A Photometric Analysis of the Open Cluster NGC 1960

Abstract

In this report, the technique of aperture photometry was used in the analysis of images in the blue and green passbands of the open cluster NGC 1960 to construct a Hertzsprung–Russell colour magnitude diagram. Isochrones (Z=0.0198) were subsequently superimposed on the data and used to determine that the cluster is comprised of hot young stars (t≈22.3 million years) at an average distance from Earth (D = 1585±349 pc).

The role of star clusters

- Open star clusters are an agglomeration of mutually attracted stars formed from a single molecular gas cloud. Such dynamics result in, to first approximation, a group of stars with identical compositions and ages at equivalent distances from Earth.
- These properties allow for the investigation of:

-Main sequence (MS) lifetime: Can investigate the relation between stellar mass and MS lifetime for stars of identical ages and compositions.

-Stellar evolution: For older clusters that contain stars that have left the MS, one can investigate evolution into red giants and beyond.

-Galactic evolution: Star clusters can be observed in galaxies other than our own. Consequently, models of galaxy evolution can be tested against multiple systems.

Observations

- Target cluster NGC1960 (M36) (RA/DEC: 05 36 18.0/ +34 08 24) was chosen primarily due to its position on the night sky in relative to London, a major source of both light and atmospheric pollution. Observations were made using the RHUL equatorially mounted Meade LX200 GPS telescope and SBIG ST-8XME CCD combination with the CWF10 colour filter wheel attachment.

The Hertzsprung-Russell (HR) diagram

- The diagram is a plot of absolute magnitude or luminosity of a star as a function of magnitude difference in two different wavelength passbands.
- The magnitude difference between two stars, $B-V$ is defined as follows where f denotes the flux of a star, the subscripts B and V indicate in which passband (either blue or visible) a measurement was taken in and C is a constant.

$$B - V = m_B - m_V = -2.5 \log_{10}(f_B/f_V) + C$$

Analysis procedure

-Data reduction: Initially, data reduction was performed on each image to remove sources of noise. Figure 1 shows a heat map of combined noise over the CCD for an image of M36.

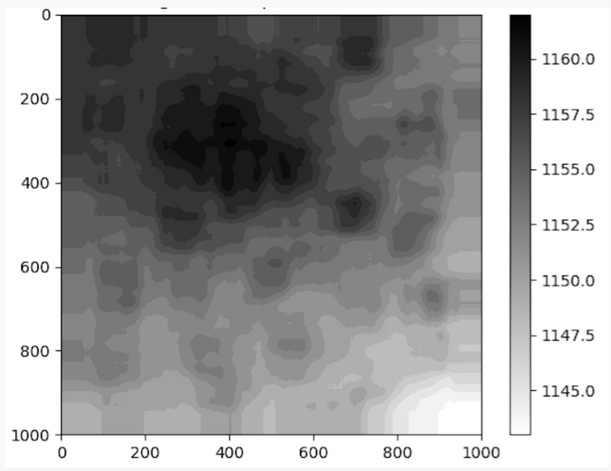

Figure 1: Heat map of background sources of noise.

-Source detection: Sources were identified by thresholding each image. The threshold was defined as pixels with ADU values greater than 4 from the the peak of the quasi-Gaussian distributed ADU values as determined from simulated 2D Gaussian sources. An example of such simulation is given in figure 2

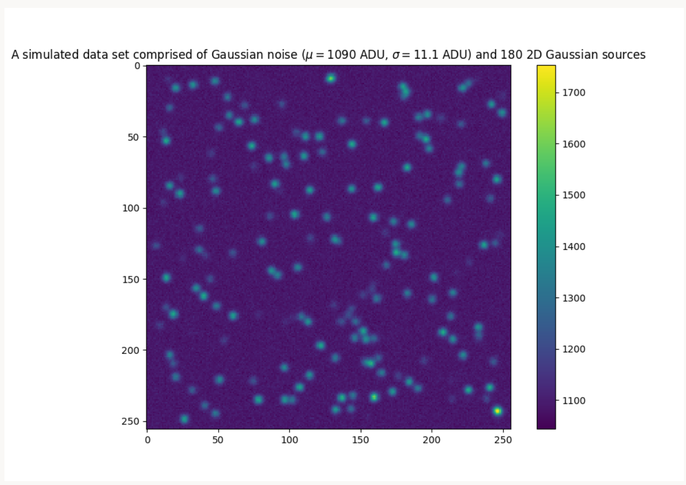

Figure 2: An example of a simulated data set, used to establish an appropriate threshold.

