Monday, October 10, 2011

Reading: Section 6.7, Chapter 7, Chapter 8 - Sections 8.1, 8.2, 8.5, 8.6, 8.10

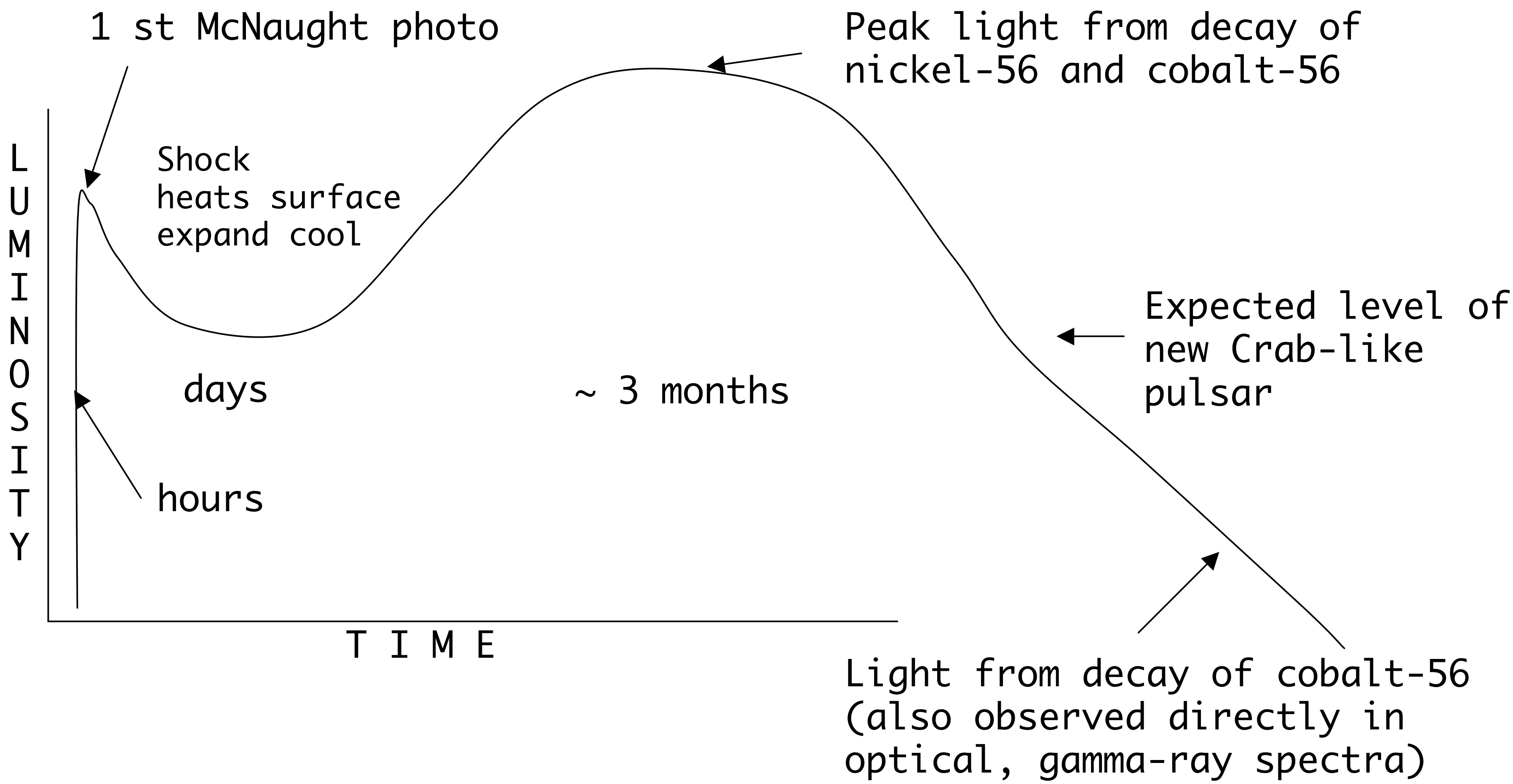
Manos new office RLM 16.308, starting Thursday

Astronomy in the news? Russian Soyuz rockets cleared for operation; should be able to launch to International Space Station on schedule.

