Multi-epoch XMM Observations of two Reflection-dominated Narroaw Line Seyfert 1s

Mrk 478 and EXO 1346.2+2645

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Abstract

Multi-epoch XMM-Newton spectral analysis of the two Narrow Line Seyfert 1 (NLS1) galaxies, MRK 478 and EXO 1346.2+2645, is presented. Different models are tested including relativistically blurred reflection (reflionx) and partial covering, which were both found to give a very good fit. The two sources are characterised by a very broad Iron K-alpha emission line and a steep photon index, as typically seen in NLS1s. They were found to be reflection dominated (hard X-ray source is hidden form view), with emission coming from a very small region (few gravitational radii), very close to a rapidly spinning black hole. Reflection-dominated spectra is explained either by a corrugated accretion flow or by light bending effects.

The spectra of the sources did not change between epochs despite flux changes. They show constant fractional rms variability and hardness ratios, in agreement with the spectrum being composed of a single component.

Although partial covering gives a good fit, the fact that the coverer parameters did not change despite the flux changes argues against an absorber that partially covers the source.

1- Introductions

- Narrow Line Seyfert 1 are the class of Seyfert 1 AGN with the lowest Balmer line widths.

- They appear as the drive of the first Eigenvector (E1) of the Principle Component Analysis (PCA) (Boroson & Green 1992).

- They have the following (defining) properties:
  - – Balmer lines are only slightly broader than forbidden lines.
  - – The line ratio $\lambda5007/\mathrm{H}\beta < 3$
  - – Strong FeII emission lines (and from higher states).
  - – Steep X-ray photon index on average.
  - – Strong X-ray variability.

- NLS1 occupy an extreme corner of E1 parameter space.

- If BLR is virialised, then narrower lines imply smaller velocities → smaller black hole mass.

Because these sources have luminosities similar to "normal" Black holes, a small mass → high accretion rate.

2- NLS1 in X-rays

- At the **low** energies, NLS1 show a soft excess that can be explained by:
  - – Relativistically smeared, partially ionised, *absorption* (Gierlinski & Done 2004). BUT, it requires high velocity outflows to reproduce the smooth shape (Schurch & Done 2007).
  - – Relativistically blurred, partially ionised, *reflection* (Crummy et al 2006) based on the model of Ross & Fabian (2005).

- At **High** energies, Boller et al (2002), reported the discovery of a sharp drop in NLS1 source 1H0707-495 (and later seen in other sources). However, It is not seen in all NLS1s (Gallo 2006). I can be explained by :
  - – *Partial covering*: where the drop is produced by a cloud that partially covers the source. This ,however, requires high iron abundance of ~30 solar.
  - – *Partially ionised reflection* (Fabian et al. 2004): where the apparent drop at ~7 keV is the blue wing of a relativistically broadened iron line (Fig. 1).

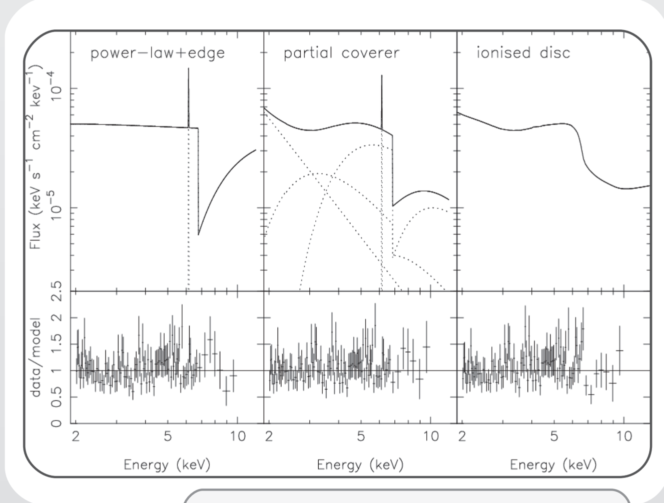

Fig.1: Partial covering and reflection fits for 1H0707-945 (Boller et al. 2002)

3- Analysis

- A simple power law shows the residuals at low/high energies.
- Adding a blackbody accounts for most residuals at soft energies.
- At high energies, a relativistically broadened iron line (of Laor et al 1991) fits the data, but it does not account for the reflection continuum.
- To model it, the data were fitted with the reflection model of Ross & Fabian 2005 (REFLIONX).

