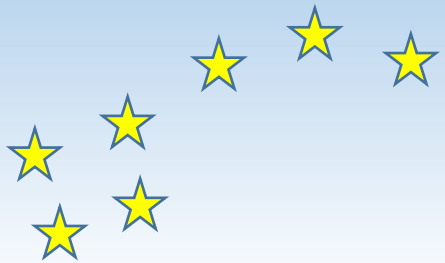


Stellar Lives

Physical Sciences

Broward College

Prepared for AST 1002

Horizons in Astronomy

Objectives

- Star’s Birth
- Star’s Lives
- Star’s Death

Interstellar Medium – Stellar Material

Figure 1. Eagle Nebula (Wiki)

Type	Factional Volume	Temperature (K)	Density
Molecular Cloud	< 1%	20 – 50	10^3 – 10^6
Cold Neutral	1% – 5%	50 – 100	1 – 10^3
Warm Neutral	10% - 20%	1000 – 5000	0.1 – 10
Warm Ionized	20% - 50%	1,000 – 10,000	0.01
H II	~10%	10,000	10^2 – 10^4
Hot Ionized	30% - 70%	1,000,000 – 10,000,000	10^{-4} – 10^{-2}

How are stars born?

Collapse

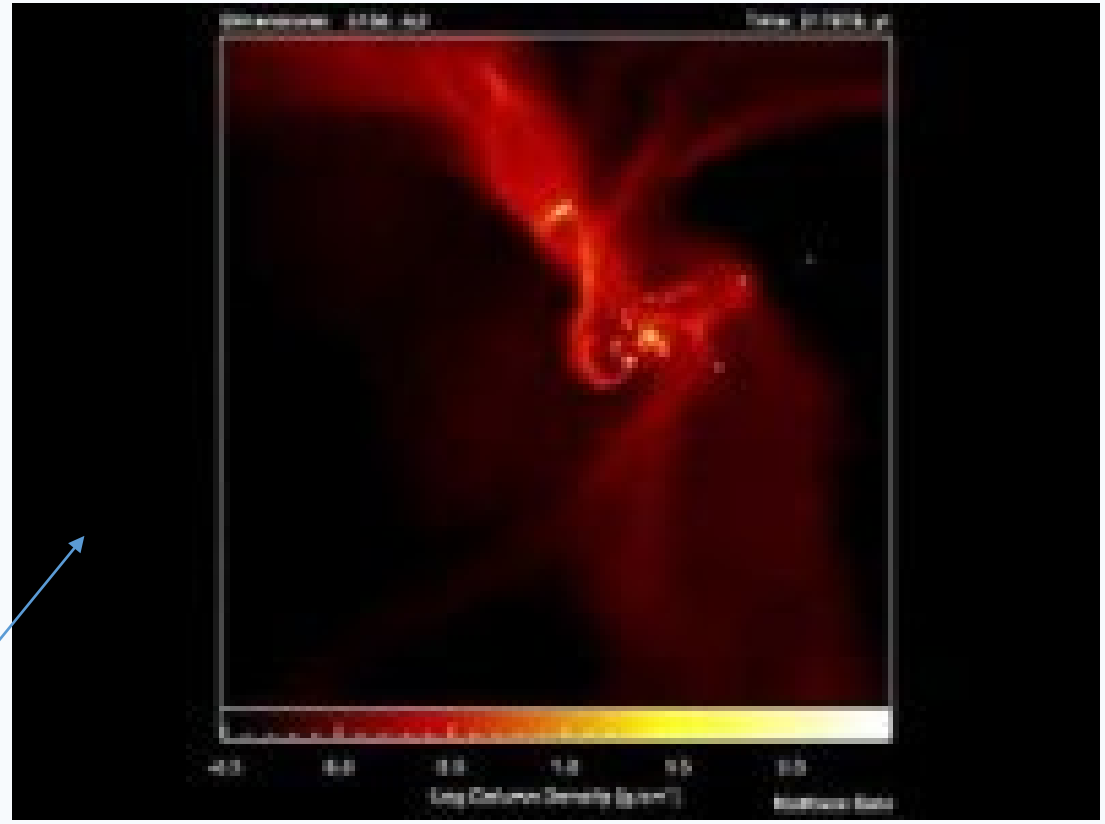
- Stars are born from interstellar medium. Disturbances from motion of the galaxy and other stars in the medium cause the initial collapse.

Core Formation

- Cores form from gravitational and external heating and they start to form clumps.

Protostar

- Protostars form from the clumps. Enough gravitational force causes fusion at the core.
- Click on the picture to see how stars form.



Protostars

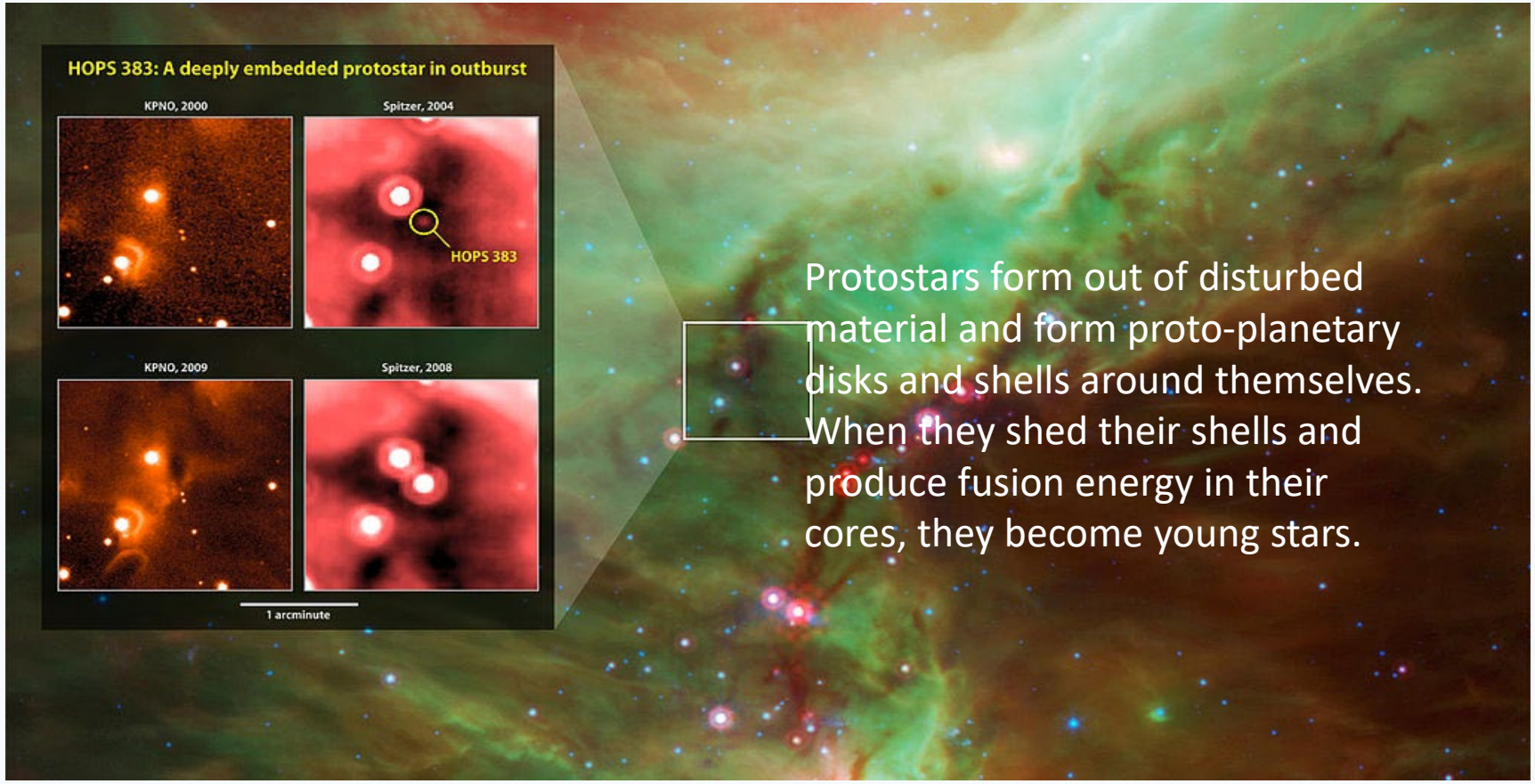


Figure 2. Protostars forming in a nebula (Wiki)

