Chandra X-Ray Observatory

Schematic of Grazing Incidence, X-ray Mirror

Field of View ±5 Deg

Focal Surface

10 meters

Mirror elements are 0.8 m long and from 0.6 m to 1.2 m diameter
Chandra X-Ray Observatory

Polishing a CXO Mirror Shell

CXO Mirror Fabrication

CXC
Chandra X-Ray Observatory

High Energy Grating (PI: C.Canizares)  Low Energy Grating (PI: A.Brinkman)
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HRC Detector (PI: S. Murray)    ACIS Detector (PI: G. Garmire)
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Orion Nebula, X-ray

Rosat HRI Observation

Chandra ACIS Observation
Neutron Star Equation of State

• Young neutron stars associated with historical remnants provide temperature vs. age data, if we can separate thermal component from magnetic and accretion effects.

• Cooling of neutron stars depends on processes in superfluid interior and core (pion condensation, strange matter, pinning of vortices, etc.)

• Absorption (or emission) features in X-ray spectra for isolated neutron stars (RXJ185635-3754) can provide M/R via gravitational redshifts and M/R² via pressure broadening of lines.

**Question**: Does gravitational settling float hydrogen (if any) to top resulting in feature-less X-ray spectrum? And/or will radiative levitation (seen in hot white dwarfs) allow metal features?

• Knowledge of M and R tests predictions of various equations of state.
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3C58 Parameters

\[ P = 65.67895 \text{ms (Chandra, Murray et al.)} \]

\[ \dot{P} = 1.94 \times 10^{-13} \text{ s/s (Chandra + RXTE ~ 3 yrs baseline)} \]

Spin Down Energy = \(-4\pi^2 I \dot{P}/P^3 = -2.6 \times 10^{37} \text{ erg/s}\)  
(assuming \( I = 1 \times 10^{45} \text{ gm cm}^{-2} \text{ s}^{-2} \) for 1.4 solar mass neutron star)

\[ L_{\text{neb}}^{\text{obs}} = 2.9 \times 10^{34} \text{ erg/s (0.1-10 keV)} \]
\[ L_{\chi}^{\text{pulsar}} (\text{observed}) = 2.5 \times 10^{33} \text{ erg/s} \]

\[ B_{\text{pulsar}}^{\text{surface}} = \sqrt{\frac{3c^3 I P \dot{P}}{8\pi^2 R^6}} = 3.6 \times 10^{12} \text{ G} \]
3C58 Parameters, cont.

\[ \tau = \frac{P}{(n-1)P} \left( 1 - \left( \frac{P_0}{P} \right)^{n-1} \right) \]

For \( n=3 \) (simple vacuum dipole) and \( P_0 \ll P \)

\[ \tau = \frac{P}{2P} = 5400 \text{ yrs} \]

Taking \( \tau = 820 \text{ yrs and } n=3 \)

\( \Rightarrow P_0 = 60.57 \text{ msec} \)

Similar Result for G11.2-0.3 (Kaspi et al.)

\( P = 65 \text{ ms} \quad \tau = 24,000 \text{ yrs} \)

\( \tau = 1615 \text{ yrs} \)

\( \Rightarrow P_0 = 62 \text{ ms} \)
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Perseus A

Hydra A

1E0658

A1795
Hydrostatic Equilibrium

\[
\frac{dP_{gas}}{dr} = - \frac{GM(< r) \rho_{gas}}{r^2}
\]

Ideal Gas Law

\[
P_{gas} = \frac{\rho_{gas} kT_{gas}}{\mu m_H}
\]

\[
M(< r) = - \frac{kT}{G\mu m_H} \left( \frac{d log \rho}{d log r} + \frac{d log T}{d log r} \right) r
\]

(or)

\[
M(< r) = - \frac{kT}{G\mu m_H} \left( \frac{d \rho / dr}{\rho / r} + \frac{dT / dr}{T / r} \right) r
\]
Chandra X-Ray Observatory

A1795 Mass Determination
Chandra X-Ray Observatory

Chandra Deep Field South

CXC
Constellation X-Ray Mission

quasar II at z = 3.7

Energy (keV)