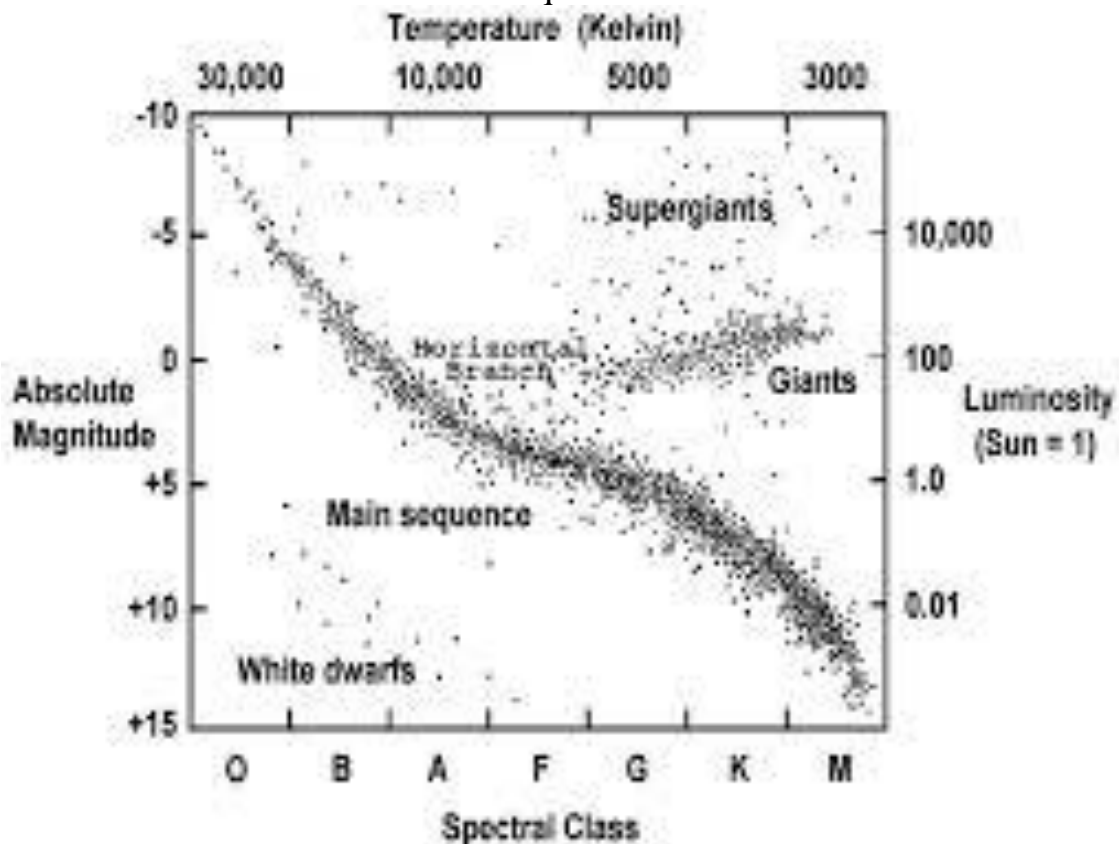


Md Rashadul Islam EVOLUTION OF SUN LIKE STAR

Introduction :

Sun is our star and it is the center of solar system ,having 99% mass of solar system .The overall structure and position of the whole solar system depends on on the sun .So it is really important to understand the overall evolution of sun or sun like stars. In the beginning of 20 th century two scientist Russel and Hertzsprung tried to fit the datas on a graph of the stars according to their absolute magnitude and spectral group which is based on temperature and saw there is a wide line started from the bottom of the left and goes all the way right to the top .This line is called main sequence .Our sun falls in the spectral group G in the main sequence .So to understand the evolution of sun ,or the sun like stars we have to really understand the evolution of main sequence .



