Timing the warm absorber in NGC4051

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X-ray time lags

For a review of X-ray spectral timing analysis in BHBs and AGN see Uttley et al. 2014.

Zoghbi et al. 2011
Does the warm absorber contribute to the observed X-ray time lags?

Can we constrain the parameters of the absorber with Fourier timing?
Variability and gas response
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- $L_{\text{ion}}$
- Ion $X'$
- Flux
- Energy
Variability and gas response
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The time the gas takes to reach equilibrium with the ionizing continuum is dependent on $n_e$

$$t_{\text{rec}} \propto n_e^{-1}$$

Krolik & Kriss 1995, Nicastro et al. 1999
Warm absorbers in AGN

Ionization parameter

\[ \xi_n = \frac{L_{\text{ion}}}{n r^2} \]

Ionizing luminosity observables

If we obtain the density we can estimate the location of the absorber and its output power

AGN feedback? NGC 4051
NGC4051

~600 ks data

X-ray time lags

Multicomponent wind

Bright and variable

For details see e.g. Pounds & King 2013

Alston et al. 2013

Vaughan et al. 2011

Silva, Uttley & Costantini (in prep.)

For details see e.g. Pounds & King 2013
Simulate light curves from NGC4051 PSD

Timmer & König 1995, Uttley et al. 2005

Recombination and ionization rates for constant SED using CLOUDY

Ferland et al., 2013

Solve time dependent concentrations


Simulate spectrum with SPEX

Kaastra, Mewe, & Nieuwenhuijzen 1996

Light curves only affected by variable WA

Timing products

$\text{n}_c = 10^8 \text{ cm}^{-3}$
Effects on different realizations

Preliminary results!

Soft (0.3-1.0 keV) vs Hard (2.0-5.0 keV)

Silva, Uttley & Costantini (in prep.)
Effects on continuum lags

Soft (0.3-1.0 keV) vs Hard (2.0-5.0 keV)

WA adds to the scatter by reducing the correlation between bands.

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Effects on continuum lags

Preliminary results!

Soft (0.3-1.0 keV) vs Hard (2.0-5.0 keV)

- Time lag (s)
- Frequency (Hz)
- Coherence

Alston et al. 2013

$n_e=10^8 \text{ cm}^{-3}$
Effects on continuum lags

Soft (0.3-1.0 keV) vs Hard (2.0-5.0 keV)

Preliminary results!

Alston et al. 2013
Assessing the contribution of the recombining gas to the time delays is vital for interpreting the continuum lags associated with propagation and reverberation effects in the inner emitting regions.

At high enough densities (or close distances), the contribution of a complex WA to the X-ray time lags may not be negligible, in particular at low Fourier frequencies, correspondent to long timescales.

WA decreases coherence, but could not cause spurious soft lags that appear significant, so reverberation measurements are secure.

Spectral timing is a promising method to constrain warm absorbers.