Young Stars - Brown Dwarf

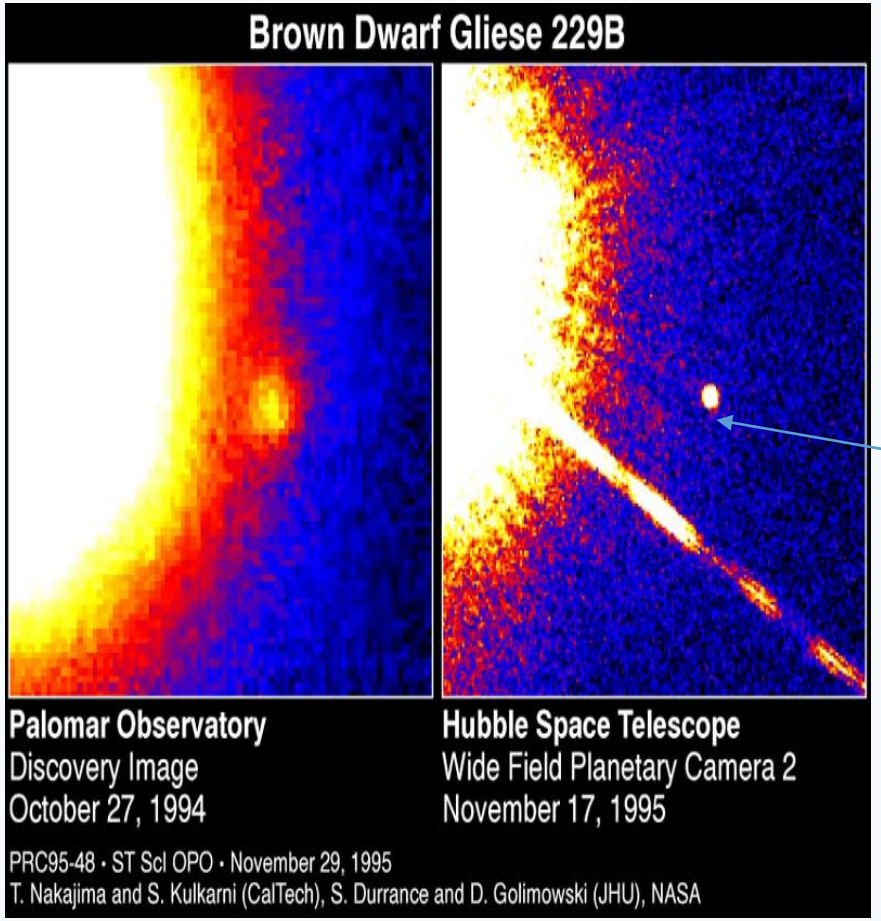


Figure 3. Brown Dwarf Gliese 229B (Wiki)

- Brown Dwarf Stars are young stars that have failed to create sustained fusion reactions.
- Their masses compare to the Jovian planets.

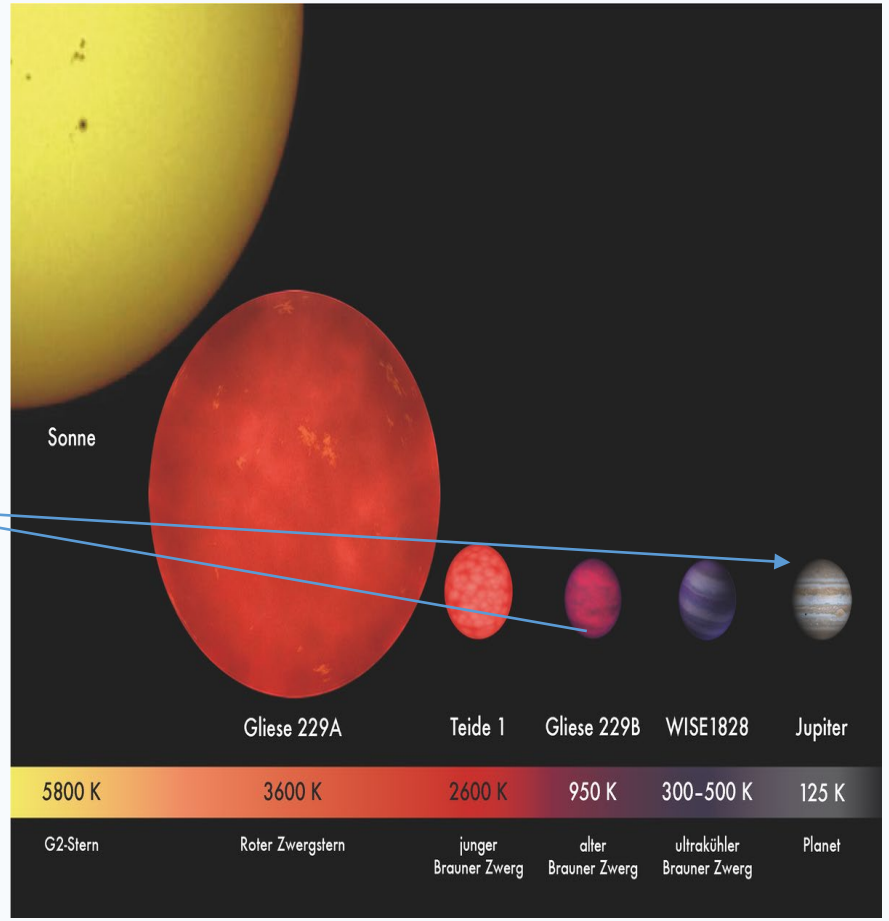


Figure 4. Brown Dwarf Comparison (Wiki)

Young Stars - Beta Pictoris

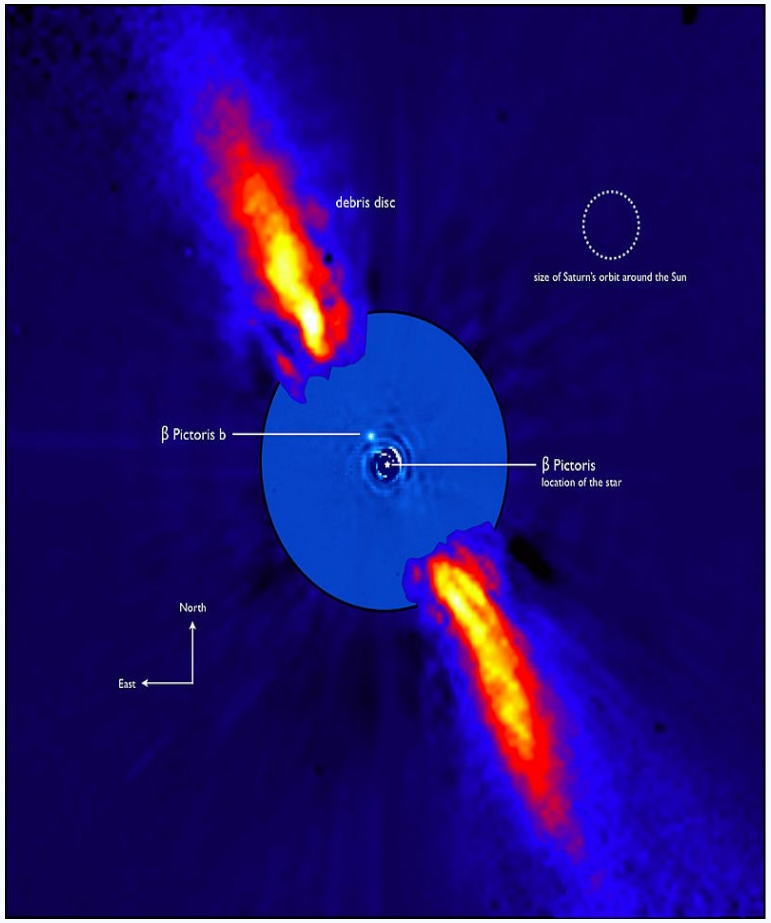


Figure 5. Beta Pictoris (Wiki)

- Beta Pictoris Stars are lower main sequence young stars.
- They start their life just above the lower main sequence.
- They take longer to settle into their main sequence lifetime because they have less mass.