Before main sequence phase :

Stellar evolution starts from the giant molecular clouds .It is of cold , low density and its size is huge . So it stars collapse under gravitational energy .At first there is no friction and the total contraction energy of gravity is free energy nothing used in heating .But later starts to collapse and it started heating up and density becomes high and there starts a fight between pressure forces and gravity .And when this forces are out of balance it started to collapse and become smaller and smaller parts . The smallest part becomes a protostar .Contraction make the temperature to increase .The source of increase of temperature the gravitational energy as it transforms into kinetic heat energy .Which cause the particle to move with certain speeds in such a way that the particle emits radiation as the temperature is still low it emits in infrared or radio waves .In the early stage radiation can escape but later increment of gravitational energy it makes it it tough to escape .As the collapse increses and the size of the protostar become smaller .

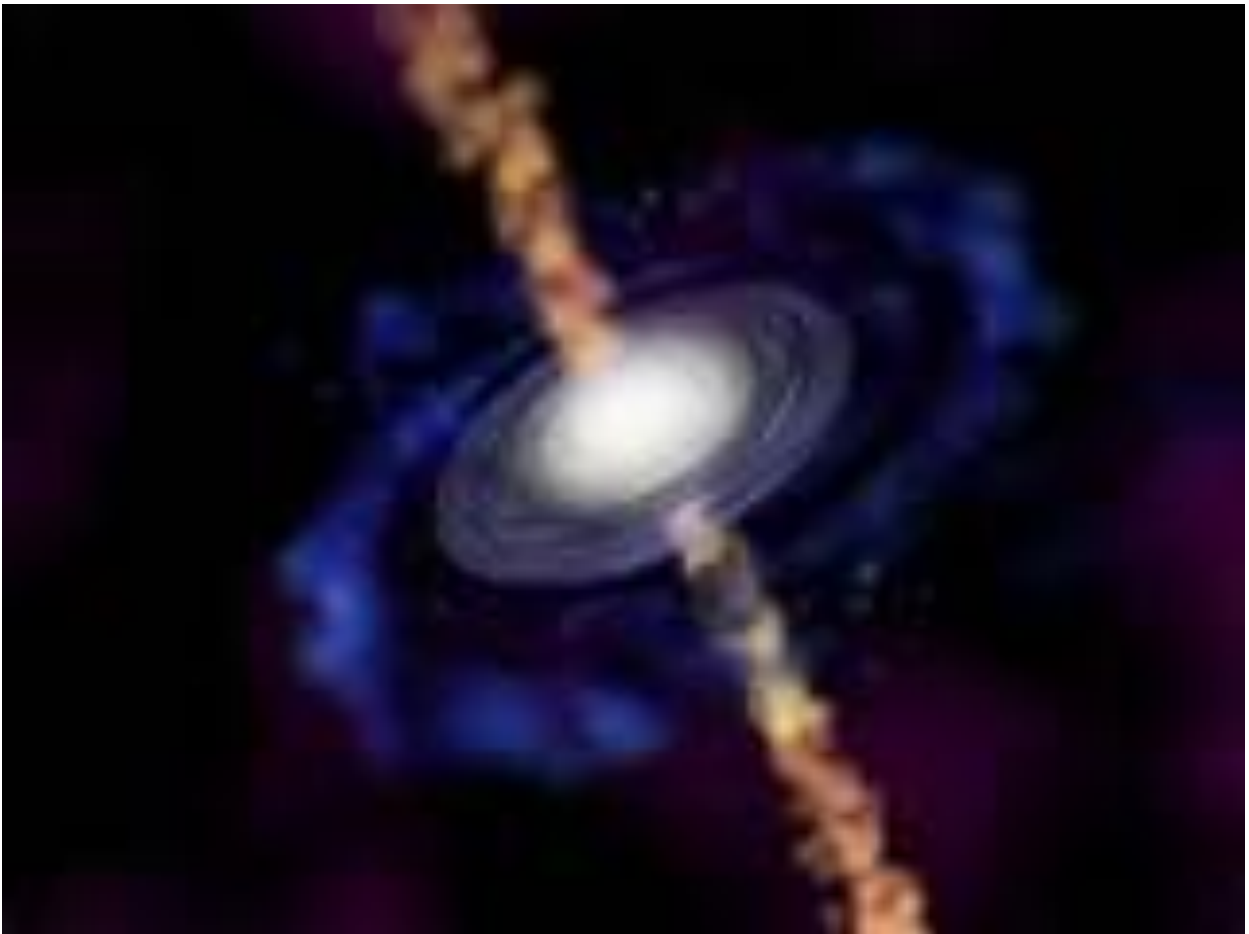


Photo: protostar

Life in main sequence:

