CHAPTER 29: STARS

BELL RINGER:

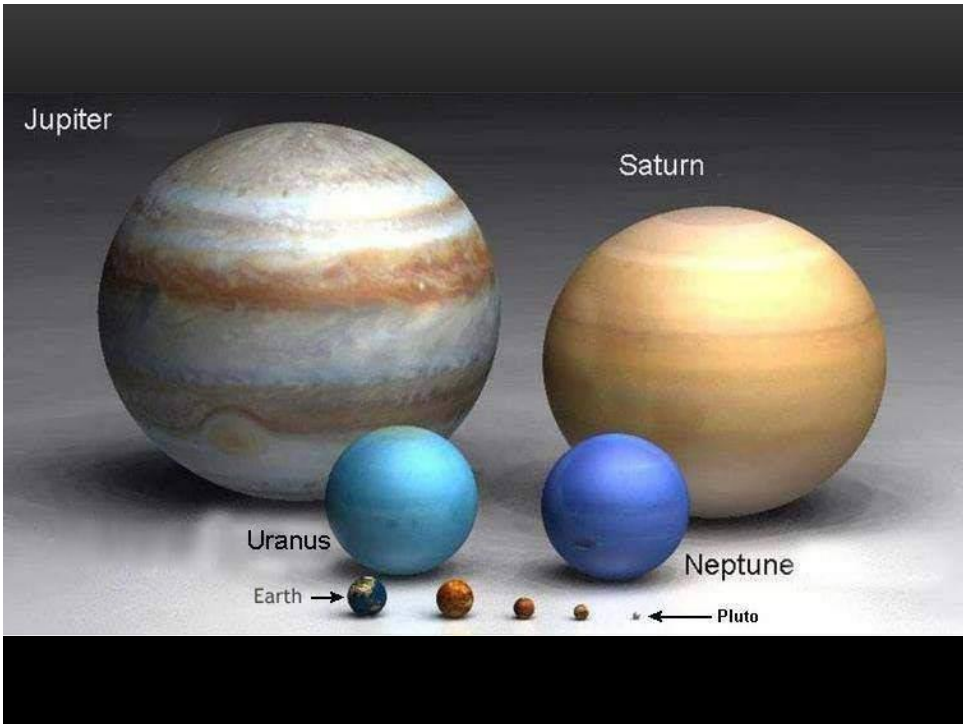
- Where does the energy of the Sun come from?
- Compare the size of the Sun to the size of Earth.

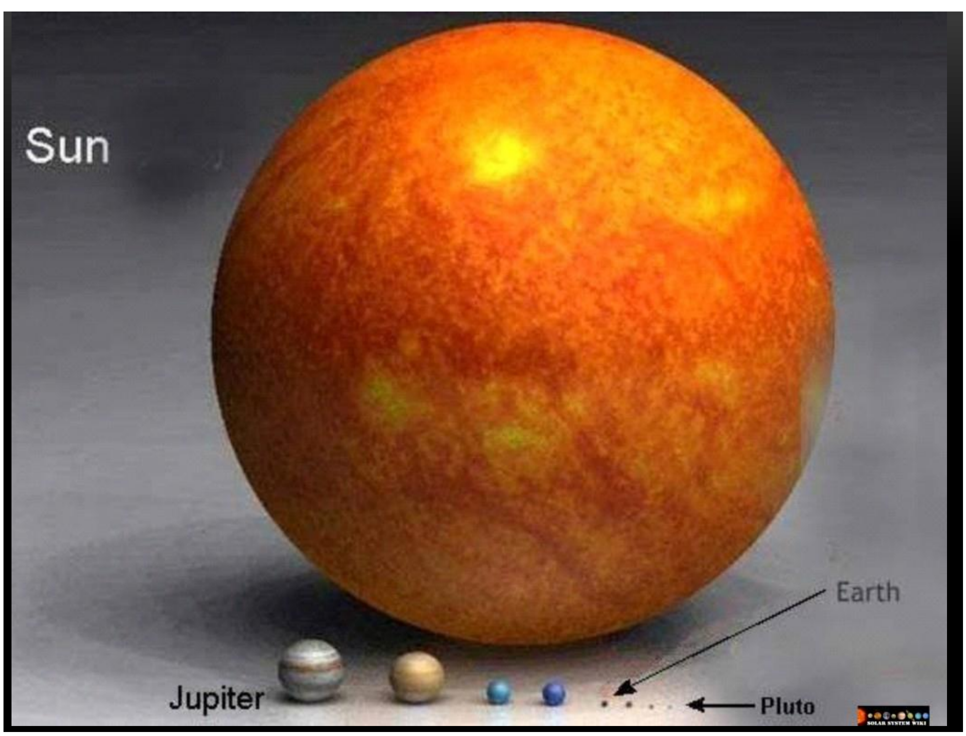
CHAPTER 29.1: THE SUN

- What are the properties of the Sun?
- What are the layers of the Sun's atmosphere?
- What is solar wind and what causes sunspots?
- What are solar activity cycles?
- What gives the Sun all of its energy?
- What is the composition of the Sun?

PROPERTIES OF THE SUN

- The Sun is the largest object in the solar system.
- It would take 109 Earths, or about 10 Jupiters, lined up edge to edge to fit across the Sun.
- The Sun contains 99% of all the mass of the solar system.


Jupiter
Saturn
Uranus
Neptune
Earth
Pluto


Sun
Earth
Jupiter
Pluto

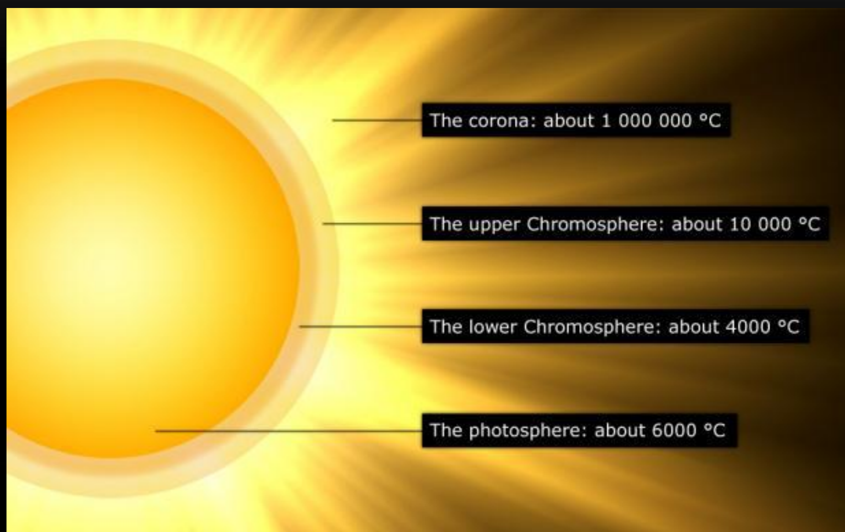
PROPERTIES OF THE SUN

- **The Sun's density is similar to the densities of the gas giant planets.**
- **The density in the center of the sun is 13 times the density of Lead.**
- **A pair of dice as dense as the Sun's center would have a mass of about 1 kg (2.2 lbs).**

PROPERTIES OF THE SUN

- **The Sun's interior is gaseous throughout because of its high temperature.**
- **All of the gas in the center of the sun is completely ionized (plasma).**
- **The Sun produces the equivalent of 4 trillion 100W lightbulbs of light each second.**

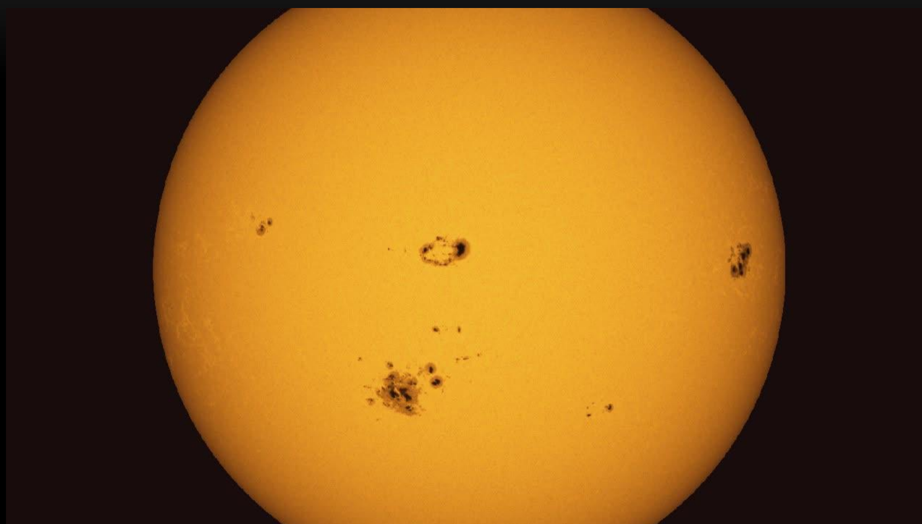
THE SUN'S ATMOSPHERE



THE PHOTOSPHERE

- **The photosphere is the visible surface of the Sun.**
- **It is approximately 400 km thick and has an average temperature of 5800K**
- **Most of the visible light of the Sun is emitted from the photosphere.**

