• Stars
• **Origin of stars**
  - Nebula $\rightarrow$ swirling cloud of hydrogen gas.
  - Random shock waves
  - The molecules to collide and produce local compressions.
  - Gravitational attraction $\rightarrow$ cluster.
  - Birth of a protostar
Protostar gas molecules gain kinetic energy.

Increase in KE and increase in mass at the center

- nuclear fusion reactions begin.
Interior of a star

- Hydrogen-Helium Cycle

- \( ^1H_1 + ^1H_1 \rightarrow ^2H_1 + ^0e_1 \)
- \( ^2H_1 + ^2H_1 \rightarrow ^3He_2 + ^1n_0 \)
- \( ^3He_2 + ^3He_2 \rightarrow ^4He_2 + 2 ^1H_1 \)

Further He fusion leads to production of C, N
• **Star temperature.**
  – Color and temperature are related.
  – Cooler stars appear reddish and hotter stars appear bluish white
  – Sun $\rightarrow$ yellow $\rightarrow$ Moderately Hot
Similar to Blackbody Radiation distribution
• **Star types.**
  – Stars are classified **Hertzsprung-Russel diagram** (HR diagram)
  – Based on temperature and luminosity
    • O type stars → M types
    • Each point → the surface temperature and brightness of a star.
  – **Main sequence stars**
    • Mature stars → nuclear fuel burn at a steady rate.
The Hertzsprung-Russell diagram.
– **Red Giant Stars**

- Bright, low temperature stars.
- These stars are enormously bright for their temperature due to their size.
– **White Dwarf Stars**
  
  • Faint, white hot stars.
  
  • Faint due to its small size.
• The life of a star.
  – Gas clouds $\rightarrow$ protostar$\rightarrow$ nuclear fusion
    • Expand to a red giant,
      – Blow off the outer shell to become a white dwarf star.
    • May also collapse on itself to become a neutron star
    • A massive star may collapse to become a black hole.
– The first stage in the life of a star is the formation of a protostar.

• Gravity

• Density, pressure, and temperature increase from the surface to the center

• \( T = 10 \text{ million Kelvin} \)
  – nuclear fusion reactions begin in the core.
– The second stage
  • Hydrogen core ➔ Fusion ➔ Helium.
  • Less hydrogen fusion reactions ➔ less energy
    – Less outward pressure
    – Collapse due to gravitational pull.
  • Collapse ➔ heat the helium core of the star
    – hydrogen expansion.
  • Red giant and will remain ➔ 500 million years.
  • He fusion reactions ➔ core
  • Hydrogen fusion reactions ➔ shell.
  • The radius and luminosity decrease and the star moves backward to a main sequence star.
– Millions of years of helium fusion reactions → carbon core

• Two shells: Helium fusion, Hydrogen fusion reactions
• Release of energy and the star reverts back to a red giant one more time.
• As the outer shells expand
  – they give off energy and again contract.
• Pulsation of shells
• Core → white dwarf
• The blown off outer shell becomes a planetary nebula
The blown-off outer layers of stars form ring-like structures called planetary nebulae.
– In a massive star, fusion continues \(\rightarrow\) Fe.
  • Since iron cannot undergo fusion
  • Loses its outer pressure and explodes as a **supernova**
– Core mass of 1.4 solar masses or more,
– **Neutron star.**
– If the neutron star becomes strongly magnetized
  • Emission of E-M pulses and it is a **pulsar**.
– Core mass after the supernova > 3 solar masses of more the star may collapse
– This is called a **black hole**.
The evolution of a star