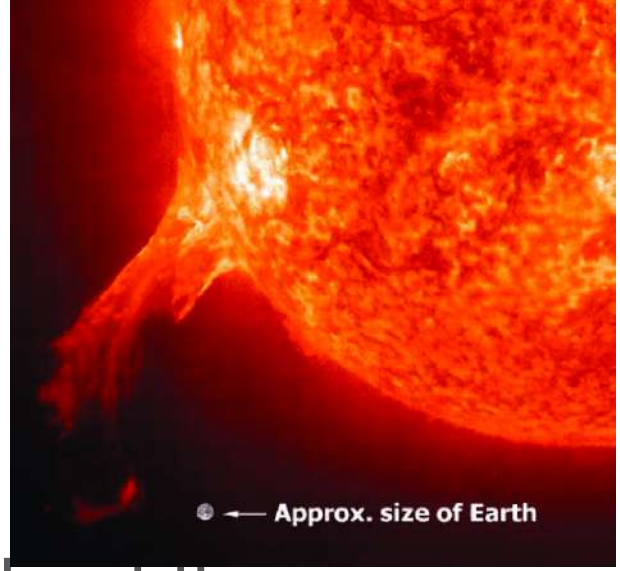
Physics Honors: Our Sun and Solar Life Cycles

Introduction to the Sun

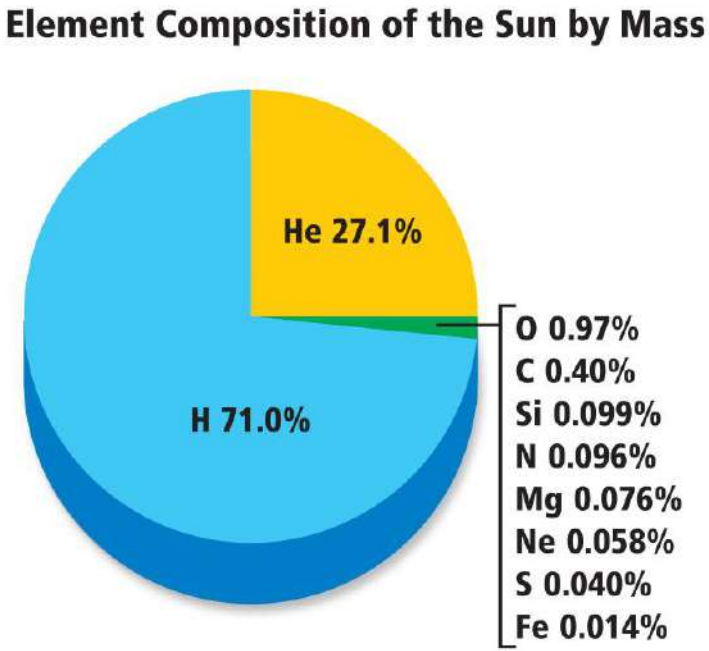
- It would take 109 Earth's lined up to fit across the sun

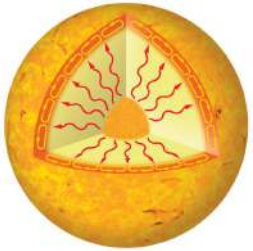


- The Sun's average density is about the same as that of the gas giant planets

The Sun's Composition

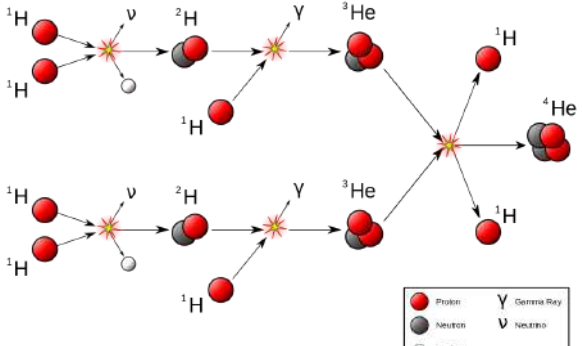
- The Sun is 71% hydrogen
- Helium is 27.1 % of the mass
- A small amount of other elements