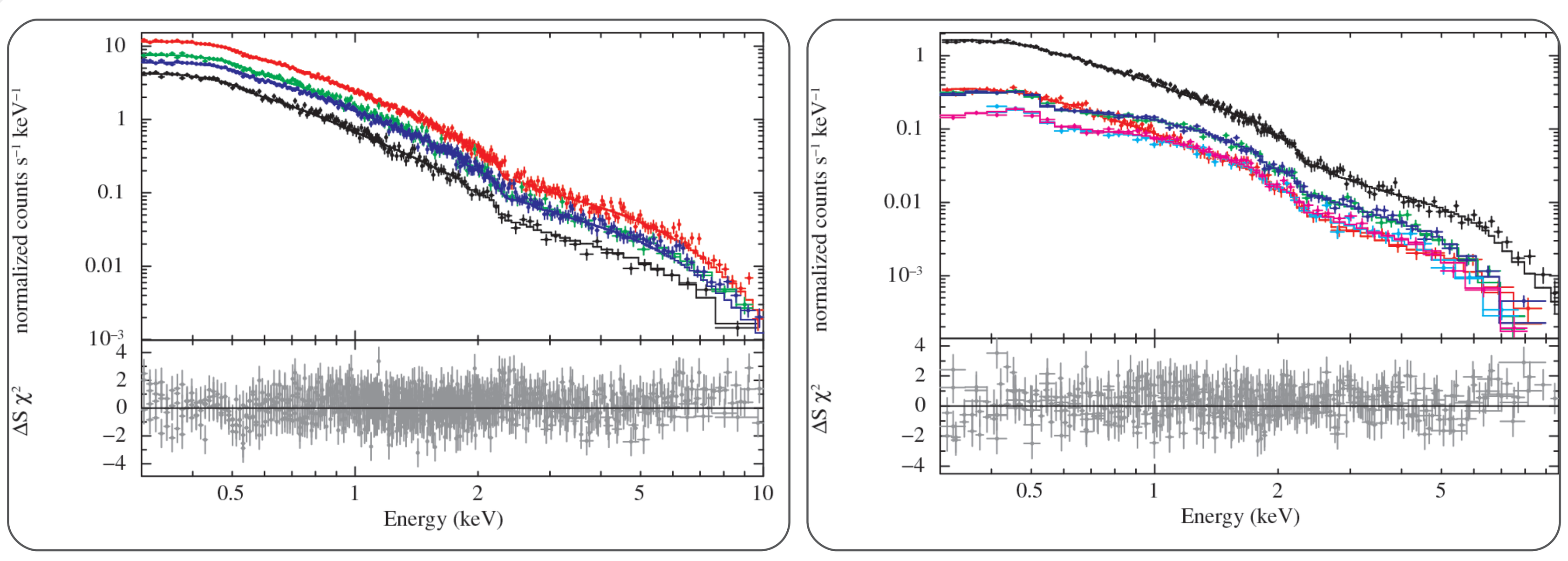

Fig.2: Spectral fits for Mrk 478 (left) and EXO 1346.2 (right), the different colours represent the different observations (and detectors)

Spectral Variability

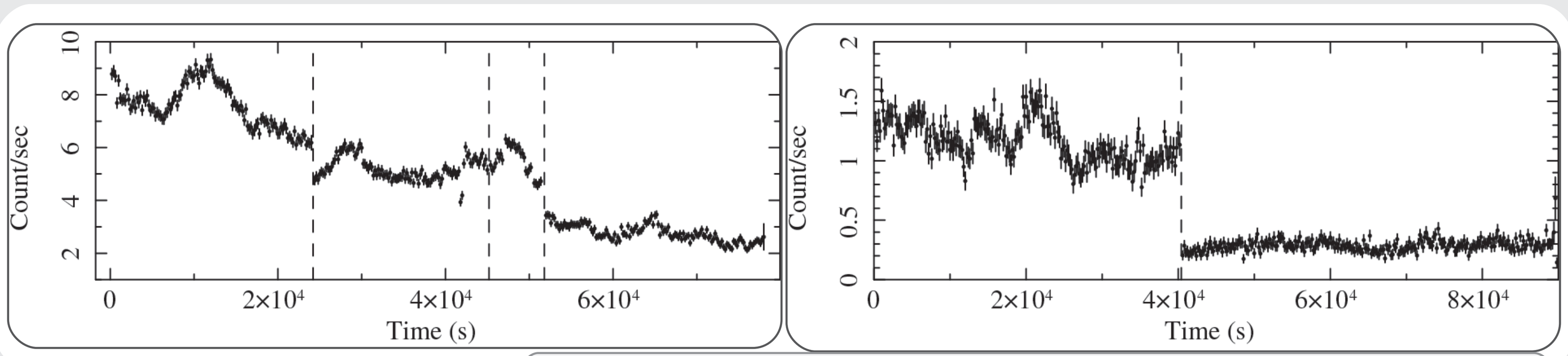

Fig.3: Light curves for Mrk 478 (left) and EXO 1346.2 (right), the vertical dashed lines separate the different observations, Mrk 478 flux changes by a factor of ~6 in 13 months, while EXO 1346.2 changes by a factor of 3.

