Week Quiz Reviw

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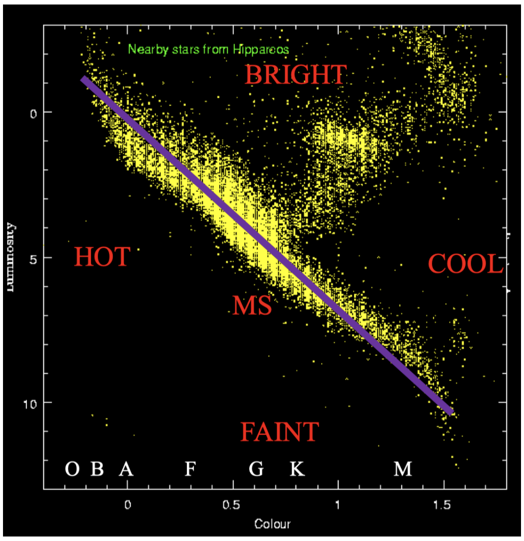
Discussion Materials

HR Diagrams



Star Clusters

Open Clusters

- Lots of open space
- Gassy and Dusty (light reflects off), bluer, younger, smaller.

Globular Clusters

- Like a globe ans stars close together
- Lots of stars (up to 10^5), little gas/dust (not that blurry), older.

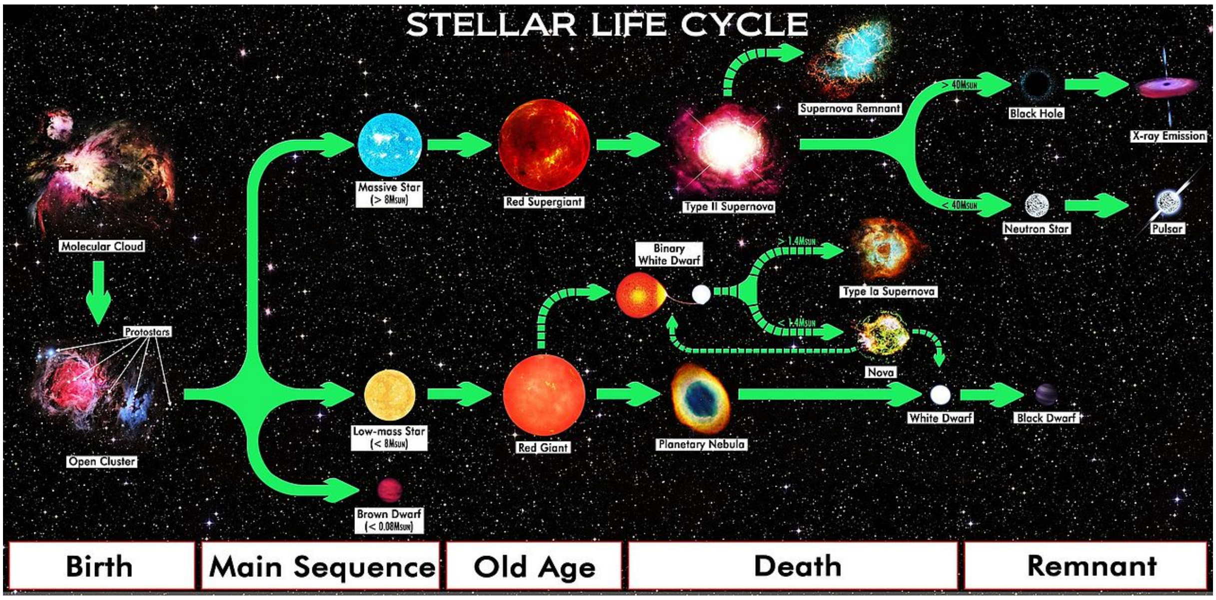
We assume that all stars relatively same distance from Earth and in same age.

Main Sequence Trends

- Mass-Luminosity Relationship: More massive, more luminous.
- Mass-Lifetime Relationship: more massive, die quickly.

Turnoff Point

Hottest, Brightest star on Cluster's MS is at the turn off point. **All stars hotter and more massive have already used up H fuel and turned off.** This point moves to less massive stars as the whole cluster ages.