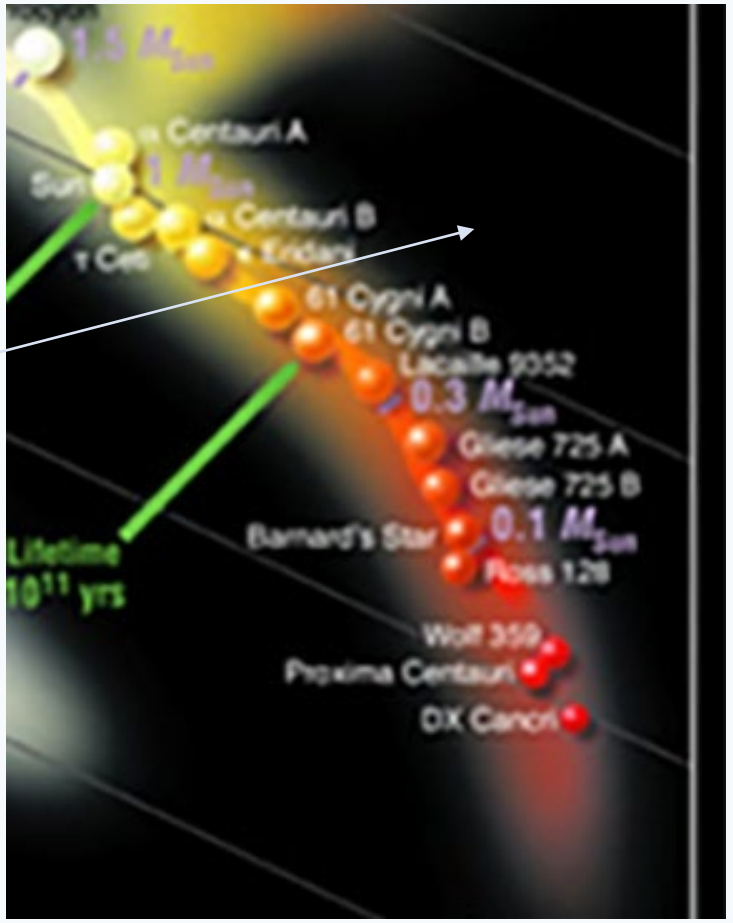


Figure 6. Theoretical H-R Diagram adapted to show Lower Main Sequence (Wiki)

Young Stars – T Tauri

Figure 7. T Tauri (Wiki)

- T Tauri Stars are upper main sequence young stars.
- They start their life just above the upper main sequence.
- T Tauri takes a short time to settle into the main sequence because they have high mass.

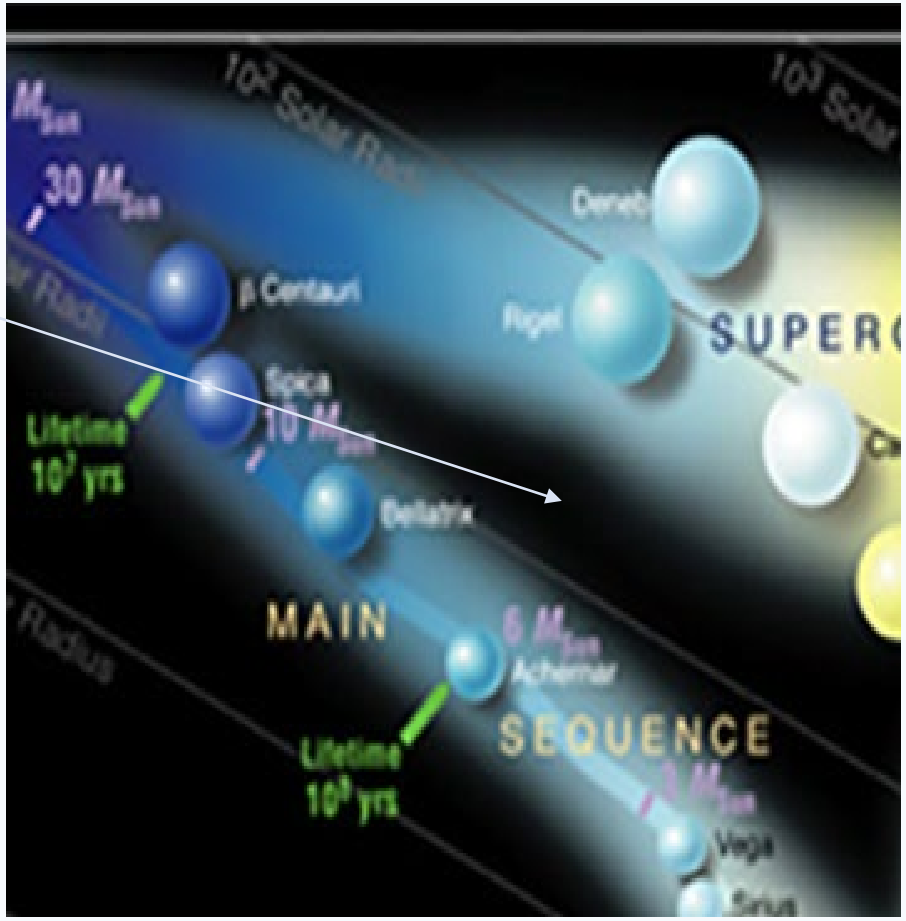


Figure 8. Theoretical H-R Diagram adapted to the upper main sequence (Wiki)

How do stars live/die?

- Protostar
- Nuclear Fusion
- Main Sequence
- Red Giant
  - Vertical Giant Branch (Mira Variables)
  - Horizontal Giant Branch (Cephied Variables)

Ages of the different spectral types.

Mass (solar masses)	Time (years)	Spectral type
60	3 million	O3
30	11 million	O7
10	32 million	B4
3	370 million	A5
1.5	3 billion	F5
1	10 billion	G2 (Sun)
0.1	1000s billions	M7

Figure 9. Ages of the different spectral types (Wiki)

Stellar Evolution

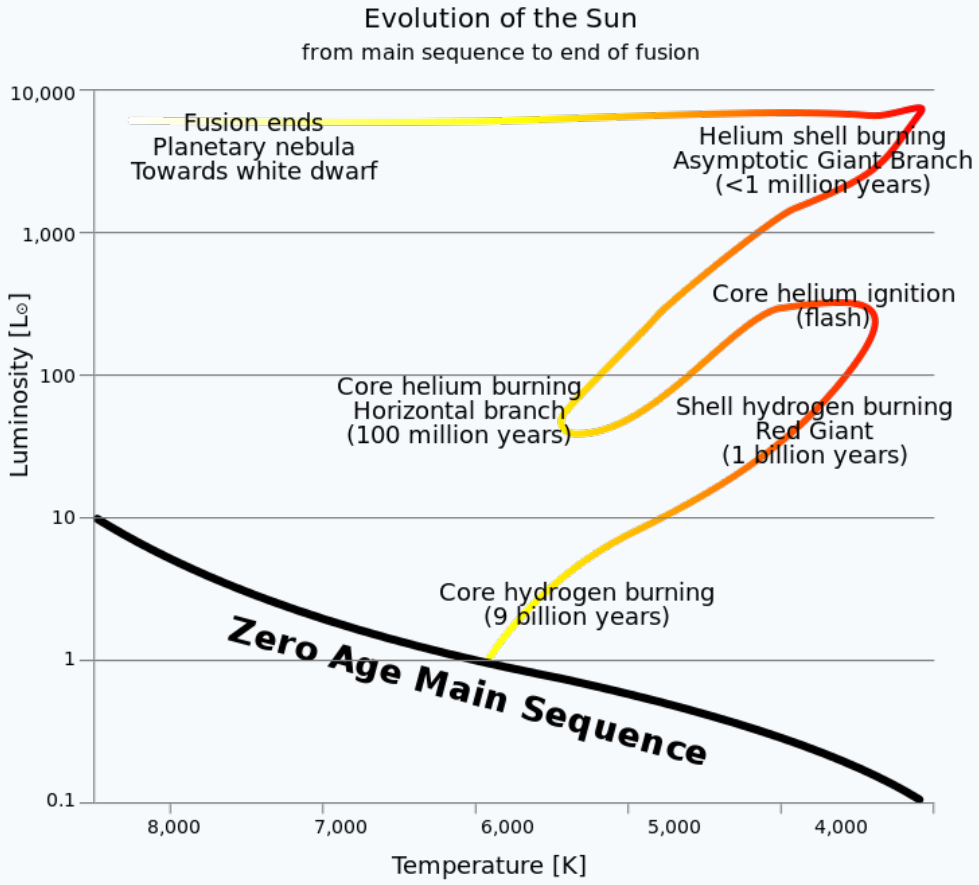


Figure 10. Evolution of the Sun (Wiki)

