Monday, March 20, 2017

Reading for Exam 3:

Chapter 6, end of Section 6 (binary evolution), Section 6.7 (radioactive decay), Chapter 7 (SN 1987A), Background: Sections 3.1, 3.2, 3.3, 3.4, 3.5, 3.8, 3.10, 4.1, 4.2, 4.3, 4.4, 5.2, 5.4 (binary stars and accretion disks). Plus superluminous supernovae, **not in the book**.

Astronomy in the news?

Astronomical significance of today?

Happy Nowruz!

Goal – to understand the nature of a new class of superluminous supernovae

This material is NOT in the book!

Current Status of Superluminous Supernovae

Superluminous supernovae involve very massive stars.

They tend to occur in regions of active star formation in low mass, irregular galaxies.

Some show hydrogen, some do not.

Some show clear evidence for the shell-shock picture, some do not.

Some show evidence consistent with the Pair-Instability model and many solar masses of radioactive nickel, some are not consistent with that model.

Another actively discussed possibility is that the explosion is driven and illuminated by an especially rapidly rotating and highly-magnetized neutron star (a magnetar, Chapter 8).

Current Status of Superluminous Supernovae

Shell shock in shell of carbon and oxygen? Some very massive stars might eject their hydrogen and helium in strong winds, then eject shells of carbon and oxygen.

Some evidence for a shell rich in oxygen in one case.

If there is a single mechanism, then it is probably shell-shock, but perhaps there is more than one mechanism at work.

When there is a shell (and even when not), the underlying supernova is obscured, so difficult to determine the nature of the supernova explosion itself.

End of Material for Exam 3

Neutron stars

Alone and in binary systems

Reading Chapter 8 - Sections 8.1, 8.2, 8.5, 8.6, 8.10

Combination of quantum pressure from neutrons and repulsion of neutrons at very close distances by strong nuclear force $\Rightarrow$ pressure to withstand gravity.

Analog of Chandrasekhar mass - maximum mass of neutron star - uncertainty over nuclear repulsion, maximum mass ~ 2 $M_{\odot}$

Probably 100 million to a billion neutron stars in the galaxy, cold, tiny, and dark.

Nearest, undetected, may be only 10 light years or so away.

Vast majority of about 2000 known neutron stars are alone in space, detected as "pulsars."

~ 20 - 30 have binary companions, ordinary stars, white dwarfs, other neutron stars, and black holes.

Goal:

To understand how isolated neutron stars are observed as "pulsars."

Pulsars were discovered in the late 1960’s as very regular pulses of radio radiation, about 1 second apart.

The pulses were so regular that there was some early (private) discussion as to whether they might be from an extraterrestrial civilization (“little green men).

Further study showed they were a natural phenomenon, rotating, magnetic neutron stars.

Nobel Prize for discovery given to supervising professor, not the woman graduate student who actually discovered them.

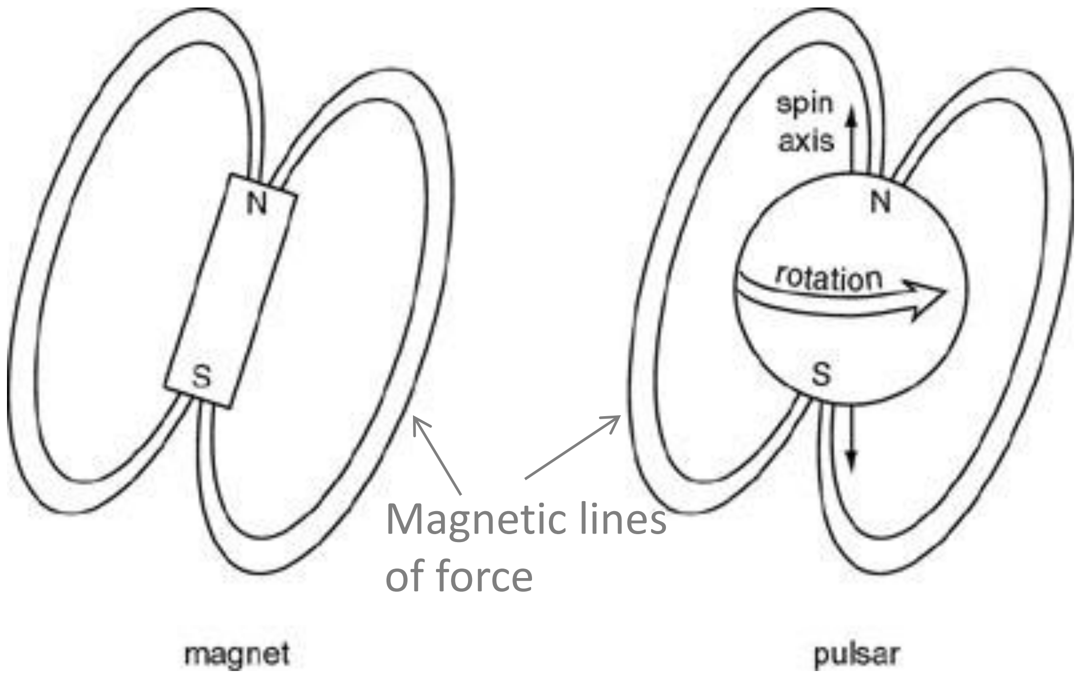
Two new principles of physics:

A moving magnetic field can can and will generate radiation.