LOW Mass	HIGH Mass
Redder	Bluer
Most in Main Sequence	Less numerous
Fuse up to **Carbon**	Fuse up to **Iron**
Die slowly and quietly	Die Quickly and Loudly
Die as **Planetary Nebula**	Die as **Supernova**

Class Materials

How we observe the stars and find out why many M stars?

Based on the assumptions mentioned before, we can ignore the effect of distance and compare their **apparent brightness** as though they were true luminosity. By this, we trust that the **brighter** stars are more **luminous**.

All stars formed within 100 million years of each other because of the effects of radiation from newly formed stars on the materials they are forming from.

Fusion & Fision

This **mass energy** can be changed by altering the atom's mass, via the processes of fission and fusion. The atoms go into either reactions will not have the same overall mass. The new atoms produced can have less or more energy, depending on the types of atoms. They can require energy because masses are added.

At 1920, suggested that 4 H nuclei can be forced to fuse into 1 He nucleus via *proton-proton chain*. This process generate energy because of the lost mass.

For sun, only small portion of mass is transformed into energy. 4 million tons of mass per sec for 5 billion years, the sun only used up less than 0.1% of total mass.

Core fusion generate huge **thermal pressure** creating inward gravity, and the gravity from material outside the core is also strongest at the core. At the surface of the sun, both gravitational and thermal pressure are both the weakest. This called **gravitational (or hydrostatic) equilibrium**, which sets the Sun's size.

All nuclei are positively charged that repel each other. So the nuclei need to be moving fast enough so that the fusion can occur. Only the **core** of sun have enough energy to overcome the repulsion for the strong nuclear force. The higher the temprature is, the faster the fusion rate will be, and more energy produced.
The region that the production of energy increases, that region expands and cools down. Then the rate slows down and the region shrinks. The shrinking process reheat the region and fasten the fusion again.
More massive stars need to be supported by the higher inner fusion rate to maintain its gravitational equilibrium (because more force from outer layers need to be balanced).
This makes the massive stars to burn very quickly even they have more materials.

B dwarf* (10 $M_\odot$) lasts	32 million yrs.
F dwarf (2 $M_\odot$) lasts	1.8 billion yrs.
G dwarf (1.0 $M_\odot$) lasts	10 billion yrs.
M dwarf (.5 $M_\odot$) lasts	56 billion yrs.

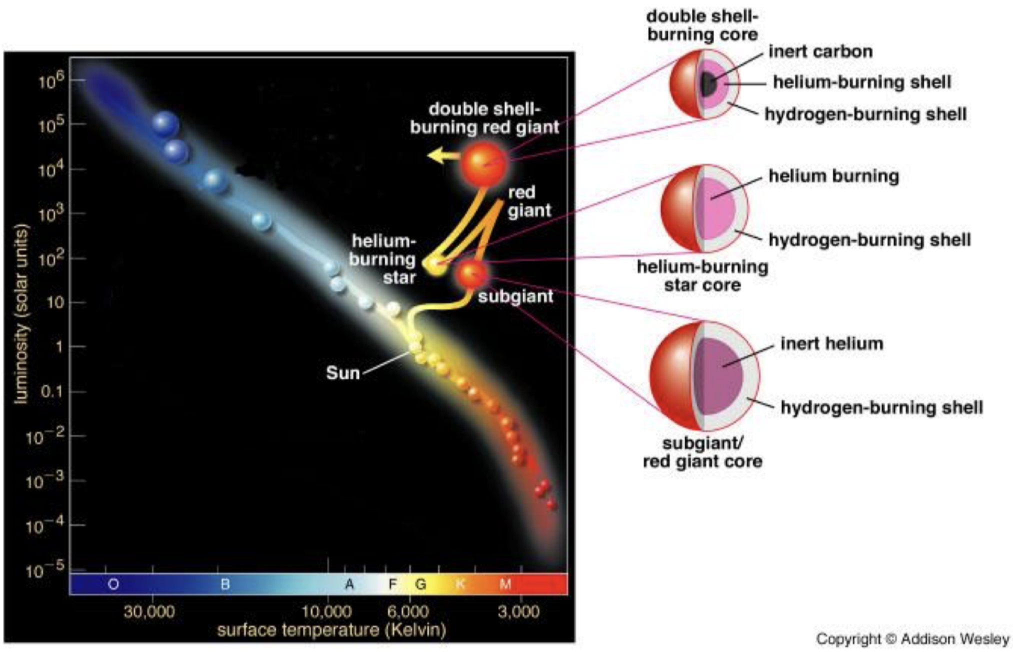
That's why there are fewer stars on the hot end of the MS of those globular clusters. This comes to the **main sequence turnoff point**. Because the massive stars die quickly.

