Hertzsprung-Russell Diagram Project   Group C- Tom, Isabelle, Cam

Introduction:

In this report we are going to be analysing globular clusters and organising them into HR diagrams from data gathered information from the Liverpool Inferred telescope. Globular clusters are groups of stars gravitationally bound containing over 100,000 stars and considered to be some of the oldest in the galaxy, they are usually positioned around the disc of a galaxy. We will be using HR diagrams which allow us to find the absolute magnitude of a star, this is the magnitude of the star if it was placed at a distance of 10 parsecs from earth; This will allow us to infer the composition of these globular clusters.

Globular Clusters:

Globular clusters are large groupings of stars which are gravitationally bound to each other and orbit around a galaxy disc, on average a globular cluster contain 100,000 stars and these stars are particularly significant as they are usually similar in age. This is because they were all believed to be formed from the same dust cloud which would mean they would have been created around the same time, relative to the life of stars, once the dust cloud reached the optimal density. However for larger globular clusters we have found that the Hubble telescope in 2014 found evidence that “They instead consisted of multiple populations of stars born at different times”[1] The reason being that they have large enough gravity to attract more dust to the cluster, allowing the formation of new stars. The usual similar age of globular clusters is evident in HR diagrams, which we plan to produce ourselves, as the main sequence doesn’t follow the expected pattern of most stellar observations; Instead, the pattern shows that the cluster is very old as only the stars with very small solar masses have not become red giants, in addition we can tell they are very similar ages from their clumped position meaning they have similar properties. To start with, we decided to do research into specific globular clusters, M5 and M10, to gather understanding from these structures and also how they can be represented in HR diagrams and allowing us to gather a contrast of results to see the variance of these clusters.

Method:

To find the values to produce the HR diagram- Magnitude of V and BMag-VMag we did the following:

We opened up LTImage and opened the 2 .fit files for B and V filters for the first cluster – M5. Next we scaled up the images to focus on the cluster using the display function and then picked out stars, sharing the choices between the group to reduce subjectivity. Using the brightness measurement tool we calculated the number of photons recorded in the exposure time for each star and divided by the exposure time to get photons per second – flux. We did this for each star under both filters. To work out the magnitude for the each filter we did -2.5log(flux). We repeated this process for M10 and used the data to produce Colour-Magnitude diagrams for each cluster. We measured the values for around 120 different stars in each cluster to give a better distribution and further accuracy to our graphs. We also made note of the stars that we recorded so that there would have been no chance that we measured the same star multiple times.

Improvements:

The data we collected was not as accurate as we had hoped due to the interference by the brightness of stars near the star we were measuring the brightness of. This could have been resolved zooming into the image as much as possible to ensure the stars we chose weren't surrounded by any other foreground stars giving a false reading.

Liverpool Telescope:

The moving structure of the LT is 8.5 metres tall, 6.5 metres wide and weighs around 24 tonnes. This is built around a 2 metre diameter mirror [2] designed to collect and direct light towards a set of instruments. The telescope is protected from the elements by a shelter, or telescope dome, that works like a clam shell. It is sited at the Roque de los Muchachos Observatory on La Palma.

I O:O

IO (Infrared-Optical) is a suite of instruments which replace the RATCam and SupIRCam cameras. The primary aims are to provide wider fields of view and improved image quality. Ultimately their design allows the ability to simultaneously image in the optical and IR bands, though this is not yet funded.[3]

Weather Conditions:

For our M5 V filter readings the wind speed was 9.0 m s^-1, the temperature was 5.9 degrees C and the humidity was 21.0%

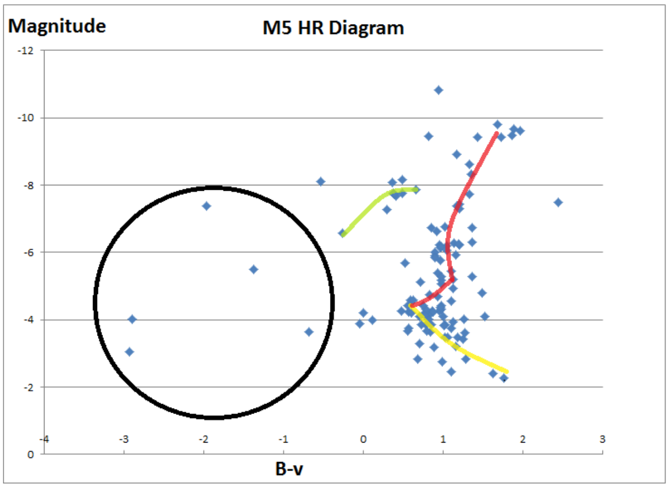
For our M5 B filter readings the wind speed was 7.7 m s^-1, the temperature was 6.0 degrees C and the humidity was 21.0%

