Estimation of physical parameters from a H-R diagram of NGC7789

Abstract

A Hertzsprung-Russell diagram is produced for NGC7789 open cluster for 30s and 300s exposure times and by inserting isochrones which match the main sequence and the cut-off point, the approximate age and distance to the cluster is determined to be (1.3±0.2)Gyr and (2150±100)pc. The 0.40m 16" Meade LX200-ACF Schmidt-Cassegrain telescope is used for the observations.

Introduction

The Hertzsprung-Russell diagram is the most important stellar plot in astronomy which comprises all the surface parameters(Temperature, Luminosity,etc.) of a star and depicts the different stages of evolution. The observation is carried out with the help of a 0.4m 16" Schmidt-Cassegrain telescope containing Johnson/Cousins filter set and different calibration and light frames are taken for different exposure times in B and V filters. Through python, the bias, dark and flat calibration frames are subtracted from the various light frames and by using various astronomical softwares like Topcat and Aperture Photometry Tool(APT), the CMD plots of the NGC7789 cluster are produced.

Planning

NGC6939 open cluster was chosen as the observing target with its transit time and altitude calculated. The cluster fulfils the criteria for the telescope with it lying within 18'x20' field of view of the SBIG ST10-XME CCD camera, the former not being too compact, having greater number of stars, not too distant so that its reddening is as low as 0.20 and having a sufficient age giving a clear main-sequence cut-off. The observation was later halted due to frequent cloud cover which led to opting for NGC7789.

Transit time and altitude calculations for NGC6939:

Observations done on November 10, 2016-

Right Ascension of the Sun, $RA_o = 15.088hr$

Right Ascension of the cluster, $RA_* = 20.525hr$

At transit, $HA_* = 0hr$

Local Sidereal time, $LST = 20.525hr$

For the sun, $HA_o + 15.088 = 20.525$

$$HA_o = 5.437hr$$

Solar time ,$ST = 5.437 + 12 = 17.437hr$

Universal time,$UT = ST + \frac{L}{15}$, Longitude,$L = 1.467°$ (Longitude of the location of observation)

$$UT = 17.538hr = 17:32:05hrs$$

This is the transit time of NGC6939.

For Transit altitude,

Latitude of the location,$\emptyset = 53.383°$

Declination ,$\delta = 60.662°$ >(90-$\emptyset$)

Transit Altitude $= 180 - (90 - 53.383 + 60.662)$

$$= 82.721° \text{ from the north of the horizon.}$$

But observations could not be completed for this cluster leading to selecting NGC7789, for which the dataset containing the astronomical images was obtained from the one acknowledged at the end of the report.

Having a diameter of 16', making it not compact, containing more than 50 stars, with a reddening of 0.217[1] mag, lying at a distance of 2337[1] pc perfectly fulfills the criteria for observing from the 0.40m telescope. The photometric conditions for observing helped gratefully in obtaining sets of calibration and light frames of 30s and 300s exposures in B and V filters respectively.
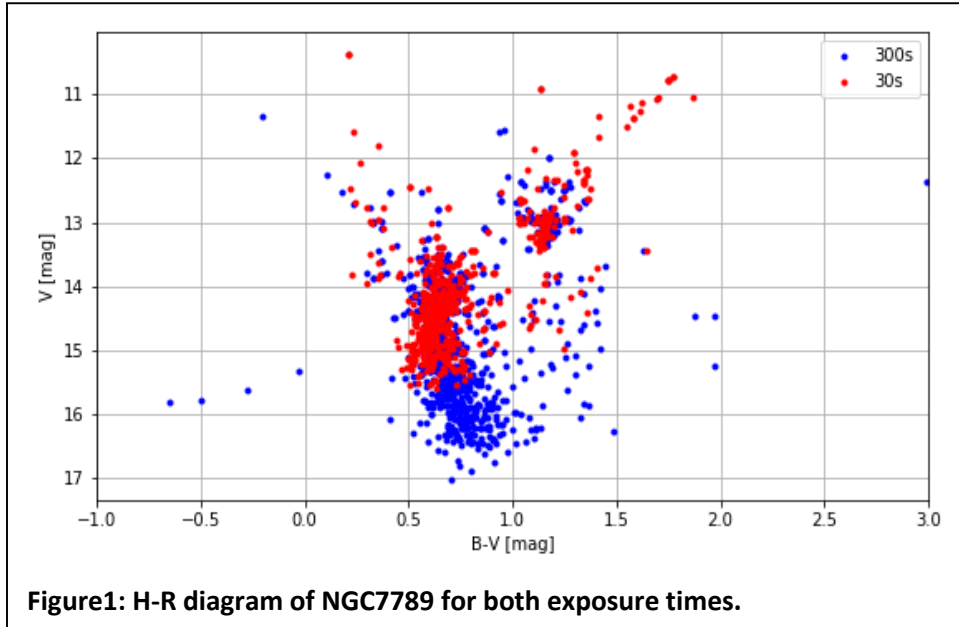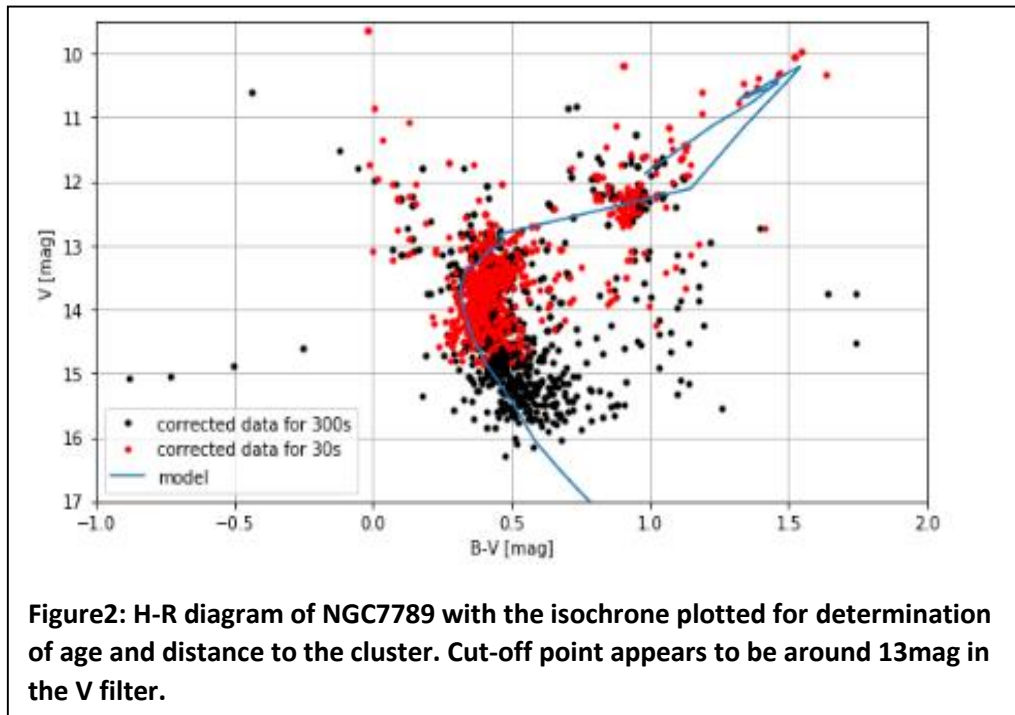
Observations

