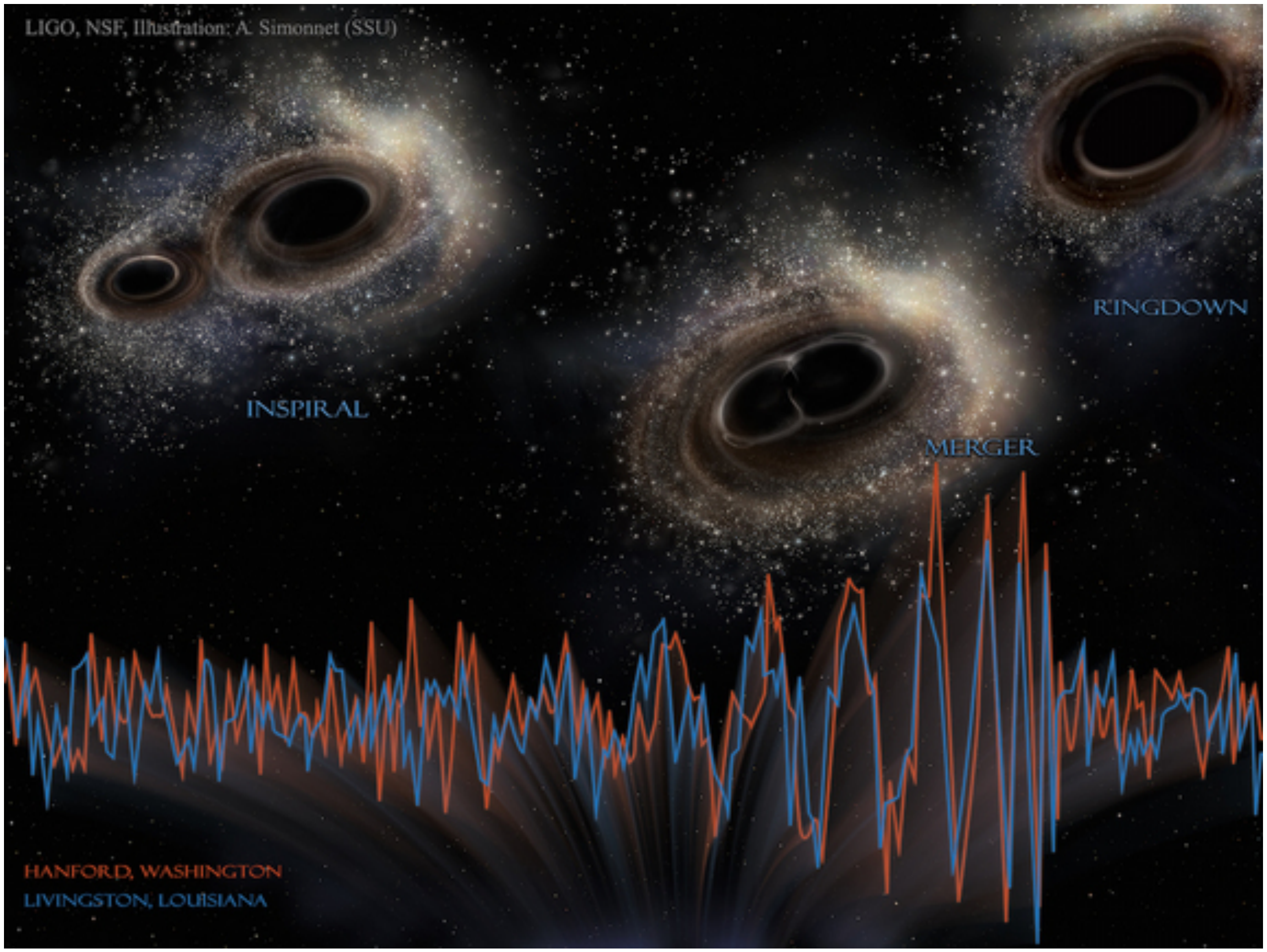
Friday, February 12, 2016