Pic of the day: interesting sunrise in Buenos Aires

Goal:

To understand the nature and importance of SN 1987A for our understanding of massive star evolution and iron core collapse.



SN 1987A had a rather peculiar light curve because it was a relatively compact blue supergiant, not a red supergiant (not sure why, maybe in binary system), brief shock heating, rapid cooling by expansion, no plateau, subsequent light all from radioactive decay.

One Minute Exam

What was the most important thing about SN 1987A in terms of the basic physics of core collapse?

- ➡ It exploded in a blue, not a red supergiant
- ⬅ It was surrounded by a ring
- ⬆ It produced radioactive nickel and cobalt
- ⬇ Neutrinos were detected from it

Saw neutrinos, neutron star must have formed and survived for at least 10 seconds.

If a black hole had formed in the first instants, neither light nor neutrinos could have been emitted.

No sign of neutron star since despite looking hard for 24 years.

Whatever is in the center of Cas A, most likely a neutron star, is too dim to be seen at the distance of the LMC, so SN 1987A might have made one of those.

Also possible that after explosion and formation of neutron star, some matter fell back in and crushed the neutron star to become a black hole.

Dim neutron star or black hole? Still do not know.

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 ⇒ 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.

Vast majority of about 2000 known neutron stars are alone in space.

~ 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."

To radiate, radio pulsars must be rotating and ***magnetic***:

Wiggle magnetic field ⇒ wiggle electric field
⇒wiggle magnetic field ⇒ ***Electromagnetic radiation***

Simplest configuration North, South poles ***Dipole*** with “lines of force” connecting poles.

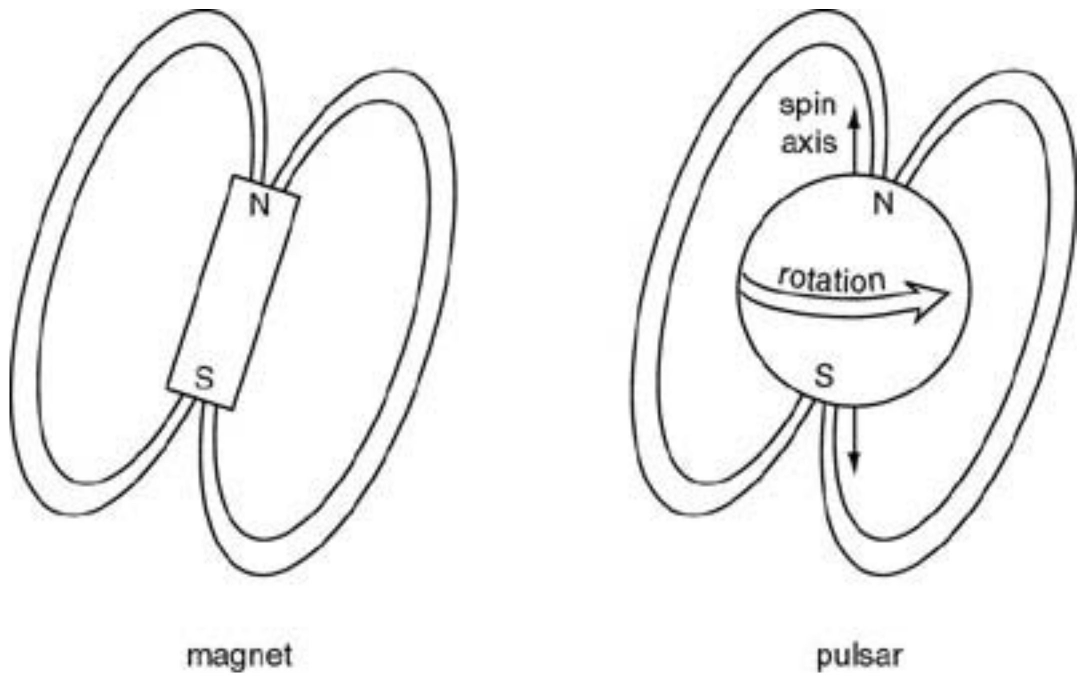
Ionized plasma can move along “lines of force,” not across them. Lines of force drag the plasma around like beads on a wire.

If the plasma blobs are aligned with the rotation axis, the system is too symmetric to “wiggle.”