The way a main sequence star survives in the main sequence is because of hydrostatic equilibrium. There is an inward pull of gravity and an outward pressure that balances it. Sometimes although it is not enough. So when the temperature of the star became 10 million K fusion of Hydrogen core occurs releasing energy which creates an outward push because of the protons on highly dense core. So the nuclear radiation and the outward pressure balances the gravity. Mass is related to effective temperature. Greater the mass, the greater the effective temperature. And higher the mass in main sequence higher the radius and greater the radius the greater the luminosity.

Most of a star's life is spent in the main sequence. For example sun took 20 million years to form but it will spend 10 billions its life time in the main sequence. Stars have different mass. The massive the star it took shortest time it is going to spend in the main sequence as gravitational pull will increase literally.

Nuclear reaction is another source of energy which is produced in the core of the star. The original view of this reaction is to produce heavier element than hydrogen. This occurs in two main processes – p-p chain or CNO cycles. In p-p chain the core is radiative and the shells are convective. In the main sequence the work of nuclear reaction is to produce He from H. In every stage of the reaction the combined mass of the reaction is greater than the product mass. So where the other mass goes. The answer is in Einstein's formula

$$E=dm c^2.$$

The helium core flash :

For stars of lower mass less than 1.8 solar mass, the helium core continues to collapse, and the core becomes strongly degenerated, and an important amount of neutrino losses from the core from the core of the star cause a negative temperature gradient near the center, the cause the energy is carried away easily by the escaping neutrino. When the temperature and density becomes high enough to start the triple alpha process (approximately about 10^8 K and 10^7 kg/m³), respectively the energy release is catastrophic. The ignition of the burning of helium occurs some in shell in the center of the star, ultimately the core involves in that. The luminosity of the helium reaches to 10^{11} luminosity of sun. which only last for a few seconds. The energy released is absorbed by the layers of the envelopes and causes some mass to lose. This period of the life of the

star is called helium flash . The original explosion energy releases is in the very weak temperature depends on the electron degeneracy process .The every must spend first to take out the degeneracy.

