Multi-Time Scale Spectral Monitoring of Seyferts with RXTE

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RXTE’s Legacy: The AGN Variability Database

Time scales of months–years are interesting for AGN!

- Average flux & typical flux range for each object

<table>
<thead>
<tr>
<th></th>
<th>Sy1</th>
<th>Sy2</th>
<th>Blzr</th>
</tr>
</thead>
<tbody>
<tr>
<td># Visited</td>
<td>57</td>
<td>47</td>
<td>51</td>
</tr>
<tr>
<td># Monitored</td>
<td>39</td>
<td>15</td>
<td>45</td>
</tr>
<tr>
<td>Tot. Mon. (obj · yr)</td>
<td>152.5</td>
<td>39.6</td>
<td>68.6</td>
</tr>
</tbody>
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RXTE’s Legacy: The AGN Spectral Variability Database

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RXTE’s Legacy: The AGN *Spectral* Variability Database

- Long-term avg. spectral properties (Rivers et al. 2011a; **SEE POSTER**)!

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- Monitoring \( \Gamma(t) \), \( I_{FeK\alpha}(t) \), \( N_H(t) \)

Time scales of months–years are interesting for AGN!
Variability in Line of Sight Absorbers

- Variations in X-ray absorbing columns in both Sy 1s & 2s, on time scales of hours–years (Risaliti+ 2002, Puccetti+ 2007, Turner+ 2008)

Lamer+ ’03: NGC 3227: 3-month eclipse, 2000–1

\( N_H \) monitoring with RXTE: complementary to short-term results
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\[ \Delta N_H = 3 \times 10^{23} \text{ cm}^{-2} \]
\[ R \sim 10 - 100 \text{ lt.-days} \]
BLR cloud likely

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Rivers+ ’11b: Cen A
6-month eclipse, 2010–1
$\Delta N_H = 8 \times 10^{22} \text{ cm}^{-2}$
$R \sim 0.1 – 0.3 \text{ pc}$
Torus cloud likely

$N_H$ monitoring with RXTE: complementary to short-term results
Absorption Variability in Cen A: From weeks to a decade

(monitoring of Cen A on even longer timescales would be ideal....)
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ALSO: NGC 6300 changed from C-thick to C-thin over 2.5 years
(Leighly et al. 1999, 2000 & Guainazzi et al. 2002)
RXTE Spectral Monitoring of NGC 4151, 1996–2004

NGC 4151: Complex, absorbed X-ray spectrum (e.g., full-covering + partial-coverer):
Can variations in absorption explain the observed trends in Hardness Ratio?
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Can variations in absorption explain the observed trends in Hardness Ratio?
Markowitz et al., in prep.: Yes: Changes in covering fraction of partial coverer drive Hardness Ratio trends (consistent with DeRosa et al. 2007, 5 BeppoSAX observations)
Clumpy torus models

(Urry & Padovani 1995)

e.g., Nenvoka et al. 2002, 2008; Elitzur & Schlossmann 2006
Reverberation Mapping with the Fe Kα Line

NGC 3227 (Markowitz et al. 2009)

50%/80% of line flux responds to continuum variations; variable portion of line originates in gas < 700/< 60 light-days from central engine

3C 111 (Chatterjee et al. 2011)

(Related: see also: Markowitz, Edelson & Vaughan 2003; Vaughan & Edelson 2001; Nandra et al. 2000)
Coronal Power Law Component

Nandra et al. (2000), 32-day RXTE+IUE campaign on NGC 7469:
- $\Gamma_X$ & $F_{UV}$ correlated
- Consistent with Comptonization in a corona
- But also supports thermal reprocessing of SX/EUV photons into UV continuum photons

(Related: see also: Chiang et al. 2000, RXTE+ASCA+EUVE campaign on NGC 5548)
Coronal Power Law Component: Links to accretion in GBHs?

- For most X-ray-bright, nearby Seyferts: Power-law softens as flux increases (e.g., Papadakis et al. 2002)
- FUTURE: Need to access more LLAGN/ lower-\(\dot{m}\) sources (which are more slowly variable)
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Constraints on Blazar Jet Emission Models

• RXTE’s flexible scheduling → participation in many ToO campaigns on flaring blazars

• RXTE spectral monitoring → better model SED(t) → constrain models of particle acceleration, jet emission
Summary

- RXTE has been the only mission to provide sustained X-ray continuum & spectral monitoring, covering timescales from hours to $\gtrsim$ a decade.
- (multi-band light curves usually not sufficient!)
- Variability of Fe Kα line, absorption, coronal power-law component, Compton reflection
- Constraints on geometry of circumnuclear (absorbing, line-emitting) gas
- Pathfinder investigations for eROSITA (launch 2013; 0.2–10 keV) and brightest AGN accessible to MIRAX-HXI (launch $\sim$2016, hopefully; $\sim$5–200 keV). (& maybe LOFT?)
Grube, J., 2007, PhD thesis
Global correlations and correlation within individual objects:

- **Zdziarski et al.** (2003)
- **Rivers et al.** (2011)
- **Markowitz et al., in prep.**

**PCA+HEXTE**

**NGC 4151; PCA**

- Other examples: Chiang et al. (2000); Zdziarski et al. (1999, Ginga)
- CAUTIONS: See Vaughan & Edelson (2001) and Nandra et al. (2000), and run those Monte Carlo sims!