Millihertz to hectohertz variability in low mass X-ray binaries as seen by XMM-Newton

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The X-ray Universe 2014
Dublin, 16. June 2014
Main result

The observed power spectral shape depends on the energy band, and hence spectral component, we are looking at.
Timing properties as seen with RXTE

Hardness - intensity diagram

power law noise

band limited noise and QPO

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Additional PDS features

- **Peaked noise component**
- **High frequency QPOs**
- **Centroid frequency at a few hundred Hz**
- **Mainly observed during intermediate states**

**Source name**

- GX 339-4
- 4U 1630-47
- GRO J1655-40
- H 1743-322
- XTE J1550-564
- Swift J1753.5-0127
- XTE J1752-223
- XTE J1650-500
- Swift J1539.2-6227
- XTE J1817-330
- XTE J1850+226
- 4U 1543-47
- XTE J1720-318
- 4U 1957+115
- XTE J1118+480
- MAXI J1659-152
- SLX J1746-331
- XTE J1652-453
- XTE J1748-288
- SAX J1711.6-3808
- GS 1354-644
- GRS 1737-31
XMM-Newton black hole X-ray binary sample

- 12 black hole XRBs
- 60 archival observations in fast modes

Compared to RXTE XMM-Newton

- has higher energy resolution
- covers softer energies
PDS in low hard state
BLN in low hard state

At least one component where $f_{1-2\text{keV}} < f_{4-8\text{keV}}$
GRS 1915+105

- detected 1992 with the WATCH instrument on-board GRANAT
- $M_{BH} \sim 14\pm 4 M_\odot$; $D \sim 12$ kpc; orbital period $\sim 33$ d
- requires its own classification scheme
- shows 12 variability classes
- $\chi$ variability class $\approx$
- conventional "hard" state
- 5 archival XMM-Newton observations of GRS 1915+105 during its $\chi$ variability class from 2003 and 2004
- source highly absorbed below 1.5 keV


PDS of GRS 1915+105

- \(\chi\) variability
- class
- 4.5 – 8 keV
- (4.9 – 14.8 keV)
- band limited noise and quasi-periodic oscillation (+ upper harmonics)
- overall shape agrees between XMM and RXTE

**PDS: Zoom in Low Energies**

**1.5 - 2.5 keV**

- decent fit with power law

**QPO upper limit of 7.2% rms, slightly below the soft band rms given in** Rodriguez et al. (2004, ApJ, 615, 416) for a similar centroid frequency; **QPO rms of \( \sim 11.5\% \) in 1.5 - 8 keV using a ZC-Lorentzian break frequency at \( \sim 0.45 \) Hz, while at \( \sim 3.35 \) Hz in the 1.5 - 8 keV band.**
similar result found for MAXI J 1659-152 based on Swift and RXTE data

in the HIMS, when the disc fraction exceeds ~30%:

- above 2 keV: BLN and QPO
- below 2 keV: power law noise

fits into the picture of a relation between State C and the hard intermediate state
Energy Spectra


- added multicolour disc component

- \( v_{\text{abs}}(\text{diskbb} + \text{refsch} + \text{Lines}) + \) excess emission

- disc component needed to obtain decent fits

- contributes \( \sim 20\text{-}30\% \) in the 1.5 - 2.5 keV band and only a few \% in the 2.5 - 3.5 keV band
Schematic picture of the possible accretion geometry

Power spectral state depends on which spectral component we are looking at!

Low luminosity hard state

High luminosity hard/intermediate state

Summary

- Energy dependence of power density spectra
  - In low hard state:
    - Break frequency of band-limited noise evolves with energy
  - In (hard) intermediate state:
    - Two different PDS states coexist simultaneously in the hard and soft band
  - Observed PDS state depends on which spectral component we are looking at