FAULKES TELESCOPE

Life Cycle of Stars

Background Information

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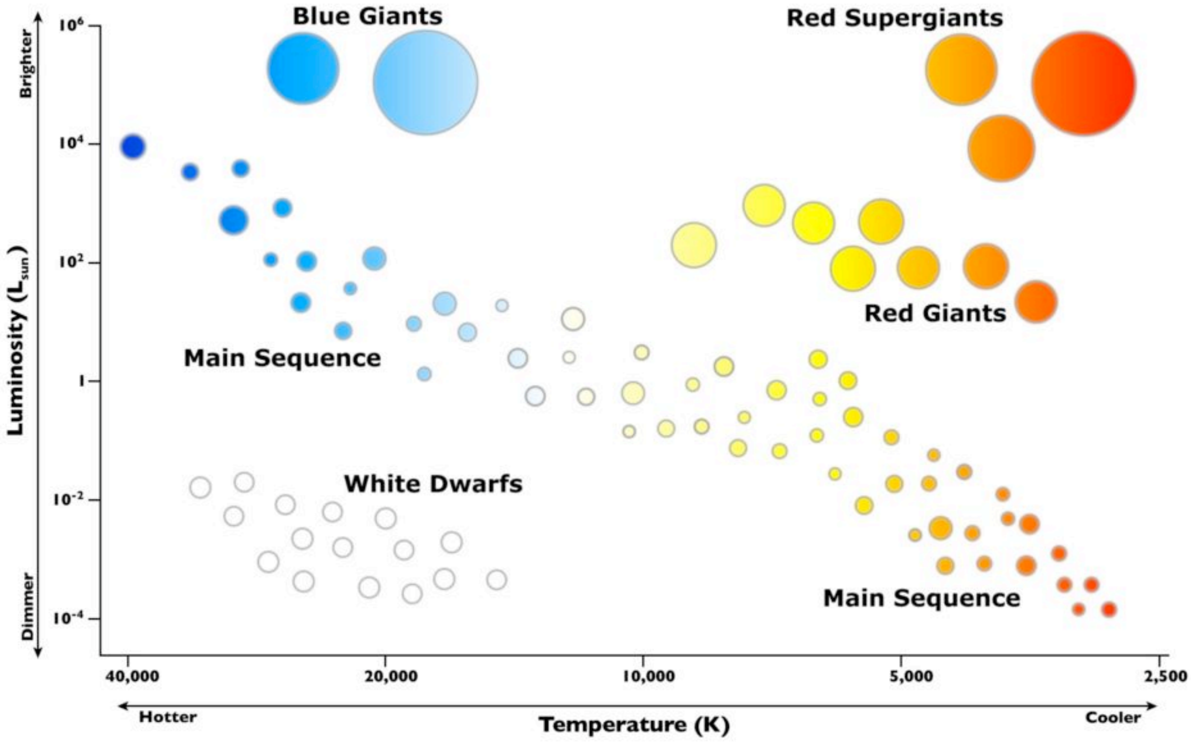
Hertzsprung-Russell (HR) Diagrams

In the early 20th century, after investigating the effects of an object's temperature and of the colour of its radiation, scientists reasoned that there should be a relationship between the temperature of a star and its luminosity. If all stars were alike, those with the same luminosity would have equal temperature and hotter stars would be brighter than cooler ones.

In 1911, Ejnar Hertzsprung (Denmark), plotted a graph of star's magnitudes against their colour. Independently in 1913, Henry Russell (USA), constructed a plot of star's magnitudes against their spectral class, confirming that indeed, there did seem to be some sort of relationship between a star's luminosity and its temperature, and the stars fell into distinct groups. Such a plot was thereafter named the Hetzsprung-Russell or H-R diagrams.

A star on a HR diagram is represented by a dot. Since a large number of stars are usually represented on a HR diagram, there are a large number of dots on the diagram, as shown below. The y axis on a HR diagram represents the star's luminosity and the x axis represents the temperature of the star.



