

ROSSI X-ray Timing Explorer detection of High Energy Rotation-powered Pulsars

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Summary

- ◆ Introduction - the role for RXTE in detecting and monitoring HE Pulsars.
- ◆ Recent results - New discoveries of HE Pulsars made possible by RXTE.
- ◆ A Future so bright - the unique role of RXTE in pulsar discovery.

Introduction

- ◆ X-ray band is important for discovering and monitoring pulsars with spin-down energies above $\dot{E} \gtrsim 4 \times 10^{36} \text{ erg s}^{-1}$,
- ◆ Necessary for pulsars lacking radio pulsation signal.
- ◆ Of the top 25 most energetic pulsars, nearly half have signals detectable by RXTE,
- ◆ Of these, 5 were in fact discovered using RXTE,
- ◆ RXTE particularly useful in detecting new pulsar, following up recently high-energy X-ray and gamma-ray sources.

Salient PCA properties for Pulsar Signal Searches

- ~ 2-60 keV X-ray energy band,
- ~ ~16% energy resolution at 6 keV,
- ~ 6500 cm² @ 10 keV, for 5 available PCU detectors,
- ~ Average ~ 3 PCU per observations,
- ~ ~100 us high time resolution in GoodXenon mode,
- ~ Field-of-view ~ 1 degree FWHM,
- ~ Mature calibration,
- ~ All-sky accessibility,
- ~ Flexible scheduling,
- ~ Available Director's Discretionary Time.

PSR J0537-6910: SNR N157B in the LMC

(Marshall et al. 1998)

- ~ Discovered while searching for signal from SN1987A
- ~ 16 ms signal located to N157B, strong radio and X-ray source in the 30 Dor region of the LMC,
- ~ Most energetic pulsar found, $\dot{E} \gtrsim 4.8 \times 10^{38} \text{ erg s}^{-1}$,
- ~ Most rapidly rotation-powered pulsar, $P = 16 \text{ ms}$,
- ~ 23 glitches/7 years (Marshall et al. 2004; Middleditch et al. 2006),
- ~ Largest glitches, $\delta\nu/\nu \lesssim 0.7 \text{ ppm}$, $\delta\dot{\nu}/\dot{\nu} \lesssim 750 \text{ ppm}$,
- ~ Predictable - next glitch \propto magnitude of last glitch.
- ~ Radio searches limits constrained by distance,
- ~ Unusually narrow X-ray pulse for a RP pulsar,

PSR J1400-6326: INTEGRAL located shell-type SNR containing a Bright PWN (Renaud et al. 2009)

- ~ PSR J1400-6326 located within the un-catalogued symmetric shell-type SNR G310.6-1.6,
- ~ SNR discovered in a Chandra survey of INTEGRAL sources,
- ~ Likely young SNR (< 1000 yr) and distant (> 6 kpc)
- ~ Bright X-ray/radio PWN $F_{\text{pwn}}/F_{\text{psr}} \sim 8$, (2-10 keV)
- ~ Spectral softening of PWN away from center, synchrotron burn-off,
- ~ No FERMI source or pulsed signal detected,
- ~ No radio pulsar with 2h Parkes observations.

PSR J0205+6449: Central Pulsar in SNR 3C58 (Murray et al. 2002)

- ~ 3C58 similar to the Crab, but ~ 1000 less luminous.
- ~ Subject of considerable interest and study (quark star?),
- ~ HRI + RXTE pulsar discovery, RXTE provided spin-down measurement,
- ~ SNR 3C58 likely young, historic SN1181 (828 yr),
- ~ Bright X-ray/radio PWN $F_{\text{pwn}}/F_{\text{psr}} \sim 8$, (2-10 keV)
- ~ Spectral softening of PWN away from center, synchrotron burn-off
- ~ No FERMI source or pulsed signal detected
- ~ No radio pulsar with 2h Parkes observations.

PSR J1846-0258: A 700 yr-old Pulsar in Kes 75 (Gotthelf et al. 2000)

- ~ Serendipitous discovery while searching a nearby magnetar signal,
- ~ Smallest spin-down age of all RP pulsars
- ~ Large spin-down implied B-field = 5×10^{13} G $>$ B_{QED} ,
- ~ Link between RP pulsars and magnetars?
- ~ HESS TeV detection,
- ~ No radio detection, limit 0.1 mJy @ 1.52 GHz

PSR J1838-0655: A Young Pulsar Associated with an TeV source

- ~ TeV emission lead to discovery of the PWN that powers it,
- ~ Displaced HESS source, relic electrons in low B-field region away from pulsar,
- ~ ASCA/IGR source long known,
- ~ Seed photons from nearby star cluster, possible birth place.
- ~ Possible second PWN within HESS TeV extended, X-ray faint, requires radio search

RXTE Rotation-Powered Pulsar Discovery Result Summary

- ~ All manifestly young, highly energetic,
- ~ Most energetic pulsar (N157B in the LMC)
- ~ Most rapidly spinning pulsar (same)
- ~ Limit-cycle glitches predictable star-quakes (same)
- ~ Magnetar-like behavior from a RP pulsar (Kes 75)
- ~ ASCA/INTERGAL/HESS ID'ed
- ~ Some FERMI !?!

Future Approach

- ~ To find new pulsars need multi-wavelength approach, now more than ever,
- ~ Energetic pulsars signaled by their PWN in radio/X-ray/GeV/TeV emission,
- ~ Faint radio searches can require 8 hrs,
- ~ Minimum flux strongly depends on spectrum.
- ~ Wish - Pulsar survey of the inner Galactic Plane, ~3x60 grid of overlapping ~30 ks GoodXenon pointed observations.