

3/22/06

*Books? Sky watching? Monday's Film on Gamma-Ray Bursts*

*Reading Chapter 7, SN 1987A DONE*

*Chapter 8, Sections 1, 2 (skip Sections 3, 4), Sections 5, 6, 7 (skip Sections 8, 9) Section 10, (skip Section 11) Neutron Stars*

*Chapter 9 - Black Holes*

*Chapters from second edition posted on web site.*

News: WMAP satellite, record of cosmic background radiation, new view on evolution of young Universe

What was the astronomical significance of Monday??

Pic of the day; Enceladus



Extra Credit (5 points in term grade, half a grade)

Evening:

Orion with Betelgeuse is moving East, have to look earlier in the evening (before 11 ish to see it). Don't wait until the end of the term to do this.

Sirius A, brightest star in the sky, has white dwarf companion.

Cassiopeia - Location of Tycho's SN 1572, Cas A (not naked eye, but direction)

Taurus - direction of Crab Nebula/Pulsar (near Mars)

Algol

Andromeda - Andromeda Galaxy

Aries - SN 2006aj/GRB060218 (very early evening then sets)

Monoceros - Black Hole X-ray nova, Nova Mon

Midnight:

Vela - Vela SN, pulsar

Virgo - Virgo cluster of galaxies, supermassive black hole in M 87, nearby bright supernovae.

Centaurus - neutron star binary Cen X-4

Morning:

Scorpius - U Sco, recurrent nova, possible future SN Ia

Cygnus - direction of Cygnus X-1, most famous binary black hole, V404 Cyg another black hole binary

Ophiuchus - Kepler's SN 1604, recent outburst of recurrent nova, RS Ophiuchus

Hercules - binary neutron star Her X-1

## NEUTRON STARS (Chapter 8)

mass of Sun

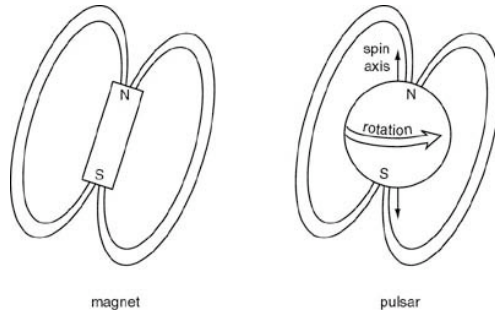
radius ~ 10 km

density like atomic nucleus (even a few times more!)

gravity at surface huge - crush human

highest "mountain" ~ 1 foot

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



Most pulsars rotate about once per second, young ones faster, Crab pulsar 30 times per second - would 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 of neutron star - uncertainty over nuclear repulsion, maximum mass  $\sim 2 M_{\odot}$

Vast majority of 600 pulsars are alone in space  
 $\sim$  dozen have binary companions

Binaries special - use Kepler's laws to measure mass  
 orbital decay  $\Rightarrow$  Gravitational Radiation 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 are alone in space or in non-transferring binary

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

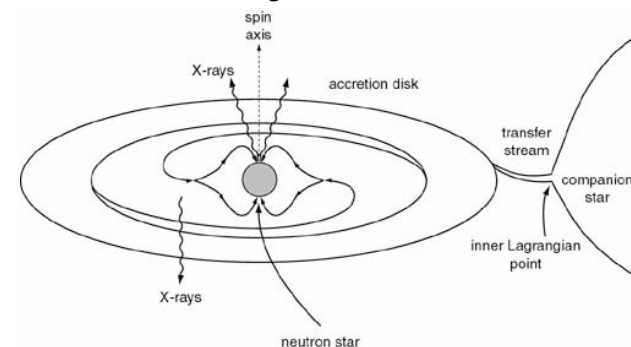
Uhuru satellite launched from Kenya 1972 found sky ablaze in X-rays  
 Neutron stars and black holes in binary systems.

For strong magnetic field matter connects to, flows *along* lines of force  
 (can't flow across field lines of force)

Automatically channels matter to poles - hot X-rays (kills radio)  
 Rotation gives X-ray "pulses" by light house mechanism.

Nobel prize in 2002 for this and related discoveries.

Figure 8.2



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