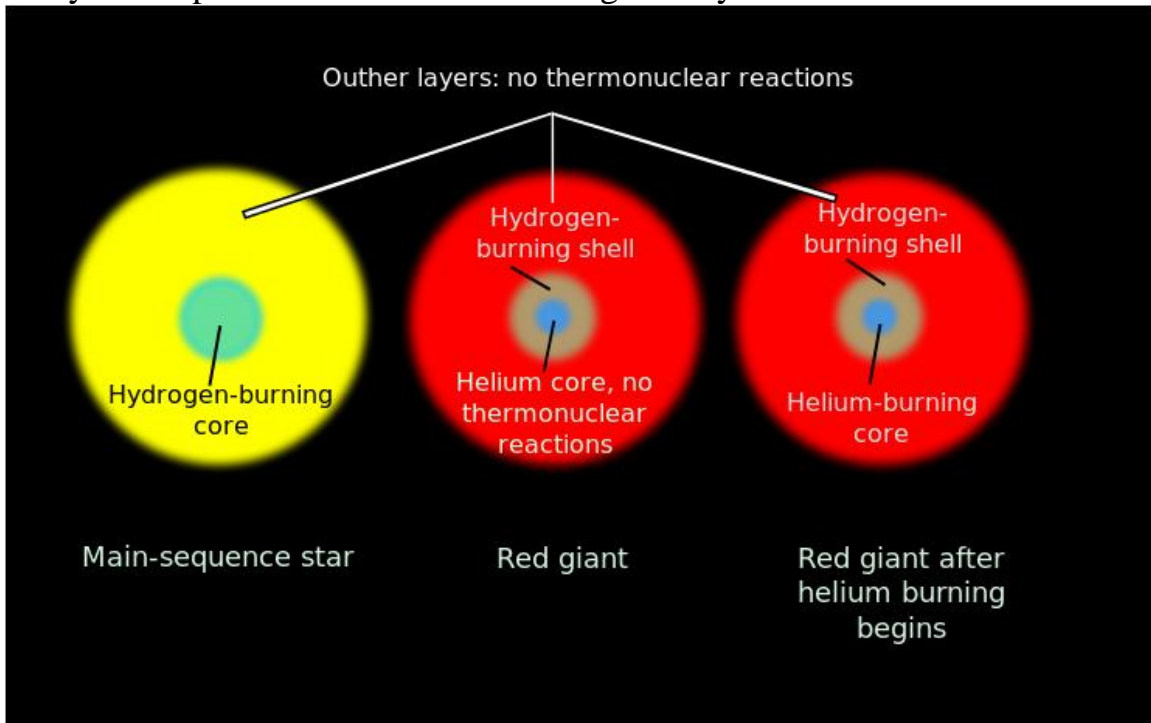
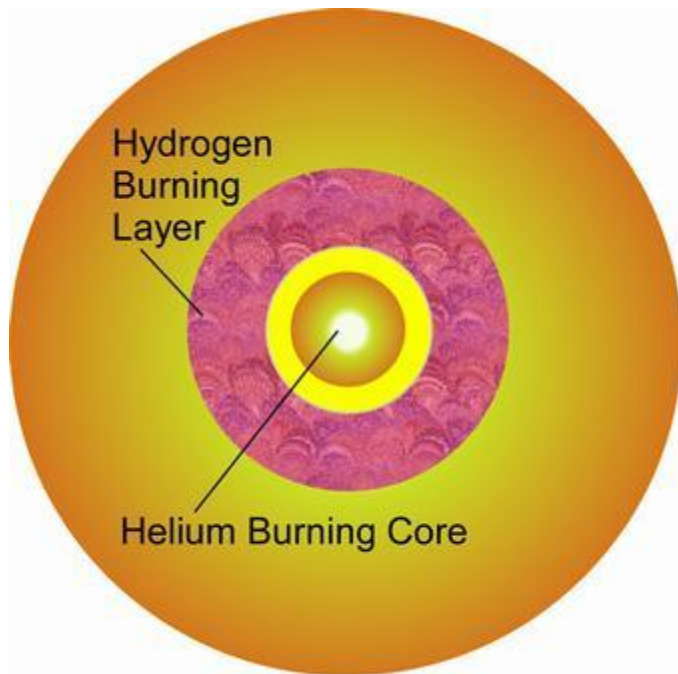


Photo:helium flash

Horizontal branch :

