October 11, 2010

Comment on Supernovas program

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

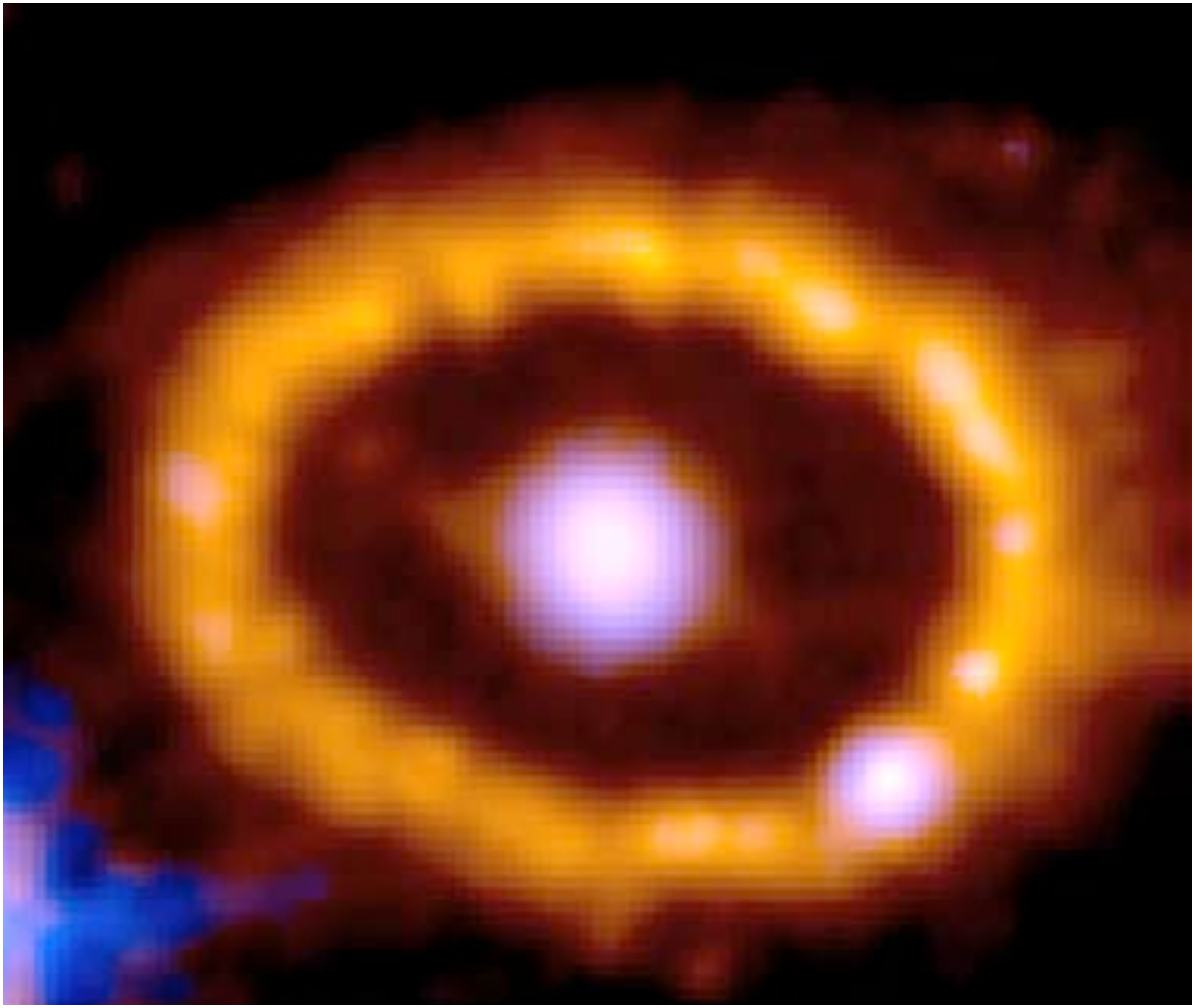
Astronomy in the News? Wheeler visited the Rio Grande Valley Teachers Association, South Texas Independent School District.