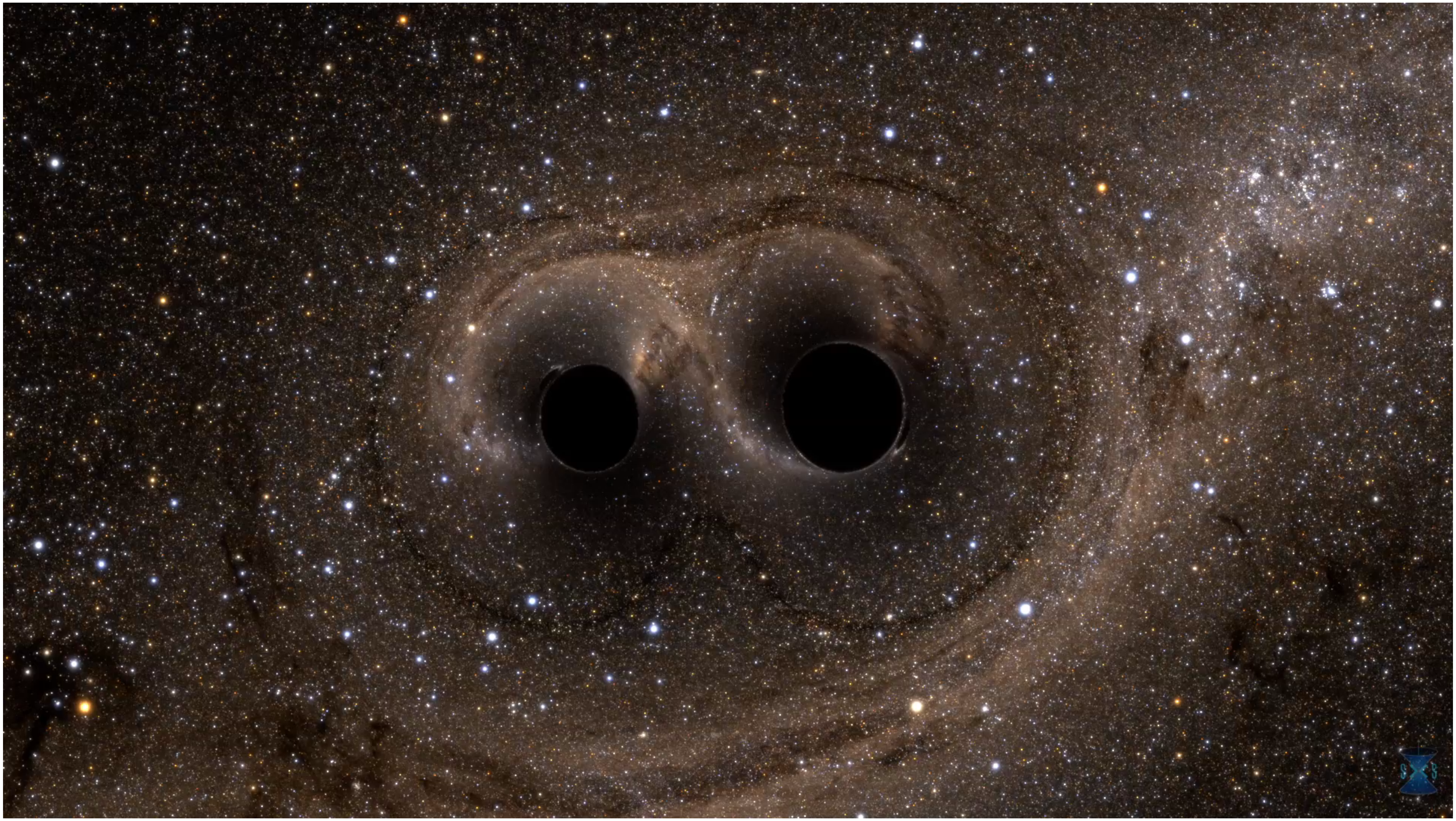
Astronomy in the news?