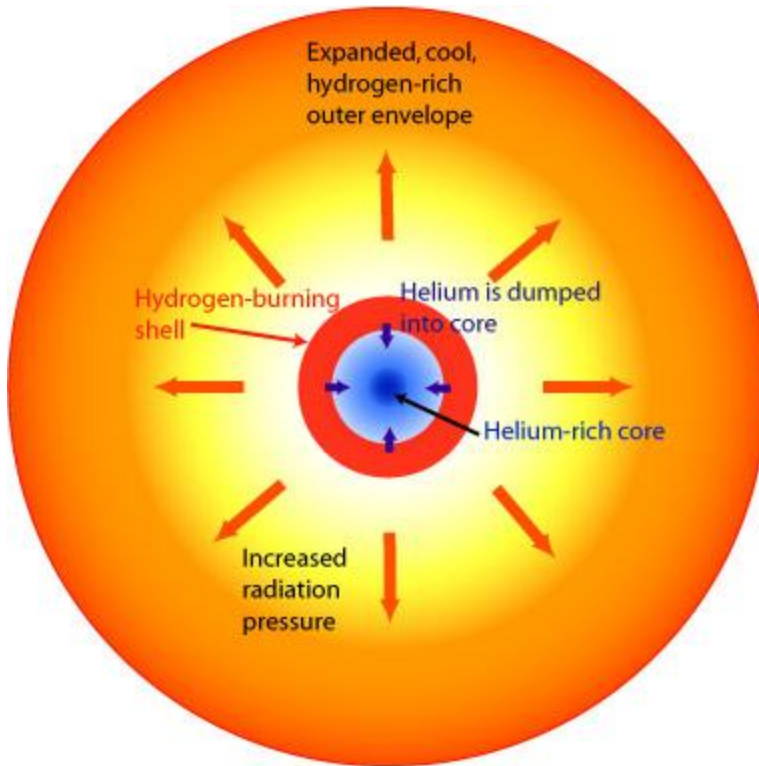
As soon as the helium flash is finished , in the core There is only an ordinary helium plasma which is transforming He into Carbon, and there exist a hydrogen burning shell convective plasmic core .this state is called horizontal branch of star in H-R diagram depends on initial mass and chemical composition and mass loss of star during the ascending to the red giant branch .



Horizontal Branch Star

On the way to a red giant :

As H is turning into He the mass of the core is rising but one He need less space than 4 H , so the core compacts .Half of the energy is going to heat up the core and half of it is going to radiates away . The temperature increase and as well as the density of the core . More and more energy is produced in the stars . So now the radiation theory is not working for carrying out the energy from the center to the shells . Now the process is going to be convective and it is much more effective . Now the radius of the star get bigger , luminosity increases and so the temperature decreases .The star get redder .So the star move to the top right hand side of H-R diagram .The core starts to become denser and denser Until it totally becomes degenerated , it is a different level where the laws of ideal gas doesn't work .Degeneracy is the state where the electrons are compacted so closely .



Hydrogen Shell Burning on the Red Giant Branch

Tripple alfa reaction :

For this reaction to happen we need a high temperature than the p-p chain and it produces more energy .He particle was known as alpha particle .So as three particle of He produces the carbon .Itis named tripple alpha process .

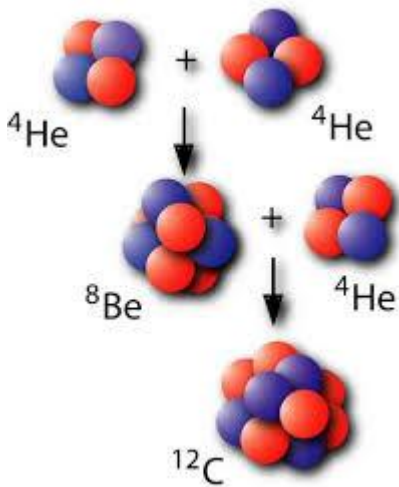
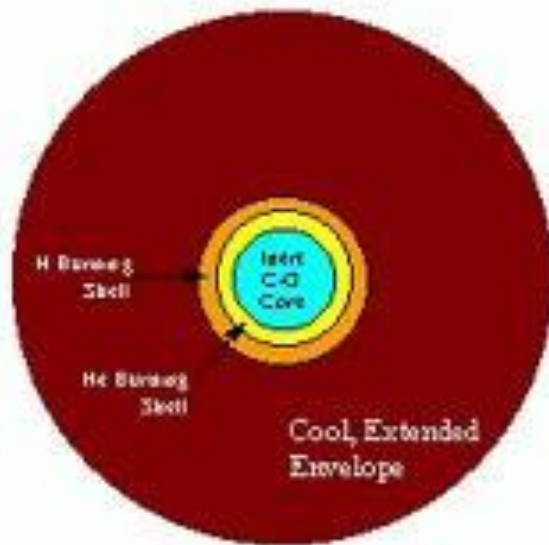


Photo: tripple alpha reaction

The asymptotic giant branch :

As the temperature gets so high that another nuclear reaction happens , so from carbon reacts with helium and produces oxygen . An here an interesting thing happens ,there produces oxygen from carbon in the core ,in the nearer shell happens helium burns into carbon and another shell burning happens from hydrogen to helium and carbon mass in the core increases as well as the reactions .envelope expands as well as the radius and the temperature decreases and star moves to the top right side of the H-R diagram , become a red supergiant .

