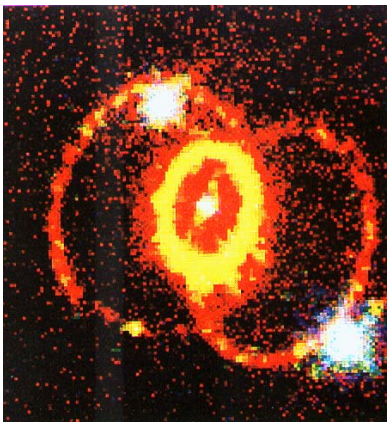
The Stars

"Stars are giant fusion reactors in space."



"All stars have a beginning and an ending."

Some Facts About The Sun

- Distance from the Earth: 1AU = 149,598,000 km
- Core, convection zone, and photosphere
- Energy travels from core to convection zone in tens of thousands of years
- Light travels from Sun's photosphere to Earth in 8.3 min.
- Mass = 1.99 x 10^{30} kg (3.33 x 10^{5} Earth masses)
- Composition: 74% hydrogen, 25% helium, 1% other elements
- Temperature: Surface (photosphere)—5800 K, Core—1.55 x 10^{7}K
- No distinct outer boundary—solar wind

How Do We Know The Life-Cycle of Stars?

- Electromagnetic Radiation
  - Direction, Distance, Composition, Temperature, Direction of Movement
- Telescopes
  - Earth based (visible and radio)
  - Space based
    - Hubble
    - Compton Gamma Ray Observatory
    - Chandra X-ray Observatory

Star Formation

- Clouds of gasses and other debris (mainly hydrogen) is collected into ever tighter packets due to gravitational attraction.
- As the matter is packed tighter together the core gets hot.
- Very large aggregates of matter have cores sufficiently hot to ignite fusion reactions.
- Equilibrium is established: gravity contracts the matter, fusion reactions expand (explode) matter.
- The larger and more massive the star, the more furious the fusion reactions in the star's core.

Hydrogen Burning

$$P + P \longrightarrow \text{Deuterium (D)} + e^{+} + \text{neutrino}$$

$$D + P \longrightarrow {}^{3}He + \text{photon}$$

$${}^{3}He + {}^{3}He \longrightarrow {}^{4}He + 2 \text{ protons} + \text{photons}$$

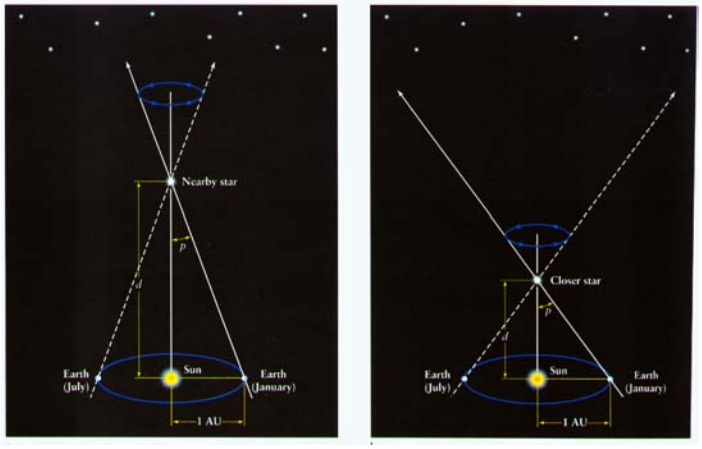
The Sun consumes over 6×10^{11} kg of hydrogen per second.

It has been burning hydrogen for 4.6 billion years and will continue for approximately another 5 billion years.