HUGE news on Thursday!

Success in 40 year effort to detect gravitational waves!
Predicted by Einstein 101 years ago.




Two massive black holes (36 and 29 solar masses) spiral together and merge in about ½ second, 1.3 billion light years away.



Triumph of engineering – measuring motion in detectors 1000 times smaller than a proton.

Triumph of numerical relativity – the ability to compute and predict in detail the gravity wave signal from inspiral and merging of two black holes.

30 Solar mass black holes?

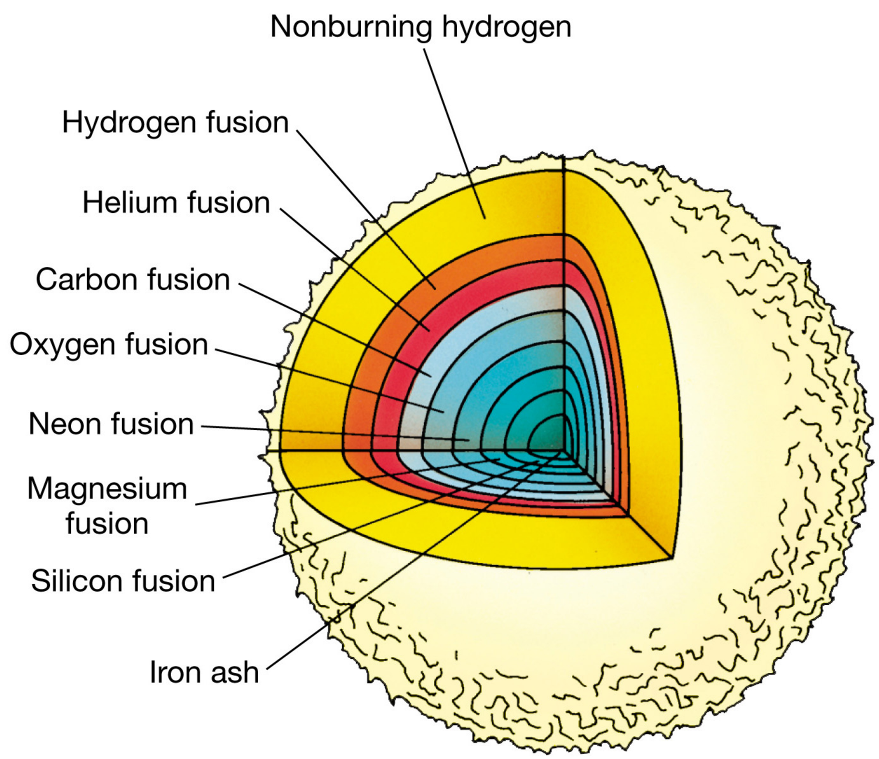
Yet to cover in class:
Binary star evolution
Einstein’s theory
Gravitational waves
Black holes in theory and fact

Check out:
https://www.youtube.com/watch?v=I_88S8DWbcU

Goal: to understand the origin of Type II, Ib, Ic

How does a massive star get from hydrogen to iron, and why iron, and what then?

Reading: Chapter 1, Section 2.1 (forces, neutrinos), Chapter 2, Section 2.1, 2.4, 2.5, Chapter 6, Sections 6.4, 6.5 (jets, but not polarization), Betelgeuse interlude, end of Chapter 6.



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.

