Friday, February 13, 2015

Astronomy in the news?

Launch of DSCOVR (Deep Space Climate Observatory: “GoreSat”).

On its way to special orbital point (Lagrange point, we’ll talk about later), but high waves prevented landing, recovery of booster.

The universe may have existed forever, according to a new model that applies quantum correction terms to complement Einstein's theory of general relativity. The model may also account for dark matter and dark energy, resolving multiple problems at once.

Chapter 14!

NASA releases photos, video, of the back side of the Moon

Goal:

To understand how pressure is created in stars, how thermal pressure controls the evolution of normal stars, and why quantum pressure makes white dwarfs liable to explode in some circumstances.

Stars with mass less than about 8 solar masses are supported by **thermal pressure** on the main sequence and during the thermonuclear burning of helium to make carbon and oxygen.

By the time the carbon/oxygen core forms, it is dominated by the **quantum pressure**, independent of temperature, basically a white dwarf waiting to be born when the envelope is ejected as a planetary nebula.

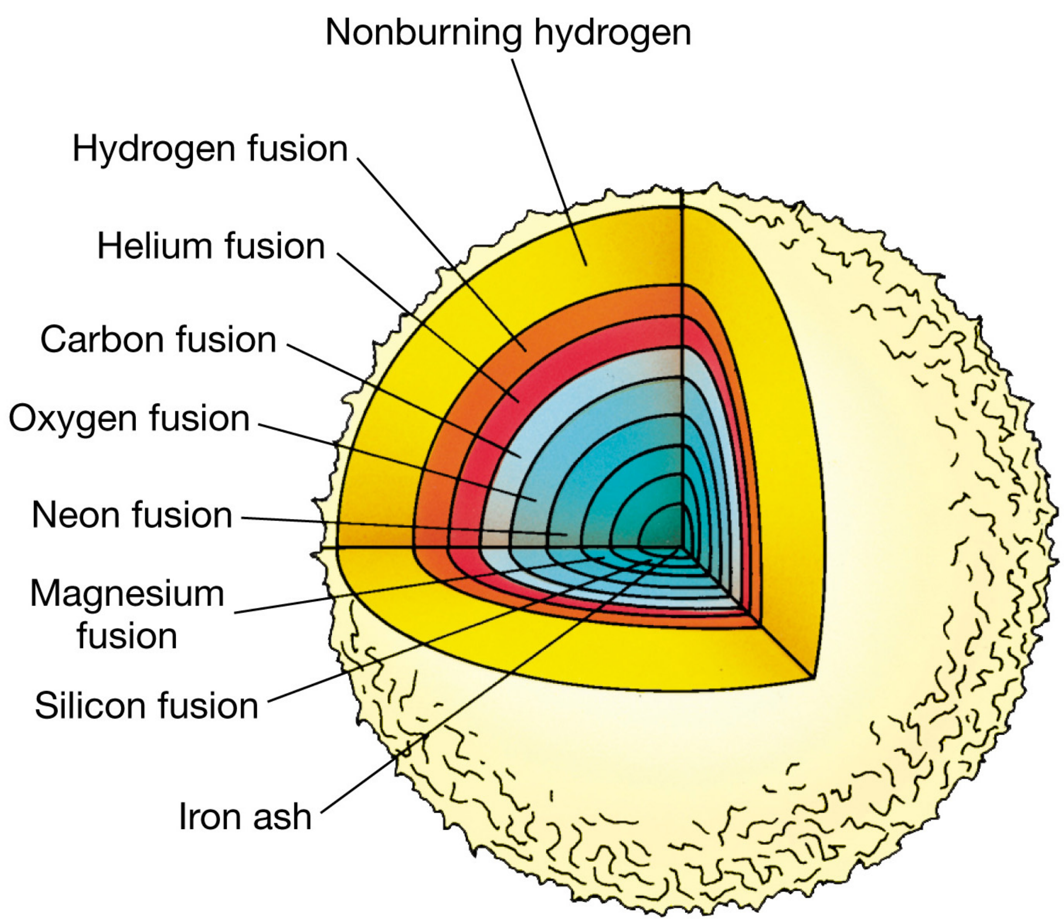
Stars with mass more than about 12 solar masses are always supported by the **thermal pressure**, not the quantum pressure, until they die.

Red giant envelopes are always supported by **thermal pressure**.

Between about 8 solar masses and about 12 solar masses, transition between thermal pressure and quantum pressure, complicated, won't discuss in any detail.

Goal:

To understand the roles of thermal pressure, charge repulsion, and the strong nuclear force in controlling the way massive stars evolve.



Evolution of Stars - gravity vs. charge repulsion § 2.1

Discussion point: Why do you have to heat a fuel to burn it?