Asymptotic Giant Branch Star



Planetary nebula phase :

As the radius increases and increases the outer shell get exposed to the surface as they are loosely bound , the triple alpha reaction happens in the surface , He flash rather becomes explosive . This is called a planetary nebula phase .



Photo: planetary nebula

White dwarf :

Although the average temperature of the nebula is low but the central star is still hotter . planetary nebula disappears . The star goes toward blue in H-r diagram and becomes a white dwarf .white dwarf ia a star of size 1000 kms and but high density .The material in the star is degenerated and this degenerated electron oppose the gravitational collapse

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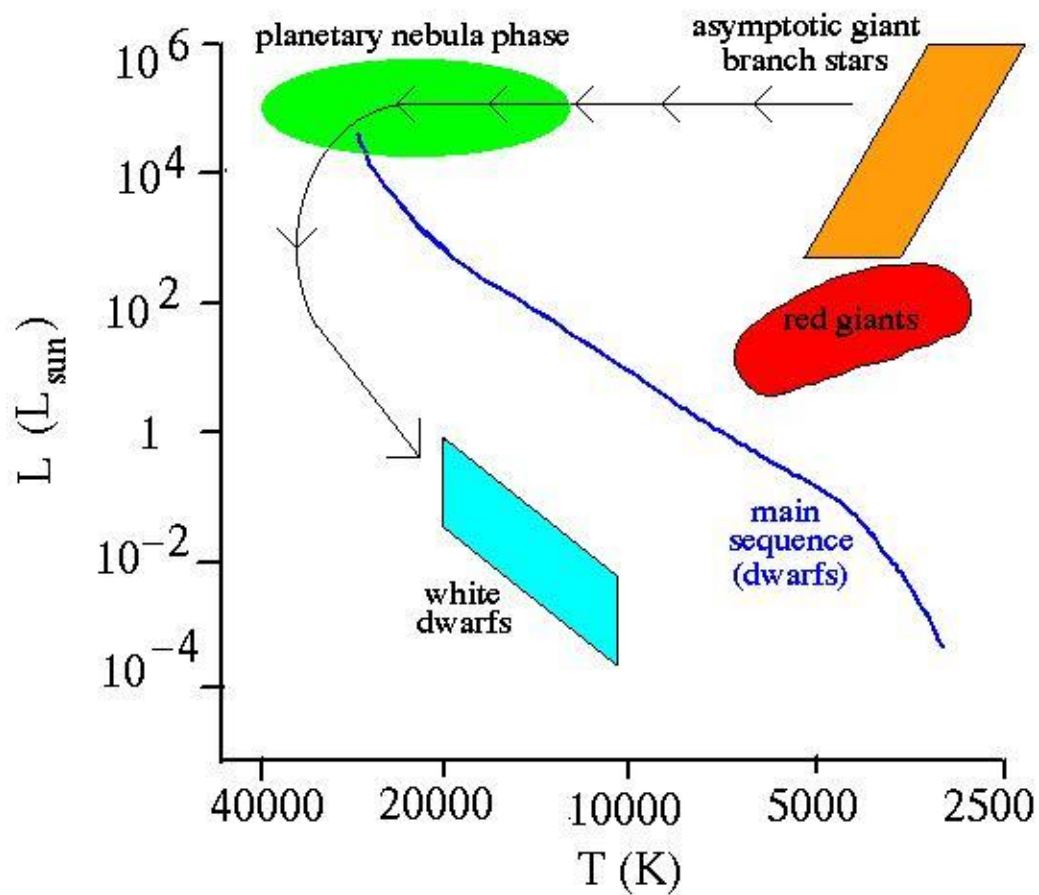


Photo: life circle of low mass stars

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