5.69

7.25	5.80
7.23	5.79
6.21	6.64
6.15	6.64
6.11	6.70

Table 1: Shows FHWM in pixels for the stars which used to estimate of the seeing for B and V filters.

By taking an average of FHWM for the values in the tables we obtain an average seeing equal to 6.751 in B- filter, and 6.22 in V – filter, or the seeing is 3.03 arcseconds in B – filter, and 2.7 arcseconds in V - filter. It is good estimation.

Values of (B – V) will be subtracted with 0.07 to correct for interstellar extinction in these calculations, assumed E (B – V) = 0.07 mag [3].

• Calculating the absolute magnitudes M (V) form our measured apparent magnitudes (m) using a distance modules μ, μ = m (V) – M (V). We know μ = 8.83 for M34, So, M (V) = m (V) - μ

• Figure 3 illustrates how a cluster of stars evolve in the HR diagram. The figure shown the relation between (B – V) on the x – axis and absolute magnitude M (V) on the y – axis.

It is clears the main sequence is fully populated with all kinds of stars from red (low-mass) to blue (high-mass).

Stars slightly more massive than the turnoff point have already evolved "away" from main sequence. In the figure we see that the turn-off point of the massive star on the main-sequence is around (B-V) = -0.04, depending on a standard table, we can estimate the age of the open cluster M34 is approximately 100 – 260 Myr.

The other stars remain on the main sequence for long periods of time.

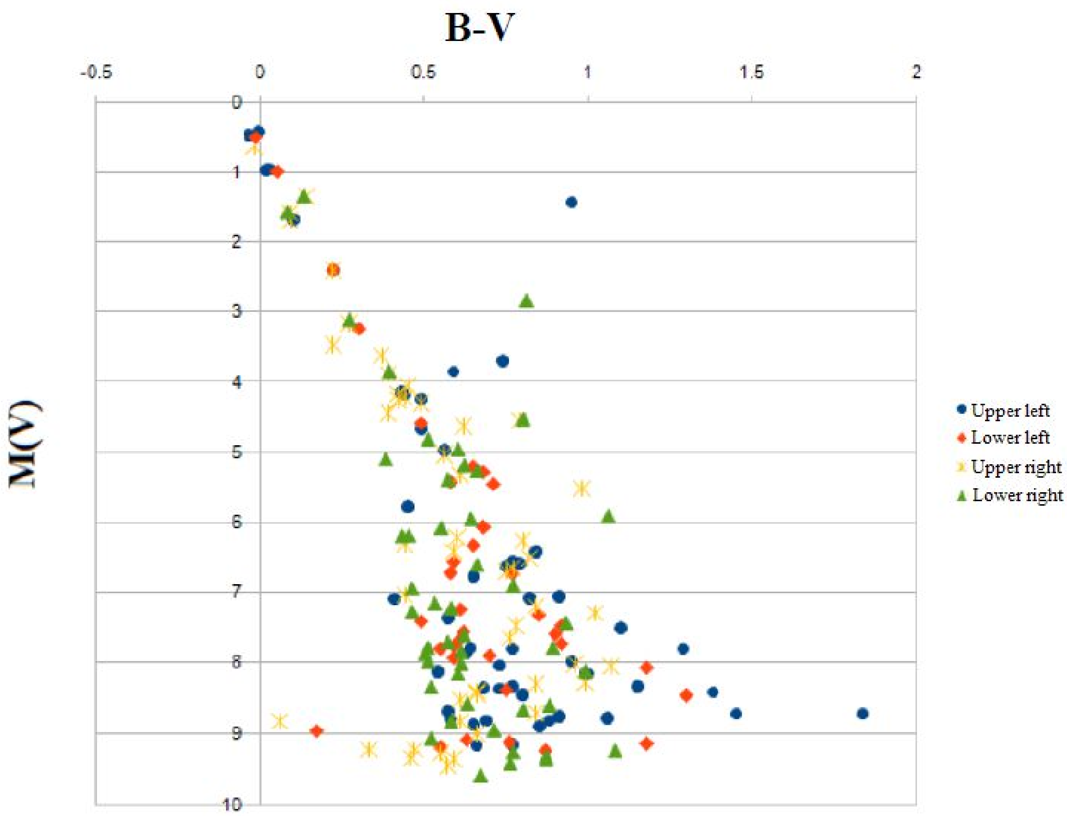

Figure 3: (B – V) color magnitude diagram for an open cluster M34 showing turn-off point of main-sequence star.

Conclusions

The conclusions of the present work can be summarized as follows:

1- The age of the open cluster M 34 is around 100 – 260 Myr, this is indicates the open cluster M34(NGC 1039) is extremely young cluster.

2- M stars in our cluster seems to fall into the main sequence stars are bright stars, on the other hand there are many stars has low luminosity and higher B – V values, which can be foreground/background stars.

3-It seems that there are a few stars on asymptotic giant branch (AGB**).** The final evolutionary stage for the main sequence.

4-Open cluster M34 contains both high and low-mass stars on the main sequence.

References

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تخمين عمر العنقود النجمي المفتوح M34 باستخدام نقطة التحويل لنجم عى التتابع الرئيسي

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الخلاصة

في هذا البحث تم رصد العنقود النجمي المفتوح M34 باستخدام تلسكوب عاكس قطره 16 انج و ذلك لتخمين عمر هذا العنقود النجمي باستخدام نقطة التحويل لنجم على التتابع الرئيسي. من المعروف ان عمر النجوم المضيئة و الحارة اقصر من النجوم الخافتة و الباردة و عند رسم تلك النجوم في مخطط Hertzsprung-Russell فان من الممكن تخمين عمر اي عنقود نجمي في السماء اعتمادا على نقطة تحويل النجوم الاكثر حرارة و التي ماتزال موجودة في العنقود. لغرض ايجاد لون كل نجم في العنقود تم التصوير بطولين موجية مختلفة باستخدام الفلتر الازرق بلطول الموجي 440 نانومتر و الفلتر الاخضر بلطول الموجي 550 نانومتر. و للتخلص من الاضائة العالية للنجوم في العنقود فقد تم تصوير اربعة اجزاء من الصورة في اعلى اليمين، اعلى اليسار، ادنى اليمين، و ادنى اليسار. باجراء حسابات فوتومترية على 232 نجم في العنقود تم تخمين عمر العنقود النجمي M34 حوالي (100-260) مليار سنة. تم ايضا قياس الرؤيا (seeing) للصورة باختبار عدد من النجوم في العنقود حيث كانت مساوية الى 3.03 ثانية قوسية بالنسبة للصورة المرصودة بلطول الموجي 440 نانومتر و 2.7 نانومتر بالنسبة للصورة المرصودة بلطول 550 نانومتر.