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Rest-frame stacking of 2XMM catalog sources Fe Kα line properties

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Abstract

The aim of this work is to characterize the average iron (Fe K) emission properties of active galactic nuclei (AGNs) in the source rest-frame. We selected a sample of 248 AGNs from the 2XMM catalog. We employed two independent rest-frame stacking procedures to compute the mean Fe K profile. The counting statistics for the integrated spectrum is comparable to the one available for the best studied local Seyferts. To assess the significance of the observed Fe K emission line features and the artifacts possibly introduced by the stacking procedures, we have carried out simulations. We report that average Fe K line profile in our sample is best represented by a combination of a narrow and a broad line. The equivalent widths of the narrow and broad (parametrized with a diskline) components are ~30 eV and ~100 eV, respectively. We also discuss the implications of the adopted continuum modeling on the broad line parameters and its significance.

I. Aims

Fluorescent Fe Kα lines in AGNs are a potentially unique tool to probe the innermost regions around a black hole. The line properties, such as the peak energy, intensity and profile carry important diagnostic information about the dynamics and physics of the region where the emission originates (Fabian & Miniutti 2005, Miller 2007, Turner & Miller 2009). In this study, we concentrate on the mean Fe Kα line properties of a large AGNs sample using two independent procedures.

II. Sample

The sample comprises 248 high galactic latitude (|BII| > 25 degrees) point sources from the 2XMM catalog (Watson et al. 2009), covering a wide redshift range 0 < z < 5 and with the sum of EPIC-PN net 2-10 keV rest-frame counts greater than 200 and power law photon indices in the range 1.5-2.2. (See Fig. 1 for distributions of the redshifts (left), X-ray luminosities (center) and EPIC-PN net counts in the rest-frame 2-10 keV band (right) of the sources used in our study.)

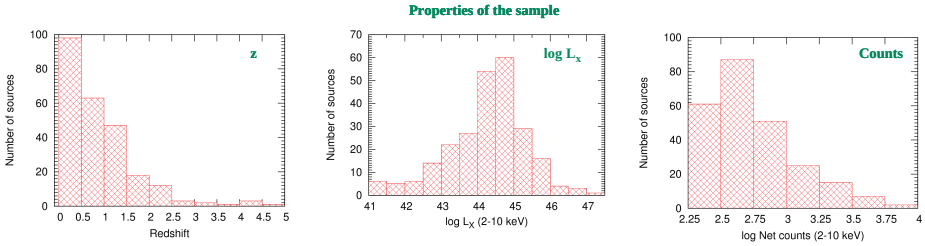

Fig. 1: Histograms of redshifts (left), 2-10 keV X-ray luminosities (center) and EPIC-PN net counts (right) of the 248 AGNs selected for our study.

III. Method

We have developed a procedure for stacking spectra in the rest-frame, which differentiates from the other published methods (Streblyanska et al. 2005; Corral et al. 2008) and involves adaptive grouping in predefined energy bins of equal width (0.25 keV) in the rest-frame 2-10 keV band, XSPEC fitting of each binned spectrum, 3σ clipping on the ratios (saved with respect to the best fit model) in each bin and subsequent averaging of these ratios. The mean ratio profile was converted to a flux spectrum with photon index of 1.8 for performing the spectral analysis.

We also created the "averaged X-ray spectrum" of these sources following the procedure of Iwasawa et al. 2011. The left panel of Fig. 2 displays the ratio profiles computed from two procedures. To assess the significance of the line features evident in the averaged ratio profile of the 248 sources (red points in Fig. 2 left panel) and the artifacts possibly introduced by the stacking method, we carried out simulations using XSPEC (see Fig. 2 right panel for the results of simulations). The narrow core is significant at > 3σ.

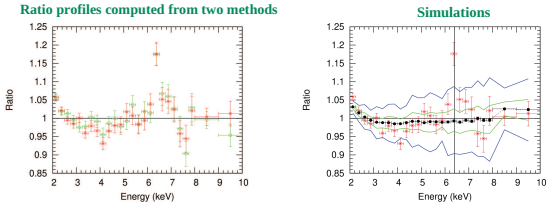

Fig. 2: *Left* **:** Ratio of the "averaged X-ray spectrum" with respect to a power law (green) overlaid with the mean ratio profile of the 248 sources created using 3σ clipping (red). *Right:* averaged ratio (red) , mean simulated continuum (black) along with its 1σ (green) and 3σ (blue line) confidence limits. The solid vertical line is drawn at 6.4 keV.

