Lec #36: 16 NOV 11 Chapter 6

Main Sequence Evolution

- core hydrogen burning phase

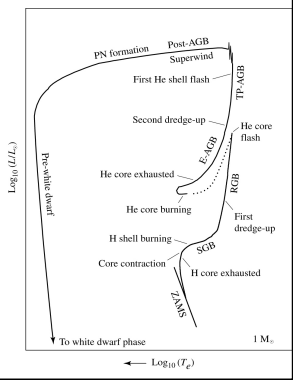
Post Main Sequence Evolution

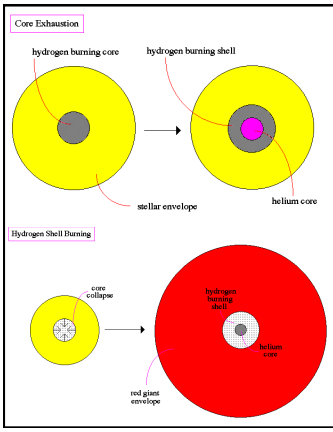
- hydrogen shell burning
- helium burning
- red giant phases
- pulsation and mass loss

THEN: Endpoints of Stellar Evolution

Evolution of 1 $M_\odot$ Stars

- Radiative core; little or no mixing
- H->He; molecular weight goes up (Y increases)
- Sun now ~40:60 H:He in the core
- He ash gravitationally settles in core; not yet hot enough to "ignite"
- core contracts, heats up, increases PP and CNO
- luminosity, temp, radius gradually increases
- once X < 1 or 2% (~90% of total lifetime), PP and CNO cannot continue
- core goes out of HSE and TE and contracts
- not hot enough for He fusion; H burns in "shell"





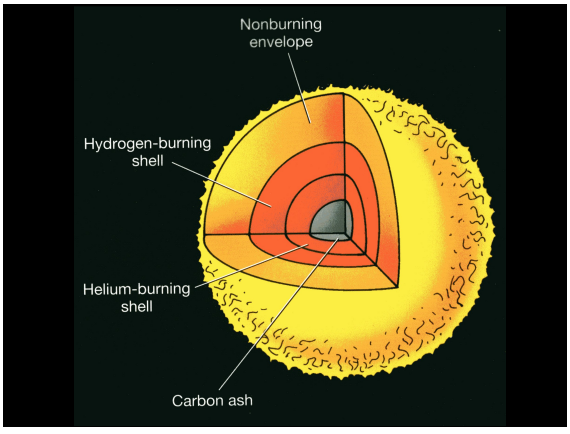
- He core contracts
- as soon as T>10^7 K, H **shell** burning starts
- energy generation up!
- envelope expands to red giant
- L, R up; T_{eff} down
- He ash falls onto core
- core becomes degenerate

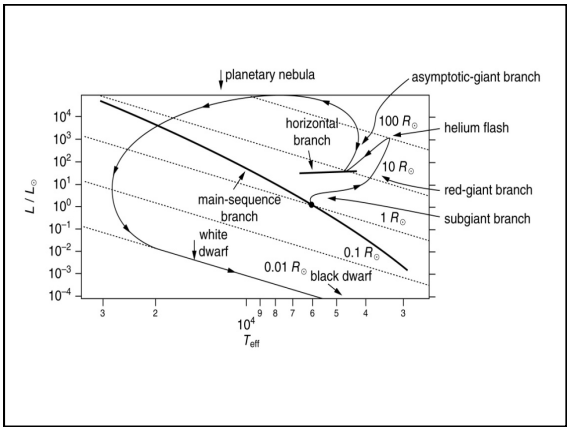
The He-flash and Core He-Burning

- when T > 10^8 K, He starts fusing (via triple-alpha process), which increases Temp more without increasing Pressure (degeneracy) --> **runaway fusion**
- Helium-Core **FLASH** within seconds!
- L ~ 10^{11} L_{sun} !!! (but not for long)
- rapid increase in *T removes* degeneracy
- pressure increases and core expands
- envelope **contracts,** T_{eff} goes up; R, L go down
  a) red giant "*clump*" if metal-rich (Pop I)
  b) "*horizontal branch*" if metal-poor star (Pop II)
- remains in this state **most of remaining 10% of its life**

Late Stages in Evolution of Solar-Mass Star

- Path depends on initial mass and mass loss on the "asymptotic giant branch"
- Triple-Alpha process creates ^{12}C and ^{16}O ash
- once He-fusion stops, core not hot enough to ignite
- core collapses again; **He** starts burning in **shell** (with H burning in shell around it, still "raining" He ash); He shell undergoes thermal pulses (e.g. R Hya variable stars)
- puffs up stars again on AGB





Evolution of Intermediate Mass Stars

- CNO cycle comparable or dominant to PP chain
- Evolution proceeds as in solar-mass stars
- If M >/~ 4 $M_\odot$ no Helium flash; instead...
- core does not become degenerate; Triple-alpha starts ($T>10^8$ K) right away; still create C/O core
- if hot enough to ignite ^{12}C core in runaway reaction
- unlike He flash, this completely destroys star in a Supernova explosion
- (type I and a half); more later