Unveiling SGRs with INTEGRAL

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Isolated Neutron Stars – London – 24/04/06
INTEGRAL Results

Short Bursts

- SGR 1806-20
  - Spectral Evolution within the bursts (H-I Anticorrelation)
  - $\log N - \log S (\alpha=0.91\pm0.09)$
  - Huge Outburst on October 5 2004

Giant Flare of December 27th 2004

- High energy afterglow

Persistent Emission

- SGR 1806-20
- SGR 1900+14
- AXPs - Comparison with SGRs

More than 400 bursts have been detected by INTERGAL Burst Alert System since then. Durations and energy spectra are typical.

~300 of them have been analyzed (including a huge outburst on October 5 2004). Thanks to the good sensitivity of IBIS/ISGRI they have been studied in detail. (Götz et al. 2004; Götz et al. 2006)
SGR 1806-20 - December 27 2004 Giant Flare

Borkowski, Götz, Mereghetti et al., 2004, GCN 2920

SPI-ACS Data

$>100 \text{ keV}$

$P=7.56s$

$\sim 10^{46} \text{ d}_{15} \text{ erg}$
Moon Reflection
Pulse Profile Variations

E > 100 keV
Possible detection of an early high-energy afterglow

Bulk Lorentz factor \( \sim 15 (E/5 \times 10^{43} \text{ erg})^{1/8} (n/0.1 \text{ cm}^{-3})^{-1/8} (t_0/100 \text{ s})^{-3/5} \)

Compatible to what derived from the radio afterglow
Persistent Emission – 1806-20

Total Exposure Time ~1 Msec
2003-2004 Data

IBIS/ISGRI 20-60 keV

60-100 keV

First detection of emission above 10 keV from an (moderately active) SGR counterpart
-> Non thermal processes in the Magnetosphere
Mosaicking contiguous observations: **Time variability**

Larger degree of twist in the magnetosphere -> more bursts and harder spectra, as predicted by Thompson, Lyutikov and Kulkarni (2002)
Persistent Emission -1806-20: Spectra

Mar 2003 – Apr 2004  Sep–Oct 2004  Burst x 10^{-4}

\begin{align*}
F_{20-100 \text{ keV}} &= (4.7 \pm 0.8) \times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1} \\
F_{20-100 \text{ keV}} &= (7.9 \pm 1.4) \times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}
\end{align*}
INTEGRAL 1806 Monitoring
Persistent emission - SGR 1900+14: an SGR in quiescence


Last bursts from 1900 detected in November 2002

Reactivation on March 25th

Very soft spectrum $\Gamma \sim 3.1$, faint flux $\sim 10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$

Exposure time 2.5 Ms (2003-2004), indication of flux increase and hardnening

Persistent hard X-ray emission can be due to:

- Bremsstrahlung photons produced in a thin layer close to the neutron star (Thompson & Belobodorov 2005). Cutoff at $\sim 100 \text{ keV}$.

- at 100 km altitude in the magnetosphere through multiple resonant cyclotron scattering (Thompson et al. 2002). Cutoff at $\sim 1 \text{ MeV}$
Homogeneous *INTEGRAL/IBIS* data analysis:

The difference among the SGR can be explained in terms of the different activity

(These) AXPs are not active from the bursting point of view and have very soft spectra below 10 keV

**SGRs and AXPs behave differently at hard X-rays!**
Summary

- SGR 1806-20 has been studied in detail:
  - bursts (spectral evolution and LogN-LogS),
  - persistent emission discovery
  - 27 December 2004 Giant Flare
    - Monitoring of the source activity
    - Search for pulsations
    - Cutoff?

- SGR 1900+14: discovery of the persistent hard X-ray emission
  - INTEGRAL AO4 monitoring proposal
  - Analysis of the 2005 INTEGRAL Data
  - Reactivation: XMM and INTEGRAL ToOs on April 1st
    (Analysis on going)

- AXPs: hardening of the tails with energy for 3 of them
  - Rest of the AXPs? Too soft or too faint?