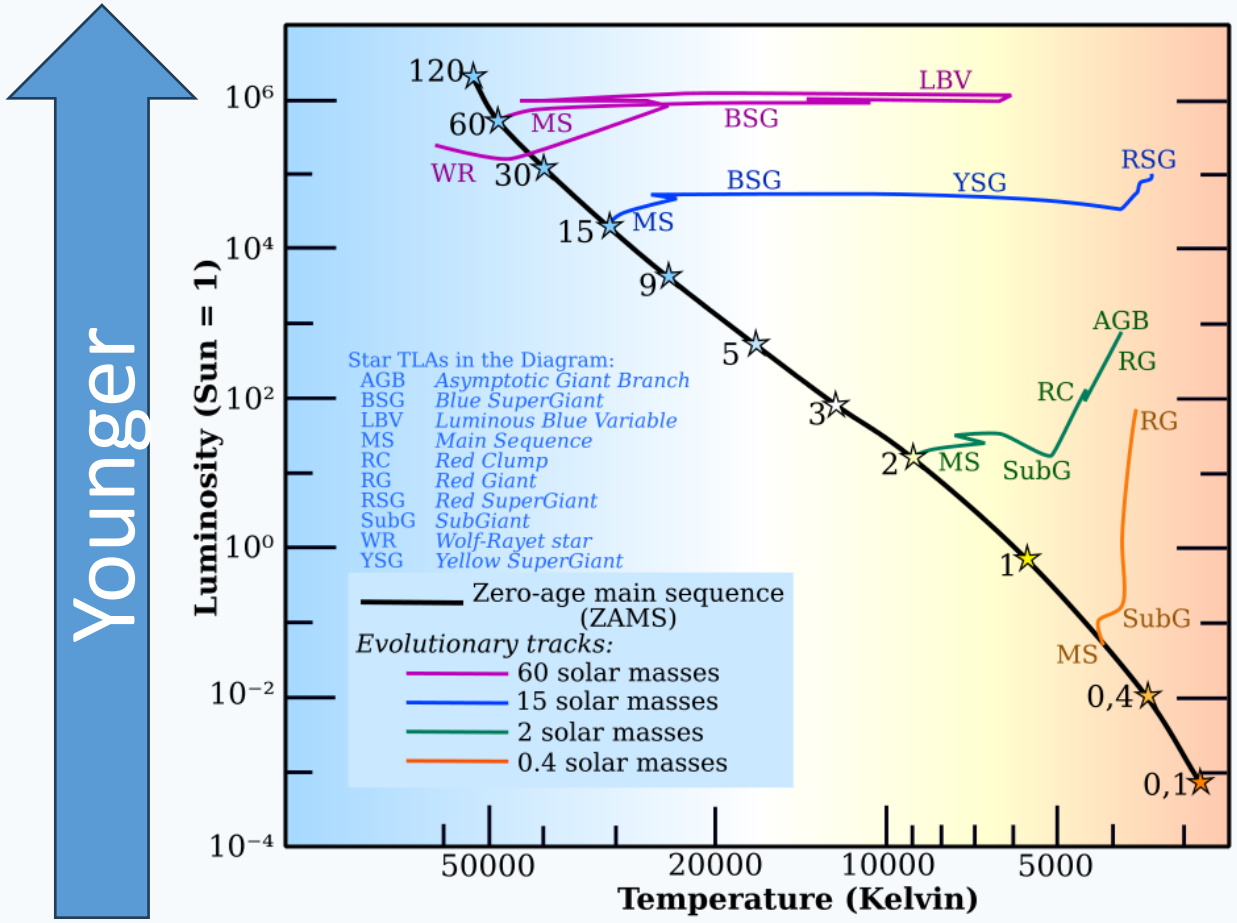


Figure 11. Stellar Evolution (Wiki)

Main Sequence Energy Transfer

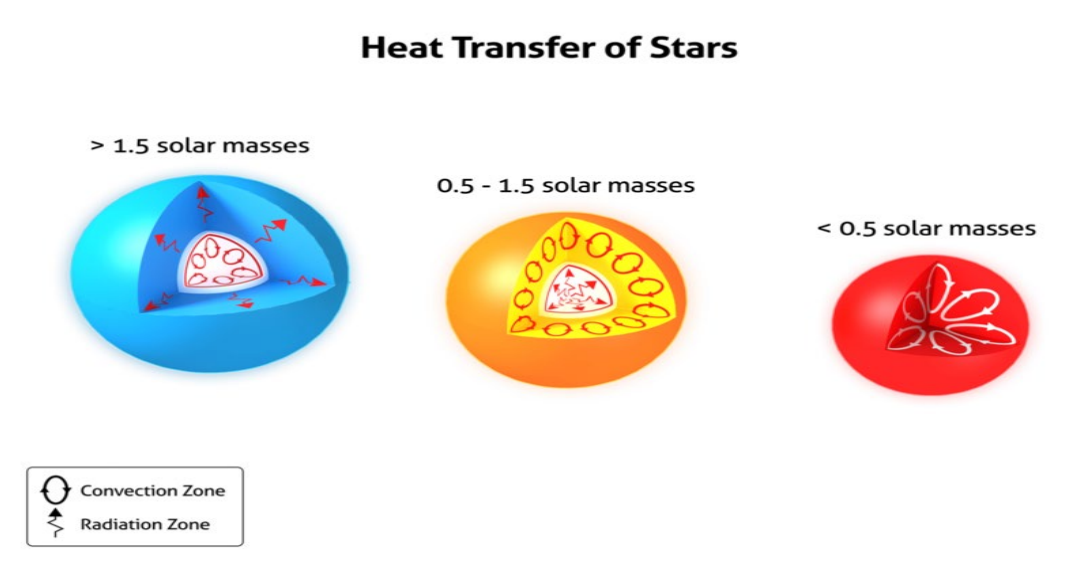


Figure 12. Heat Transfer of Stars (Wiki)

Depending on their mass, star transfer energy differently. O – G type stars have many layers while K-M type star have only one layer. O – F stars have an initial convective layer while G type have initial radiative layer.

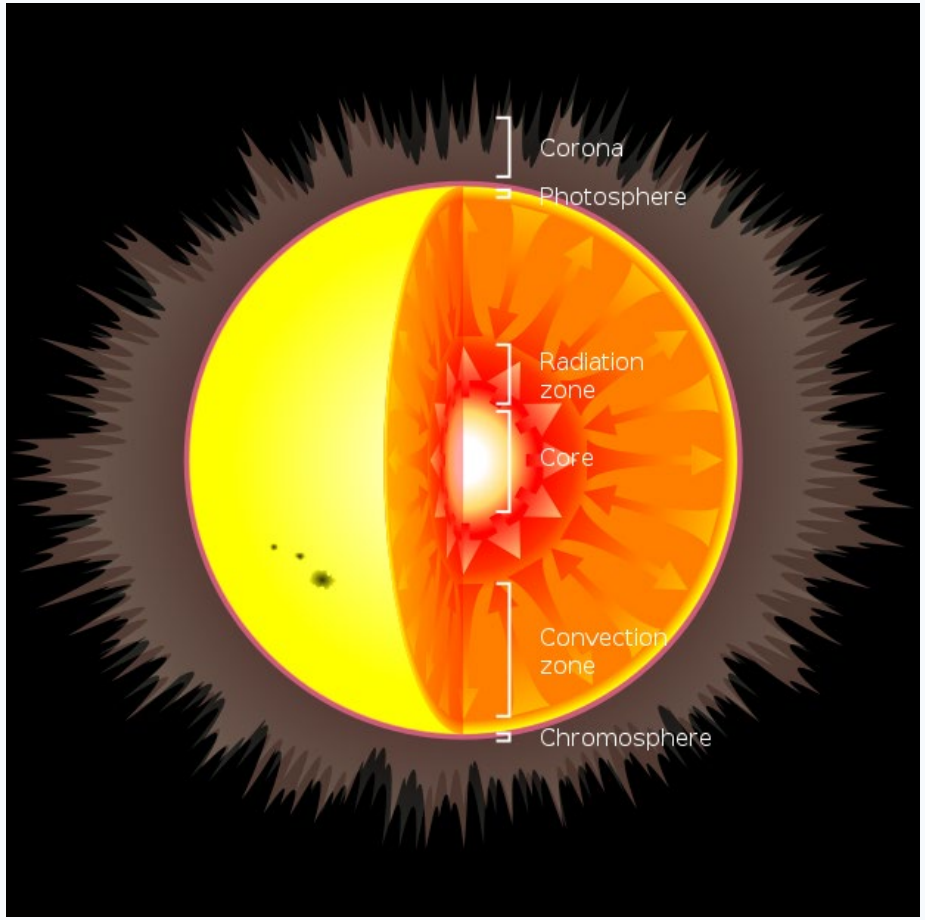


Figure 13. Main Sequence Star Structure (Wiki)

