Wednesday, February 8, 2012

Exam back, key posted

Reading Chapter 6 (continued) Sections 6.4, 6.5, 6.6, 6.7 (background: Sections 1.2, 2.1, 2.4, 2.5, 3.3, 3.4, 3.5, 3.10, 4.1, 4.2, 4.3, 4.4, 5.2, 5.4)

Astronomy in the news?

News:

Make succession of heavier elements

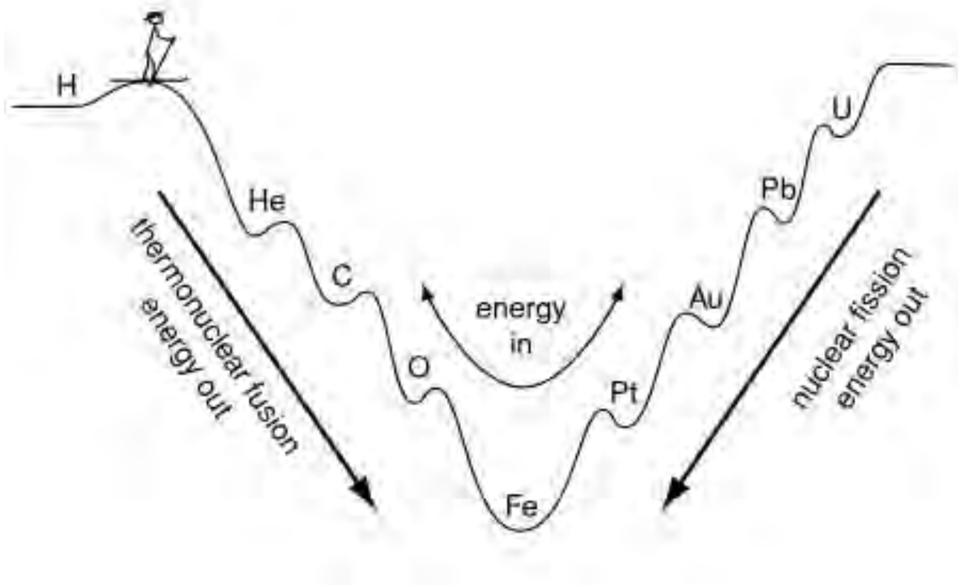


Figure 2.3 measure of binding energy of protons and neutrons in the atomic nucleus

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.

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 make neutrons

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 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 energy of collapse is carried off by neutrinos
(Ch 1.2, 2.1, 2.2)

Collapse leads to a neutron star.

Neutron Star - mass of Sun, but size of small city, ~ 10 kilometers in radius, density of atomic nucleus.

Huge gravity - surface is now ***much closer*** to the center!

One minute exam

What is the importance of iron in massive stars?