Ionized gas, plasma, can move *along* lines of magnetic force, but cannot move *across* them. Magnetic fields will drag or channel plasma.

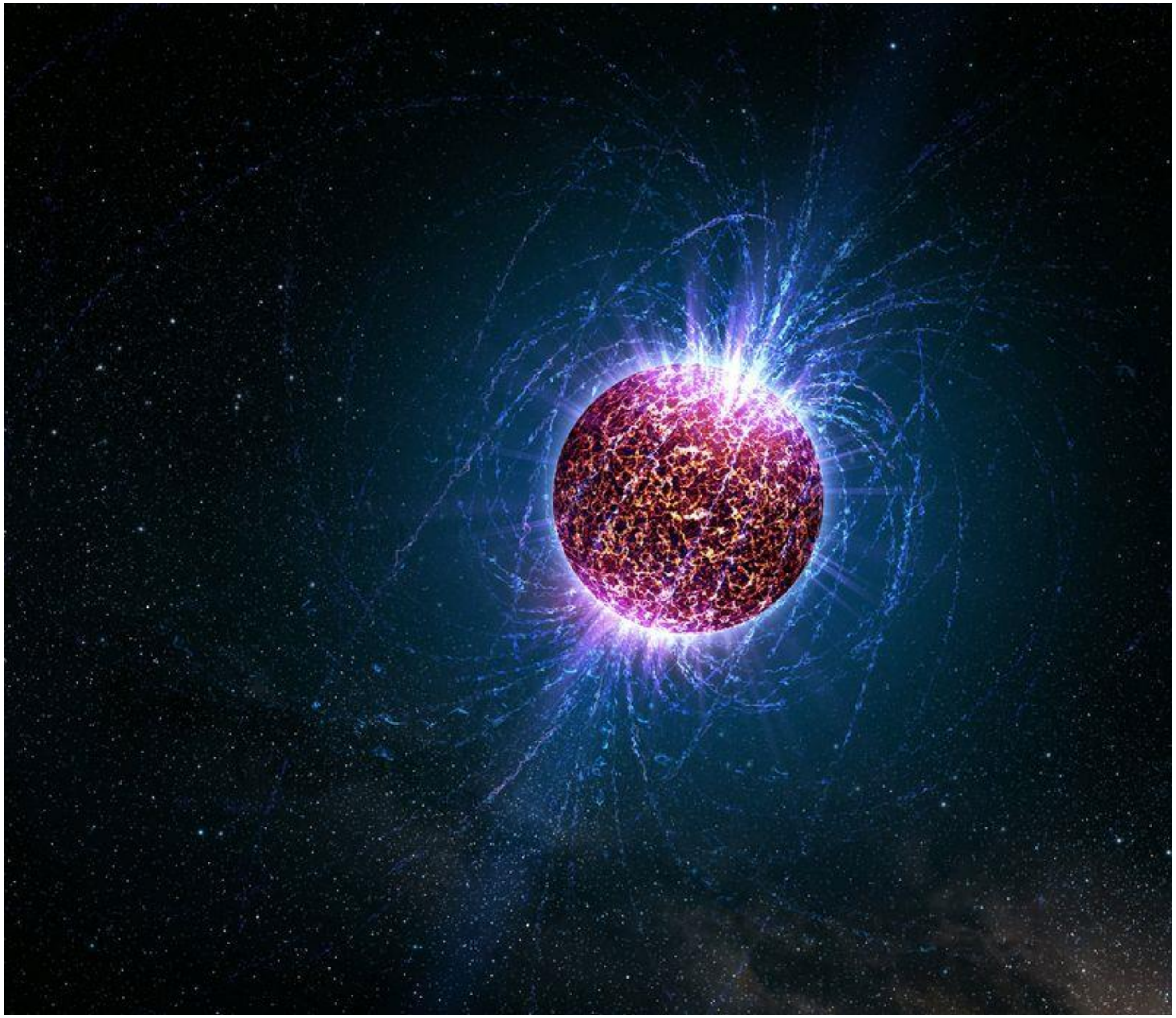
One possibility to explain pulsars - field axis is tilted.

Radio Pulsars could be rotating, magnetic neutron stars with magnetic axis **tilted** with respect to spin axis.



Most radio pulsars rotate about once per second, young ones faster, Crab pulsar rotates 30 times per second - would rip apart anything but a neutron star

Artist's conception of neutron star with tilted magnetic field.



Courtesy Casey Reed, Penn State University.
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Radio emission from "sparks" "thunderstorms," blobs of plasma, perhaps at tilted magnetic poles or "speed of light" circle

Tilted Poles: whip magnetic field around ⇒ huge electric fields create huge currents, "thunderstorms" ⇒ radio "static"

Blobs of plasma locked to magnetic fields lines, like beads sliding on a wire.

Speed of light circle - distance from rotation axis at which plasma whipped around by "stiff" magnetic field would be moving at the speed of light. The field and plasma must be disrupted there.

In either case, radiation is produced steadily from off-center blobs of plasma, see "pulses" by "lighthouse" mechanism

Flashlights

The neutron star itself does not pulse!