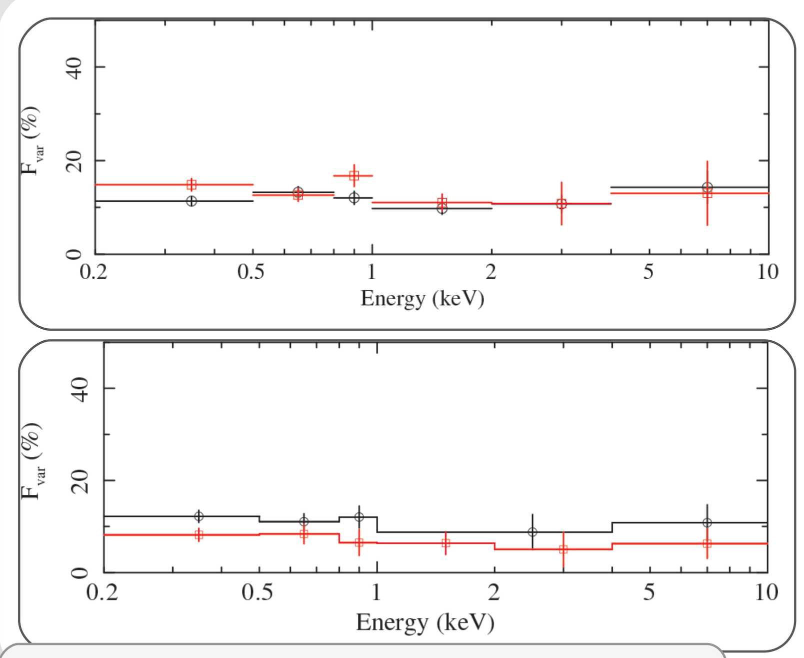

Fig.4: The fractional rms variability for Mrk 478 (top, for 1st and 4th observations) and EXO 1346 (bottom). The value remained constant in a single observation and between observations.

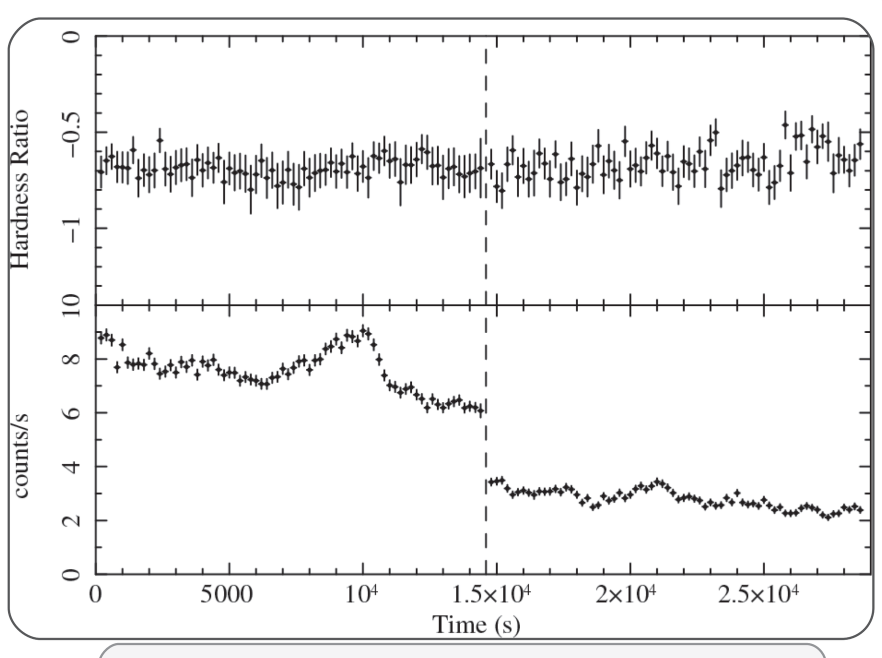

Fig.5: The hardness ratio for Mrk 478 (top) with corresponding light curve (bottom) for the high (obs1) and low (obs2) states. the hardness ratio does not respond to the flux variability.

