Monitoring Accreting Pulsars with Fermi GBM

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Talk Outline

• Introduction
  – Fermi GBM
  – Techniques

• Sources – Be X-ray binaries
  – XTE J1946+274
  – EXO 2030+375
  – V0332+53

• Summary and Conclusions
Fermi Gamma Ray Burst Monitor (GBM)

**GBM NaI Detectors (12)**
8 keV – 1 MeV

**GBM BGO Detectors (2)**
150 keV – 40 MeV

**LAT**
GBM Pulse Searches

• Daily Blind Search
  • 24 source directions equally spaced on the galactic plane + LMC and SMC.
  • Each direction - FFT based search from 1 mHz to 2 Hz.

• Source Specific Searches.
  • Small ranges of frequency and frequency derivative
  • Phase shifting and summing pulse profiles from short intervals of data
  • Barycentered and possibly orbitally corrected times.
  • Typical exposure times are ~40 ks/day.

• Detections – Total of 37 systems monitored
  • 8 of 8 persistent sources
  • 26 of 29 transients
Blind Pulse Search

Blind pulse search in 20-50 keV band, for 2010 January 8.

Vela X-1 h2
Vela X-1 h3
Vela X-1 h4
4U 1608-67
Cen X-3

Corrected Power

Frequency (Hz)
XTE J1946+274 – New Orbital Solution

- Discovered with RXTE in 1998
- 15.8 s pulsations with BATSE
- Active 1998-2001, 2010-11
- GBM (red) – spin periods, RXTE (green), Swift/BAT (grey) – fluxes
- 2-3 outbursts per orbit
- GBM data crucial to orbit determination

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<thead>
<tr>
<th>Parameter</th>
<th>Disk</th>
<th>Wind</th>
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<tbody>
<tr>
<td>axsini [lt-s]</td>
<td>$471.2^{+2.6}_{-4.3}$</td>
<td>$471.1^{+2.7}_{-2.8}$</td>
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<tr>
<td>Porb [d]</td>
<td>172.7±0.6</td>
<td>171.4±0.4</td>
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<tr>
<td>$\tau$ [d]</td>
<td>$55514.8^{+0.8}_{-1.1}$</td>
<td>$555515.5^{+0.8}_{-0.7}$</td>
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<tr>
<td>eccentricity</td>
<td>0.246±0.009</td>
<td>0.266±0.007</td>
</tr>
<tr>
<td>$\omega$ (°)</td>
<td>$-87.4^{+1.5}_{-1.7}$</td>
<td>$-87.1^{+1.2}_{-1.0}$</td>
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12/8/15
C.A Wilson-Hodge Fermi Symposium 2015
EXO 2030+375 ($P_s = 42$ s, $P_{\text{orb}} = 46$ d)

- Discovered during a giant outburst in 1985 with EXOSAT; Second giant outburst in 2006 (RXTE)
- Transitioned to spin down in 1995; In 2014, transitioned to neither spin-up or spin down (frequencies flattened)
- Abruptly shifted in outburst orbital phase in 1995 accompanied by drop in outburst flux; in 2015, outburst flux has again dropped.
- Detected in outburst at nearly every periastron passage since 1991, unlike most Be X-ray binaries.
- Correlated peak flux and orbital phase of outburst peak – delay of accretion from Be disk onto NS due to accretion disk?
EXO 2030+375 Long Term Behavior

Flux

Spin Frequency

Orbital Phase

Time (date)

12/8/15
GBM Observations of V0332+53

- V0332+53 – 4.3 s pulsar orbiting an O8-9Ve star in a 34.25 d orbit
- Current outburst shows considerable pulse profile evolution
- Existing orbital solutions do not propagate well to 2015 outburst
- New orbital analysis in progress
Summary and Conclusions

The full sky coverage of GBM enables long term monitoring of the brighter accreting pulsars allows:

• Detection and study of new transient sources or new outbursts of known transients.
• Precise measurements of spin frequencies and orbital parameters (e.g. XTE J1946+274, soon for V0332+53)
• Study of spin-up or spin-down rates and hence the flow of angular momentum and accretion disk physics
• Observations of unexpected and long-term outburst behaviors (e.g. possible ~20 year cycle in EXO 2030+375)

GBM Pulsar Project
http://gammaray.nsstc.nasa.gov/gbm/science/pulsars/

GBM Earth Occultation Project
http://heastro.phys.lsu.edu/gbm
Future directions

– What can we learn from classical accreting pulsars in Be X-ray binaries to further our understanding of gamma-ray Be binaries?

Many Thanks to the GBM Pulsar Team!

Background Subtraction

The rates in each channel of the 12 NaI detectors are fit with a model with the following components:

- Models for bright sources.
- A stiff empirical model that contains the low-frequency component of the remaining rates.

The fits are made independently for each channel and subtracted from the rates.