➡ It produces a great deal of energy

⬅ It absorbs energy

⬆ It produces neutrinos

⬇ It combines with oxygen and produces rust

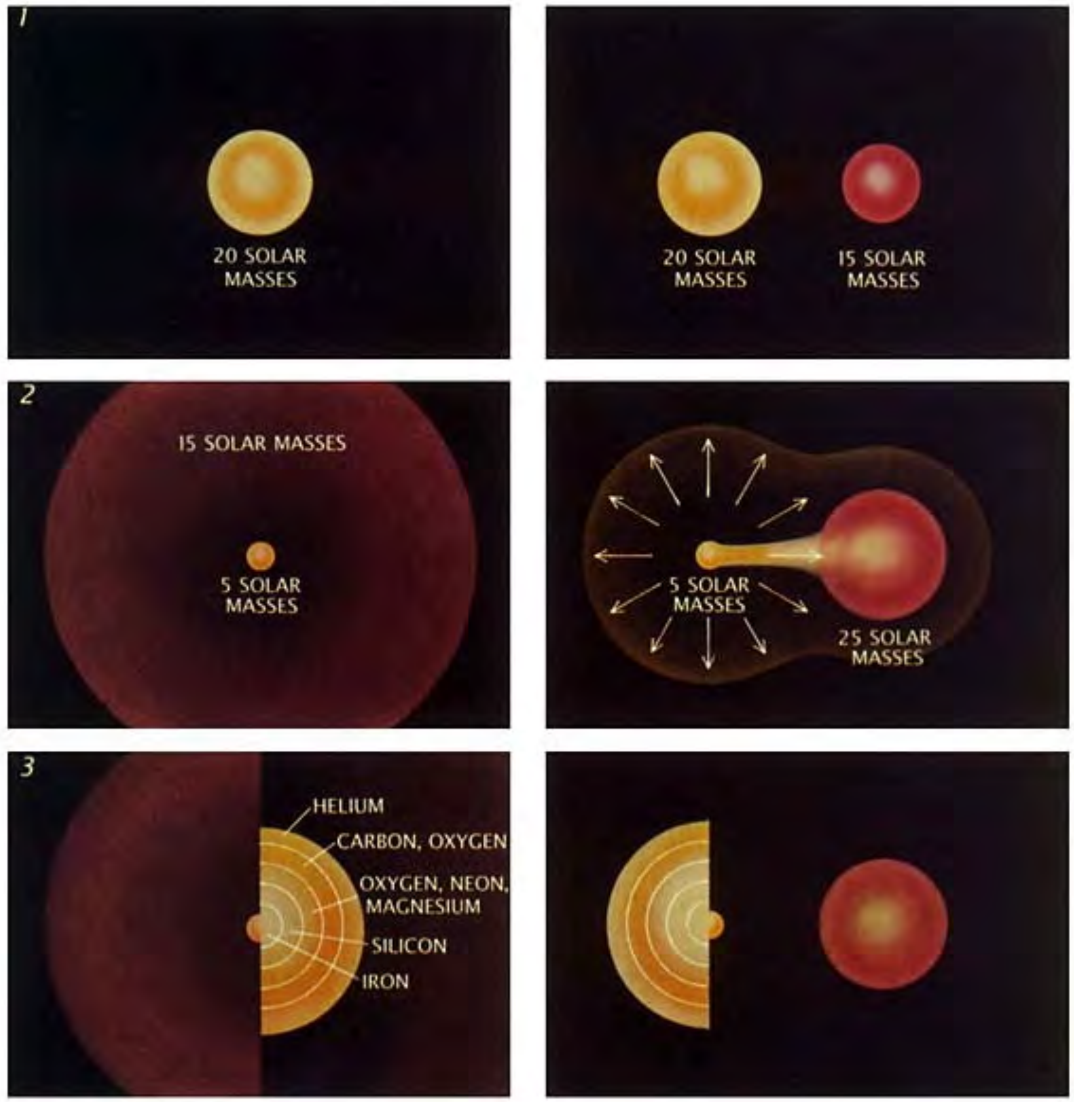
Goal

To understand how the iron core process works in Type II, Type Ib, and Type Ic supernovae.

To understand how they are alike and why and how are they different.