Dwarfs, Giants, and Gold

The lower limit of main sequence stars - brown dwarfs. They are not massive enough for fusion to happen in core. How they hold themselves stable against gravity?
It is because of **degeneracy pressure**, a twist added by the quantum properties of subatomic particles.
With tightly packed electrons, they are forced to move faster into higher energy states. The extra velocity creates a pressure that pushes back against the gravitational forces. It doesn't need input fuel like fusion and doesn't decay over time. So objects supported by this force can stay in gravitational equilibrium for unlimited amount of time.
What happens to stars of different types as this equilibrium evolves?

The core of star begins to run out and collapse with a decrease in fusion pressure. This makes the interior heat up and the region previously can't fuse, fuses, producing much more heat. This create increase in radiative and thermal pressure from central region, while the outer layers expand and cool to ward a new equilibrium. In to **Red Giant** phase.

The He continues to collapse and reach 10^8K. Then the **He fusion** begins, which we called as **helium flash**. And becomes stable again. These stars are shown in H-R is **horizontal branch**. They are hotter, dimmer, and smaller as they in Red Giants.
However, this equilibrium stays much shorter than that previous one (thousand times faster). Then the star swells up in size and becomes a **asymptotic giant branch (AGB)** star, which also called double-shell burning giants.



What happends next depends on the star's mass (how much gravitational forces hold the star together).

- less than 8 solar masses: the force are not enough to resist the increase of luminosity, and blows itself apart slowly into **planetary nebula**. The dust produced during these stages is responsible for most of the carbon in the universe. Not massive enough to heat cores to 6×10^8K, where Carbon can fuse. They do eventually collapse only because of electron degeneracy pressure.

- for much massive stars, they have enough gravitational energyto start carbon fusion into Oxygen, while the Carbon used up pretty fast. So the core collapse again when Oxygen itself begins to fuse. This process repeats to heavier and heavier elements. As the "shells" of fusion around the core increase in number, thermal and radiative pressure again overbalances the gravity in the outer layers and the surface of the star expands and cools. They become **supergiant** type stars.
  They are unstable, and are categorized as **luminous blue variables (LBVs)** and **Wolf-Rayet (WR)**.
  Their luminosities push away the outer atmospheres at 10^{-4} solar masses per year (lose 10-90% of their masses).

  Their fusion comes to dead end as silicon begins to fuse into iron, because Fe is the lowest mass per nuclear particles of any element, which means it cannot fuse into another element without creating masses. Thus, the fusion of Iron **consumes energy**!

With the Fe continues to be made, the density climbs high (10^{13}) for protons and electrons to form neutrons. This kind of cores no longer supported by electron degeneracy pressure, but by **neutrons** degeneracy pressure. The collapse takes less than a second from a Earth size to few km. This heats up a neutron rich core to temprature up to 100 billion degrees K. The atmosphere above the core falls on to this hot and effectively incompressible surface and recoils, resulting in a shock wave that rips through the outer layers of the star over several hours and sends them blasting outward.
The heat enables **explosive nucleosynthesis (fusion)** to occur in its atmosphere. The unstable and radioactive elements decay and produce gamma rays heating up the expanding **supernova remnent** that eventually produces bright debris clouds. Such steller

death sequences are responsible for most of the periodic table. These are distributed into neaby intersteller space.

In specific, differences are (for high than low):

- less numerous;
- shorter lives;
- fuse element heavier than Carbon;
- die as supernova instead of planetary nebula;
- different corpses behind.