ASTR 1040: Stars & Galaxies in Fiske Planetarium

Blinking Eye Nebula

Prof. Juri Toomre TAs: Ryan Horton, Loren Matilsky
Lecture 15 (mid-course!) Tues 16 Oct 2018
zeus.colorado.edu/astr1040-toomre

Topics for Today & Thur

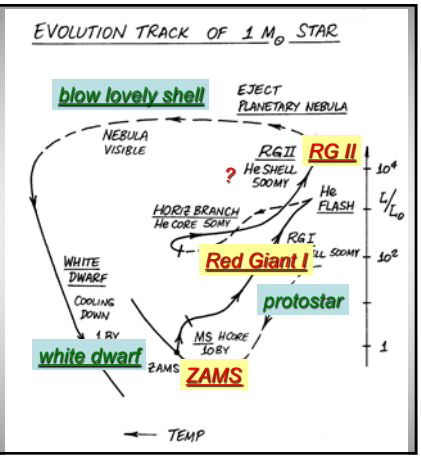
- Life tracks of massive stars: late stages allow fusion like "layers of an onion"
- Massive stars end life with supernova explosion, when iron core exceeds 1.4 M_{sun}
- Pulsars – fast spinning neutron stars with fierce magnetic fields; gradually slow down
- We take a tour of our galaxy and star birth regions, then turn to Black Holes show

Things to do

- Review 17.3 'Life as High-Mass Star'
- Read Chap 18: "Bizarre Stellar Graveyard" and white dwarfs in detail, neutron stars next lecture
- Homework #6 now graded (plus answers), outside for pickup
- Observatory Night #7 tonight Project 2 of binary stars with spectroscopy (signup + pink instructions)

Life track in H-R diagram of solar-mass star

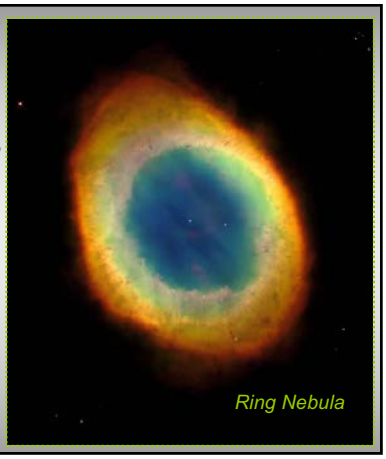
Many meanders, but MS phase longest, red giant phase(s) shorter, finally white dwarf left to cool slowly



Life after brief "planetary nebula" stage ....

Hot central core emerges as

WHITE DWARF



Ring Nebula

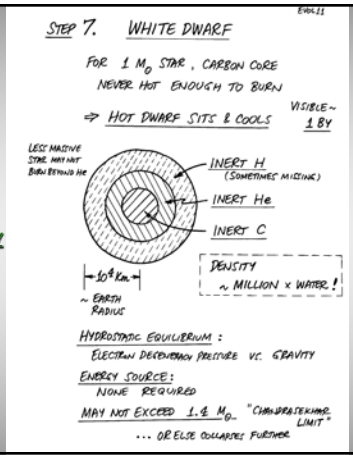
7. White Dwarf

Inert C core, He & H shells

electron degeneracy pressure holds it up

Very dense, size of Earth

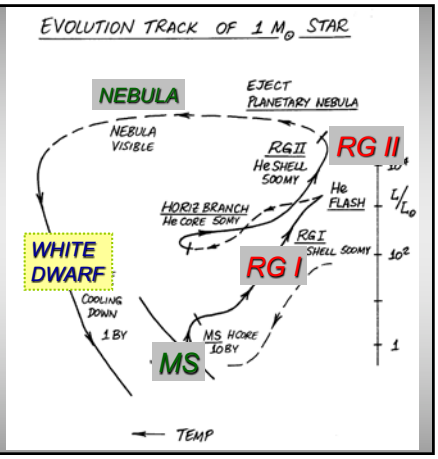
max mass of 1.4 M_{SUN}



Final stage:

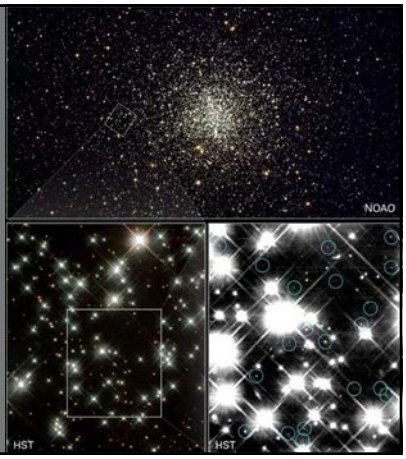
Cooling white dwarf --- snooze ….