Fusion

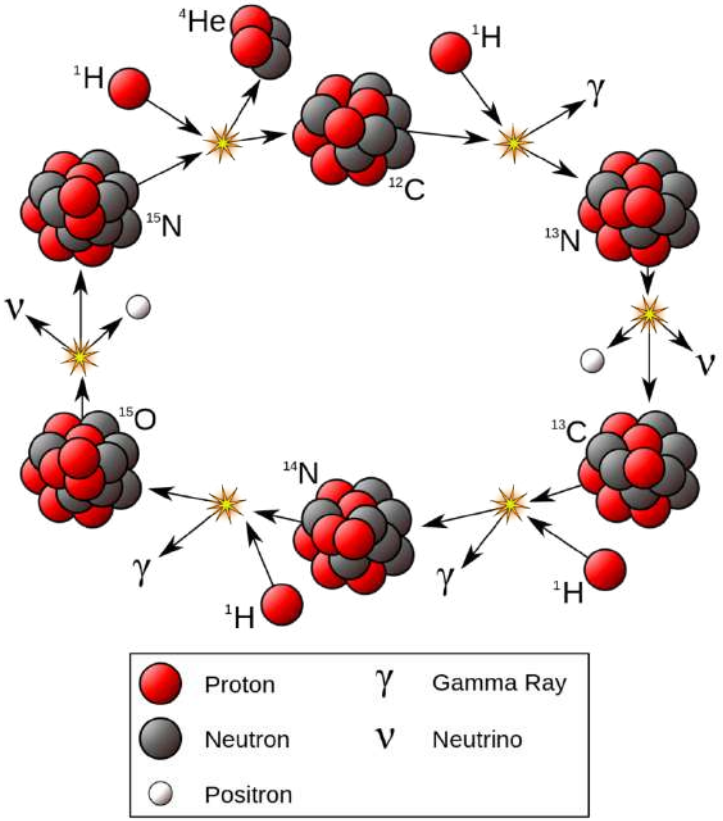
- In order for an object to be a star, it must be fusing hydrogen into helium.
- Fusion combines smaller particles into heavier ones. The process gives off gamma rays, which eventually escape the sun as light rays



Fusion

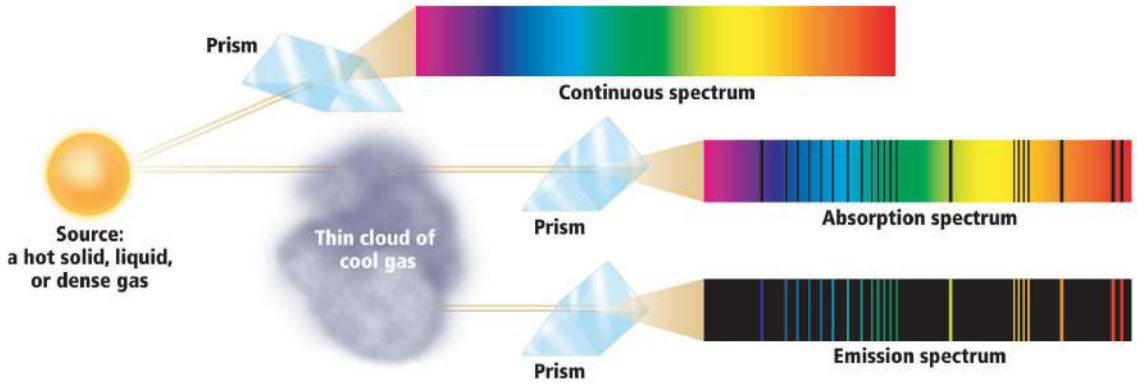
- Once all the hydrogen in a star has fused, it will start to fuse together heavier elements.

- Stars begin their death cycles when they run out of elements to fuse



How do we know what a star is fusing?

