Towards a new synergy between X and $\gamma$-ray astronomies

Patrizia Caraveo

In collab. with A. DeLuca, M. Marelli, G. Bignami
γ-ray astronomy: last century view

- 271 sources
- 172 UGO

- Active Galactic Nuclei
- Unidentified EGRET Sources
- Pulsars
- LMC
- Solar FLare
- E > 100 MeV
The current $\gamma$-ray view
A lot of new NS detections

- Many radio pulsars- (expected)
- Many msec radio pulsars- (less expected)
- Many Geminga-like NSs (expected?)
When it comes to discover pulsations, can LAT do all by itself?

Are X-ray observations useless?

YES and NO
Time Differencing Technique

A Periodic signal will also show up in the differences of the arrival times => Calculate FT based on the time differences


# of FFT bins = \( f \times t_{\text{max diff}} \times 2 \)
PC with 2GB can handle \( 33 \times 10^6 \) bin FFT

Credit: M. Ziegler
The CTA-1 supernova remnant

Radio map

3EG J0010+7309

Fermi-LAT

RX J0007.0+7302 (very faint!)

90 arcmin diameter
5-15 kyr old
1.4 ± 0.3 kpc

No optical counterpart (R>25.1)
No radio counterpart

E\text{rot}=4.5 \times 10^{35} \text{erg/cm}^2 \text{s}

\tau \sim 14 \text{ kyr}
The role of X-ray astronomy

Source position

Swift/XRT observations of all unexplored fields

11 PSR observed
4 possible counterparts

Source physics

XMM-Newton / Chandra follow-up of most interesting PSRs

CTA1 PSR
“Next Geminga”
XRT image of J0633
The role of X-ray astronomy

Source position

Swift/XRT observations of all unexplored fields

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CTA1 PSR
“Next Geminga”
130 ks XMM-Newton observation

1) The PSR and the compact PWN

Discriminating PSR from PWN

- Spatial-spectral deconvolution
- Simultaneous spectral fit using different EEF coefficients for PSR and PWN
  - PSR (point-like) ∼ EPIC PSF
  - PWN (diffuse) ∼ Chandra map

PSR: BB+PL(?)
- $kT \sim 0.1$ keV,
- $r \sim 650$ m
- $\Gamma \sim 1.3$

Inner PWN: PL
- $\Gamma \sim 1.5$

Obs. flux $1.3 \cdot 10^{-13}$ erg cm$^{-2}$ s$^{-1}$ (0.3-10 keV) 60% PSR, 40% PWN

PSR: 20% th, 80% non-th
2) The extended plerion

Already seen by ROSAT & ASCA
(Seward et al. 1995, Slane et al. 1997)

No significant thermal component within EPIC FOV
Spectrum steepens with radius
3) Pulsations in X-rays

Search at LAT period yields significant detection

130 ks XMM not enough to detect pulsation in blind search!

Folding with LAT ephemeris

~80% pulsation below 0.7 keV

No evidence for modulation at E > 2 keV
3EG J1835+5918 a.k.a. “Next Geminga”

unfolded spectrum

A very faint, middle-aged INS

Brightest unidentified EGRET source off the plane

Deep MWL investigations possible radio-silent INS

LAT detection of pulsations!

$E_{\text{rot}} = 1 \times 10^{34}$ erg $s^{-1}$

$N_H = 1.8$ Myr

Variability issue – ruled out

2 XMM observations (15 ks each)

BB+PL spectrum ($kT \sim 60$ eV, $r \sim 1.5$ km, $\epsilon \sim 1.7$)

$N_H < 2.5 \times 10^{20}$ cm$^{-2}$

$F_X \sim 5 \times 10^{-14}$ erg cm$^{-2}$ s$^{-1}$ (50% non-th)

3EG J1835+5918 a.k.a. “Next Geminga”
The new role of gamma-ray astronomy

• Single out interesting NSs
The NEW role of X-ray Astronomy

• Position, position, position ➔ to secure detection

• Deeper observations ➔ to probe the emission mechanisms