But if WD has binary companion, much fun can begin !



- Hubble Space Telescope spies 12-13 billion year old white dwarfs

Formed less than 1 billion years after creation of the universe



Clicker review – red giants

- The main source of energy for a star as it grows in size to become a red giant is _____ .

B.

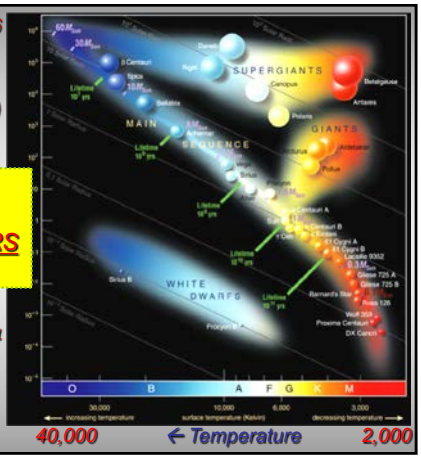
- A. gravitational contraction
- B. hydrogen fusion in a shell around core
- C. helium fusion in the core
- D. hydrogen fusion in the core

10^6

Luminosity (solar units)

Now consider evolution of MASSIVE STARS after MS

10^{-4}

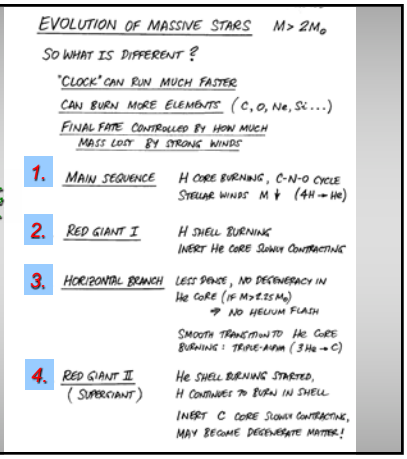


40,000 ← Temperature 2,000

Evolution of massive stars

Clock runs faster, can burn heavier elements

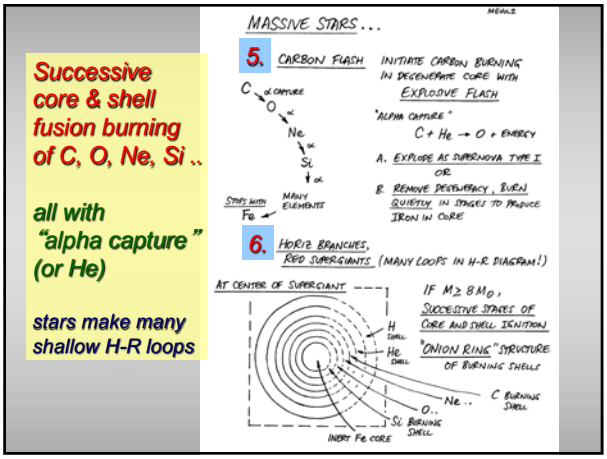
First 4 steps pretty familiar, but no helium flash



Successive core & shell fusion burning of C, O, Ne, Si ..

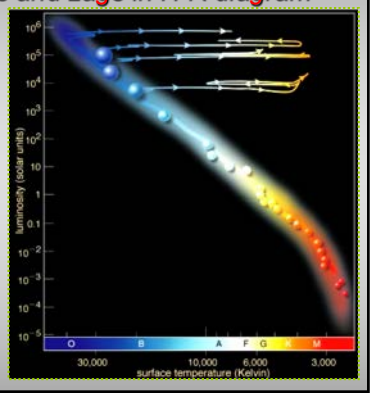
all with "alpha capture" (or He)

stars make many shallow H-R loops

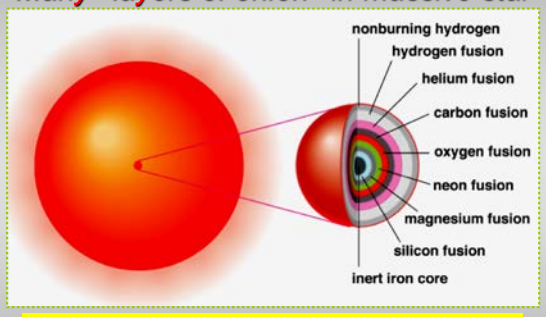


High-mass zigs and zags in H-R diagram

- Elements of higher mass fusion burn successively, releasing energy to support the star against gravity.
- Reactions may change too fast for outer layers to respond, so last zig/zags are small