-Source matching: Correcting the offset between frames was achieved by investigating a histogram of the average separation between any two sources over the two frames as shown in figure 3

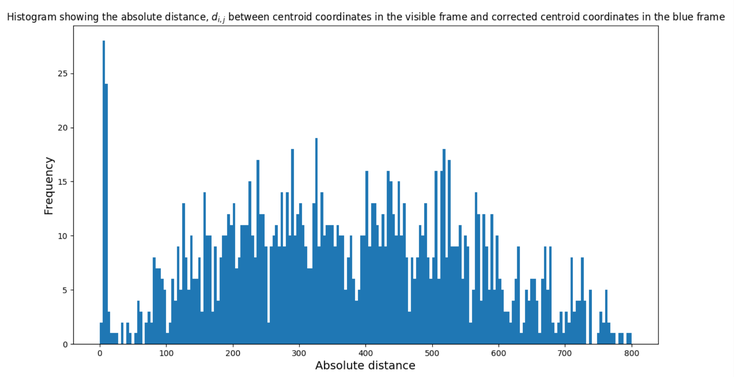

Figure 3: A histogram showing the distance from each star in the blue frame to all stars in the visible frame.

Results

In order to determine the age of M36, isochrones of varying ages and metallicity equivalent to that provided by SIMBAD [2] were fitted to the HR diagram. Figure 4 shows collected and published data with the best fit isochrone superimposed on top.

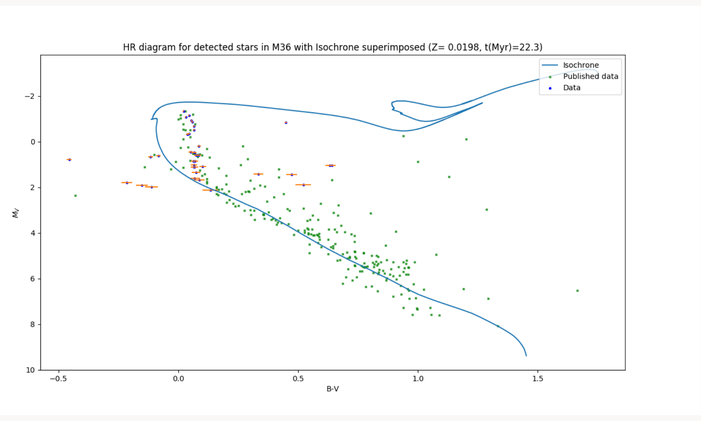

Figure 4: The HR diagram of experimental and published data with the isochrone (t=22.3 million years) plotted.

- The HR diagram indicates most stars within the cluster are approximately the same temperature.
- The best fit isochrone of metallicity $Z = 0.0198$ gives an approximate cluster age of t=22.3 million years which is relatively young.
- this is reflected in the diagram: despite a broad range of stellar masses, all stars in the cluster are still on the main sequence as an insufficient amount of time has passed since formation for them to evolve off.

The distance in parsec to M36 was also determined from the vertical offset between the visual magnitudes of the data and Zero Age Main Sequence (ZAMS) isochrone using

$$D = 10^{(m_V - M_V + 5)/5}$$

where M_V is the absolute magnitude in the visible passband. This gave a distance of $D = 1585 \pm 349$ pc which is within 1σ of the value $D \approx 1300$ pc taken from [3].

References

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[2] SIMBAD Astronomical Database - CDS [internet]. [cited 10/3/2019]. Available from: (Strasbourg)http://simbad.u- strasbg.fr/simbad/sim-id?Ident=M36NbIdent=1Radius=2Radius.unit=arcminsubmit=submit+id

[3] Pols OR. Stellar structure and evolution. Astronomical Institute Utrecht; 2011 Sep.

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