Red Giant Energy Transfer

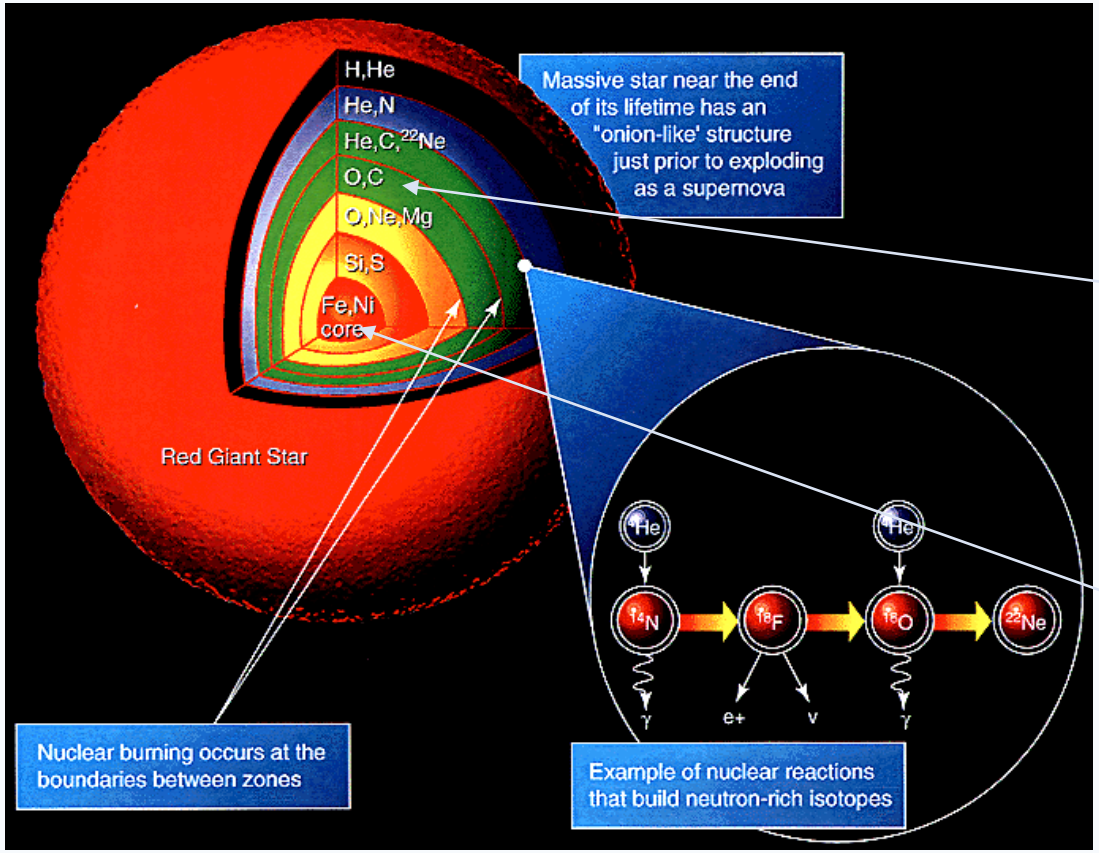


Figure 14. Energy production in Massive Star (Wiki)

- As the density of hydrogen depletes in the core of the star, the star contracts and creates layers of shell burning.
- The smaller stars (<1.5 solar masses) can only burn up to carbon, while larger stars can burn up to iron.

Henrietta Leavitt

- 1868 – 1921
- Born in Lancaster, Massachusetts
- Daughter of Congregational Church father
- Graduated and went to work at Harvard a “computer”.
- Worked under Pickering along side Annie Jump Cannon.
- In 1912, she published a study of variable stars in the Large Magellanic Cloud.
- She found a Period-Luminosity relationship for Cephied Variable in the cloud.

Figure 15. Henrietta Leavitt (Wiki)

Types of Pulsating Variables

Mira Variables – Low Mass (<1.5 Solar Masses) Pulsating Variable

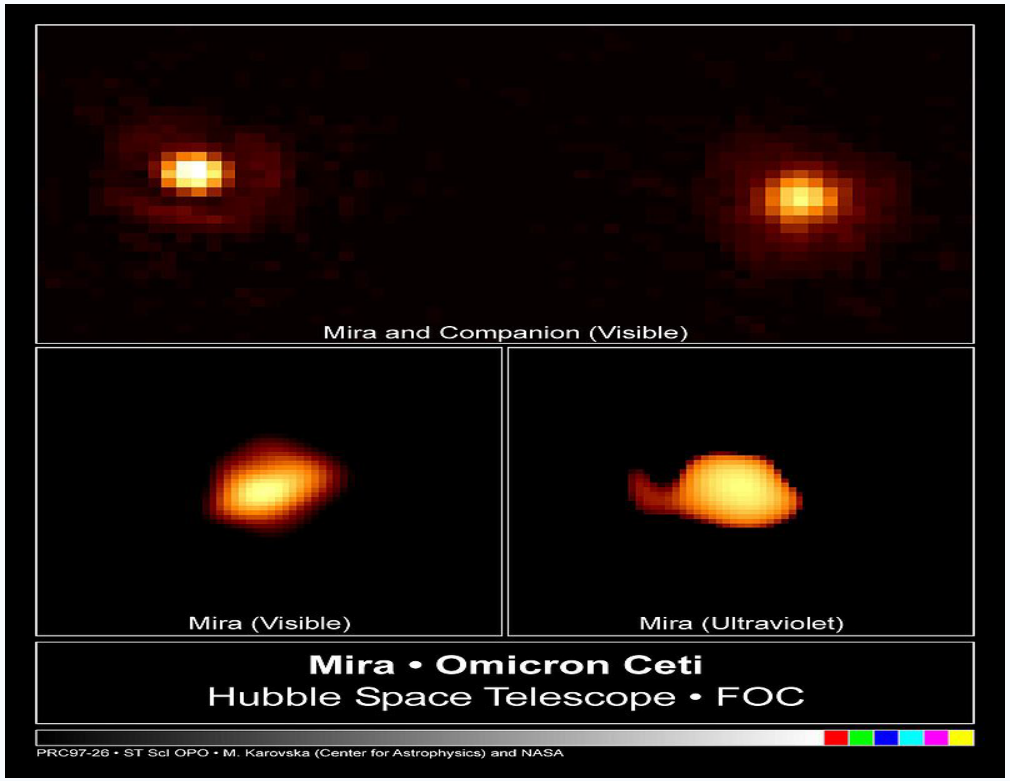


Figure 16. Mira Variable (Wiki)

Cepheid Variables – High Mass (>1.5 Solar Masses) Pulsating Variable

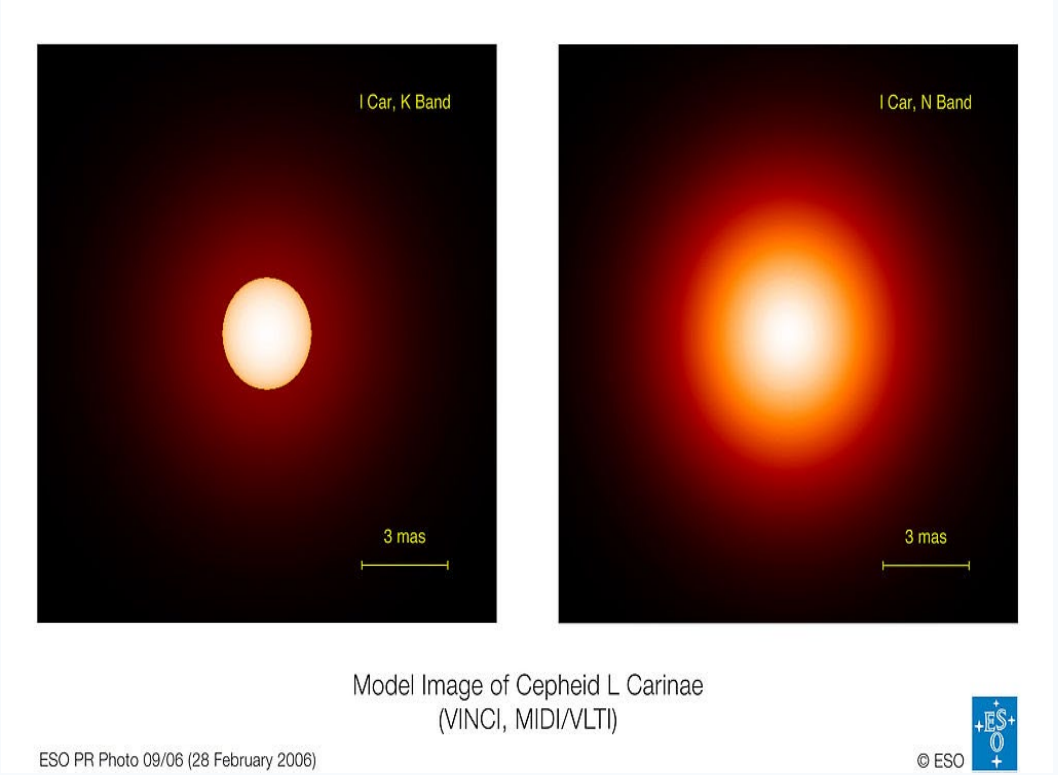
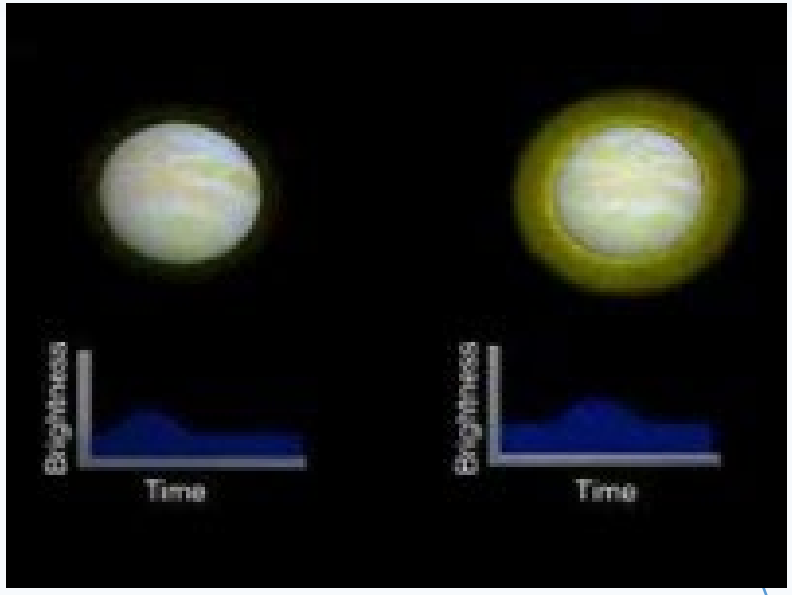