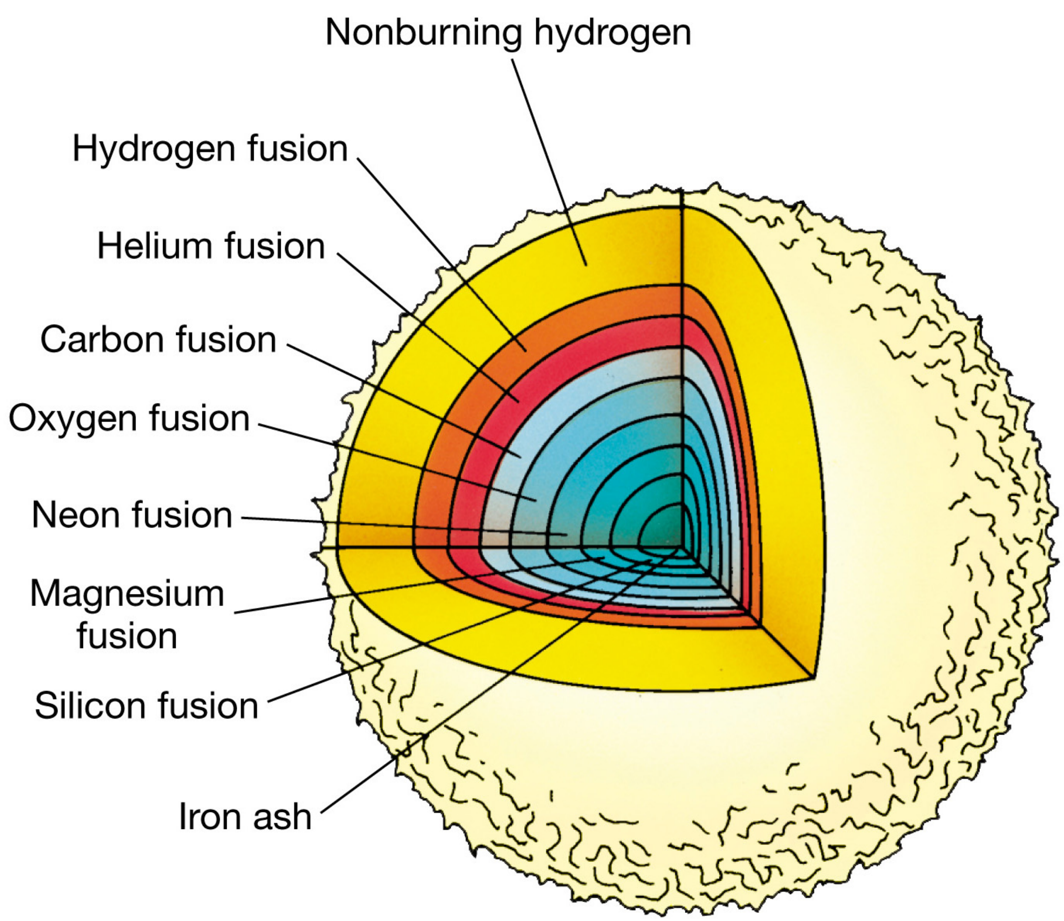
Stars with mass more than about 12 solar masses are always supported by the **thermal pressure**, not the quantum pressure, until they die.

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.