H → He → C → O
more protons, more charge repulsion, must get ever hotter to burn ever "heavier" fuel

Just what massive stars do!
Support by thermal pressure.
When fuel runs out, **core loses energy**, but gravity squeezes, core contracts and HEATS UP
overcomes higher charge repulsion, burns new, heavier fuel, ***until get to iron***

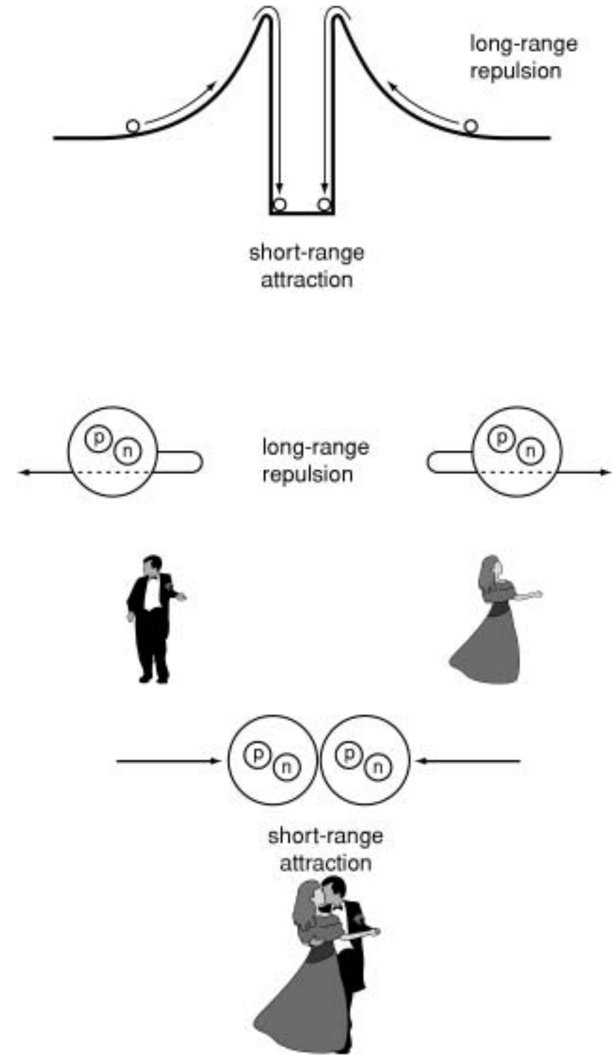


Figure 2.1

Massive stars make a succession of heavier elements

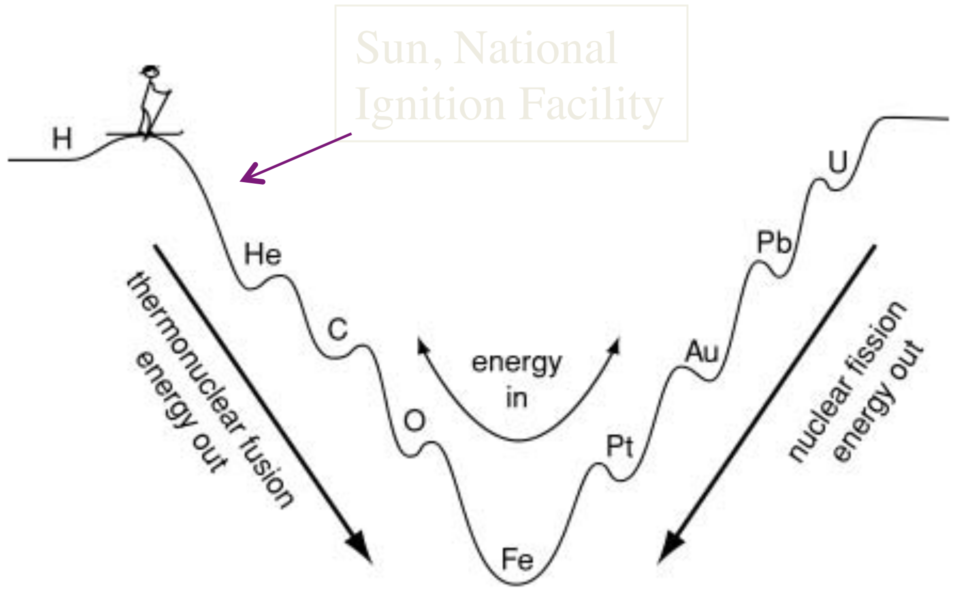
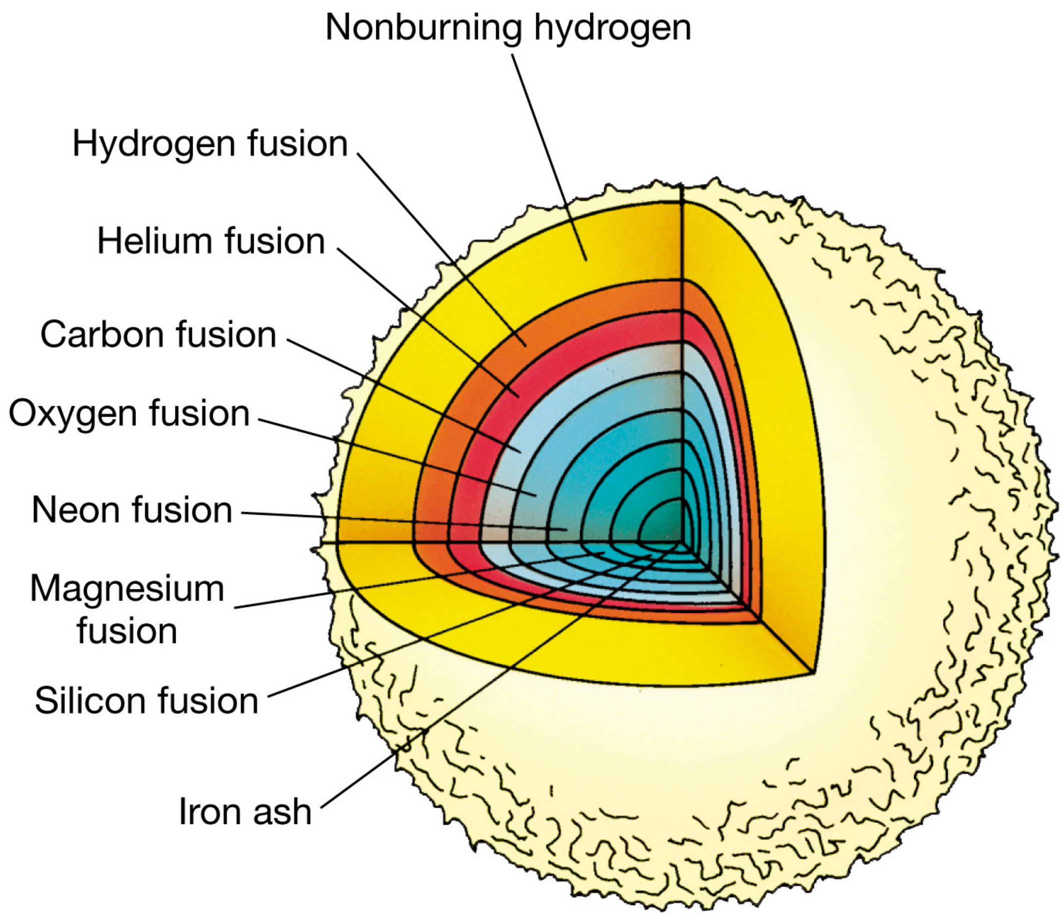


Figure 2.3 measure of binding energy of protons and neutrons in the atomic nucleus

Special role of Iron - 26p, 30n, most tightly bound arrangement of protons and neutrons.

Endothermic - must put energy in to break iron apart into lighter elements or to forge heavier elements. Irons absorbs energy, lowers pressure, core contracts, iron absorbs more energy, more contraction…

=> The iron core quickly collapses! Catastrophic death of the star.


Nonburning hydrogen
Hydrogen fusion
Helium fusion
Carbon fusion
Oxygen fusion
Neon fusion
Magnesium fusion
Silicon fusion
Iron ash

One minute exam

Why do you have to heat a nuclear fuel to make it burn?

➡ Charge repulsion keeps nuclei apart

⬅ The strong nuclear force keeps nuclei apart

⬆ To break chemical bonds

⬇ To break apart iron

Goal

To understand what happens after a massive star forms an iron core

Iron core of massive star absorbs energy.

When iron core forms - star is doomed to collapse.

Iron core collapses in about 1 second to form a ***neutron star*** (or maybe a black hole), composed essentially of all neutrons. Neutrons are formed when protons and electrons combine.

$p + e \rightarrow n + \nu$ ***neutrino***,

Action of Weak Nuclear Force (Chapter 1.2)

One neutrino is generated for every proton that is converted, a star's worth of protons

$\Rightarrow$***lots of neutrinos***

During iron core collapse, essentially all protons and electrons are converted to neutrons with the emission of a ***neutrino.***

Neutrinos have a tiny mass, no electrical charge, interact little with normal matter, only through weak nuclear force (Chapter 1.2).

Normal stellar matter is essentially *invisible* to neutrinos.

$\Rightarrow$99% of the energy of collapse is carried off by neutrinos
(Ch 1.2, 2.1, 2.2)