Figure 17. Cepheid I Carinae (Wiki)

Pulsating Variables Pulsation



When stars are contracting to burn more material sometimes, they become unstable, and they pulsate. The more massive pulsating variables take longer to pulsate. This happened when the stars pass through the instability strip on the H-R Diagram. We can use Cepheid variables periods to calculate distances. Click on the image to see how these pulsations work.

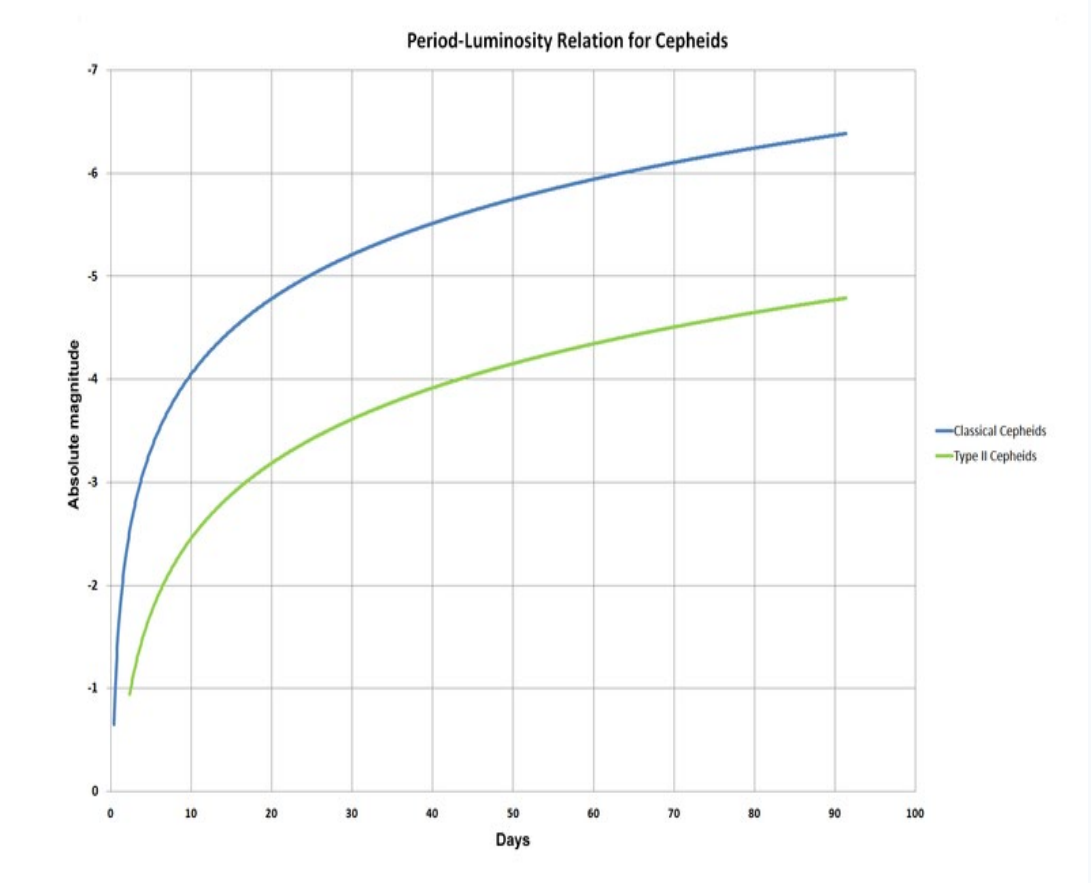


Figure 18. Period-Luminosity Relationship for Cepheid Variables (Wiki)

What are the end states of stars?

- When nuclear fuel is exhausted, hydrostatic equilibrium is upset causing the star to collapse.
  - Nova ($< 1.5M_{\odot}$)
  - Supernova ($\geq 1.5M_{\odot}$)
- Depending on the amount of material the stars will end up as:
  - White Dwarfs ($< 1.5M_{\odot}$)
  - Neutron Stars/Black Holes ($\geq 1.5M_{\odot}$)

Nova

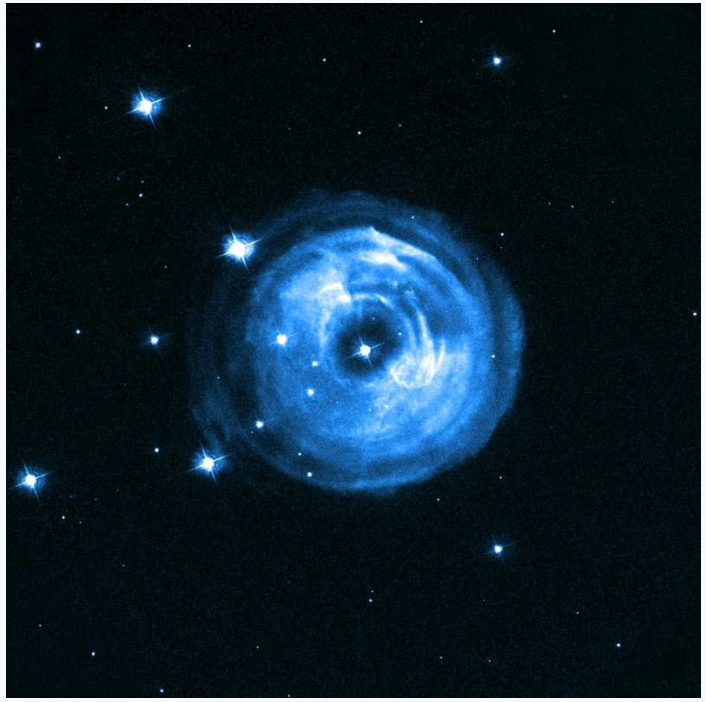


Figure 19. Nova V838 (Wiki)

Figure 20. Planetary Nebula V838 (Wiki)

Both Red Giants and Super Red Giants Luminosity Type I and II) slough off material in their last stages of CNO fusion; this a nova explosion . In case of low mass stars, the material exposing the white dwarf. The rest of the star diffuses to become a planetary nebula.