Before observing the open cluster, three calibration frames(bias, dark, flat) were taken, giving the errors lying in the telescope. The bias frame, at 0s exposure time, sets the minimum error lying in the astronomical observation. At 30s and 300s exposures, dark frames are obtained which indicate the thermal state of the CCD. Thermal excitation of electrons in the CCD results in the flow of dark current appearing in the form of hot pixels on the dark frames taken. Finally the flat frames account for the uniform distribution of light across all the pixels. Taken at B and V filters for shorter exposure times(7s), the telescope is exposed to a uniform light source providing information regarding the presence of dust particles on the lens/CCD(shown in the form of donut-shaped structures) and also explaining the problems like vignetting.

Observations for NGC6939 were abruptly stopped due to frequent cloud cover, leading to the selection of NGC7789 open cluster. The photometric observing conditions favoured the telescope and sets of light frames were taken at 30s and 300s exposures for B and V filters. Various astronomical softwares like Topcat and APT and also with the help of python coding, the reduction of the data obtained was possible leading to the CMD plots for NGC7789.

Results

Starting from the raw data obtained and calibrating them with respect to the calibration frames, absolute photometry is performed on the reduced data which involves using the Vizier catalogue service for comparing different star catalogues and the raw dataset giving the photometric zero point required for obtaining calibrated magnitudes in B and V bands. These magnitudes are corrected for interstellar extinction resulting in intrinsic values which lead to creating Colour-Magnitude diagrams (CMDs) for the open cluster. On fitting isochrones to the plot, the one matching perfectly with the main sequence and the cut-off point, provides the age and distance to NGC7789.

Figure1: H-R diagram of NGC7789 for both exposure times.

Figure2: H-R diagram of NGC7789 with the isochrone plotted for determination of age and distance to the cluster. Cut-off point appears to be around 13mag in the V filter.

Comparing to 2337[1]pc given by the literature values, the estimated distance, 2150pc , deviates to about 200 pc, which account for more uncertainties. In addition, the estimated age of 1.3Gyr lacks greatly in accuracy in contrast to 1.7Gyr[1] , as per the published values. The error in selection of reddening for the cluster and the technical issues with the telescope regarding the focus and the problems in the measurement due to thin cloud layers may contribute to the inaccuracy.

Analysis

The estimated values of age and distance to the cluster comprise of more inaccuracy in comparison to the literature values. The issues regarding the selection of the aperture sizes while performing photometry on the calibrated light frames may have affected in the final calculation of the calibrated magnitudes.

Seeing poses as a major issue in the determination of the focus of the telescope. The inaccuracy in selecting the focus may have a considerable effect on the FWHM of the star profile which in the end could cause discrepancies in the signal to noise ratio. The values for the settings in the APT software while performing absolute photometry ,in order to find an astrometric solution, could affect the presence of faint stars in the frame.

Conclusion

A H-R diagram is produced for the open cluster NGC7789 at 30s and 300s exposure times and the age and distance to the cluster is estimated to be (1.3 ± 0.2)Gyr and (2150 ± 100)pc by fitting isochrones which overlap with the main sequence and the cut-off point. The results determined from the plot correspond to a greater discrepancy with respect to the literature values[1].

References

[1] - Burbidge, E. M. & Sandage, A(1958)"The Color-Magnitude Diagram for the Galactic NGC7789", Astrophysical Journal, vol. 128, p.174

Acknowledgements