We are able to determine what elements are in a star using spectra



The Basic Properties of Stars

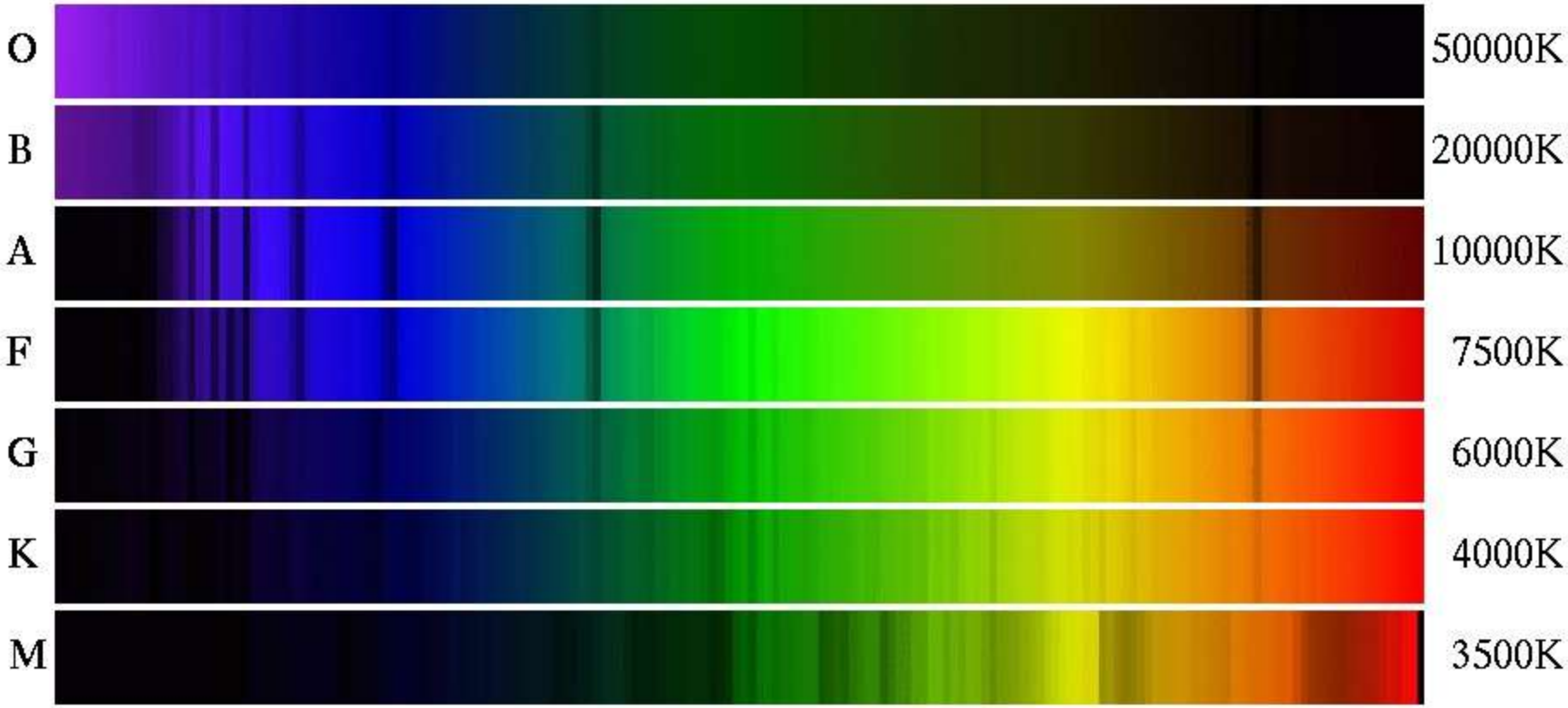
- We categorize different types of stars based on these properties:
  - **Mass**
  - **Diameter**
  - **Luminosity**
  - **Temperature**