White Dwarf

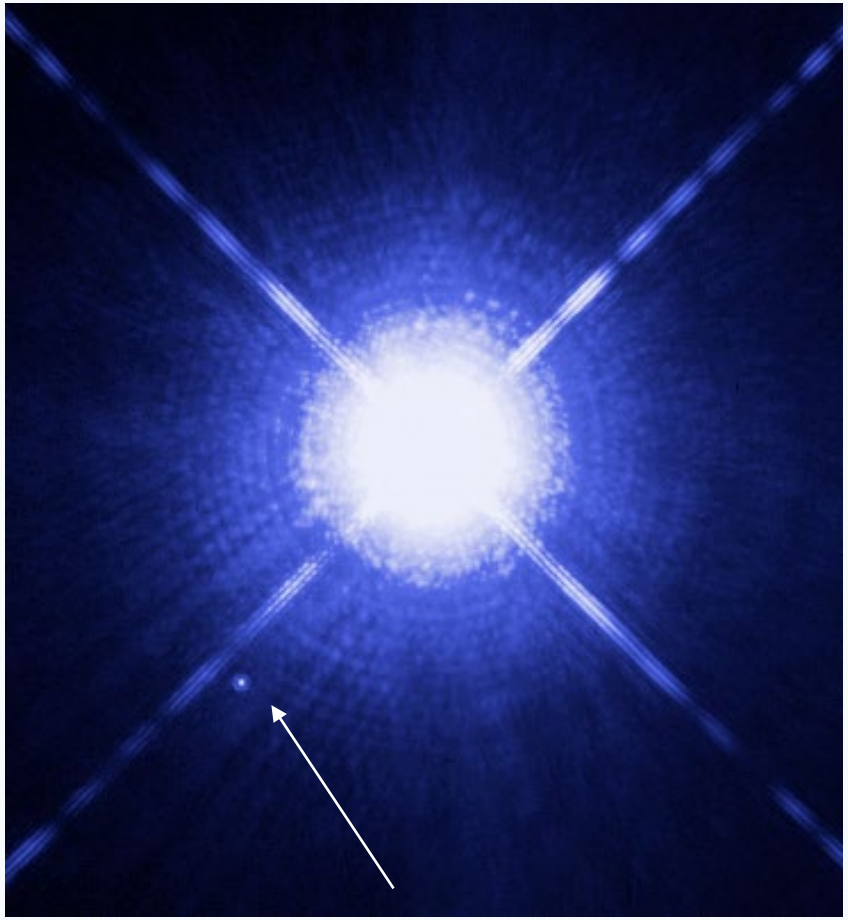


Figure 21. White Dwarf Sirius B (Wiki)

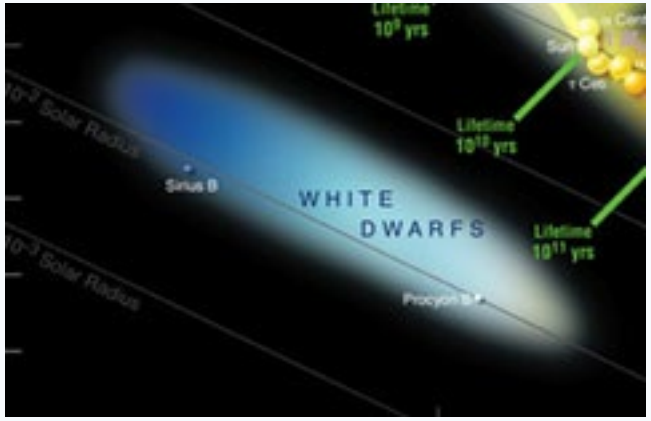
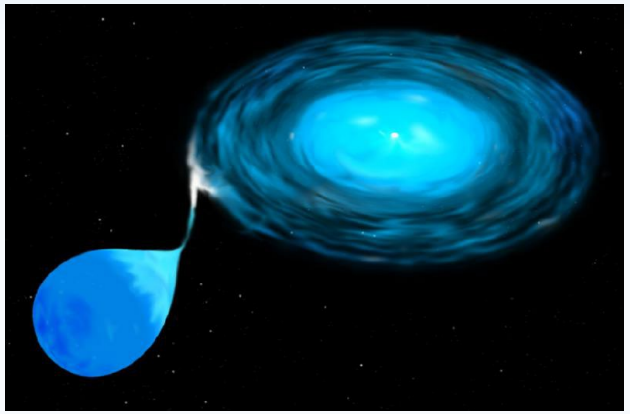


Figure 22. Theoretical H-R Diagram adapted to show the White Dwarf branch (Wiki)

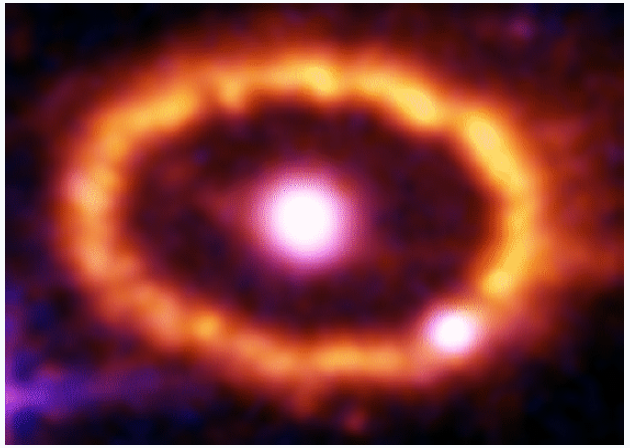
White dwarf stars appear below the main-sequence of the H-R diagram. The electrons are degenerate; they exist in one atomic level. One teaspoon equals the populations of China.

Supernovas



Type I – Helium Flash on an interacting white dwarfs. Peak early and then fade quickly.

Figure 23. Type I Supernova (Wiki)



Type II – Catastrophic collapse of high mass star. Peak early and the fade slowly.

Figure 24. Type II Supernova 1987a (Wiki)

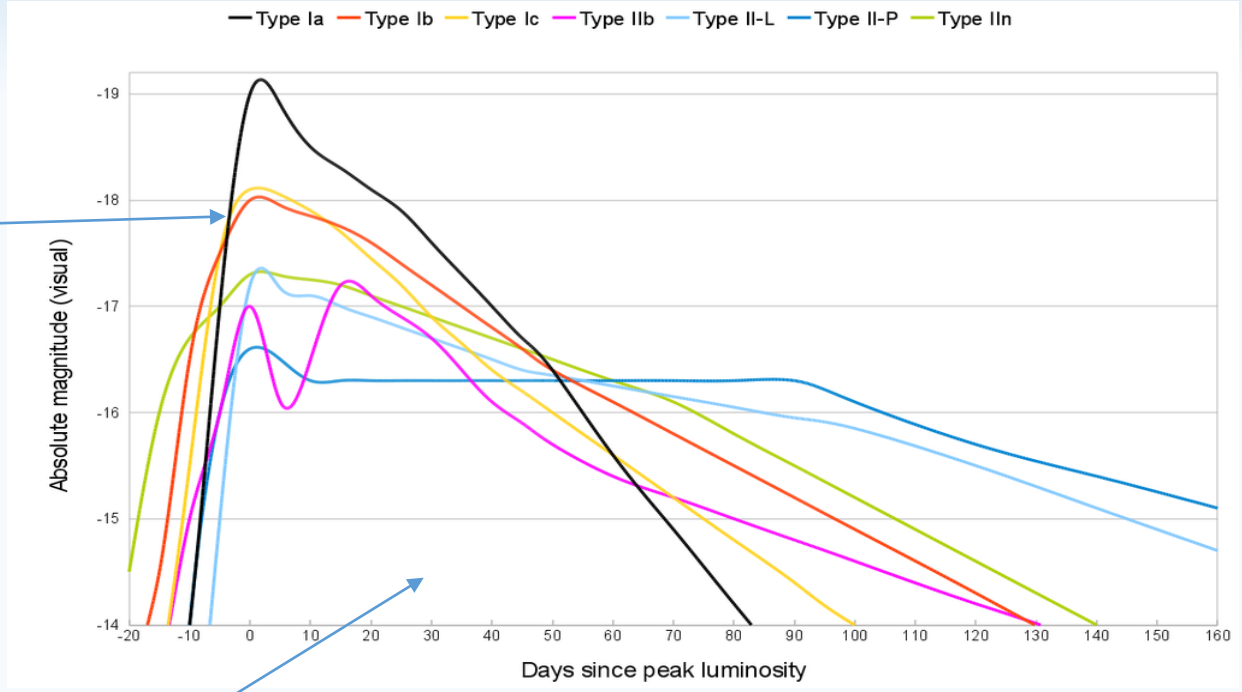


Figure 23. Supernova Lightcurve (Wiki)

Supernovas occur for various reasons; but both types accelerate mass out a high velocity with fission occurring at the edges of the mass creating heavier materials in their remnants. We can use the peak magnitude to determine the distance to the supernova by comparing it to the magnitude of supernova in our galaxy.