Single star: Type II   Same star in binary: Type Ib/c

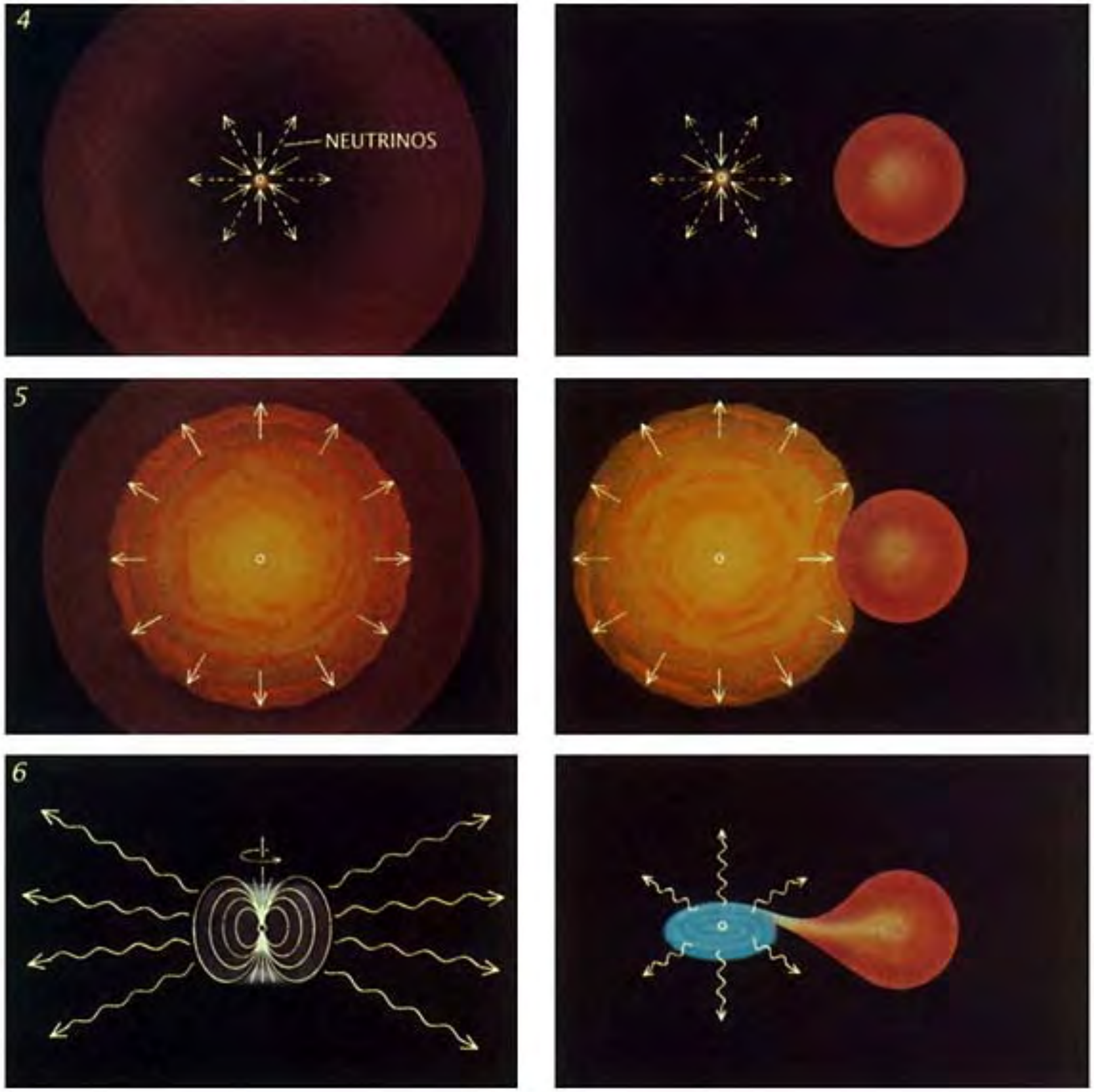
Same evolution inside star, thermal pressure, regulated burning, shells of heavier elements, *whether hydrogen envelope is there or not*.



Single star: Type II   Same star in binary: Type Ib/c

Both types leave behind a neutron star

Rotating, magnetic radio pulsar.



Neutron star in binary system, X-ray source

One minute exam

What is the importance of neutrinos in massive stars?

➡ They cause the collapse of the iron core

⬅ They carry off most of the energy of collapse

⬆ They convert electrons into protons

⬇ They inject energy into the explosion

Goal

To understand how the collapse of an iron core can trigger a supernova explosion

When a neutron star forms, get huge energy from dropping from size of Earth or White Dwarf to size of Austin.

100 times more energy than is needed to explode off the outer layers of the massive star.