Stars are classified by Temperature and Brightness/Color

Spectral Type	Color	Temperature (K)*	Spectral Features
O		28,000-50,000	Ionized helium,especially helium
B		10,000-28,000	Helium, some hydrogen
A		7,500-10,000	Strong hydrogen, some ionized metals**
F		6,000-7,500	Hydrogen and ionized metals such as calcium and iron
G		5,000-6,000	Both metals and ionized metals, especially ionized calcium
K		3,500-5,000	Metals
M		2,500-3,500	Strong titanium oxide and some calcium

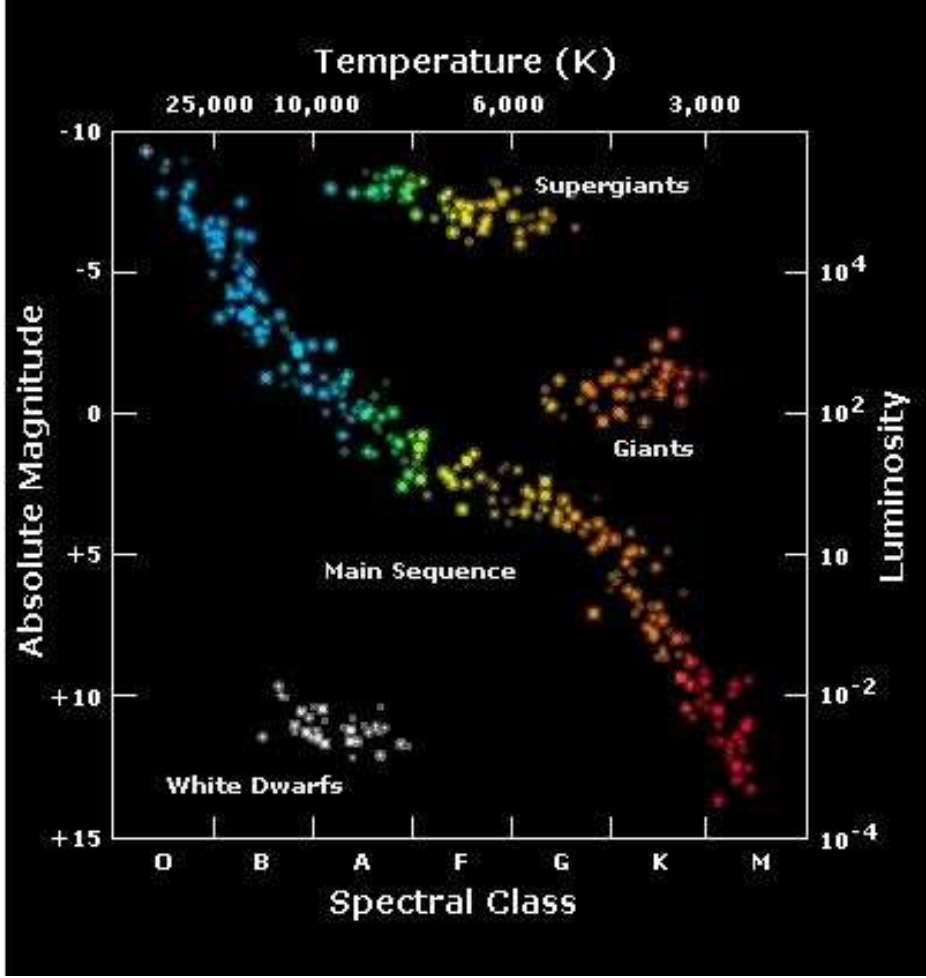
* To convert approximately to Fahrenheit, multiply by 9/5.

