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XMM-Newton observations of the inner accretion flow in AGN

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In collaboration with...

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- Dan Wilkins
- Poemwai Chainakun
- Andy Young
- Michal Dovciak
- Barbara De Marco
- Chia-Ying Chiang
- NuSTAR AGN Team

(Those present at XRU in **bold**)

XMM-Newton and inner accretion flows

Seyfert Galaxies





Alternative spectral models



Timing can break these degeneracies

Spectral-timing of 1H0707-495



Fabian et al. 2009

Spectral-timing of 1H0707-495



Fabian et al. 2009

Discovery of the soft band lag





Alternative interpretations?



Can obscuration explain the lags?

Miller, Turner et al., 2010



Alternative interpretations?



Can obscuration explain the lags?

Miller, Turner et al., 2010



Iron K lag is seen at high frequencies!



Discovery of the iron K lag



Compton hump lags



Compton hump lags



Modelling the iron K lag



See Maria Caballero-Garcia's talk this afternoon and Michal Dovciak's Poster

But! Absorption is important!



Spectral-timing of partially absorbed Seyfert



Low-frequency soft lag due to nH decreasing during observation





EK, Zoghbi +15

Low-frequency soft lag due to nH decreasing during observation



EK, Zoghbi +15

Low-frequency soft lag due to nH decreasing during observation





Low-frequency soft lag due to nH decreasing during observation

Reverberation is common in bare Seyferts



How common is reverberation?



Spectral-timing analysis of of Seyfert Galaxy 1H1934-063 Frederick, Kara et al., in prep.

2.5





Variability in the soft lags



Uttley+14, adapted from EK+13

Iron K lag scale with black hole mass



EK+16b

Geometrical changes with Eddington Luminosity



Corona-jet connection?

Coronal Height



NVSS 1.4 GHz Radio Luminosity

 Outflowing corona, where velocity increases with accretion rate and propagates out to jet

Markoff et al., 2005



King, Lohfink & Kara 2017 Based on model of Beloborodov 1999

Disc affected by UV line-driven wind?



Correlation from Laor & Davis 2014; Eq. 12

Modelling time lags with extended coronae

Wilkins et al., 2016 Chainakun & Young 2017 v = 0.01c $f_{\text{break}} = 5 \times 10^{-2} \, \text{c}^3 / \text{GM}$

 $R = 30r_g$

 $v_{\rm visc}$ $f_{\rm break}$

See Dan's talk at 17:45 today!



(a) Lag-frequency spectrum





(b) Lag-energy, low frequency

(c) Lag-energy, high frequency

Reverberation in BHB

GX 339-14

See Phil Uttley's Talk at 17:00 today!



Reverberation in Tidal Disruption Events



What's next?

What's next?



Credit: Phil Uttley









Conclusions

- We're at the tip of the iceberg in X-ray spectral timing observations
 - Important for reflection and absorption studies!

- Reverberation offers an orthogonal approach to spectral analyses, giving insights into:
 - reverberation as a probe of disc/coronal structure
 - disc structure in BHBs and TDEs, too
- See our review: Uttley, Cackett, Fabian, EK & Wilkins `I4 for more