The main areas of a HR diagram are labelled above and are briefly described below for stars **about the mass of our Sun (solar mass stars):**

Main sequence

The main sequence is a band which stretches from the bottom right of the HR diagram up to the top left, hence it goes from cooler, dimmer stars up to brighter, hotter ones. Most stars, including our Sun spend most of their lives on the main sequence as they fuse their Hydrogen into Helium in their cores.

Red Giant Branch

Once solar mass stars have fused all their Hydrogen into Helium, they evolve off the main sequence into the Red Giants area (which astronomers call the Red Giant branch or RGB). At this point, the Hydrogen shell surrounding the core of the star begins to burn, producing even more Helium.

Red Supergiants

When the Hydrogen shell burning is finished, the shell of Helium begins fusing into heavier elements such as Carbon and Oxygen. As this happens, the star moves into the Red Supergiants region of the HR diagram.

White Dwarfs

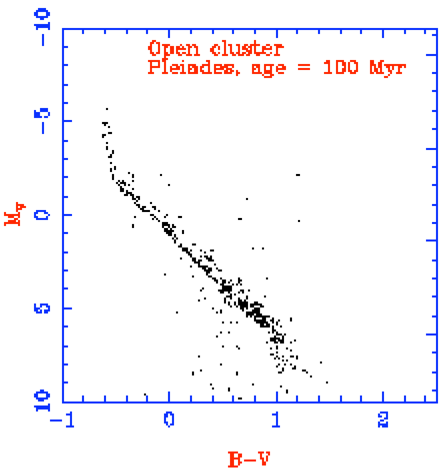
Once all the Helium has been fused into other elements, the outer layers of the star are ejected outwards into what is known as a planetary nebula. The exposed core of the star (made up of Carbon and Oxygen) which is leftover, is a white dwarf. A white dwarf cannot keep the fusion going and gradually becomes fainter and cooler. Evolution from the red supergiant area to the white dwarf area, happens very quickly in comparison to how long the star stayed on the main sequence.

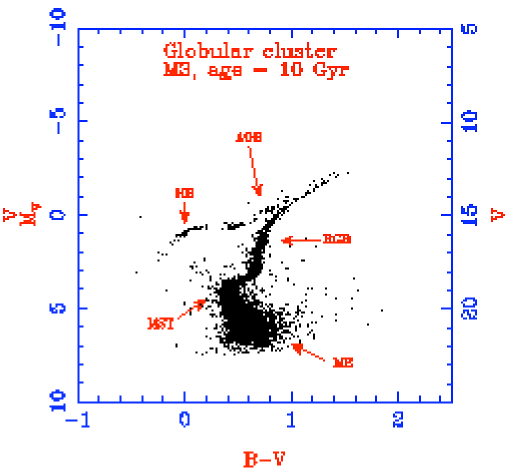
Colour-Magnitude Diagrams (CMDs)

In order to plot a HR diagram, the temperature and luminosity of the stars need to be known. The simplest indication of a star's temperature is its colour. A star's colour is simply a measure of the amount of light from the star in one filter compared to another. The most common colour system is B-V, which is simply an object's magnitude as measured through the B filter, minus its magnitude as measured through the V filter.

The luminosity of a star can be determined from its magnitude and distance. However, if you don't know the distance to the star then you can't find the luminosity. To overcome this problem, astronomers commonly use a colour-magnitude diagram, which is effectively a simple form of the HR diagram.

Below are examples of CMDs for both an open cluster and a globular cluster. Globular clusters are spherical groups of tens of thousand to millions of old (12-20 billion years!) stars, held together by gravity. Open clusters however, are looser collections of young stars, with no apparent central concentration.





On the CMDs of open clusters, the main sequence can clearly be seen. This is usually better defined than the main sequence for globular clusters since globular clusters generally contain older stars which have evolved off the main sequence onto the Red Giant Branch (labelled RGB on diagram above). If the main sequence is well defined then this implies that the stars in the cluster are roughly the same age since the more massive stars with longer main sequence lifetimes have not moved to the giant branch.