Reminders

1. Online Quiz Chapter 14 Opens Friday
2. Read Chapter 14
Lecture 28 — More Pulsars and Relativity
Lighthouse Model
Pulsar as Light House
As in the case of Earth, the magnetic axis of a neutron star could be inclined to its rotational axis.

The rotation of the neutron star will sweep its beams around like beams from a lighthouse.

While a beam points roughly toward Earth, we detect a pulse.

While neither beam is pointed toward us, we detect no energy.

Beams may not be as exactly symmetric as in this model.
Pulsars Produce Syncrotron Radiation
HST Visible Image
Crab Nebula: Composite Image

Composite image
Radio + visual + X-ray

© 2006 Brooks/Cole - Thomson
Neutron stars are produced by
(a) Type Ia supernovae
(b) core collapse of the iron core of a massive star
(c) novae on carbon/oxygen white dwarfs
(d) CNO burning in solar-type stars
Clicker Question

The bulk of neutron stars are made of

(a) neutrons of course
(b) iron
(c) neutrons, with some protons and electrons
(d) we have no idea
Clicker Question

• Pulsars are the result of
  (a) the rotation of a neutron star with a strong magnetic field
  (b) core collapse supernovae
  (c) little green men
  (d) we have no idea
All Neutron Stars Pulsars?
Puppis SN Remnant Isolated NS with $T = 700,000$ K
Binary Pulsar: PSR 1913+16
GR Proven

![Graph showing radial velocity vs. time for a binary pulsar system.](image_url)
FIG. 7: The binary pulsar PSR B1913+16. In (a) we see a snapshot of the spacetime distortion caused by the orbiting pair of pulsars, which are shown in (b) (with the pulsar sizes greatly exaggerated). In (c) we see the accumulated observational results from 1974-2005; the GR prediction is in blue, and the observations with red points. In (d) the effect of a large mass on a passing gravity wave is shown – the mass attracts the energy in the wave, so that the different parts of the wave start to move towards each other, eventually focussing and forming a caustic pattern.
X-Ray Pulsars: Hercules X-1

Period: 1.2 sec. Pulses disappear every 1.7 days
X-Ray Burster: WD and NS orbital period 11 minutes
Common Envelope removed by NS
Black Widow Pulsar
Spin up leads to millisecond pulsars

X-ray image (red/white) + visual image (green/blue)
Pulsar Planets

[Graph showing pulsar period variation and a diagram of a neutron star with orbits.]