Determination of the Distance to Stars

- Variables: luminosity (magnitude), spectrum of light emitted
- Light Year – 6.2 trillion miles; the distance light travels in one year
- Parsec – 3.3 light years
- Nearby stars—use parallax method
- Distant stars – use Cephid star method

Stellar Parallax



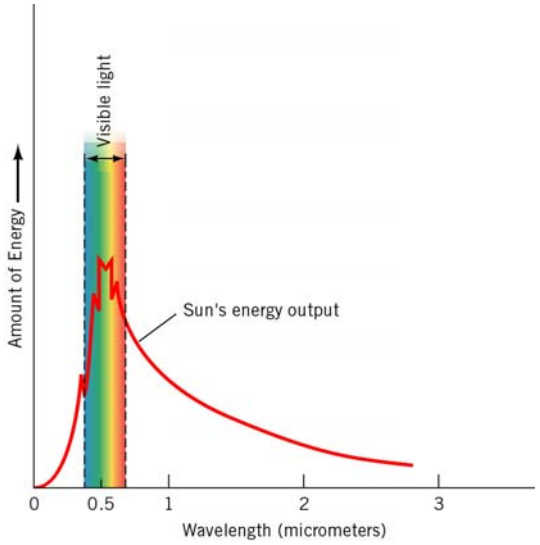
d = distance in parsecs; p = parallax angle in arcseconds

AU = Astronomical Unit; d = 1/p

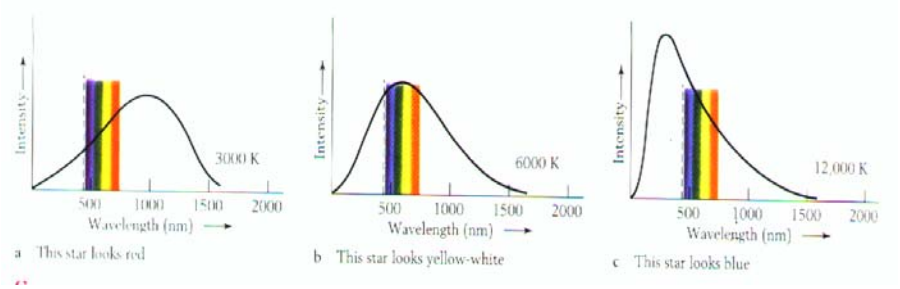
Cephid Stars

- First discovered in constellation of Cepheus
- Constantly change from bright to dim at a constant rate
- Rate of change dependent upon magnitude of the star
- Can be used as rulers to determine the distance to galaxies