** Astronomers regard elements heavier than helium as metals.

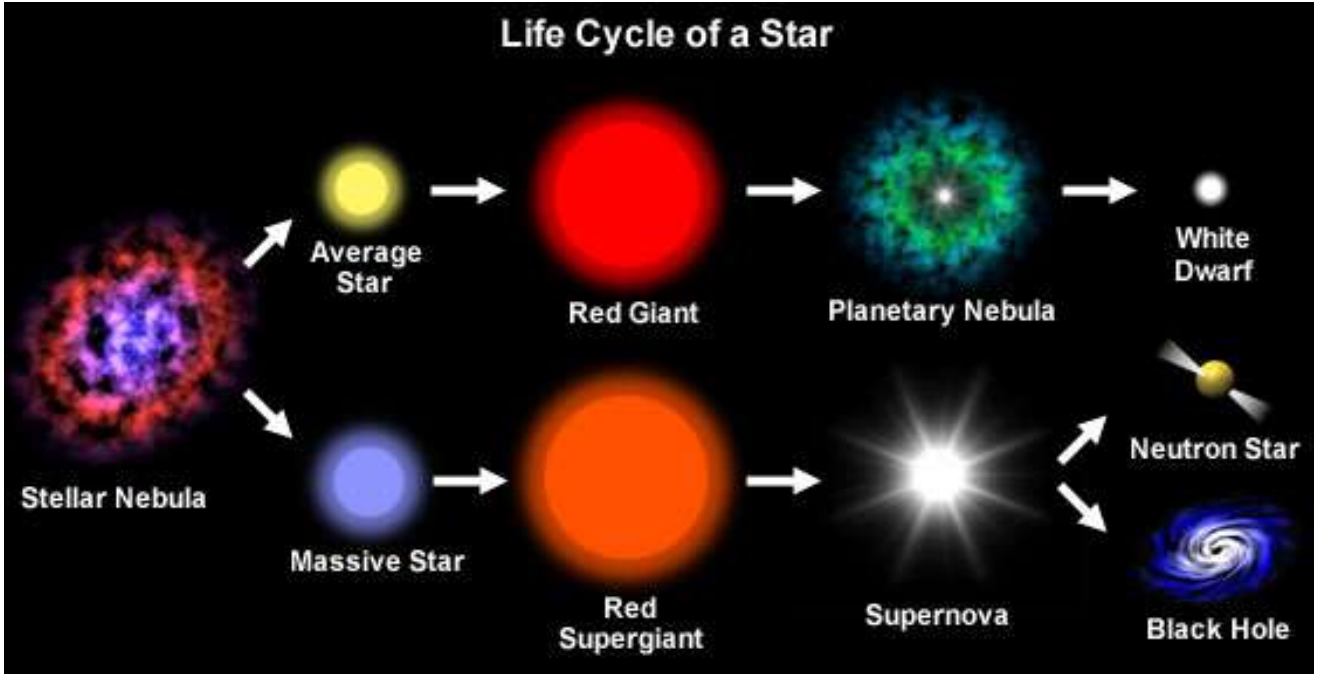

O
50000K
B
20000K
A
10000K
F
7500K
G
6000K
K
4000K
M
3500K

HR Diagram

- The Hertzsprung Russell (HR) Diagram relates the different colors of stars to their temperature and spectral class.
- It is also used to show the life cycle of stars