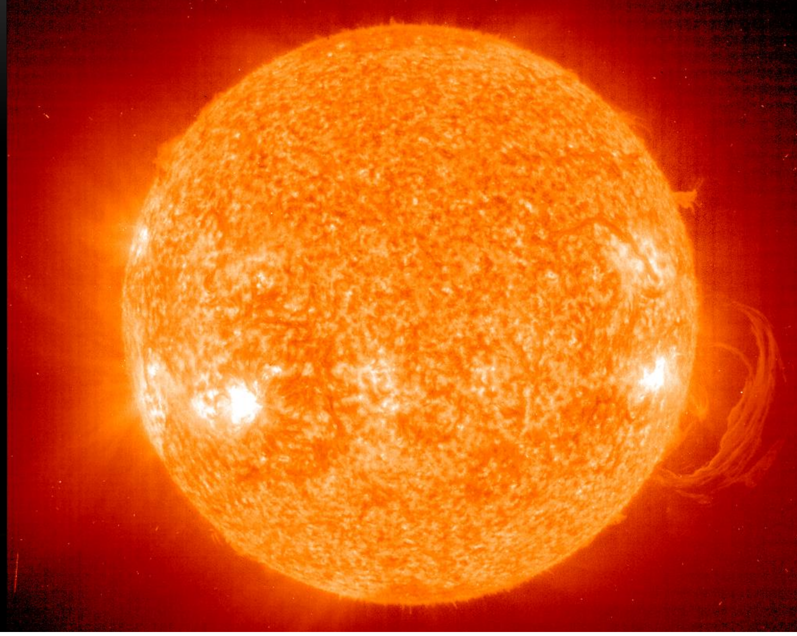
THE PHOTOSPHERE



THE CHROMOSPHERE

- **Outside the photosphere is the chromosphere.**
- **Average Thickness: 2500km**
  Average Temperature: 30,000 K
- **Visible only during a solar eclipse when the photosphere is blocked.**
- **Special filters can be used to view this layer. (Mostly UV Rays)**

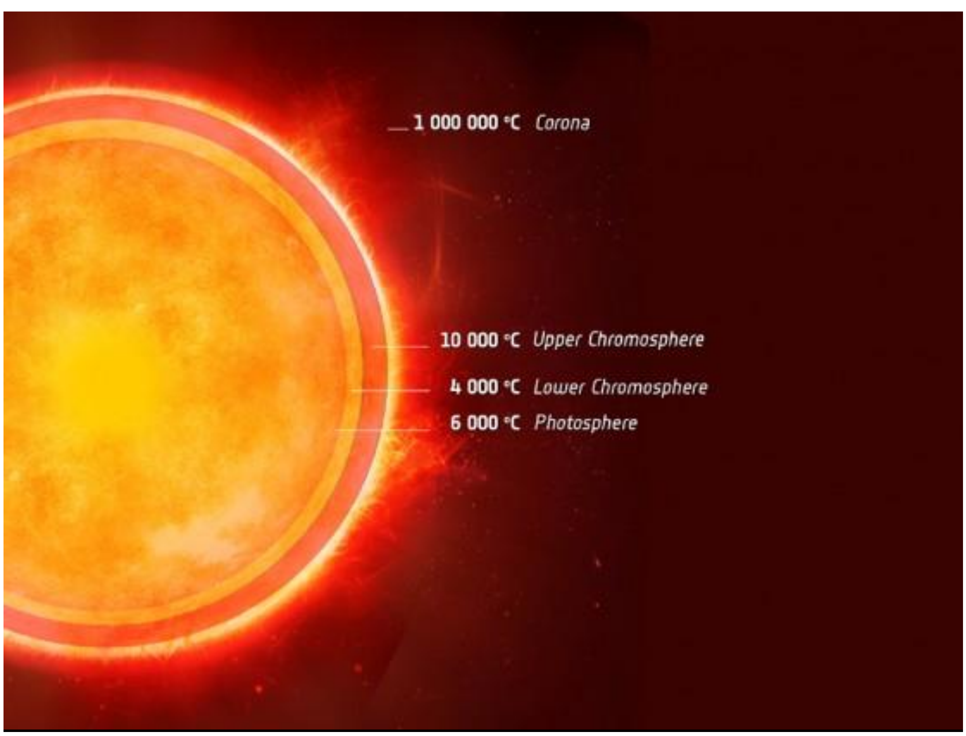
THE CHROMOSPHERE



THE CORONA

- The outermost layer of the Sun’s atmosphere.
- Extends for several million kilometers from the outside edge of the chromosphere.
- Temperature: 1 Million – 2 Million K
- Radiation is mostly X rays.


THE CORONA

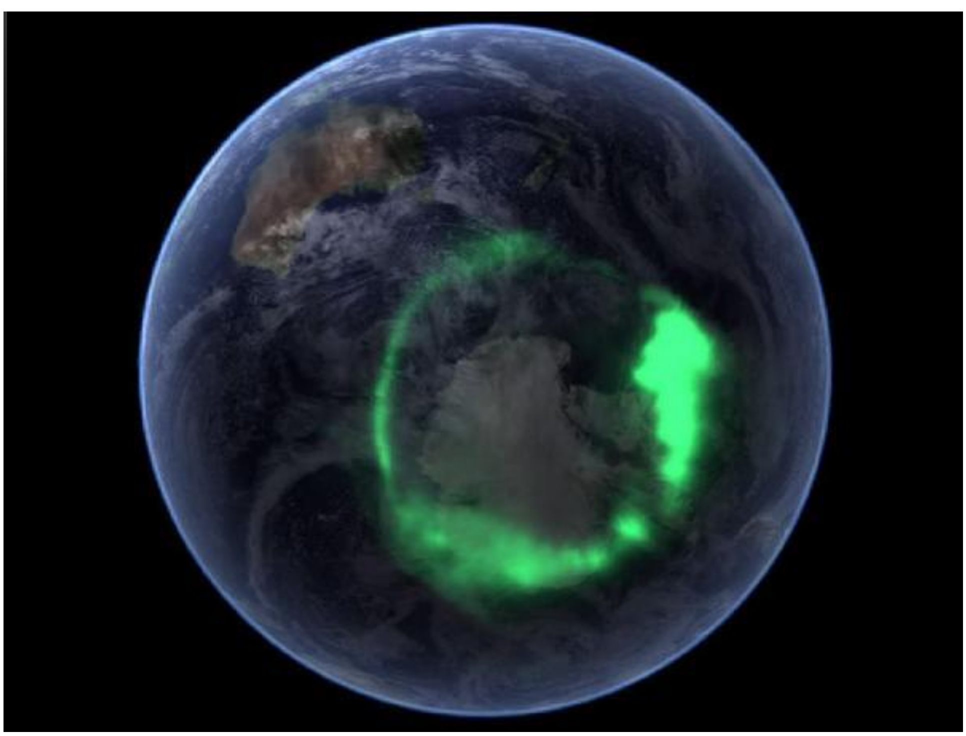

1 000 000 °C Corona
10 000 °C Upper Chromosphere
4 000 °C Lower Chromosphere
6 000 °C Photosphere

SOLAR WIND

- **The corona of the Sun does not have an abrupt edge.**
- **Gas flows outward from the corona at high speeds and forms the solar wind.**
- **These high energy particles are deflected by Earth's magnetic field and trapped in two huge rings. (the Van Allen belts)**

SOLAR WIND

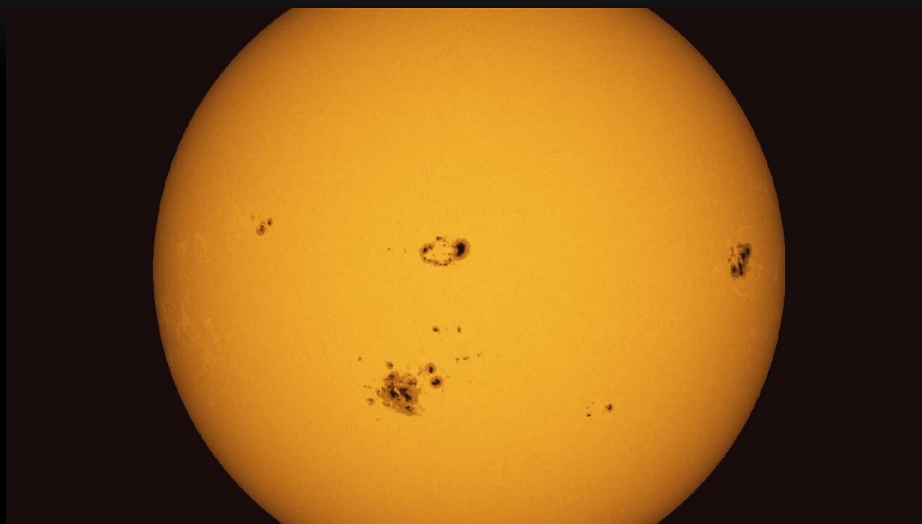
- **High energy particles in these belts collide with gases in Earth's atmosphere, causing them to give off light.**
- **This light is called the aurora.**



SUNSPOTS

- **The Sun's magnetic field disturbs the solar atmosphere and causes features called sunspots.**
- **Sunspots are dark features on the surface of the photosphere.**

THE PHOTOSPHERE



SUNSPOTS

- **Sunspots appear dark because they are cooler than the surrounding areas.**
- **Sunspots are located where the Sun's magnetic fields penetrate the photosphere.**

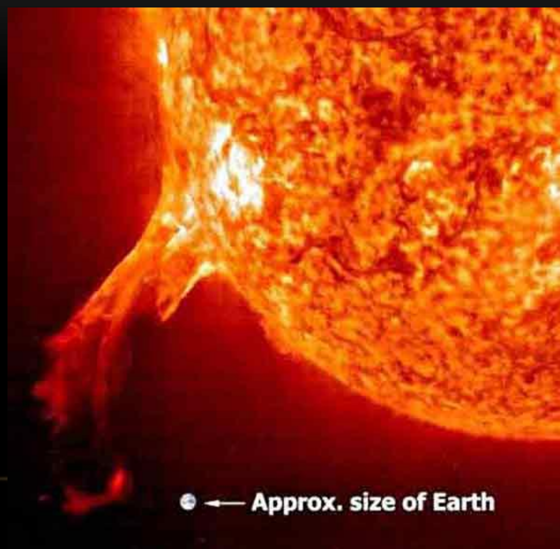
SUNSPOTS

- **Astronomers have observed that the number of sunspots changes regularly, reaching a maximum number ever 11.2 years.**
- **At this point, the Suns magnetic field reverses.**

SOLAR FLARES

- **Solar flares are violent eruptions of particles and radiation from the surface of the sun.**
- **The released particles often escape the surface of the sun and bombard earth a few days later.**

