
Notes on stars & Galaxies

(Summarized)

■ Stars

1. What is a Star?

- A star is a massive, luminous (glowing / shining) sphere of plasma (hot gas) held together by gravity.
- It emits light and heat due to nuclear reactions happening in its core.

2. Color and Brightness of Stars

- Stars vary in color from red (coolest) to blue (hottest) due to their surface temperature.
- Brightness depends on distance and size; a star may appear bright but be far away.

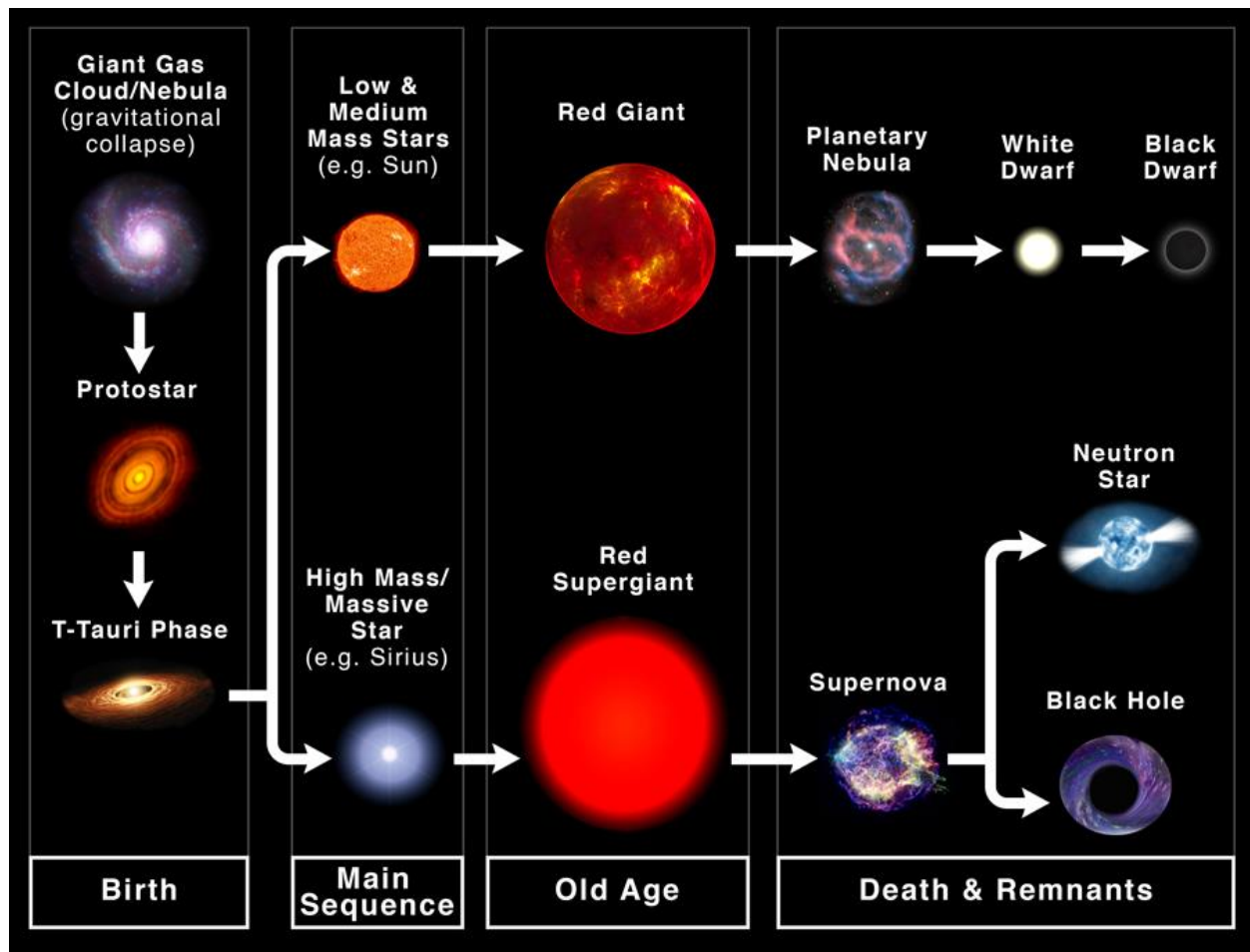
3. Source of Energy in Stars

- Stars generate energy through nuclear fusion, where hydrogen atoms combine to form helium.
- This process releases a tremendous amount of energy, which powers the star's luminosity.

4. Life Cycle of a Star

All stars have a similar beginning or birth, but what they become after birth and how they die depends on their mass.

Refer to the figure below as you read through the stages described below;



Formation (Birth of a star): Stars begin their life cycle in dense clouds of gas and dust called nebulae. Gravity causes these clouds to collapse, forming a protostar—a hot, dense core that continues to accrete material from its surroundings. As the protostar gathers more mass, its core temperature rises, eventually reaching a point where nuclear fusion ignites. This marks the birth of a star.