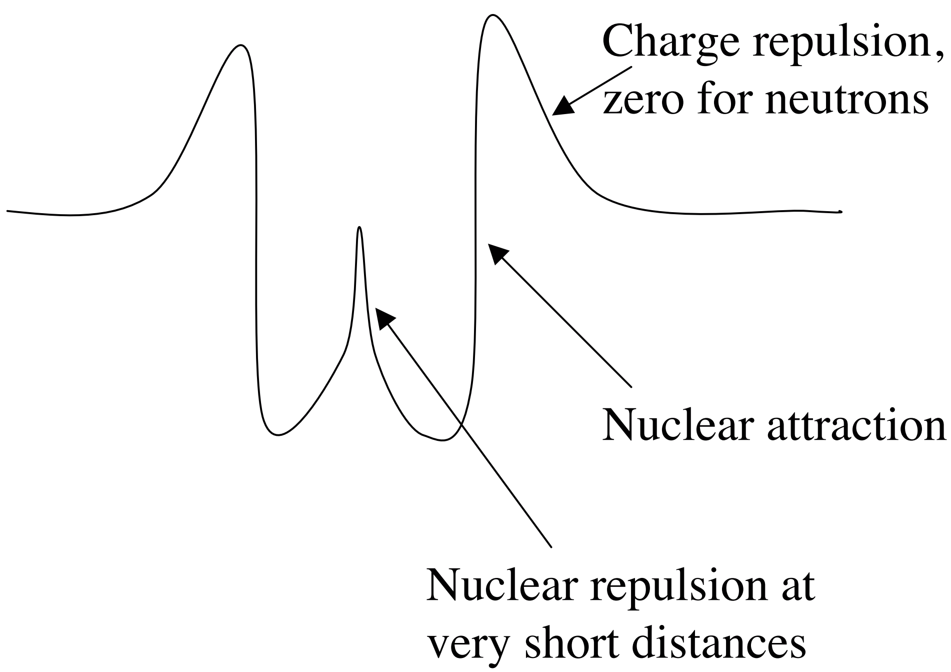
That does not guarantee an explosion!

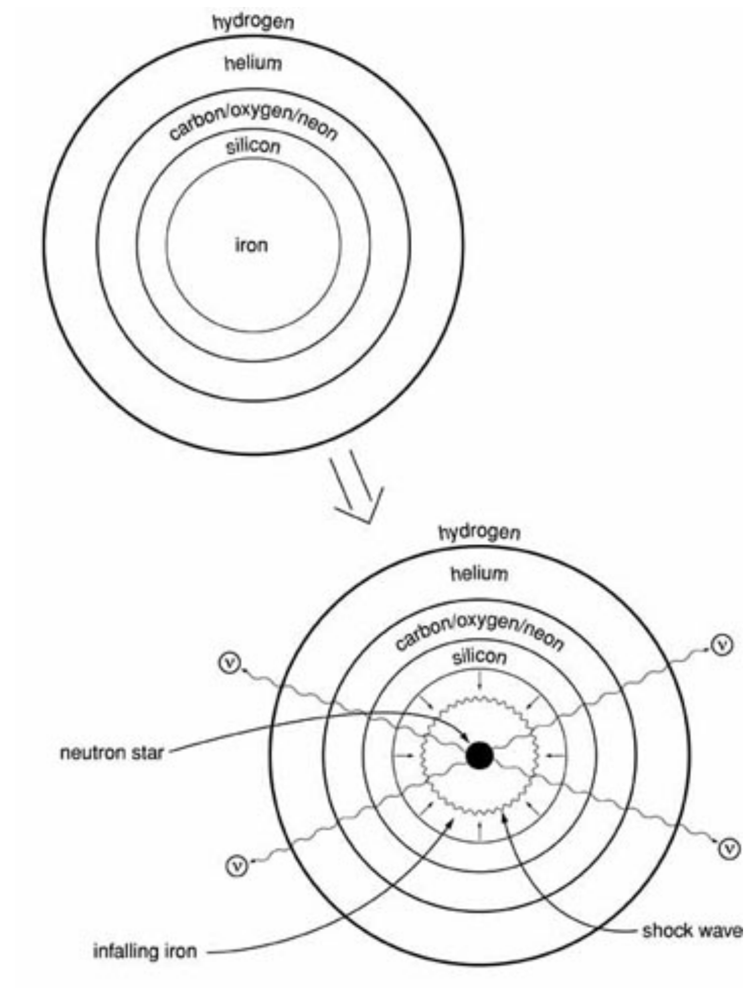
The outer parts of the star, beyond the neutron star, are ***transparent to the neutrinos***, the neutrinos flood out freely and carry off most of the energy, about 99%.

Is 1% of the neutrino energy left behind to cause the explosion?

Tough problem! 1.5% is plenty, 0.5% is too little.

Collapse is halted by the repulsive nuclear force (somewhat uncertain) + quantum pressure of neutrons





Maximum mass of a neutron star is 1.5 to 2 solar masses