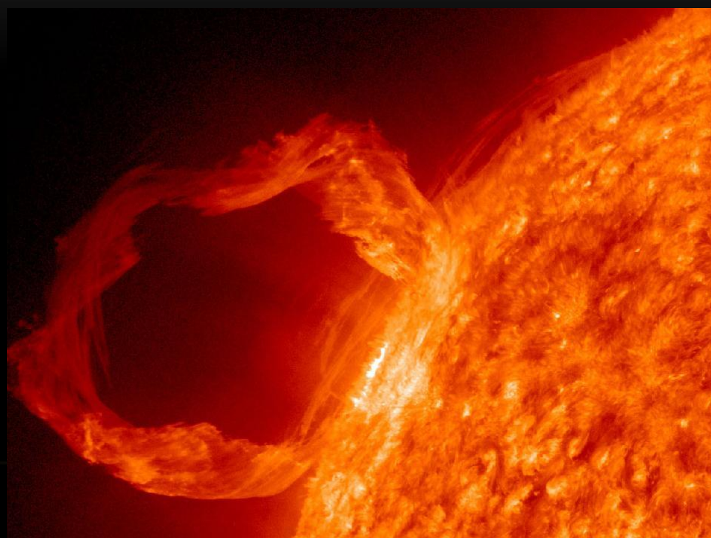
SOLAR FLARES



PROMINENCE

- **Another active feature associated with flares is a prominence.**
- **A prominence is an arc of gas that is ejected from the chromosphere and rains back to the surface.**

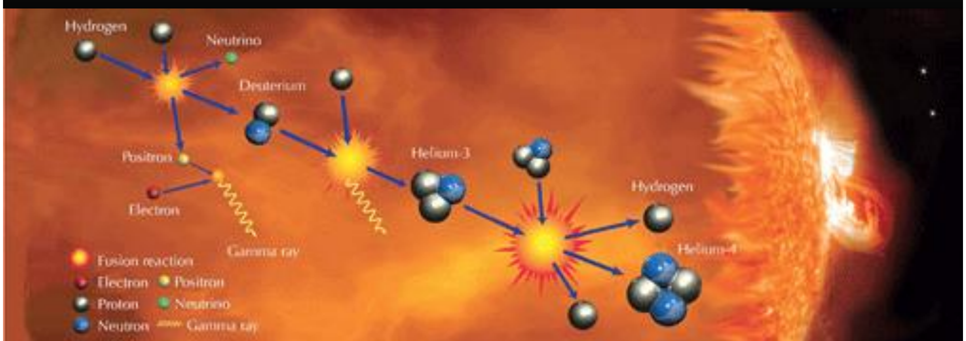
PROMINENCE



THE SOLAR INTERIOR

- **Nuclear fusion** occurs in the core of the Sun, where pressure and temperature are extremely high.
- Fusion is the combination of lightweight atoms into heavier atoms. (Hydrogen into Helium)

THE SOLAR INTERIOR



THE SOLAR INTERIOR

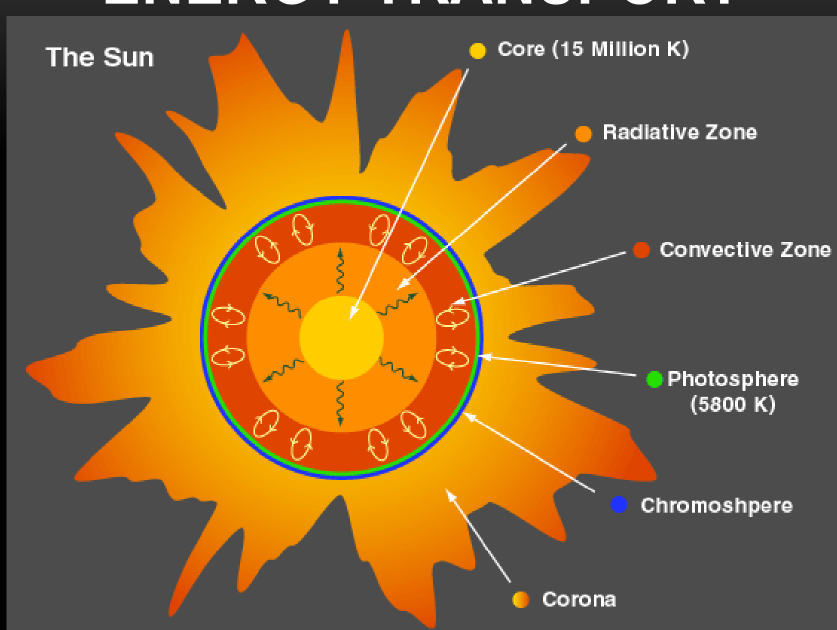
- **In the core of the Sun, helium is a product of the process in which hydrogen nuclei fuse.**
- **This produces massive amounts of energy since mass is lost during the process.**

$$E=mc^2$$

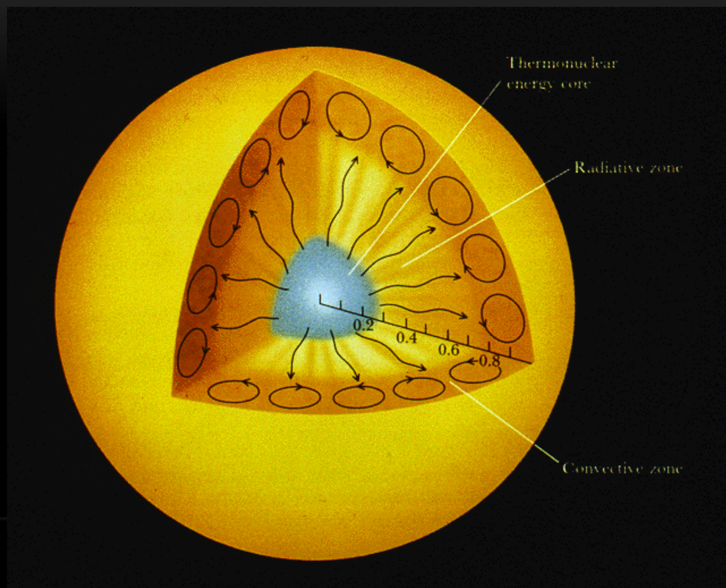
THE SOLAR INTERIOR

- **At the Sun's rate of hydrogen fusing, it is about halfway through its lifetime, with approximately 5 billion years left.**

ENERGY TRANSPORT

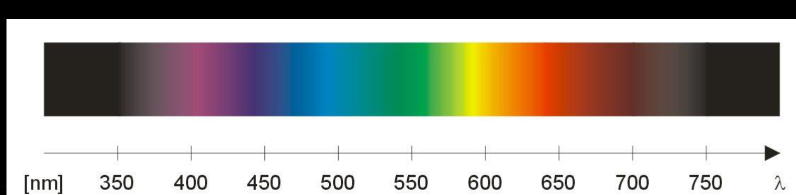


ENERGY TRANSPORT



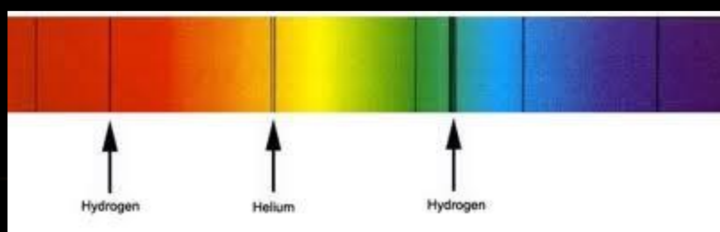
SPECTRA

- **A spectrum is visible light arranged according to wavelengths.**

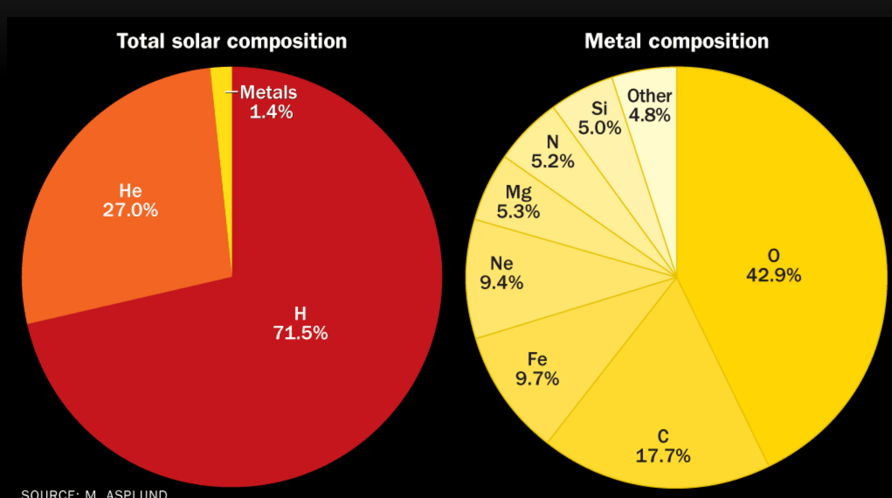


SPECTRA

- **A spectrum from the Sun's light shows a series of dark bands. These dark lines are caused by different chemicals that absorb light at specific wavelengths.**



SOLAR COMPOSITION



BELL RINGER:

- What is a constellation?
- Write down the names of any constellations you know.

CHAPTER 29.2: MEASURING THE STARS

- How are distances between stars measured?
- What is the difference between brightness and luminosity?
- What are the properties used to identify stars?

