Travels on the H-R Diagram
Most of a star’s life is spent on M.S.

- More massive, the faster it “lives”
  - High mass, means high gravity leading to higher T in core, so faster fusion rates
    - O & B stars, $10^6$ yrs on M.S.
  - Low mass, just the opposite
    - M stars, trillions of yrs on M.S.
H-R Diagram

- Table 11-2 - star ages on M.S.
Hydrogen Conversion

- When Hydrogen is completely converted to Helium, fusion stops.
- Why?
  - No radiation pressure to support gravitational collapse.

Shell H fusion
More efficient radiative transfer
Envelope expands (cools) to 3500 K - red, but L is high (surface area bigger) = Red Giant

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Red Giant

- Envelope becomes so extended, it “leaks” away
  - **Mass Loss**

- Helium “ash” dumps onto core, increasing mass, causing it to shrink and heat up

The core is about the size of the Earth

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Core heats and when $T \sim 10^8$ K, Core Helium Fusion begins

$$3 \text{He} \rightarrow 1 \text{C} + \gamma$$
$$1 \text{C} + 1 \text{He} \rightarrow 1 \text{O} + \gamma$$

Helium fusion only lasts $\sim 20\%$ the Main Sequence lifetime

Why?

In ordinary gas, contraction leads to heating leading to expansion leading to cooling, a safety valve

Core contracts so much to heat up it squeezes electrons together and core becomes degenerate

Degenerate gas does not act like an ordinary gas $= \text{no safety valve}$. So core FLASHES in seconds, explosively, and degeneracy is lifted

After core helium ignition, star is smaller, dimmer, & hotter
Globular Clusters

- Old star clusters outside of, but orbiting galaxies
- 100,000s of stars all born simultaneously
- By plotting their HR diagrams, we can determine ages by their turn-off points
- Turn off point = age of stars here (where H fusion is just finishing in core), and thus the age of the cluster

Open Clusters = Typically younger and smaller star clusters within a galaxy

Horizontal Branch = post-helium flash are of H-R diagram (He fusion in core)
Variable Stars

- Core fusion in red giant branch changes lead to varying energy output
  - Stars pulsate in brightness
- Cepheid variables have a relationship between period of pulsation and luminosity
- Why important?
  - Bright and can see them at large distances
  - Measure L for objects with known distance
    - Then measure period for more distant objects and get M
    - Measure m and get D!!
  - Hubble Key Project
Variable Stars

viewgraphs