Towards a Reliable Method of Measuring AGN Masses Using X-ray Variability

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in collaboration with Dimitrios Psaltis
Global timing properties ARE similar!
Mass Measurements from breaks

![Diagram showing mass measurements from breaks in a plot of break timescale versus black hole mass.](image-url)
However..

X-ray binary Power Spectra are \textbf{NOT} well described by power-laws

Characteristic frequencies are \textbf{NOT} constant

Nowak 2000
Belloni et al. 2002

Pottschmidt et al. 2003
Correlations

BHC
Atoll
XRP

Wijnands & Van der Klis, 1999

Belloni-Hasinger Effect

Belloni et al., 2002
Belloni-Hasinger Effect in AGN?

Data from:
- Belloni et al. '02
- Cropper et al. '03
- Markowitz et al. '03
- Marshall et al. '03
- Uttley et al. '02
- Vaughan & Fabian '03
From Observations

Data from Turner et al. '99

\( \sigma_{\text{rms}}^2 \)

\( \log L_x \) (2–10 keV)
We wish...

\[ \sigma_{rms}^2 = \sigma_{rms}^2(M, \dot{M}) \]
\[ L = L(M, \dot{M}) \]
\[ M = M(\sigma_{rms}^2, L) \]
\[ \dot{M} = \dot{M}(\sigma_{rms}^2, L) \]

We have...

\[ v_{\text{high}} < v_{\text{ISCO}} = \frac{1}{2\pi 6^{3/2}} \frac{c^3}{GM} \]
\[ M < \frac{1}{2\pi 6^{3/2}} \frac{c^3}{Gv_{\text{high}}} \]
\[ L < L_{\text{Edd}} = 1.310^{38} \frac{M}{M_\odot} \frac{\text{erg}}{\text{s}} \]
\[ M > 7.710^{-39} \left( \frac{L}{\text{erg} / \text{s}} \right) M_\odot \]
From Model PSD to RMS

\[ \nu P_\nu(\nu) \left[ \frac{\text{rms}}{\text{mean}} \right]^2 \]

\[ \nu [\text{Hz}] \]

\[ 10^{-4} \rightarrow 10^{-3} \rightarrow 10^{-2} \]

\[ 10^{-8} \rightarrow 10^{-6} \rightarrow 10^{-4} \]
From Model PSD to RMS
From Model PSD to RMS

\[ \nu P_\nu(\nu) \left[ \frac{\text{rms}}{\text{mean}} \right]^2 \]

\[ \nu \text{[Hz]} \]

\[ 10^{-4}, 10^{-3}, 10^{-2} \]

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High Energies in the Highlands
Fort William, Scotland, 27 June - 1 July 2005
From Model PSD to RMS
From Model PSD to RMS

Parametrize RMS in terms of highest characteristic frequency.
Upper Bounds from RMS

\[ M < \frac{1}{2\pi 6^{3/2}} \frac{c^3}{G\nu_{\text{high}}} \]
Lower Bounds from $L_x$

\[ M > 7.710^{-39} \left( \frac{L}{\text{erg} / \text{s}} \right) M_\odot \]
Upper and Lower Bounds for AGN Masses
Summary & Conclusions

- Robust method to constrain AGN masses
- Explore unification on more solid grounds
- Systematic studies of GBHC & AGN
- Better models for PSD(M) & RMS(M)
- Sampling effects in models (Pessah ‘05)