IASF-INAF contributions on

Isolated Neutron Stars

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A NS is a source of

- Thermal emission (somewhat PULSED) from its (rotating) surface tiny radius, very high T optical/UV, soft X-ray

- Non thermal emission (strongly PULSED) from its (rotating) magnetosphere radio, optical, X-ray, γ-ray

- Non thermal emission (NON pulsed) from its surroundings radio, optical, IR, X-ray
NSs as X-ray emitters

~ 40 Classical NSs
~ 20 msec PSR

- Pulsed emission from virtually all objects
- Pulsed emission from 5 objects
- Pulsed emission from 2 objects + 1 outliers?

7 INSs
7 CCOs

• AXP, SGR
Our contributions

- Phase resolved spectroscopy (4)
- Search for new sources
- Binary system
- Detection of pulsation from RXJ1856.5-3754
- Detailed studies of 1E1207 and 1E1613, more CCOs
- 40 Classical NSs
- ~20 msec PSR
- 7 INSs
- 7 CCOs +
- AXP, SGR
Phase-resolved spectroscopy

Applied to PSRs with composite spectra

P.A. Caraveo, A. DeLuca, S.Mereghetti, A. Pellizzoni, G.F. Bignami
*Phase resolved spectroscopy of Geminga shows rotating hot spot(s)*
*Science, 305, 376, 2004*

A. DeLuca, **P.A. Caraveo**, S.Mereghetti, M. Negroni, G.F. Bignami
*On the polar caps of the three musketeers*
*ApJ 623, 1051, 2005*

A. Manzali, A. De Luca, P.A. Caraveo
*Phase Resolved Spectroscopy of the Vela Pulsar with XMM-Newton*
*ApJ. 669, 570, 2007*
4 similar objects

Unfolded EPIC spectra
and a somewhat different Vela
and Vela
PSR J1357-6429


We discovered its X-ray emission using XMM and CXO data.

- Very young: $P/2\dot{P} = 7.3$ kyr
  (9th youngest Galactic radio pulsar)
- Thermal emission
- Some evidence ($\sim 3\sigma$) of PWN
- Energetic ($E_{\text{dot}} \sim 3 \times 10^{36}$ erg s$^{-1}$) and nearby (2.5 kpc).

Hard $\gamma$-ray ($>100$ MeV) counterpart? To be observed with AGILE ...

Positionally compatible with the new gamma-ray source HESS J1357-645.
RX J0002+6246: a fake NS

Our analysis of the XMM data.

Position consistent with that of a bright (non-degenerate) star present in various optical/IR catalogues.

Absence of X-ray pulsation and no associated SNR.

X-ray spectrum well described by an optically thin plasma model with kT typical of stellar atmospheres.

Optical/IR colours and X-ray flux consistent with a nearby (0.2 kpc) F7-type main-sequence star.

⇒ RXJ is not a NS but rather a star!
Double neutron star system 0737-3039

Orbital p.: 2.4 h
eccentricity=0.09
Separation 3 sec.

PSR A: P=22.7 ms
$E_{\text{ROT}}=6 \times 10^{33}$ erg/s,
$\tau=210$ Myr
$B=6.3 \times 10^9$ G
1.337 $M_{\odot}$

PSR B: P=2.7 s
$E_{\text{ROT}}=2 \times 10^{30}$ erg/s
$\tau=50$ Myr
$B=1.2 \times 10^{12}$ G
1.25 $M_{\odot}$
Pellizzoni et al., submitted (XMM/EPIC, 250 ks, 5000 photons)

PSR A
PSR B (detected around ascending node of the orbit)
PSR B (detected around ascending node of the orbit)

But Edot is not enough
Pairs from A’s wind flow into the open field line region of B and lose energy via curvature radiation and IC $\gamma$-rays heating polar cap region.
INSs


No radio em.
Faint optical em.
Thermal spectra
Low T
Whole surface
Shallow puls.

Pulsed fraction: ~1.2%
CCOs

No radio emission
No optical emission
Thermal spectra
Small R, high T
EPIC view of 1E1207.4-5209 : 260 ksec
Pn data 208,000 photons

Bignami et al, Nature 2003
After a long debate, Gotthelf et al 2007 have shown that P is very stable.

Thus, $B < 3.5 \times 10^{11}$

$\dot{E} < 1.5 \times 10^{32} \Rightarrow L_x = 2 \times 10^{33}$

Fallback accretion???
CCOs as a class: slow rotators, low B neutron stars?

Fallback accretion fuels X-ray em. but hampers radio one.
The phenomenology of 1E1613

Genetically tied to a 2 ky-old SNR

Unique phenomenology

A young binary?

A peculiar INS?

De Luca et al, Science 313, 814, 2006
On the nature of 1E1613

A young binary?  
A peculiar INS?  
Binary system formation?  
Luminosity/variability from accretion?  
Analog of a Polar featuring a magnetar?  
Spin down by propeller effect on debris disc  
Unique phenomenology points to "braked magnetar"  
Spun down by fallback  
IR data allow for M6-M8 companion
NSs as Optical emitters

9 Classical NSs
1 msec
4 INSs
0 CCOs
Our contribution (over 10 y.)

- 9 Classical NSs
- 1 msec
- 4 INSs
- 0 CCOs

Discovery of 4 counterparts
Meas. of 5 PMs
Meas. of 2 parallaxes

Search for count.
1E1207
1E1613
Vela Jr.
HST PSRs gallery

PM & par

PM & par

PM & par

Geminga

PM & par

PM

PM

PM

PM

PM

PM

PM

Geminga

0540-69

1055-57

0656+16
Elusive CCOs

Vela Junior

1E1207

1E 1613
A varying PWN for 0540-69

A. De Luca, R.P. Mignani, P.A. Caraveo, G.F. Bignami

*HST multi-epoch imaging of the PSR 0540-69 system unveils a highly dynamic synchrotron nebula*

Back to the future

Agile and Glast will discover many Geminga-like sources

We plan to lead the effort to identify them.

(G. Novara and F. Senziani)