4- Results & Discussion

- The reflection model gives excellent fits to both sources.

- The fit parameters imply emission from very small region, close to the ISCO of the black hole. **with** $r_{in} < 2r_g$, and an emitting region of few gravitaional radii, implied by the high emissivity indices (~9, the model assumes a powerlaw emmisivity profile)**.**

- Both sources were **reflection dominated** (i.e. no powerlaw is required). This means that we are only seeing the reflected spectrum and not the orginal powerlaw continuum source (corona).

This can be explained in terms of two models: a corrugated accretion disc (Fabian el al. 2002), or light bending model of Miniutti et al 2003.

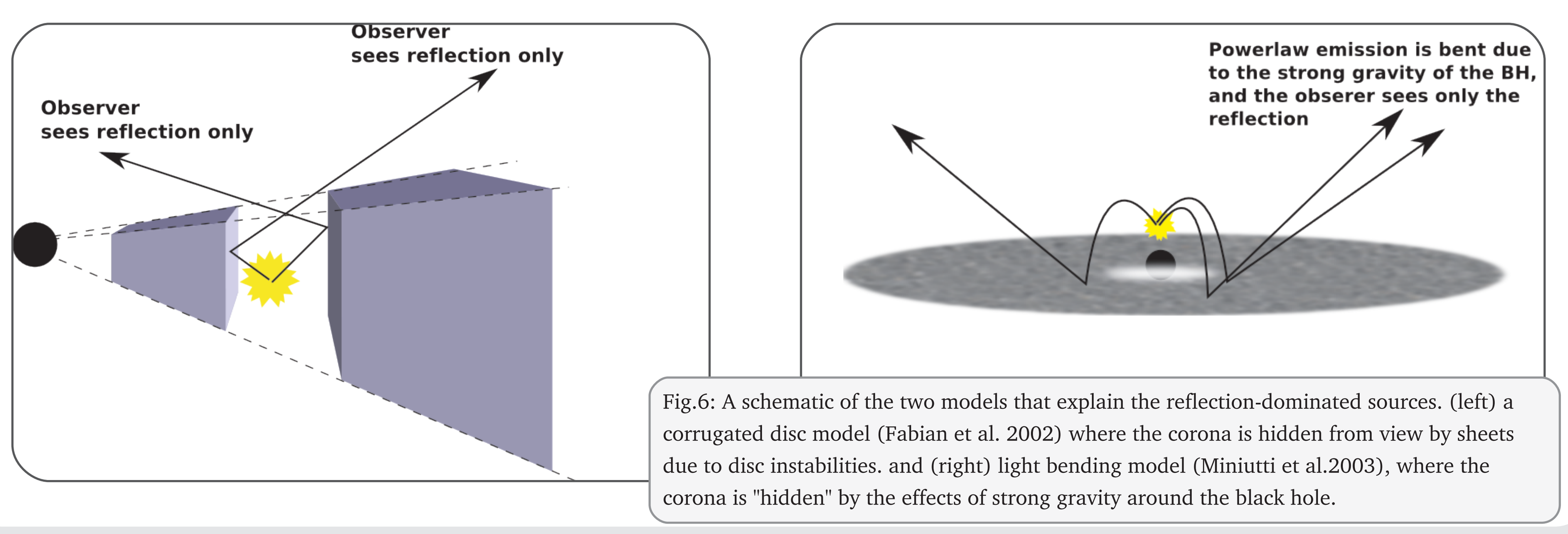

Fig.6: A schematic of the two models that explain the reflection-dominated sources. (left) a corrugated disc model (Fabian et al. 2002) where the corona is hidden from view by sheets due to disc instabilities. and (right) light bending model (Miniutti et al.2003), where the corona is "hidden" by the effects of strong gravity around the black hole.

- It is remarkable how a single component can fit the multi-epoch data.

- The fractional rms variability is constant within a single observation and between observations, and
- The hardness ratio is constant too, and does not respond to flux changes.
- This is in total agreement with a single component spectrum.

- Although a partial covering model gives an equally good fit, the fact that the spectrum does not change (hence the coverer parameters), implies that the flux variations are due to variability in the intrinsic source not the coverer. By considering the sizes of the emitting region and the absorber, the chances of the source being just partially covered are small.

References

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