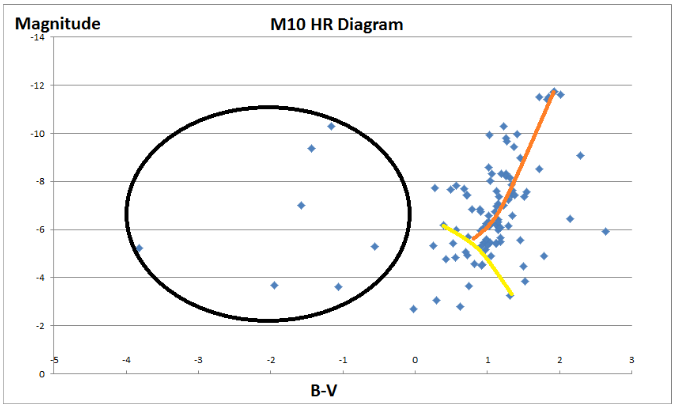
For our M10 V filter readings the wind speed was 8.1 m s^-1, the temperature was 5.9 degrees C and the humidity was 29.0%

For our M10 B filter readings the wind speed was 7.4 m s^-1, the temperature was 6.0 degrees C and the humidity was 23.0%

Strong winds will affect the telescope mechanical structure, and also leave significant amounts of dust on the mirror. It also causes some of the picture to streak to distort the star and affect brightness readings. Readings under 14 m s^-1 don't have a significant affect [4] so our results.

The amount of water the air can hold is a function of temperature. When it cools it can hold less water so when warm fully saturated air (100% RH) cools, be it on the telescope, or as it meets a cold front over the observing site, then water will condense out until the relative humidity gets below 100%, at which point the dewing or cloud formation will stop. Thus any high humidity (over about 90%) restricts any viewing as there is risk of moisture developing over the lens, there is also risk of the image 'clouding up.[5]





<u>HR Diagrams:</u>

We decided to use coloured lines to represent the different parts of the HR diagram. The yellow line represents the main sequence of the globular cluster. The main sequence is where stars spend the majority of their lives after they are formed from dust clouds and form a proto-star, from which they gain enough energy from the pressure due to gravity where they fuse Hydrogen into Helium, causing them to become a main sequence star. This diagram specially shows that the main sequence stars in the cluster are relatively close to becoming red giants; meaning they are starting to run out of Hydrogen to burn.

From the transfer from Main sequence stars into red giants, we can see a significant curve in our diagram, this curve tells of the age of the cluster because it tells us that only those stars with a relatively small solar mass haven't turned into red giants and all the other stars of varying solar masses when the cluster was formed have already gone super nova. There are less stars at the curve as this transition only takes roughly 10,000 years which is very small compared to the entire life cycle of stars.

The Red line shows us the Red Giants, which are stars that have used up all the hydrogen in their core and burnt it into Helium with the outer core still being hydrogen, this causes them to increase in size and reduce in temperature and luminosity as they turn red.

The green line represents the horizontal branch stars where the Red giants have finally run out of Hydrogen to fuse and begin to fuse heavier elements starting with Helium; this causes the star to burn brighter than hydrogen main sequence because Helium burns much more efficiently. These stars will continue to become dimmer and smaller until they become white dwarfs.

The black circle represents our anomalous results which are most likely caused as a result of foreground stars (in our own galaxy) in the picture we analysed, this is supported by our data as they have a higher brightness as they are closer to us meaning more photons can reach us.

Conclusion:

In conclusion we have found, with the aid of Hertzsprung- Russell Diagrams, that star clusters contain stars of similar age and are very old as the clusters natural progression is very advanced as only stars containing relatively small solar masses remain.

From the two clusters we have analysed, there is a clear similarity in the structure of how there is a link from the main sequence stars to the red giants and a clear curvature showing us that Globular clusters tend to be very old and have stars of similar ages. However, there are differences in the graphs such as the lack of the Horizontal branch stars in M10. Furthermore, The graph of M10 is much more unclear than M5 which could be a result of many more of the main sequence stars in M10 being converted into red giants, leading us to believe that that M10 could be older than M5, this would also explain why there are few to no horizontal branch stars in M10.

As we only had a certain amount of time, we were unable to collect as much data as the real diagrams as they contain almost every star in the cluster and we could not gather that much data but we feel our results are adequate as they show rough guide lines for what the rest of the results should look like.

[1] http://www.nasa.gov/content/goddard/hubble-revisits-a-globular-cluster-s-age/#.V4dRcPkrLIW

[2] http://www.schoolsobservatory.org.uk/astro/tels/lt

[3] http://telescope.livjm.ac.uk/TelInst/Inst/IOO/

[4] http://www.ls.eso.org/lasilla/dimm/dimm.html#W_Restric

[5] https://stargazerslounge.com/topic/176128-how-does-humidity-affect-viewing/