IV. Results

We have carried out a detailed spectral analysis of the averaged spectra (created from two independent procedures) by employing various continuum and line models. Our main results are the following :

1.) We find that the average narrow core equivalent width (EW) for the whole sample comprising 248 AGNs is ~30 eV and is stable in various continuum models employed. We also recovered the "Iwasawa-Taniguchi effect" (Iwasawa, K., & Taniguchi, Y. 1993; see also Bianchi et al. 2007; Chaudhary et al. 2010).

2.) We report that the broad line parameters, e.g. shape, EW and its detection significance are dependent on the assumed continuum and adopted stacking method as illustrated in the *left panel* of Fig. 3. In particular, despite having a well defined sample with reasonable statistics (net counts ~198000) in the "averaged X-ray spectrum", we do not detect a clear extended red-wing, and the measured EW of the broad feature is always lower than 150 eV, in a good agreement with the recent studies of the average Fe K emission from local AGNs (Guainazzi et al. 2006, Nandra et al. 2007, Longinotti et al. 2008). Our results are also consistent with predictions of the relativistic Fe K line intensities from the integrated spectra of AGNs presented by Ballantyne 2010.

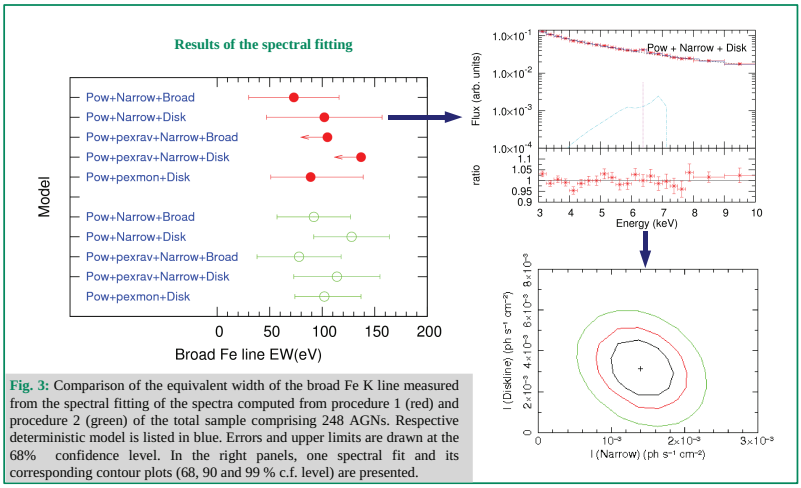

Fig. 3: Comparison of the equivalent width of the broad Fe K line measured from the spectral fitting of the spectra computed from procedure 1 (red) and procedure 2 (green) of the total sample comprising 248 AGNs. Respective deterministic model is listed in blue. Errors and upper limits are drawn at the 68% confidence level. In the right panels, one spectral fit and its corresponding contour plots (68, 90 and 99 % c.f. level) are presented.

Figures adapted from Chaudhary et al. 2011 (submitted to A&A)

References: Ballantyne, D. R. 2010 (ApJ, 716, L27); Bianchi et al. 2007 (A&A, 467, L19); Corral et al. 2008 (A& A, 492, 71); Chaudhary et al. 2010 (A&A, 518, A58); Fabian, A. C., & Miniutti, G. 2005 (arXiv:astro-ph/0507409); Guainazzi et al. 2006 (A&A, 446, 87); Iwasawa, K., & Taniguchi, Y. 1993 (ApJ, 413, L15); Longinotti et al. 2008 (Mem. Soc. Astron. Italiana, 79, 259); Miller, J. M. 2007 (ARA&A, 45, 441); Nandra et al. 2007 (MNRAS, 382, 194); Streblyanska et al. 2005 (A&A, 432, 395); Turner, T.J. & Miller, L. 2009 (A&A Rev. , 17, 47); Watson et al. 2009 (A&A, 493, 339)

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