Energy Output of the Sun

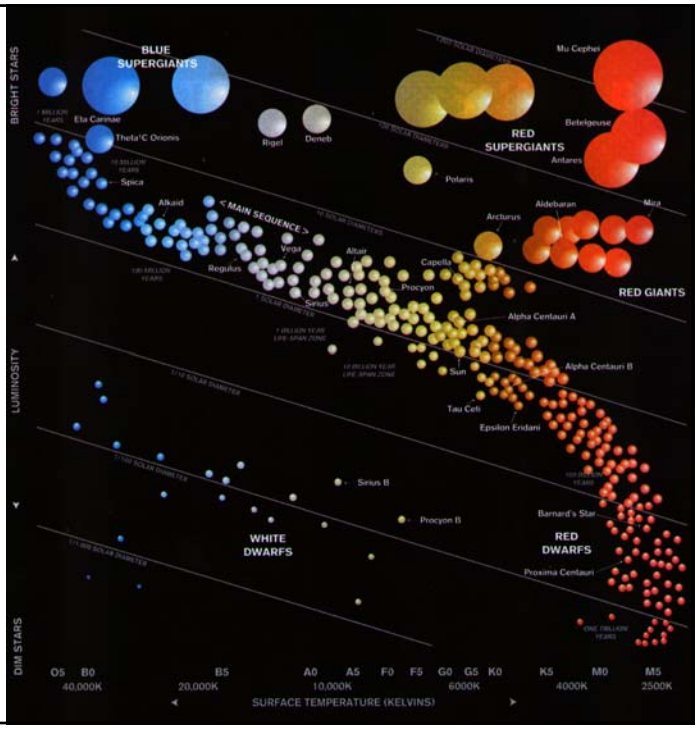


Energy Output of Stars Cooler and Warmer than the Sun

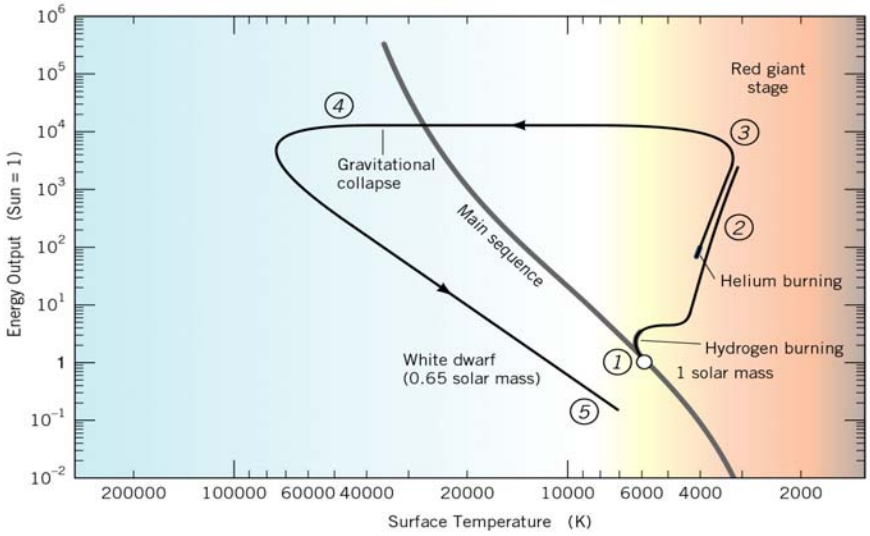


The HR Diagram

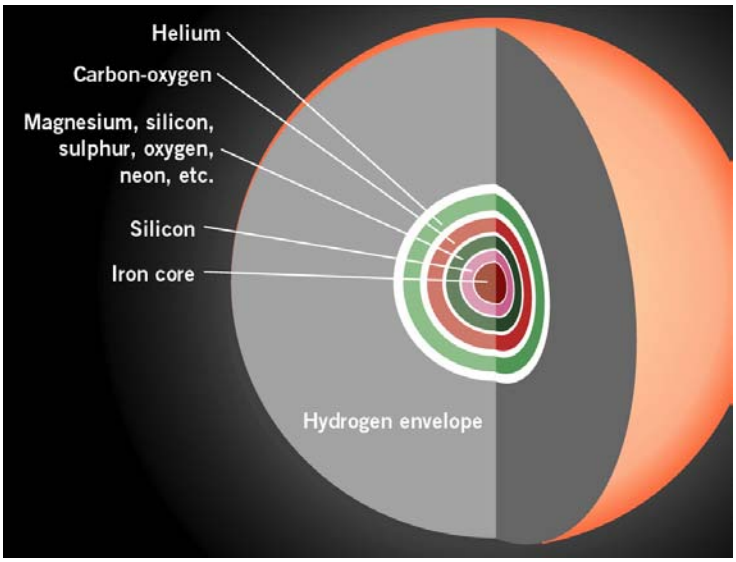
Hertzsprung-Russell



The Life-Cycle of a Star



Large Stars Have Concentric Shells of Fusion Reactions



Fusion Reactions In Large Stars

$$^4He + {}^4He \longrightarrow {}^8Be$$

$$^4He + {}^4He + {}^4He \longrightarrow {}^{12}C$$

$$^{12}C + {}^4He \longrightarrow {}^{16}O$$

Similar reactions occur to form all elements up to iron Fe. Atoms larger than Fe formed upon explosion of supernovas.

The Death of Stars

- White dwarfs
- Supernovas
- Neutron Stars and Pulsars
- Black Holes