GROUPS OF STARS

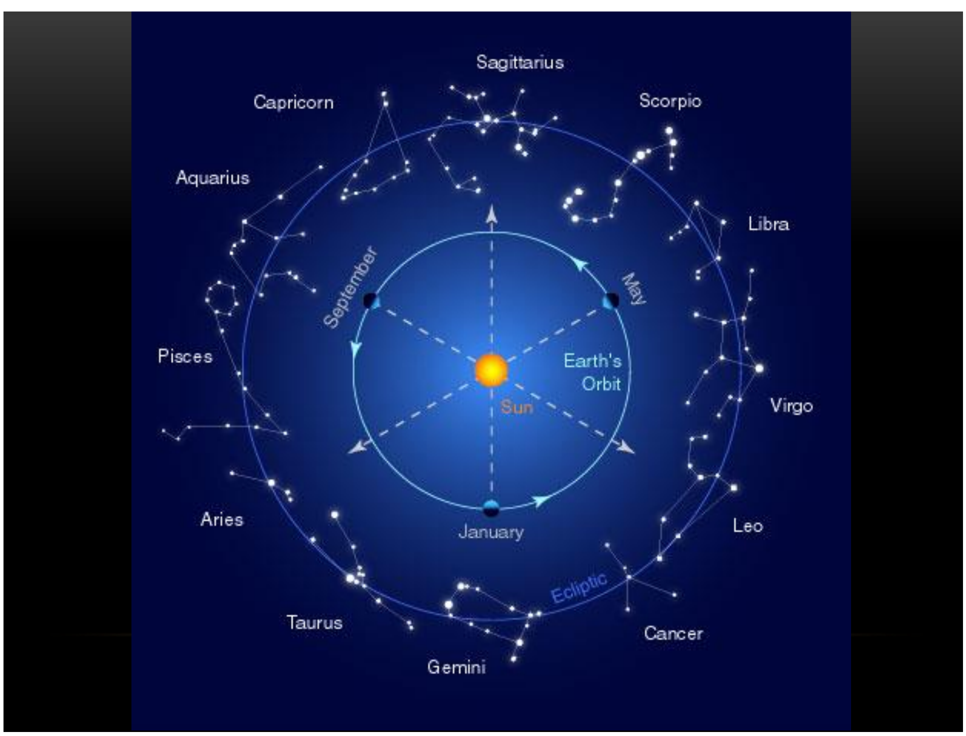
- **Many ancient civilizations looked at the brightest stars and named groups of them after animals, mythological characters, or everyday objects.**
- **These groups of stars are called constellations.**

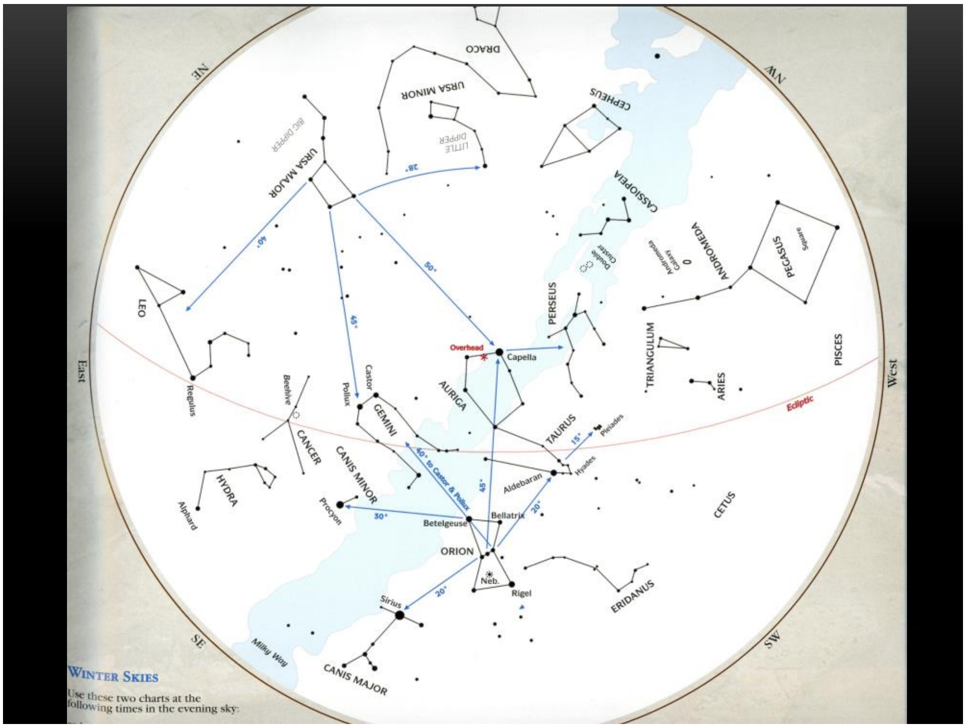
GROUPS OF STARS

- **Some constellations are visible throughout the year, depending on the observer's location.**
- **The Big Dipper (Ursa Major) is a circumpolar constellation, meaning it can be seen year round.**

GROUPS OF STARS

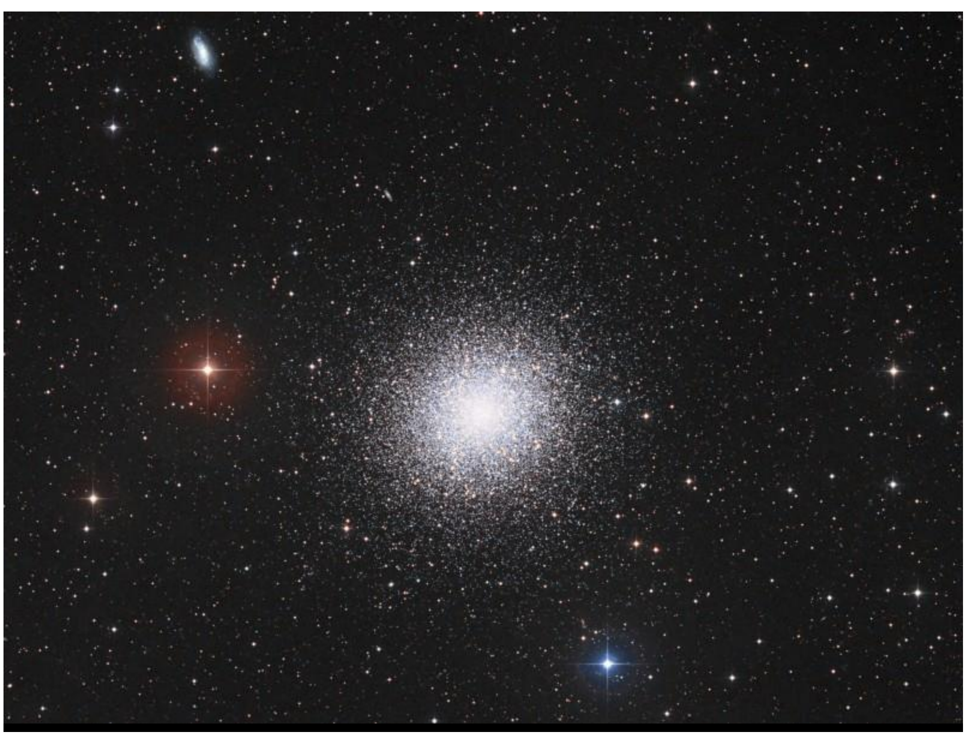
- **Other consellations can only be seen during certain times of the year because of Earth's changing position in its orbit.**
- **Orion is a constellation we can only see during the winter.**
- **The most familiar constellations are the 12 signs of the zodiac.**


Sagittarius
Capricorn
Scorpio
Aquarius
Libra
September
May
Pisces
Earth's
Orbit
Sun
Virgo
Aries
January
Leo
Ecliptic
Taurus
Cancer
Gemini

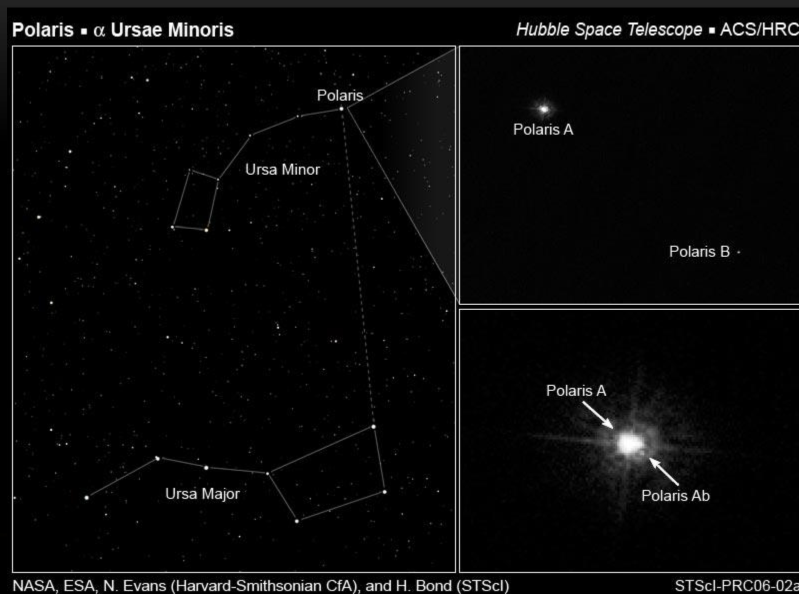


GROUPS OF STARS

- **Star clusters** are groups of stars that are gravitationally bound to one another.
- **The Pleiades is an open group cluster.**
- **M13 is a globular cluster.**