# Massive stars make a succession of heavier elements

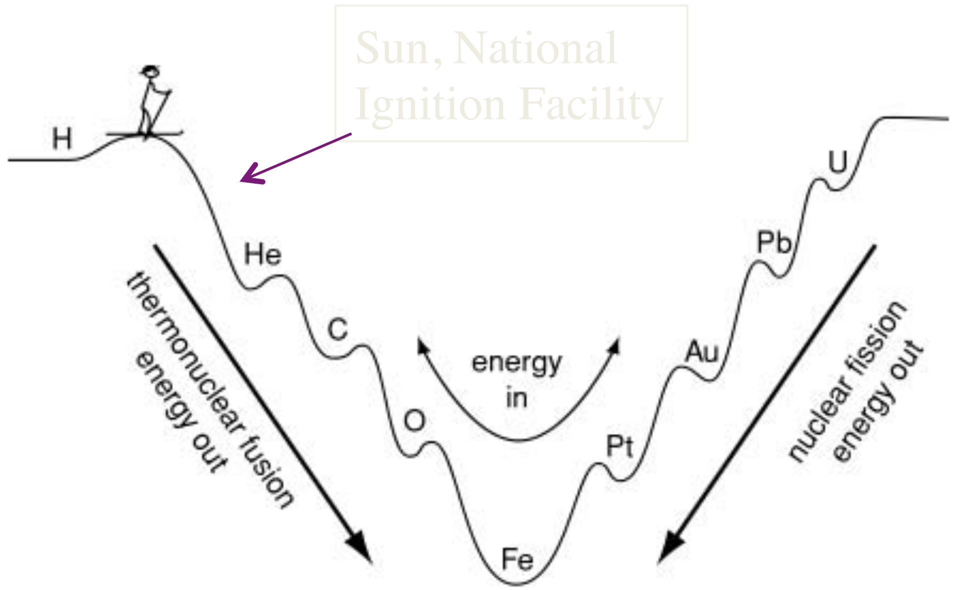


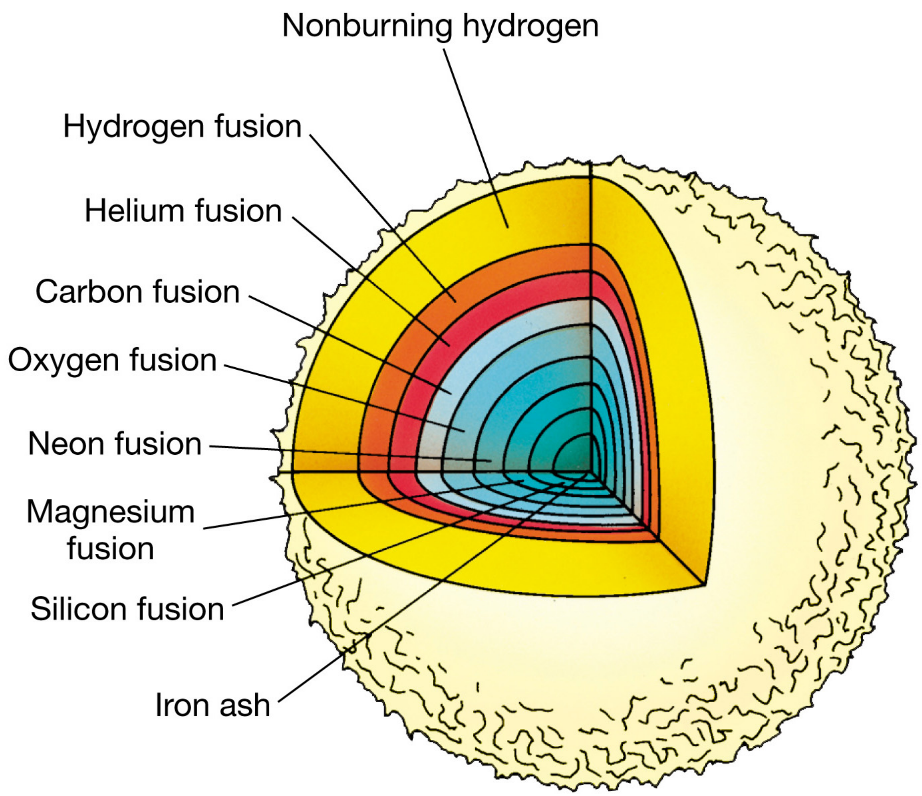

Figure 2.3 measure of binding energy of protons and neutrons in the atomic nucleus

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.

Massive stars form layers of ever heavier elements, eventually iron because they are always supported by the thermal pressure.




Charge repulsion does not provide the pressure to support the star, but it is critical in demanding that heavier fuels get hotter before they can burn, stars supported by the thermal pressure automatically do that.

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

One minute exam

What is the importance of iron in massive stars?

→ It produces a great deal of energy

← It absorbs energy

↑ It has more gravity than lighter elements

↓ It combines with oxygen and produces rust

## 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.

100x more energy is created in iron core collapse to a neutron star than is needed to explode the star

But

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