Life Cycles of Stars



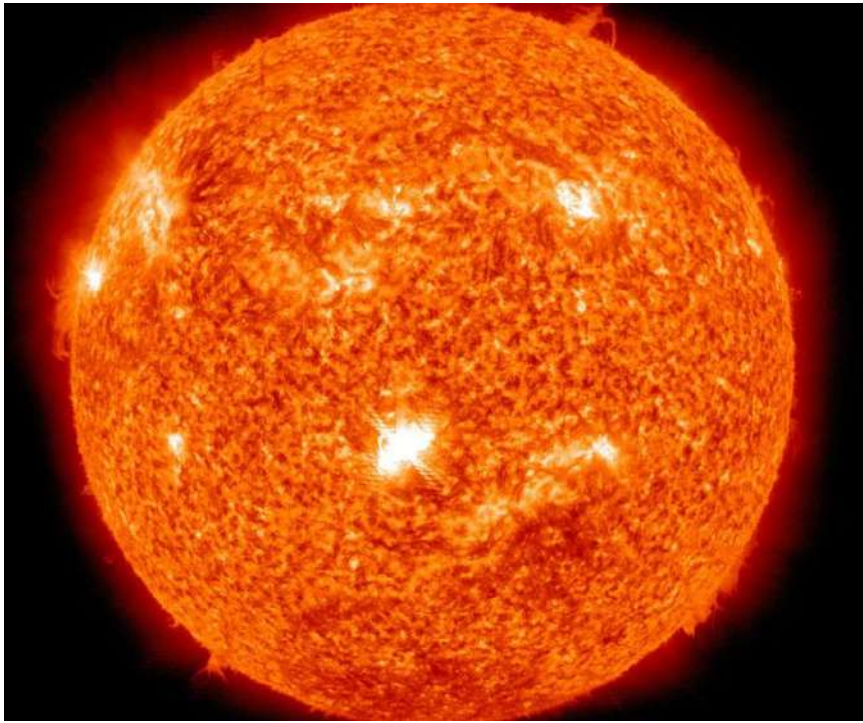
Stellar Nebula

- Mostly made of Hydrogen gas
- Will start to collapse because of gravity
- Once there is enough pressure, it will begin to fuse

Fusion

- A star will spend the majority of its life on the main sequence, fusing hydrogen into helium.

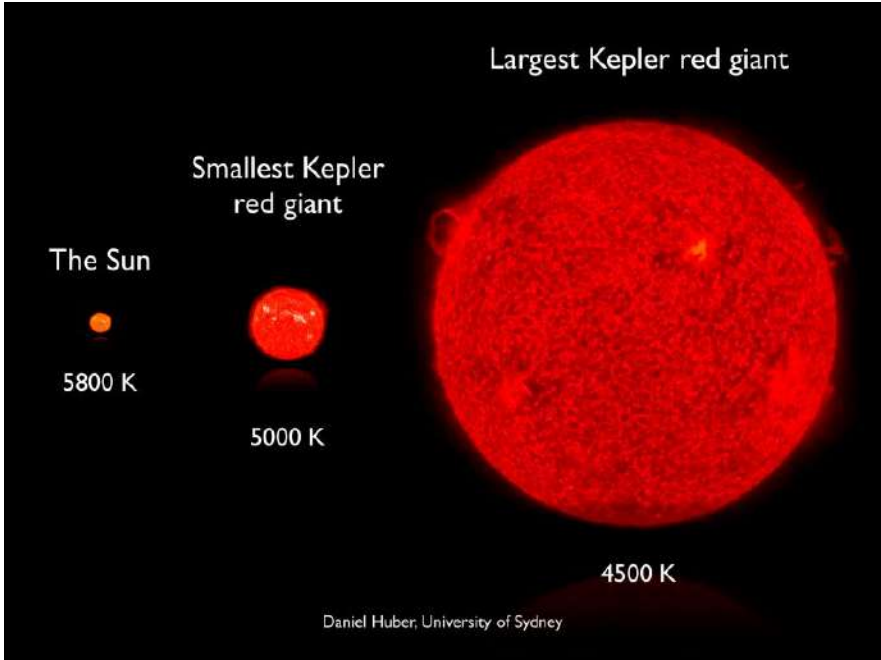
- This is the stage our star is in now, and will be for another about 4 billion years



Red Giant Stage

- Occurs when the hydrogen runs out, and helium fusion begins

- When our sun enters this phase, it will be big enough that it will encompass Earth’s orbit

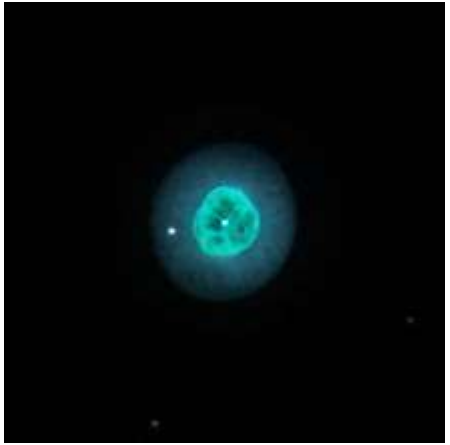


Planetary Nebula

As red giants run out of helium to burn, they start to collapse

During their collapse process, they give off a large amount of ionized gas.