POLARIS: THE NORTH STAR

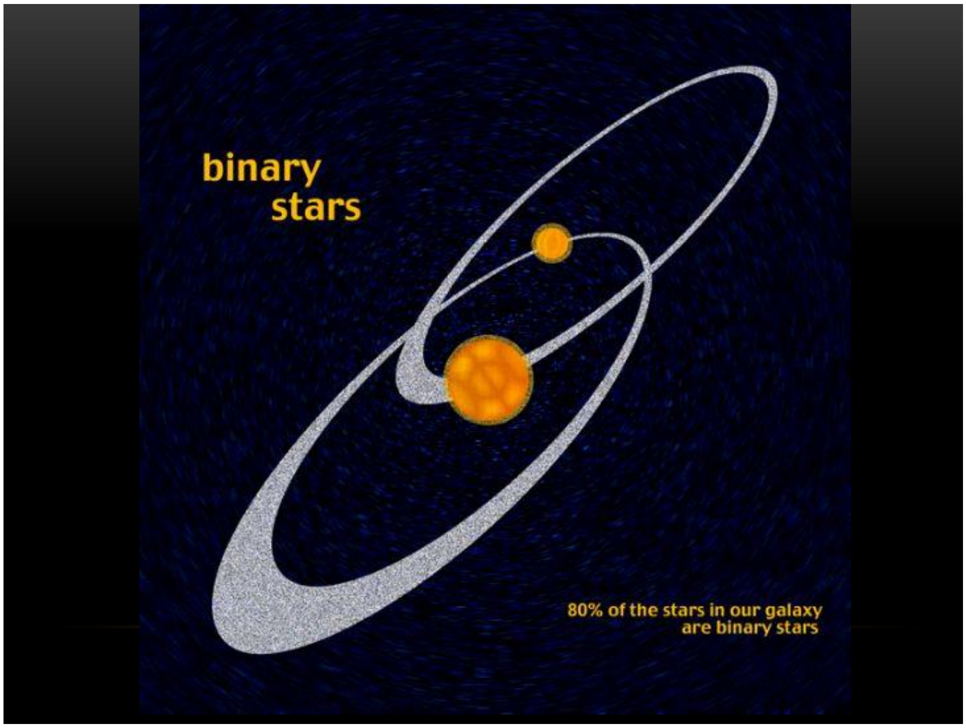


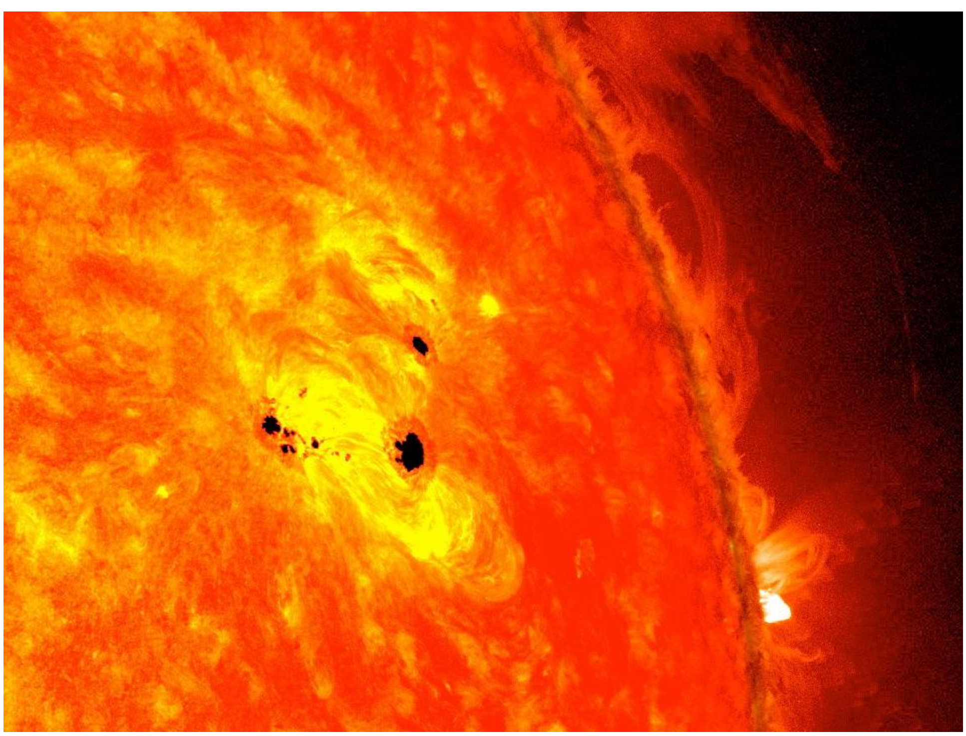
SIRIUS: THE DOG STAR

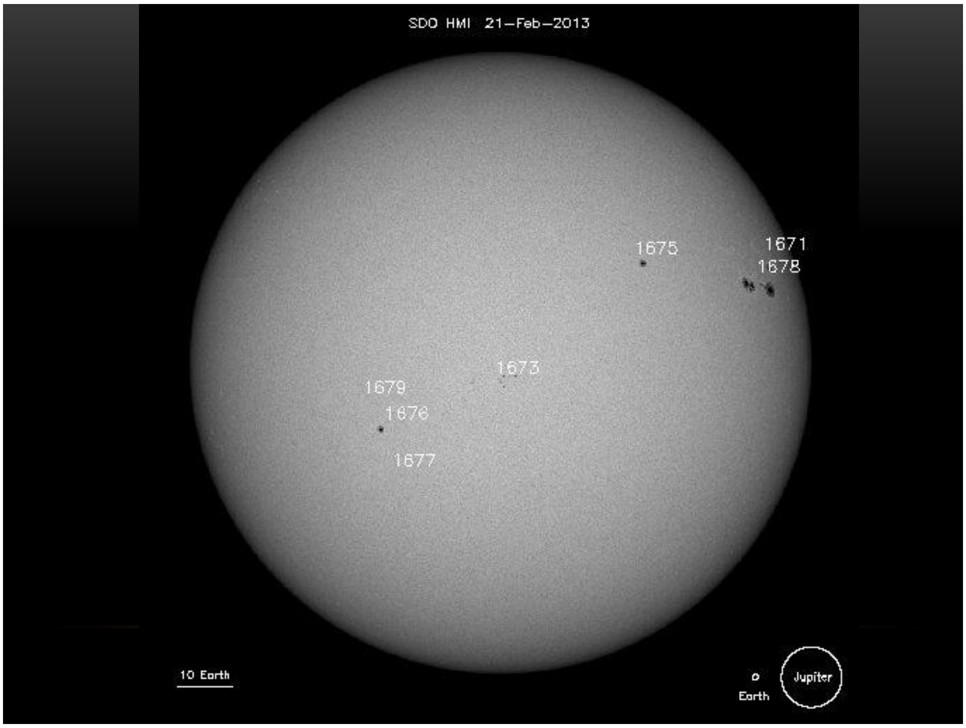
TONIGHTS SKY:
JUPITER AND THE SEVEN SISTERS

GROUPS OF STARS

- **When only two stars are gravitationally bound together in orbit, they are called binary stars.**
- **More than half of the stars in the sky are either binary stars or members of multiple star systems.**


binary
stars
80% of the stars in our galaxy
are binary stars





STAR CLASSIFICATION

- Most stars are currently classified using the letters O, B, A, F, G, K, and M, with the O class stars being the hottest and the M class stars being the coolest.

STAR CLASSIFICATION

- **Stars are then subdivided from with numbers from 0-9 within the spectral category.**
- **Ex: O1, 05, A9, G7, M1**
- **The sun is a type G2 star with a surface temperature of 5800K**

STAR CLASSIFICATION

- Temperatures range from 50,000 K for type O stars to as low as 2000 K for type M stars.

STAR CLASSIFICATION

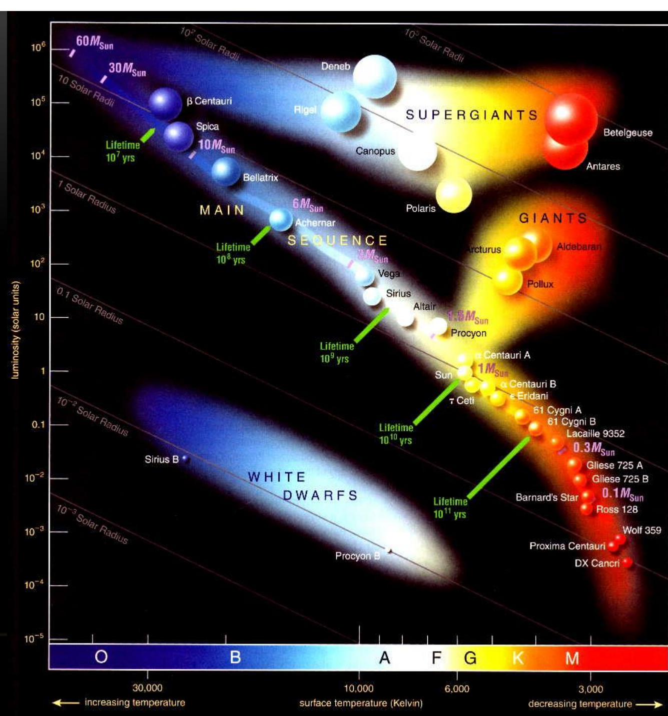
- Useful mnemonic device for remembering the spectral type letters:
  "Oh Boy An F Grade Kills Me".

STAR CLASSIFICATION

- All stars have nearly identical compositions despite the differences in their spectra.
- Typically, a star is 70% H, 25% He, and 2% other elements

H-R DIAGRAMS

- A Hertzberg-Russell diagram demonstrates how the properties of mass, luminosity, temperature, and diameter of a star are related.

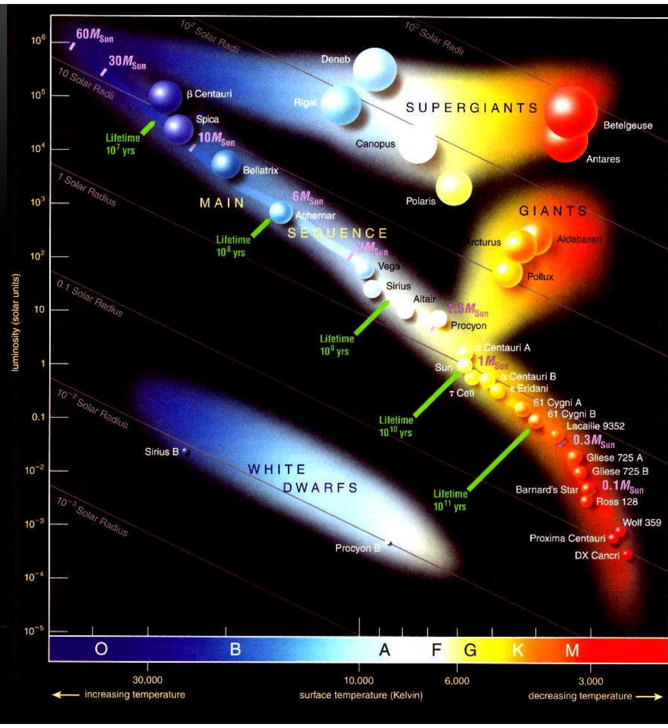


MAIN SEQUENCE STARS

- Most stars occupy the region in the diagram called the main sequence, which runs diagonally from the upper left corner to the lower right corner.

