RRAT J1819-1458
and its extended X-ray emission

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Rotating Radio Transients

- In 2006, a new class of neutron stars, the "Rotating RAdio Transients" (RRATs), is reported (McLaughlin et al. 2006).

- Characterized by repeated dispersed radio bursts

- Flashes are very short and rare: one hundredth of a second long

- The total time a RRAT is visible is only about 1/10th of a second per day.

- Periods ranging from 0.7 to 7 seconds

- Located in the Galactic plane at 2 – 7 kpc distances

- About ~70 RRATs found over the past several years in archival and new pulsar surveys (McLaughlin et al. 2009; Keane et al. 2011; Boyles et al 2011)

- The spin-down parameters with a tendency towards longer periods

- High magnetic fields ($2 \times 10^{12} - 5 \times 10^{13}$G) and ages from 0.1 to 4 Myr

- X-ray detections: only for RRAT J1819-1458.
Rotating Radio Transients

19 sources (red stars) with known P-derivative

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- Only RRAT with detected X-ray counterpart (Reynolds et al. 2006)

- Radio bursts detected every ~3 minutes, 2 glitches observed (Lyne et al. 2009)

- Anomalous glitch recovery, with net decrease in Pdot, suggesting a magnetar origin (Lyne et al. 2009).

\[ P_{\text{spin}} \sim 4.3 \text{ s spin period, age of } \sim 117 \text{ kyr and at distance of } \sim 3.6 \text{ kpc} \]

\[ B \sim 5 \times 10^{13} \text{ G } \Rightarrow B_{\text{crit}} = 4.4 \times 10^{13} \text{ G} \]

\[ \dot{E}_{\text{rot}} \sim 3 \times 10^{32} \text{ erg s}^{-1} \]

- No optical counterpart detected, possible IR candidate (Rea et al. 2010)

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RRAT J1819-1458

**Spectrum**

(Black points) absorbed blackbody

\[ N_H = 6(2) \times 10^{21} \text{ cm}^{-2} \]

\[ kT = 0.12(2) \text{ keV} \]

plus

1 keV absorption line (McLaughlin et al 2007, Miller et al. 2013):

- resonant cyclotron line
- due to NS atmosphere
- overabundance of Ne along the line of sight
Discovery of extended X-ray emission around this source (Rea et al. 2009)

0.3-10 keV image + annular region of 13"

Surface Brightness Radial Profile
RRAT J1819-1458

Chandra Observations

- ObsID 7645, 2008 May 31 for 30 ks
- ObsID 12670, 2011 May 28 for 90 ks

with the Advanced CCD Imaging Spectrometer (ACIS-S)
1/8 subarray S3

Time resolution ~0.4 s
Imaging

Combined Image 0.3-10 keV:
central source ~2.5” + extended emission ~20”

Surface Brightness Radial Profile

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Imaging Nebula's variability?

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Spectroscopy

**RRAT J1819-1458**

- $N_H = 6 \times 10^{21}$ cm$^{-2}$
- $T_{BB} = 0.130(2)$ keV
- $E_{\text{Gauss}} = 1.16(3)$ keV and $\sigma = 0.17(3)$ keV
- Flux (0.3-5 keV) = 1.35(2) erg cm$^{-2}$ s$^{-1}$
- Reduced $\chi^2 = 1.10$ (44 dof)

**NEBULA**

- $N_H < 7 \times 10^{21}$ cm$^{-2}$
- $\Gamma = 3.7(6)$
- Flux (0.3-5 keV) = 0.23(2) erg cm$^{-2}$ s$^{-1}$
- Reduced $\chi^2 = 1.26$ (19 dof)
Timing

- New *Chandra* X-ray observation folded using the radio ephemeris (Lyne et al. 2009).

- Confirming the sinusoidal X-ray modulation seen by *XMM-Newton* and *Chandra* (McLaughlin et al. 2007, Rea et al. 2009).

-Pulse Fraction:

XMM-Newton 2006 --> 34(6)%
Chandra 2008 --> 37(3)%
Chandra 2011 --> 31(4)%

-No long-term timing variability observed
Observational Summary

- Extended X-ray emission from 2.5 - 20 arcsec
- RRAT J1819-1458's spectrum:
  abs. BB (kT=0.130(2) keV) + 1 keV line
- Nebula spectrum: power law ($\Gamma=3.7(6)$)
- Pulsed emission at ~35%
- No spectral and timing long-term variability observed
- $\eta_x \equiv \frac{L_{pwn}(0.5-8 \text{ keV})}{\dot{E}_{\text{spin-down}}} \sim 0.2$ (high)
- $L_X > L_{\text{spin-down}}$
- Need of an additional source of energy
Possible Interpretations for the extended X-ray emission

a) Scattering halo

b) PWN

c) Magnetic Nebula?
   Examples: . 1E 1547-5408 (Sholtz & Kaspi, 2011)
   . Swift J1834.9-0846 (Younes et al. 2012; Esposito et al. 2012)

For RRAT J1819: only in the case of a Compton nebula (not in the case of synchrotron emission)

THANKS!!
RRAT J1819-1458

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