This gas is referred to a planetary nebula (even though it has nothing to do with planets!



White Dwarfs

A white dwarf is the leftover core of a star. It is no longer fusing, so it only has residual heat.

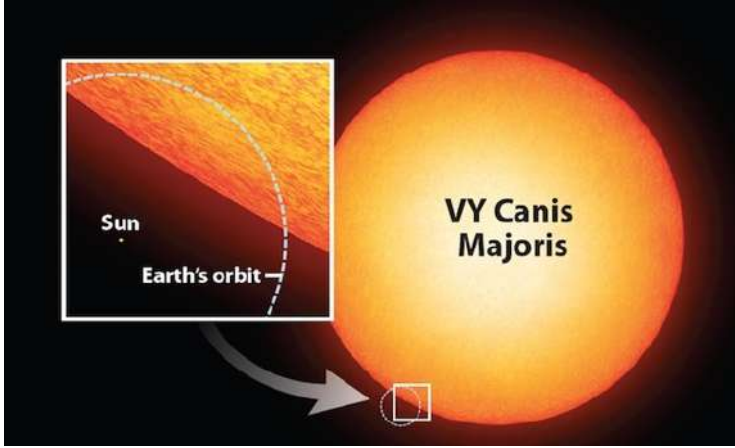
As it gives thar heat off, it will slowly get dimmer until it is just a ball of carbon and oxygen floating in space

Red Supergiants

- Stars that are much bigger than our sun (8 to 40 times bigger) go through a red supergiant phase

- Red giants get hot enough to burn carbon

- Betelgeuse is a red giant- and it’s been dimming since 2019. If we are lucky, we might get to see it supernova in our lifetime



Supernovas

When giant stars leave the red supergiant stage, they collapse in on themselves because the outward pressure of fusion can no longer support against the inward pull of gravity

Once there is no more room for it to shrink inward, it rebounds and explodes outward bowing off all the outer layers

Neutron Stars

When the supernova rebounds, there is often a section left behind called a neutron star.

Neutron stars are composed of densely packed neutrons. While they weigh more than the sun, they are smaller across than most cities

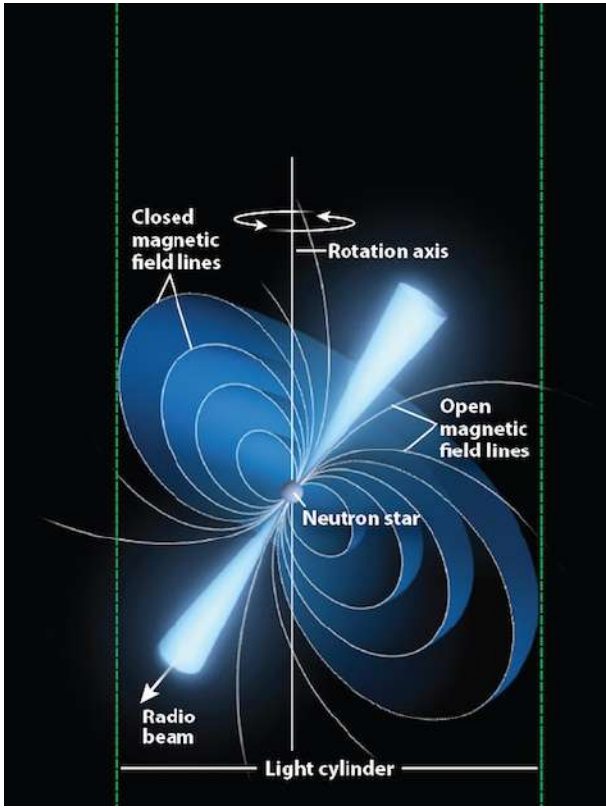
A thimble of neutron star would weigh as much as Mt Everest.

Pulsars

Pulsars are a type of Neutron star that emits radio waves from it’s poles.

If the pulsar is oriented correctly, it will look like a lighthouse that is periodically flashing emissions toward Earth.

