## 3/25/05

3/21 Chapter 6, Sections 5, 6
3/23 Chapter 7, Chapter 8, Sections 1, 2 (skip Sections 4, 5)
3/25 Chapter 8, Sections 6, 7 (skip Sections 8, 9) Section 10.

News:

Pic of the day

Huygens Lens



To radiate, pulsars must be magnetic:

Wiggle magnetic field  $\Rightarrow$  wiggle electric field  $\Rightarrow$ wiggle magnetic field  $\Rightarrow$  *Electromagnetic radiation* 

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

Magnetic axis must be tilted

If aligned, system is too symmetric to "wiggle"

Magnet, filings

Figure 8.1





magnet

pulsar

*Pulsars* are rotating, magnetic neutron stars with magnetic axis tilted with respect to spin axis.

Radio emission from "sparks" "thunderstorms" at poles or "speed of light" cylinder

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

Most pulsars rotate about once per second, young ones faster, Crab pulsar 30 times per second - rip apart anything but a neutron star 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 to neutron star - uncertainty over nuclear repulsion Maximum mass  $\sim 2-3 \text{ M}_{\odot}$ 

Vast majority of 600 pulsars are alone in space

dozen have binary companions

Binaries special - use Kepler's laws to measure mass

orbital decay ⇒ Grav Rad<sup>n</sup>
Nobel Prize 1993

Recent discovery 2 radio pulsars in eclipsing binary system,

fascinating new laboratory, extra information from eclipses.

Binary radio pulsars - no mass transfer, would kill radio mechanism.

With mass transfer  $\Rightarrow$  X-rays another story

Radio pulsars alone in space or in non-transferring binary

Other NS in binaries with mass transfer High gravity of NS, rapid motion in inner disk, great friction, heat => X-rays matter lands on, collides with NS Surface => X-rays

Uhuru satellite launched from Kenya 1972 - sky ablaze in X-rays Neutron stars and black holes in binary systems.

For strong magnetic field matter connects to, flows *along* lines of force (can't flow across field)
Automatically channels to poles - hot X-rays (kills radio) Rotation gives X-ray "pulses" by light house magnetism

Nobel prize to Riccardo Giacconi in 2002 for this and related discoveries.



Some neutron stars are in binary systems, they accrete mass through an accretion disk and produce *X-rays*.

Accretion onto tilted magnetic poles can give pulses of X-rays by "lighthouse" mechanism

<u>X-ray Transients</u> - flare every few years for a month or so: suspect *disk instability* like *dwarf novae*, but neutron star, not white dwarf.

<u>X-ray Bursters</u> - rise in about a second, decay in a minute, no "pulses," suspect low magnetic fields, Analog of *classical novae*, thermonuclear burning on surface of neutron star not white dwarf H is *thermally supported* - regulated burning H → He He, high density, *quantum pressure* - unregulated → *flash!* little matter expelled because of high gravity

One Case Both Phenomena