If blobs of plasma are off-center from the rotation axis, they are whipped around by the rotating magnetic field and generate radiation. Magnet, filings

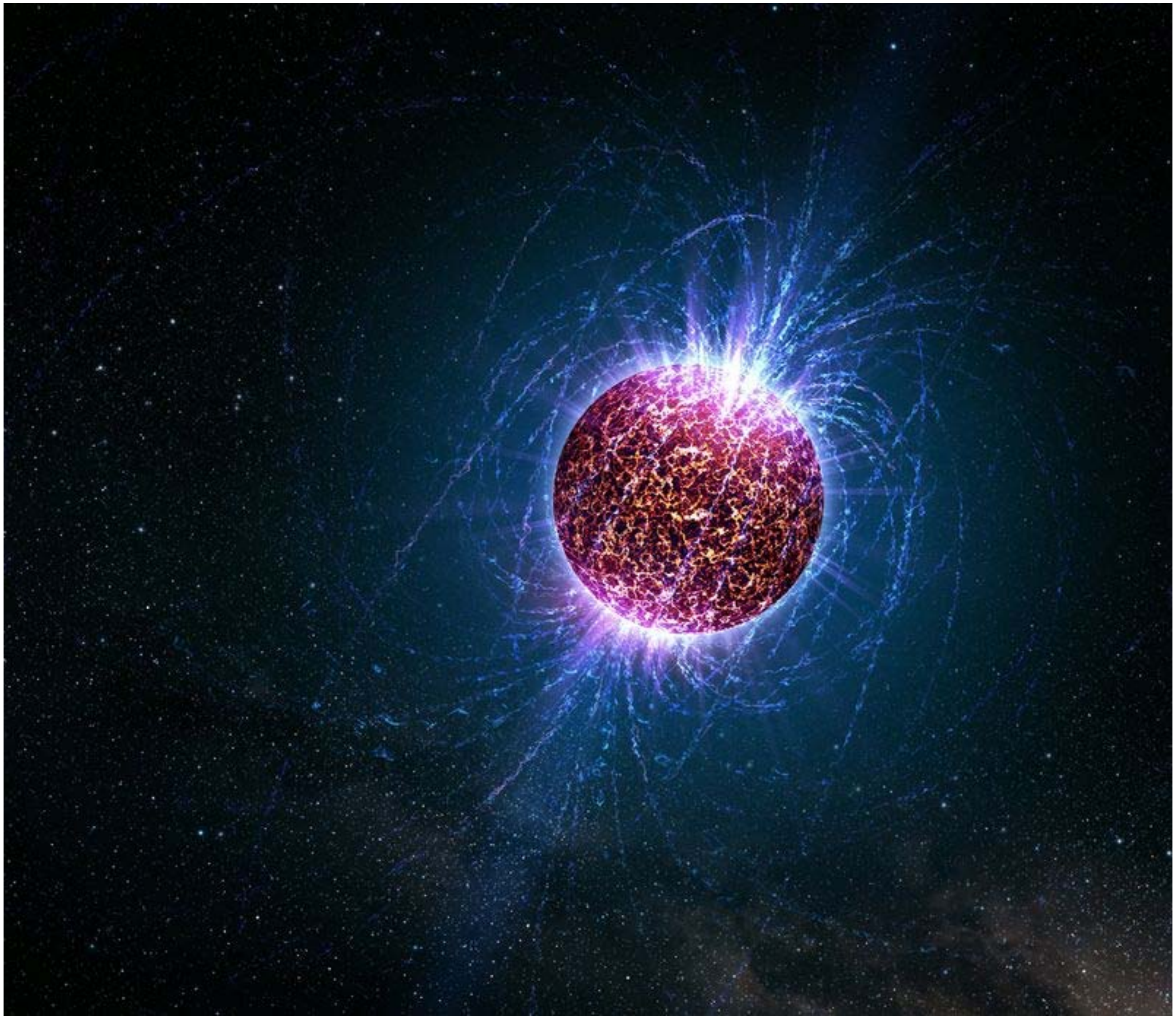
One possibility - field axis is tilted.

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 titled poles or “speed of light” cylinder

Speed of light cylinder - 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.

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

Radiation is produced steadily from off-center blobs of plasma, see “pulses” by “lighthouse” mechanism

Flashlights