Joycelyn Bell Burnell

Figure 25. Joycelyn Bell Burnell (Wiki)

- 1943
- Born in Belfast, Ireland
- Grew up in the countryside and studied physics and astronomy
- Graduated Cambridge University in England
- Worked under Anthony Hewish at the 2.5 acre radio telescope at Cambridge
- Studied object that varied in the radio with the telescope.
- Hewish and Burnell discovered an object that varied on a time scale of 1.3 seconds.
- The objects were named LGM (Little Green Men) because they thought they were receiving signals from Mars.
- Hewish won Nobel prize in 1974 for the discovery of Pulsars.

Pulsar

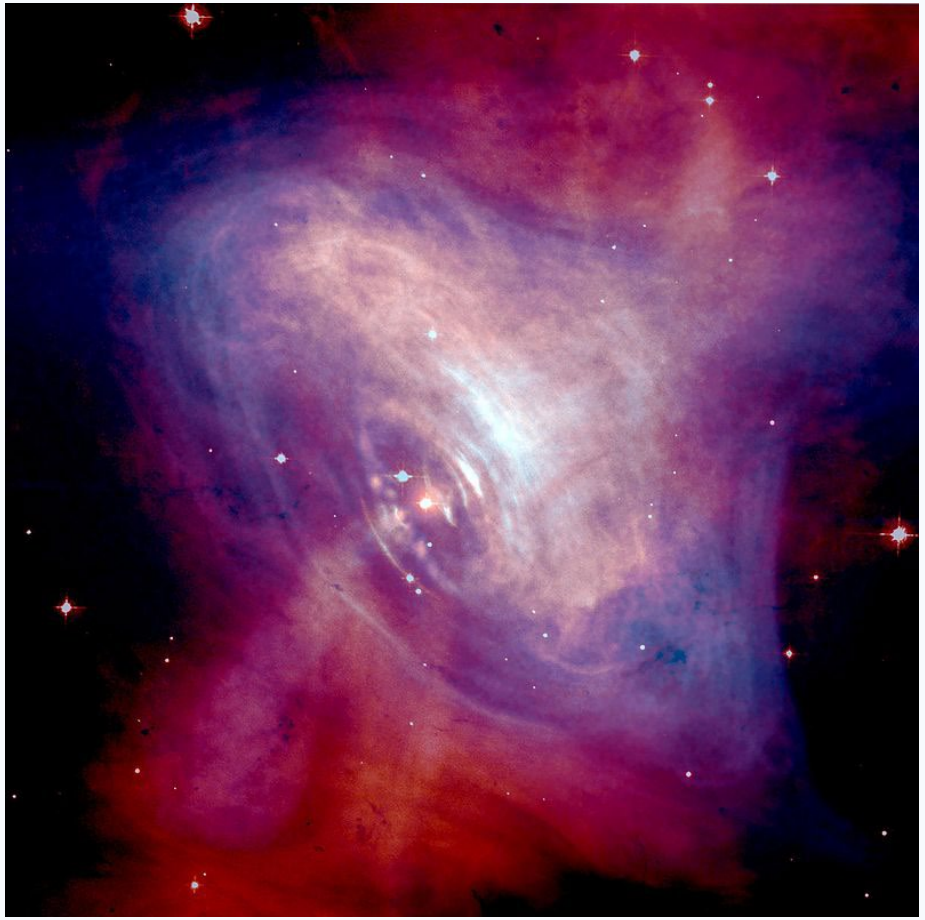


Figure 26. Pulsar in Crab Nebula (Wiki)

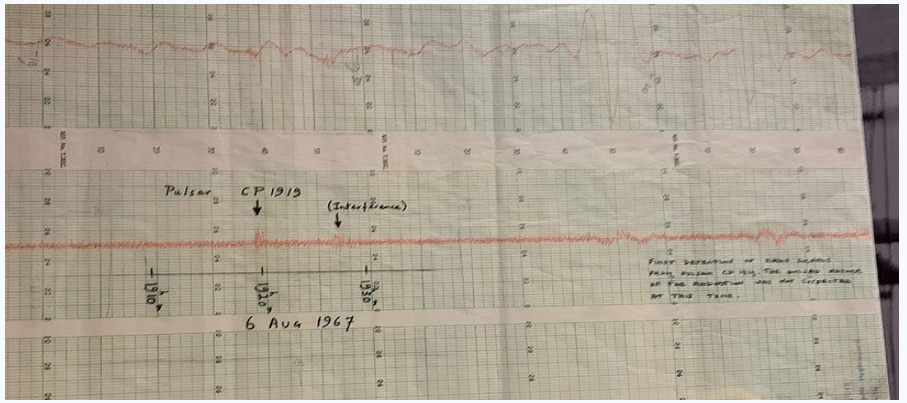


Figure 27. Light curve of CP 1919 (Wiki)

Pulsars occur when the electrons are degenerated into the protons creating a mass of neutrons. The process is so violent the resulting star spins and has an ionized jet of material. That jet rotates quickly, and we observe a set of quick pulses. Once it slows down, it is called a neutron star. One teaspoon of a pulsar could bore its way through the Earth. The remaining material is called a supernova remnant.

Black Holes

- Sometimes the collapses creates a hole in the space time surface of the Universe, creating a black hole.
- Nothing in our matter-dominated Universe can escape a black hole as the escape velocity is the speed of light.
- Click on the image to see how black holes work.

Types of Black Holes

- Schwarzschild: A non-rotating simple singularity with an event horizon. A “naked” black hole.
- Kerr: A rotating singularity with and ergosphere and charge. A “hairy” black hole.
- Mass Types:
  - Micro: Smaller mass than the Sun. Hypothetical at this point.
  - Stellar: Around the mass of the Sun and up to O type stars.
  - Supermassive: Millions times the mass of the Sun. Usually at the center of galaxies.

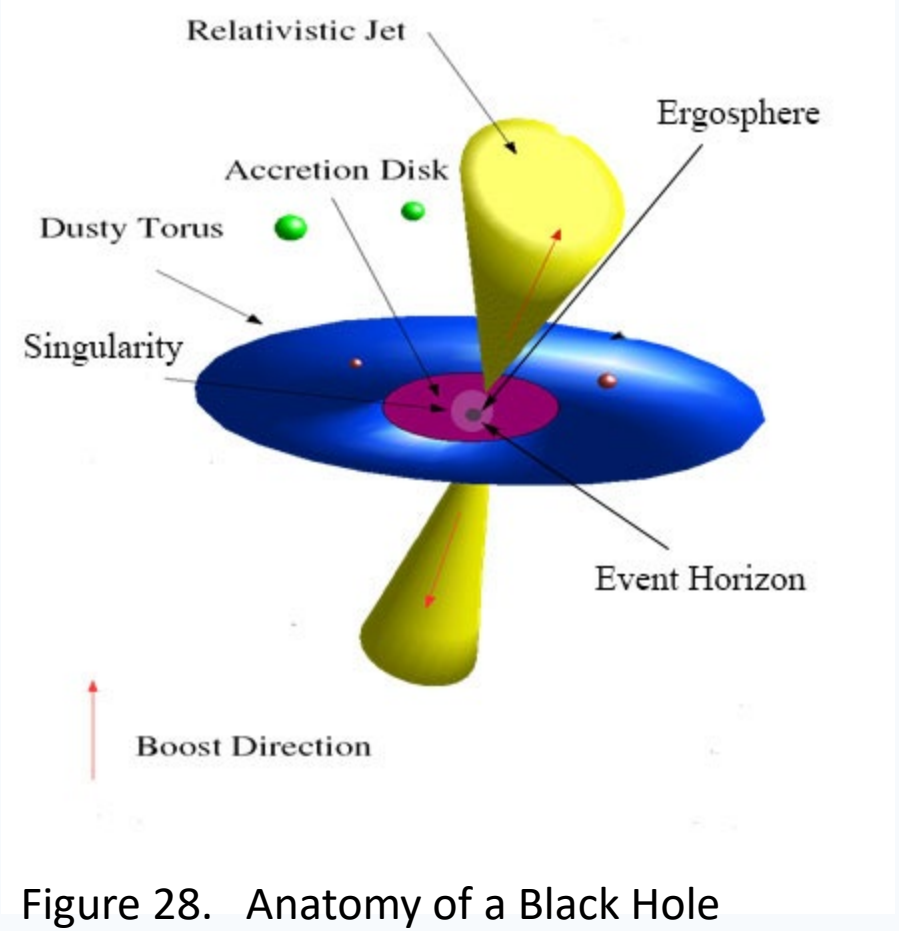


Figure 28. Anatomy of a Black Hole

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