Pic of the Day – NGC 2683, spiral galaxy like the Milky Way in constellation Lynx, 20 million light years away

Goal:

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

Updated to 2010



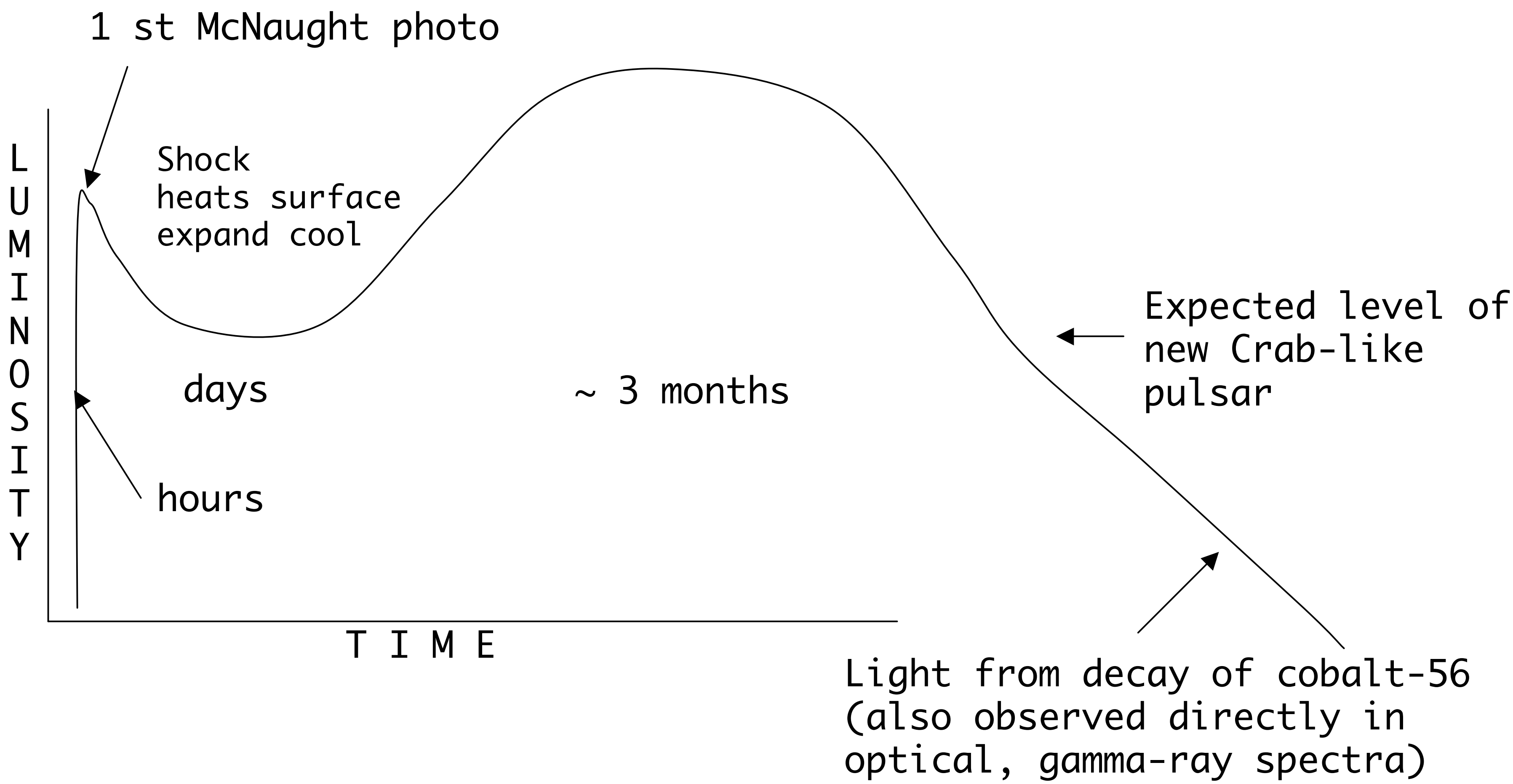
The single most important thing about SN 1987A is that we detected the neutrinos!

It was definitely a core-collapse event

10^{57} neutrinos emitted, most missed the Earth. Of those that hit the Earth, most passed though since neutrinos scarcely interact.

About 19 neutrinos were detected in a 10 second burst.

170,000 year history!