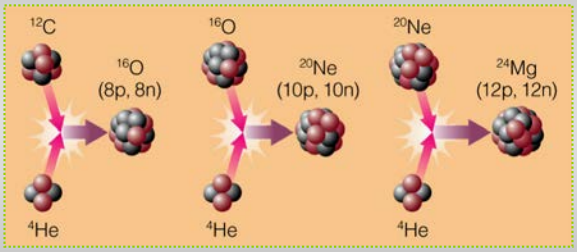


Many "layers of onion" in massive star



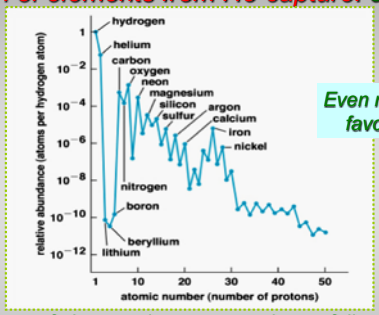
Core structure from successive burning stages: lesser elements on outside, heavier on inside

Fusion by "helium-capture" (alpha-particles) burns C, O, Ne, Mg, Si .. "layers of onion"



- Helium nucleus (2 protons) is absorbed, energy is released
- Elements are created going up periodic table in steps of 2

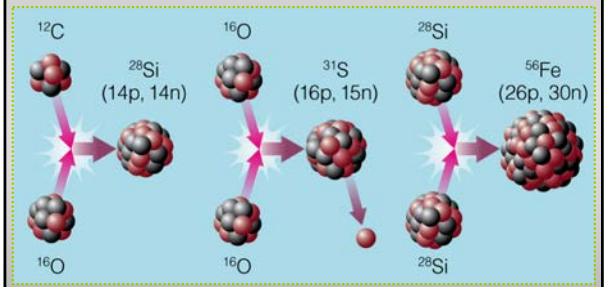
Creation of elements from He-capture: evidence



Even numbers favored !

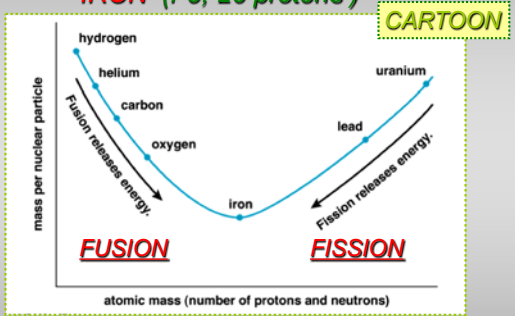
- Mixture of elements in our near universe follows the pattern of He-capture fusion reactions, up to iron
- Even heavier elements are made by nucleosynthesis during supernova explosion

A few of many other fusion reactions also feasible in high-mass stars



"Onion-shell fusion burning" stops with IRON (Fe, 26 protons)

CARTOON



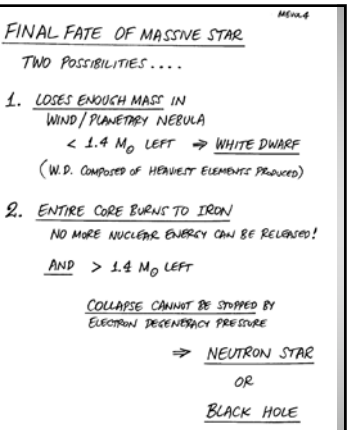
Iron does NOT release energy when it fuses !

Several fates for massive star

1. Strong winds shrink star, may end as WHITE DWARF

2. Or core burns to Fe, eventually sudden CORE COLLAPSE !

⇨ SUPERNOVA



Now on to travels within our galaxy with the big-sky of the planetarium

… and then the black-holes program