Main Sequence: Once nuclear fusion starts, the star enters the main sequence phase, where it remains stable for most of its life. During this phase, the star converts hydrogen atoms into helium in its core through a series of nuclear reactions. The energy released from this process creates a balance between gravity pulling inward and the energy pushing outward, maintaining the star's shape and luminosity.

Old age & death of a star: As a star exhausts its hydrogen fuel, it expands and enters the red giant or supergiant phase, depending on its mass. Smaller stars like our Sun become red giants, while more massive stars can become super-giants. During this phase, the core contracts and heats up, while the outer layers expand and cool, causing the star to appear larger and brighter. Eventually, the outer layers are shed into space, forming a colorful cloud called a planetary nebula. The core that remains becomes a white dwarf—a small, dense star that slowly cools over billions of years. In contrast, massive stars end their lives in spectacular supernova explosions, leaving behind either a neutron star or a black hole, depending on their mass.

5. Different Types of Stars

Stars can be classified based on their color & temperature, this is known as the *spectral classification*, in this system, stars are classified with letters, O, B, A, F, G, K, and M. I will not be using this classification system for these notes as it is a bit technical for this level.

Good news is, stars can also be categorized basing on their evolutionary stage and characteristics after formation; this is known as the *stellar classification* and is given below:

- **Main Sequence Stars:** This is Most common type of stars, they are in their youthful stage and within their core, they convert hydrogen into helium. Popular examples include the sun.

- **Red Giants:** These are large, older stars that have exhausted their core hydrogen fuel and expanded. They are cooler than main sequence stars but brighter due to their larger size.
- **Supergiants:** These are massive stars in the later stages of their evolution, having exhausted their core hydrogen fuel and expanded significantly. They can be many times larger than the Sun.
- **White Dwarfs:** These are small dense remnants (remains) of low to medium mass stars after they have shed their outer layers as planetary nebulae. They are small, extremely dense, and gradually cool over time.
- **Neutron Stars:** These are incredibly dense remnants of massive stars that have undergone supernova explosions. They are composed mainly of neutrons and have strong magnetic fields.

5. Black Holes

These are regions of spacetime where gravity is so intense that nothing, not even light, can escape. They are formed when massive stars die due to gravitational collapse.

Key Takeaways:

- Stars come in different types based on size, age, and lifecycle stage.
- Their color and brightness vary due to temperature and distance.
- Nuclear fusion powers stars, converting hydrogen into helium.
- Stars form from gas and dust, live through various stages, and end in different ways based on their mass.

■ Galaxies



1. What is a Galaxy?

- A galaxy is a massive system of stars, gas, dust, and dark matter held together by gravity.
- Galaxies come in various shapes and sizes, ranging from spiral and elliptical to irregular.

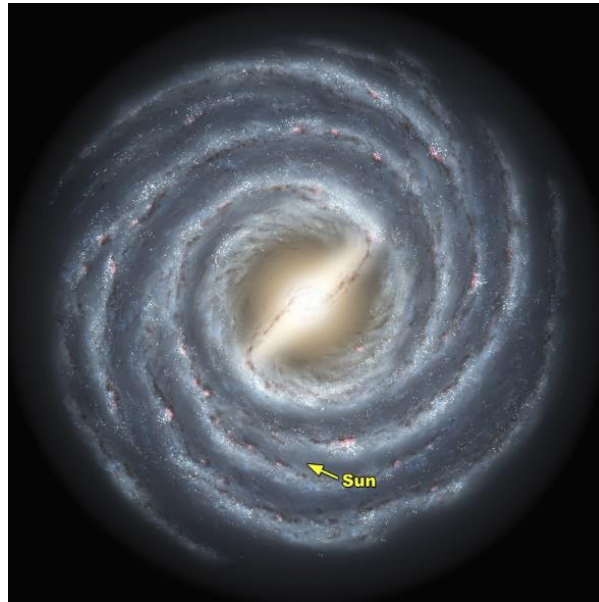
2. Types of Galaxies:

Galaxies are classified mainly depending on their shape, you can take a look at the figure above and try to observe the different shapes of galaxies.

- **Spiral Galaxies:** These have a spiral arm structure, like the Milky Way, with a central bulge and disk.
- **Elliptical Galaxies:** Shaped like ellipsoids, they have older stars and less gas and dust compared to spirals.
- **Irregular Galaxies:** These have no definite shape and often result from gravitational interactions between galaxies.

3. Milky Way Galaxy:

Our solar system is located in the Milky Way Galaxy, the milky way galaxy is a spiral galaxy containing billions of stars, including our Sun. It has a central bulge, spiral arms, and a disk where most stars, including the Sun, are located.



4. Other Galaxies:

- **Andromeda Galaxy:** A spiral galaxy like the Milky Way and the closest large galaxy to us.
- **Elliptical Galaxies:** Examples include M87 in the Virgo cluster, known for its massive black hole.

5. Galaxies and the Universe:

Galaxies are the building blocks of the universe, clustering together in groups and superclusters. The study of galaxies helps us understand the structure, evolution, and history of the universe.