MAIN SEQUENCE STARS

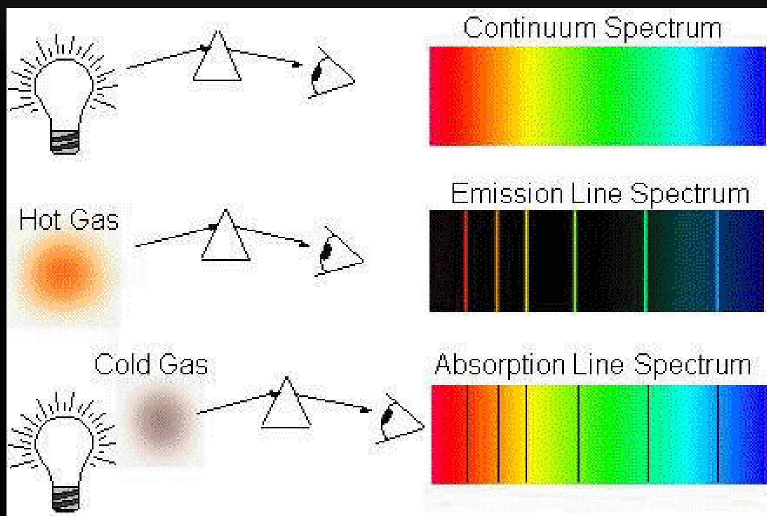
- 90% of stars, including the Sun, fall within the main sequence.
- Main sequence stars are stable and fuse hydrogen in their core.



MAIN SEQUENCE STARS

- About 90 percent of stars, including the sun, fall along the main sequence.
- The sun lies near the center of the sequence, being of average temperature and luminosity.

ABSORPTION AND EMISSION LINES



SPECTRA

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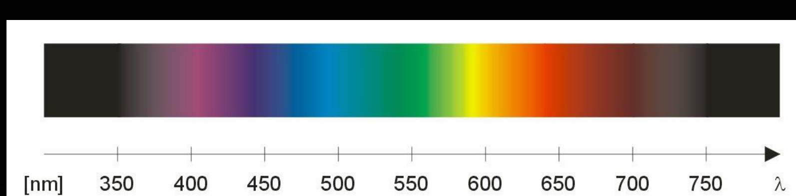

SPECTRA

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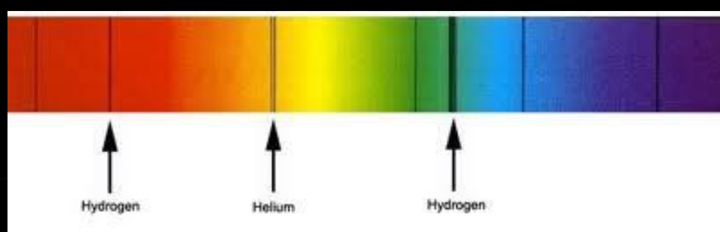
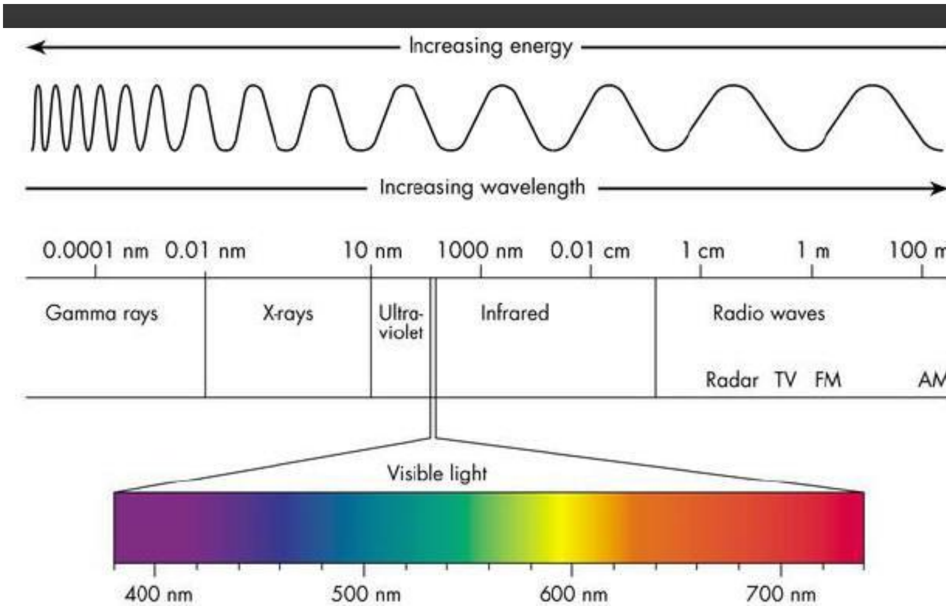


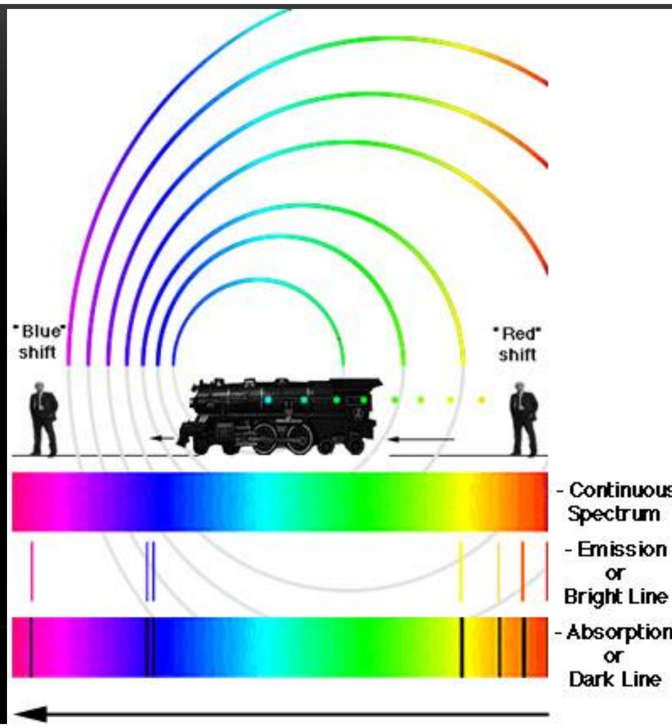
DOPPLER SHIFT

- **The Doppler effect is used in astronomy to tell whether a star or other object is moving towards us or away from us, as well as the direction of rotation.**
- **The Doppler effect also works the same way with sound.**

THE DOPPLER EFFECT

- **When a star moves toward the observer, the light emitted by the star shifts toward the blue end of the spectrum.**
- **When a star moves away from the observer, the light shifts towards red.**





SELLAR POSITIONS AND DISTANCES

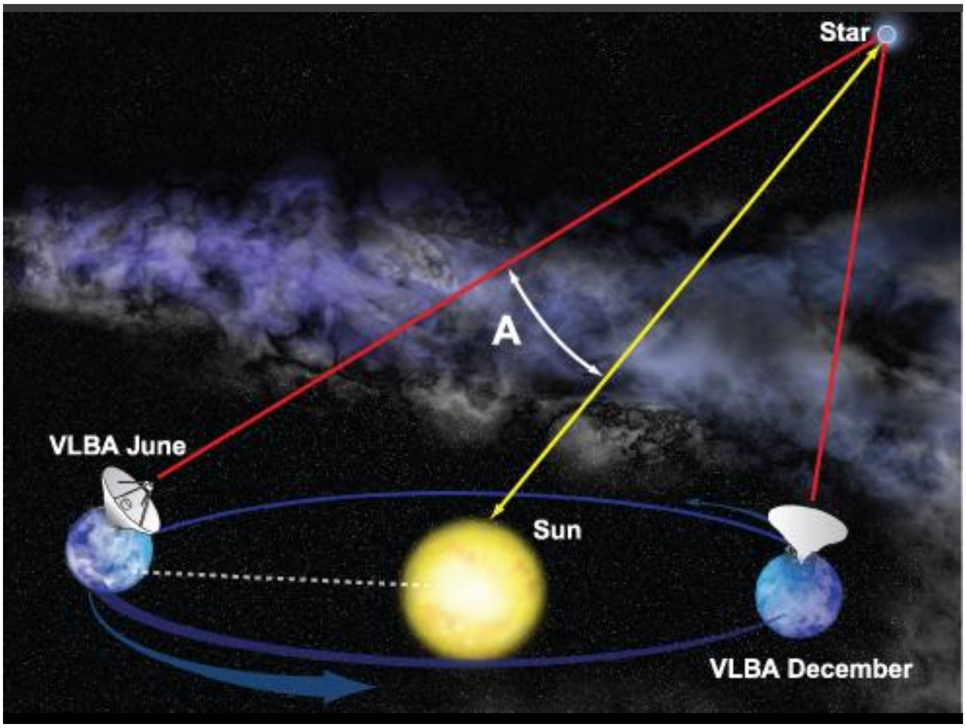
- **Astronomers use two units to measure long distances.**
- **The light-year (ly): the distance light travels in one year (9.461×10^{12} km)**
- **A parsec (pc) = 3.26 ly**

