CONSTRAINING LONG-TERM AND SPATIAL VARIABILITY OF THE PN LOW ENERGY RESPONSE WITH RXJ1856

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RX J1856.5-3754 (RXJ1856)

- **Brightest** of the “Magnificent Seven”, or X-ray Dim Isolated Neutron Stars (XDINSs) (e.g. Turolla 2009 for a review)

- **The closest known neutron star**: $d \sim 120$ pc (Walter et al. 2010)

- No (detected) radio emission (Kondriatev et al. 2010)

- **Flux** $\sim 1.5 \times 10^{-11}$ erg s$^{-1}$ cm$^{-2}$ [0.2 – 10 keV]

- **BB spectrum**, $kT \sim 61$ eV, no features (e.g. Burwitz et al. 2003)

- $P \sim 7.055$ s, low PF ($\sim 1.2\%$) (Tiengo & Mereghetti 2007)

- $P_{\text{dot}} \sim 10^{-13} – 10^{-14}$ s s$^{-1}$ (van Kerkwijk & Kaplan 2008)

- Optical/UV counterpart ($m_V \sim 26$): **optical excess** $\sim 7x$ RJ tail of X-ray BB (Kaplan et al. 2011)
Why studying RXJ1856 variability?

- **Astrophysical goal:**
  - Constrain spectral evolution (as observed in RX J0720.4-3125)

  ![Plot showing RX J0720.4-3125](image)

  Possible cause:
  - Precession
    (e.g. Haberl et al. 2006)
  - Glitch episode
    (e.g. Kaplan et al. 2007)

  - If no spectral changes, cumulative spectrum (huge statistics to test NS EOS)

- **Instrumental goal:**
  - Constrain PN response stability at low energies (<1.2 keV)
Preliminary results
(presented last year by Nicola Sartore)

Significant changes, possibly correlated to position on the detector (and time?)
New calibration observation

October 2011 observation divided into 4 pointings to sample different RAWX positions

<table>
<thead>
<tr>
<th>Observation</th>
<th>Date</th>
<th>Obs.ID</th>
<th>Net Exposure Time [s]</th>
<th>Counts</th>
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<td>Q4</td>
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</table>

Observations at larger distance have higher temperatures, but in the same range as in previous observations ($\Delta kT_{BB} \sim 1$ eV)

$\Rightarrow$ The effect is present also at different detector positions, but it does not strongly increase with $\Delta$ RAXW

Equally good fit with absorbed BB model by freeing:

• gain slope (~4%) and offset (~15 eV)

OR

• BB temperature and normalization

Target positions clustered in two regions: hard and soft
Observations in “soft region” (I)

Include ~50% of all RXJ1856 observations: $\Delta kT \sim 0.5\%$ and $\Delta f_X < \sim 3\%$

Time evolution:

✓ No significant variability in 2005-2011 period

✓ Obs. of April 2002 is “anomalous”:
  • fit with a constant profile rejected at 4 $\sigma$
  • $\Delta kT \sim 0.5$ eV in 3 years
Observations in “soft region” (II)

Merged spectrum: \(~250\) kiloseconds; \(~2 \times 10^6\) counts

- No spectral features (EW < 6 eV)
- Extrapolation of 2BB model in optical band is 5x higher than single BB
  \(\Rightarrow\) consistent with optical/UV flux
Conclusions

✓ Calibration results

- Small PN gain variations (slope ~4% and offset ~15 eV) related to target position
- PN response in “soft region” is very stable (with possible exception of earliest observation in 2002), slightly more unstable (>2 times larger $\Delta kT$) in “hard region”

✓ Astrophysical results (if calibration issues fully understood)

- RXJ1856 very stable in time ($\Delta kT < 0.5\%$ and $\Delta f_X < 3\%$ from March 2005 to present)

⇒ Still a good standard candle

- April 2002: possible hint of small scale heating episode

- High-statistic cumulative spectrum: 2BB model provides much better fit and its extrapolation is compatible with optical/UV emission
Future prospects

✓ **Re-analysis** of all RXJ1856 observations with SASv12.0 to check whether position dependent gain is correctly accounted for.

✓ **Further observations** might show instrumental problems or onset of heating episode in RXJ1856

✓ **Improvements in calibration** of PN low energy response are needed to fully exploit the cumulative spectrum of RXJ1856 (the best ever to study NS thermal emission)