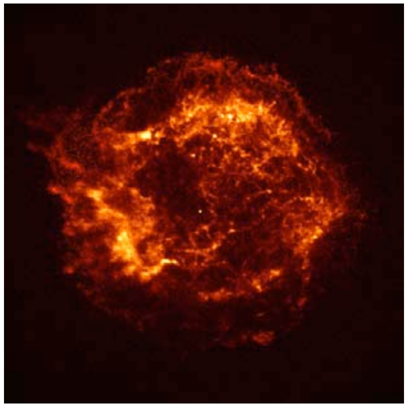


SN 1987A had a rather peculiar light curve because it was a relatively compact blue supergiant, not a red supergiant, brief shock heating, rapid cooling by expansion, no plateau, subsequent light all from radioactive decay

Neutrinos from SN 1987A proved a neutron star formed and lasted for at least 10 seconds while neutrinos were detected - where is it?

Expected to see it in ~ 1 year - still looking 23 years later

Any neutron star is dimmer by at least a factor of 10 than the 1000 year-old Crab pulsar



If similar to central object in Cas A, much too dim to detect, 100 to 1000 × dimmer than Crab pulsar

Possibly black hole, not neutron star??
Don't know. Can't rule out.

Neutron star could be "hidden," by dust, or be a slow rotator, or with a weak magnetic field (but counter to notion of jet - some evidence for jet), or a very strong magnetic field that would radiate and slow it down quickly.

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

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.

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 ***magnetic***:

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

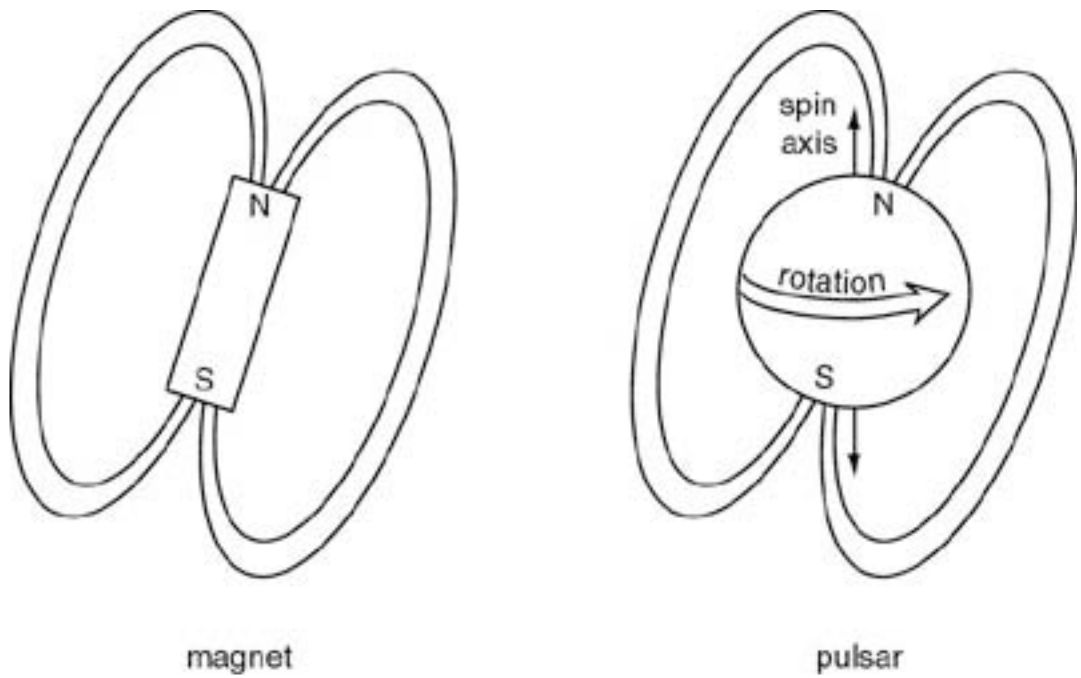
Simplest configuration North, South poles ***Dipole***
"lines of force" connecting poles

Magnetic axis must be ***tilted*** with respect to the rotation axis

If the magnetic axis is aligned with the rotation axis, the system is too symmetric to "wiggle"

Magnet, filings

Radio Pulsars are 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

Radio emission from “sparks” “thunderstorms” at 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.

Poles: whip magnetic field around $\Rightarrow$ huge electric fields create huge currents, “thunderstorms” $\Rightarrow$ radio “static”

Radiation is beamed from magnetic poles, see “pulses” by “lighthouse” mechanism

Flashlights