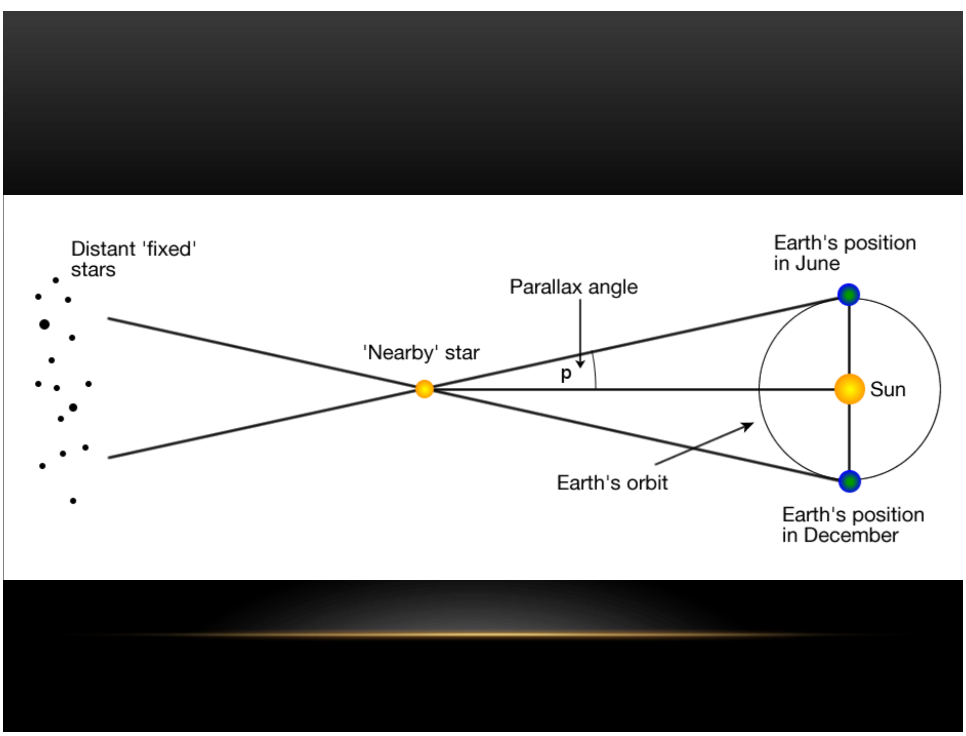
PARALLAX

- **Precise position measurements are important for measuring distance to stars.**
- **Nearby stars shift in position when observed at different times in Earths orbit..**

PARALLAX

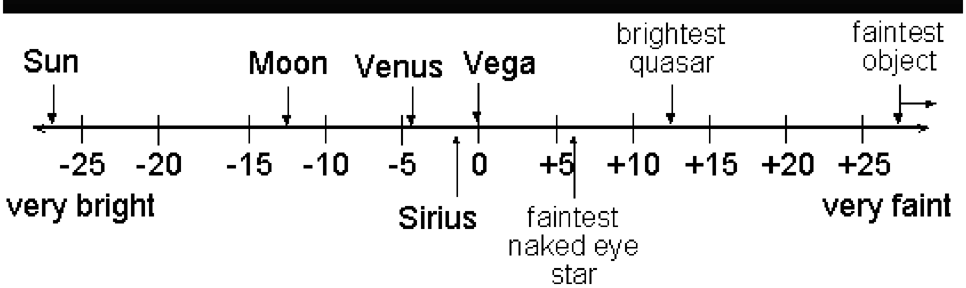
- **This apparent shift in position caused by the motion of the observer is called parallax**


Star
A
VLBA June
Sun
VLBA December


Distant 'fixed' stars
Earth's position in June
Parallax angle
'Nearby' star
p
Sun
Earth's orbit
Earth's position in December

BASIC STAR PROPERTIES

- **One of the most basic observable properties of a star is how bright it appears, or apparent magnitude.**
- **The ancient Greeks established a classification system based on star brightness which we still use today.**



Apparent brightnesses of some objects in the magnitude system

BASIC STAR PROPERTIES

- Apparent magnitude does not indicate actual brightness of a star because it does not account for distance.
- **Absolute magnitude** is how bright a star would appear if it were placed at a distance of 10 pc

BASIC STAR PROPERTIES

- **Luminosity** is a measurement of the energy a star puts out per unit of time.
- Luminosity is measured in units of energy emitted per second.

(Watts)

STELLAR SPECTRAL LINES

- Types of Spectra

Continuous - No spectral lines

Absorption - Dark lines superimposed on continuous spectrum

Emission - Isolated bright lines

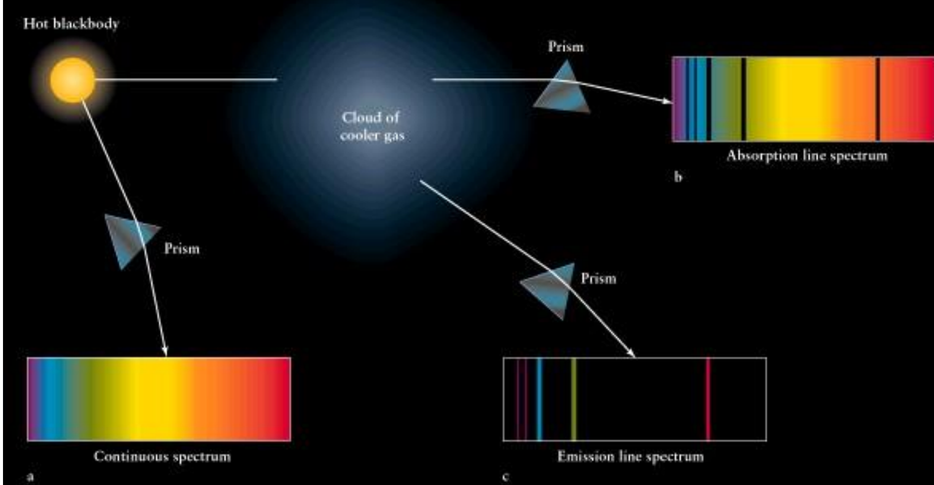
STELLAR SPECTRAL LINES

- **Kirchoff's Laws**

1. **An opaque object emits a continuous spectrum.**

2. **An opaque object viewed through a cooler gas will produce an absorption spectrum.**

3. **A gas viewed against an empty background produces an emission spectrum**

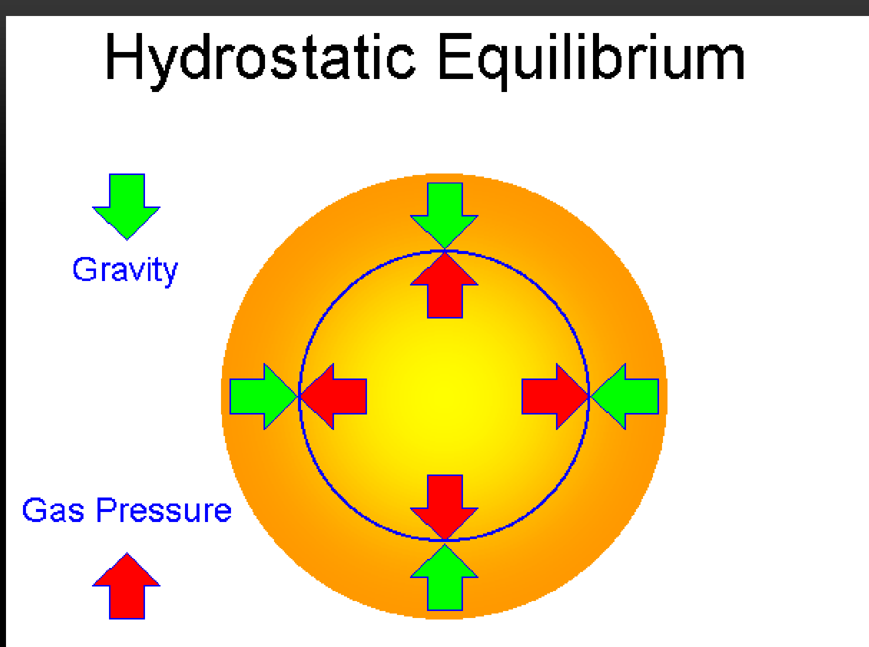


STELLAR EVOLUTION

- **Mass** determines a star's temperature, luminosity, and diameter.
- Mass and composition alone determine almost all of a star's properties

STELLAR EVOLUTION

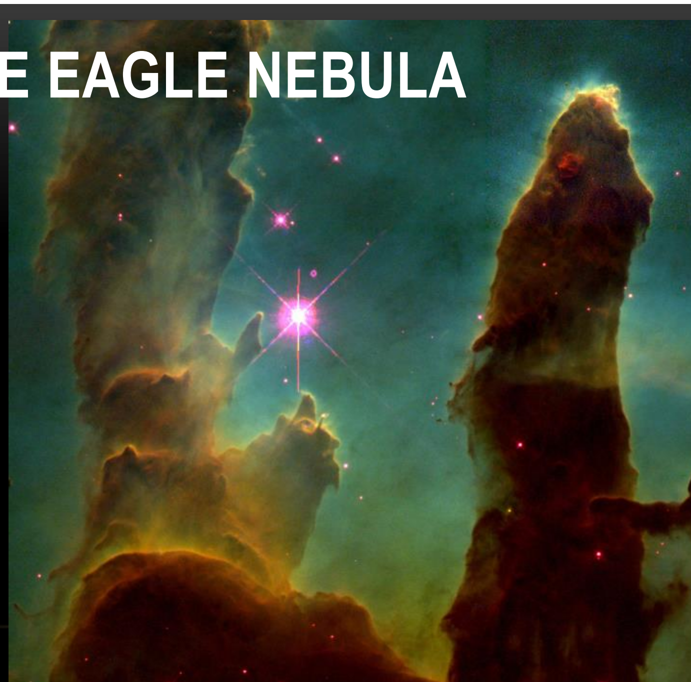
- The more massive a star is, the greater the gravity pressing inward, and the hotter and more dense the star must be to balance its own gravity.
- Hydrostatic equilibrium



STAR FORMATION

- All stars form in much the same way as our Sun.
- The formation of a star begins with a cloud of interstellar dust and gas called a nebula.

THE EAGLE NEBULA



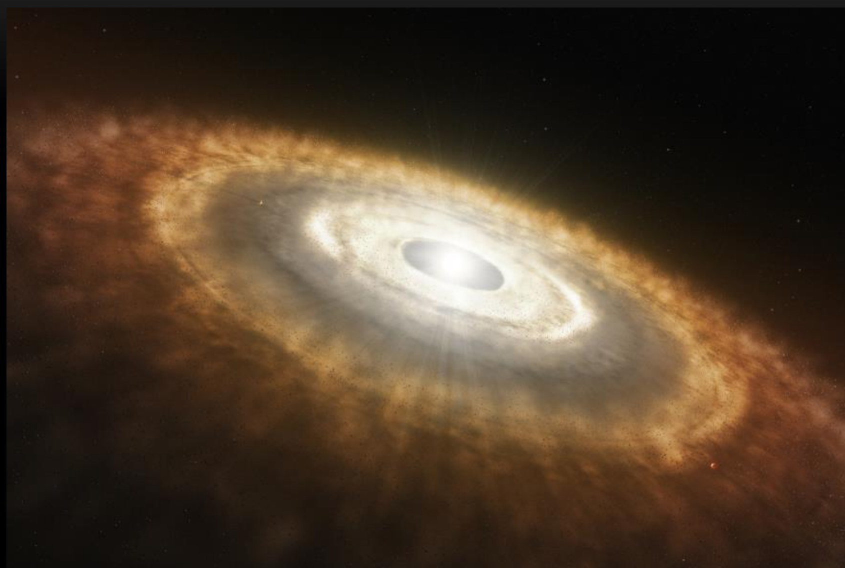
STAR FORMATION

- As this cloud contracts by its own gravity, its rotation forces it into a disk shape with a hot, condensed object at the center, called a protostar

STAR FORMATION

- Once ignition temperature is reached, nuclear reactions take place and the object becomes a new star.

