1. About NGC 4051

- Narrow-line Seyfert 1 galaxy with z=0.0023
- \(M_{\text{BH}}=(1.7\pm 0.5)\times 10^9 M_{\odot}\) [1]
- Observed by XMM in 2009 with ~600 ks exposure time [2]
- Have a number of absorption/emission lines

2. Spectral fitting

- We used a grid table model made by running XSTAR to explain absorption features.
- Three absorbers and several narrow emission lines are needed.
- WA1 makes a deep Fe-L UTA feature.

3. RMS spectra

- \(F_{\text{var}}\): Variation amplitude fraction, the long-timescale variability across the whole observation period [3]
  \[ F_{\text{var}} = \frac{1}{\langle X \rangle} \sqrt{S^2 - \langle \sigma_r^2 \rangle} \]
  where \(\langle X \rangle\) is the mean count rate, \(S^2\) is the variance of the light curve, and \(\langle \sigma_r^2 \rangle\) is the mean error squared.

\begin{align*}
\text{Wavelength (Å)} & \quad \text{Normalized counts per 1Å} \\
0.7 & \quad 0.8 & \quad 0.9 & \quad 1.0 & \quad 1.2
\end{align*}

- A peak at ~0.8 keV is due to variation of WA1
- Dips at ~0.6 and ~0.9 keV are due to the O VII and Ne IX lines

4. Geometry of warm absorber outflows

- Assuming an X-ray absorber follows Kepler motion, the location of the absorber (r) is calculated to be
  \[ r = \frac{2 \times 10^{-4} \left( \frac{\Delta T}{10^5 \text{sec}} \right) a}{R_s} \left( \frac{M_{\text{BH}}}{1.7 \times 10^9 M_{\odot}} \right)^{1/2} \]
  where \(R_s\) is the Schwarzschild radius, \(\Delta T\) is the variability timescale, and a is the size of the X-ray emission region.

- WA1 is variable, and locates at \(\sim 10^9 R_s\).
- We propose that WA1 partially cover the X-ray source, and that the partial covering fraction varies.
- On the contrary, WA2 and WA3 show no variation.
- We propose that they locate at \(\sim 10^{10} R_s\).

References


[ XMM-Newton: The Next Decade (ESAC, 2016.5.9-11) ]