The periods of rotations are so set for pulsars that some early astronomers thought they were alien transmissions

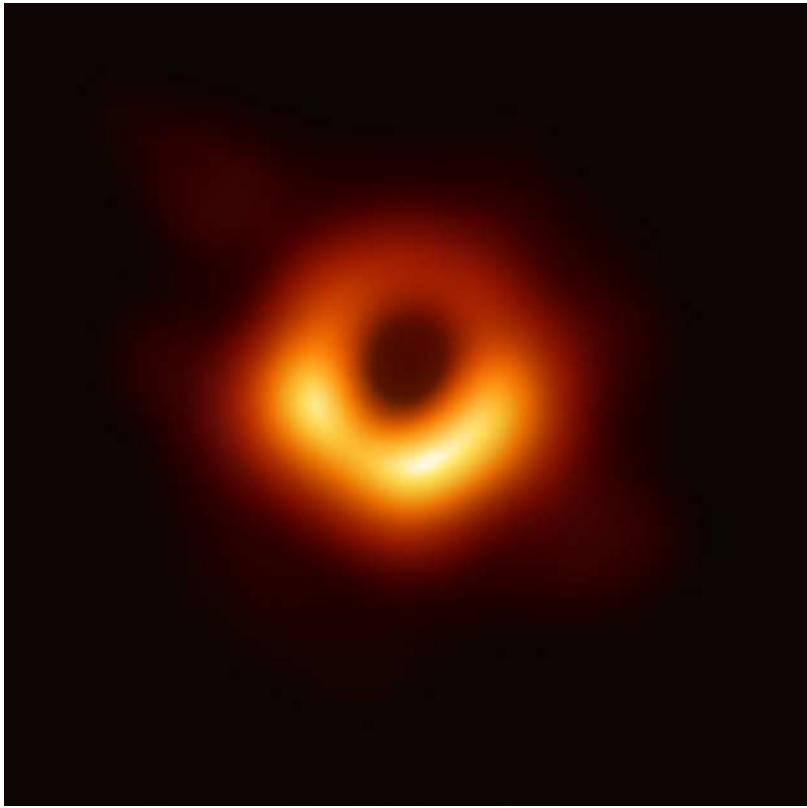


Black Holes

If a neutron star has more mass than about 3 solar masses, then it will collapse in on itself. As the density increases, it has so much gravity that not even light can escape.

This object is a black hole

If the mass of Earth was compressed to the density of a black hole, it would be the size of a grape

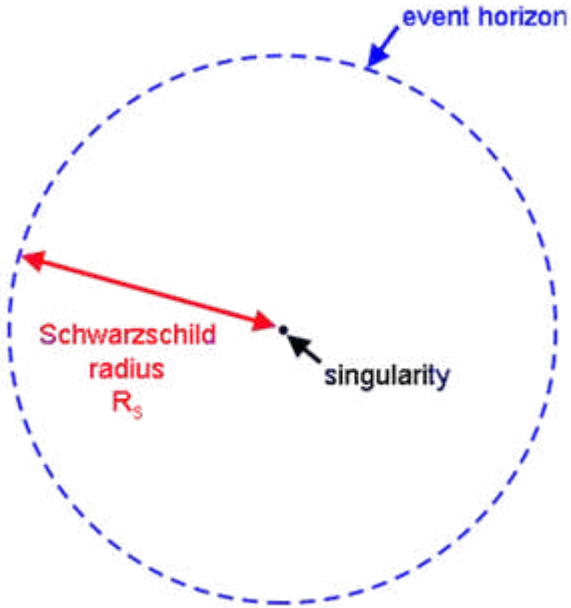


Black Hole Properties

The event horizon is the distance from which light can no longer escape. We generally think of the event horizon as the “surface” of the black hole

The Schwarzschild Radius is the distance from the singularity to the event horizon. This radius is determined by the mass of the black hole

The singularity is the center of the black hole. It is the single point that contains all of the mass



General Relativity and Black Holes