PROTOSTAR



PROTOSTAR

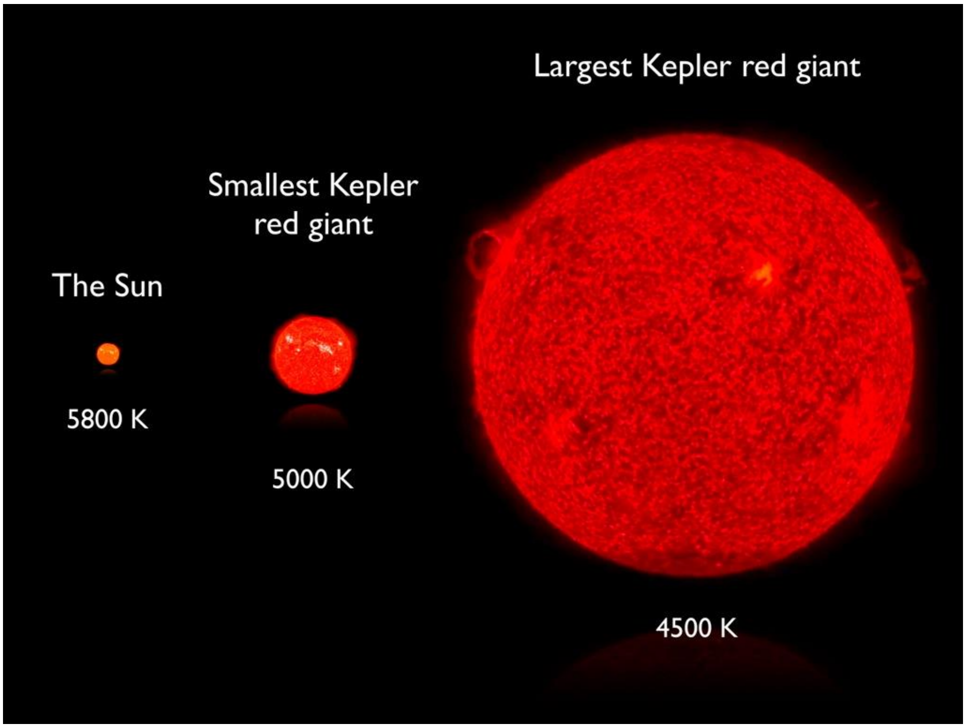
STAR FORMATION

- The first reaction to ignite once nuclear fusion begins is the conversion of hydrogen into helium

$$H + H \rightarrow He$$

LIFE CYCLE OF A STAR

- It takes about 10 billion years for a star with the mass of the sun to convert all of the hydrogen in its core into helium.
- From here the next step in its life cycle is to become a red giant.



LIFE CYCLE OF A STAR

- Helium is converted into carbon in the central region of a red giant.
- Hydrogen still fuses into helium in a thin shell which forces the outer layers of the star to expand and cool.

LIFE CYCLE OF A STAR

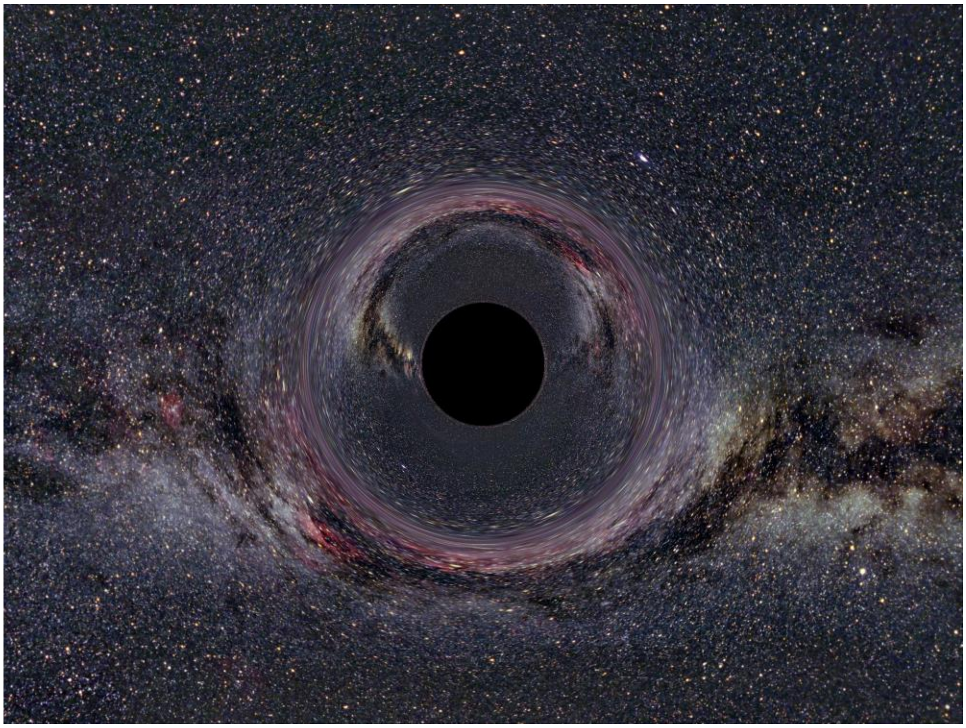
- After all the helium in the core is depleted, the red giant is left with a core made of carbon.
- All of the layers of gas are expelled away in a planetary nebula and a core of carbon is left behind (white dwarf)

LIFE CYCLE OF A STAR

- Supergiants are massive stars 8-20 times larger than our Sun.
- Many elements are formed in supergiant stars by fusion reactions, the heaviest of which is Iron.

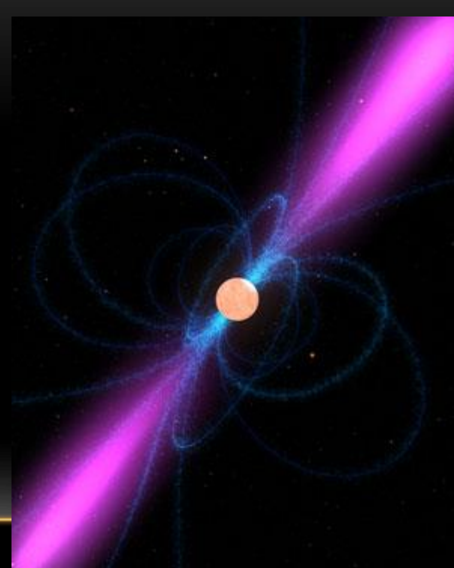
LIFE CYCLE OF A STAR

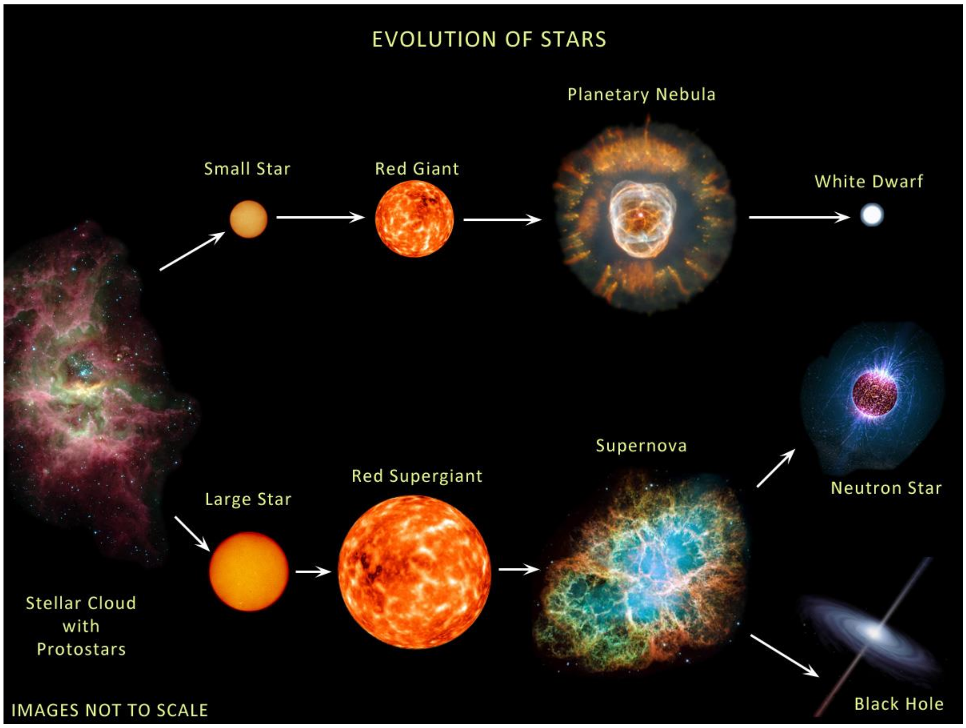
- Such massive stars are too large to be supported by electron pressure.
- They come to a very violent end forming a neutron star after a supernova, or collapsing to form a black hole.



LIFE CYCLE OF A STAR

- A pulsar is a neutron star which emits intense radiation on its poles and rotates several times per second.




EVOLUTION OF STARS
Planetary Nebula
Small Star
Red Giant
White Dwarf
Supernova
Neutron Star
Red Supergiant
Large Star
Stellar Cloud
with
Protostars
IMAGES NOT TO SCALE
Black Hole