THE HIGHLY RED-SHIFTED FE Kα LINE IN ESO 113-G010

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ABSTRACT

We present a spectral analysis of the Seyfert 1.8 ESO 113-G010 observed with XMM-Newton for 4 ks. The spectrum shows a soft excess below 0.7 keV and more interestingly a narrow emission Gaussian line at 5.4 keV (in its rest-frame), most probably originating from a red-shifted iron Kα line. No significant line at or above 6.4 keV is found contrary to other objects showing red-shifted lines, ruling out a strong blue-wing to the line profile. The line is detected at 99% confidence, from performing Monte Carlo simulations which fully account for the range of energies where a narrow iron line is likely to occur. The energy of the line could indicate emission from relativistic (0.17–0.23 c) ejected matter moving away from the observer, as proposed for Mrk 766 by Turner et al. (2004). Alternatively, the emission from a narrow annulus at the surface of the accretion disk is unlikely due to the very small inclination angle (i.e. less than 10 degrees) required to explain the narrow, red-shifted line in this intermediate Seyfert galaxy. However emission from a small, localized hot-spot on the disk, occurring within a fraction of a complete disk orbit, could also explain the redshifted line. This scenario would be directly testable in a longer observation, as one would see significant variations in the energy and intensity of the line within an orbital timescale.

Key words: X-rays; Seyfert; Emission line.

1. INTRODUCTION

In Active Galactic Nuclei (AGN), from Seyfert galaxies to quasars, the analysis of several X-ray features can help us to understand the central region of these powerful objects. Especially in the hard X-ray band, the Fe Kα line complex observed in the 6–7 keV range is an important spectral diagnostic tool to probe dense matter from the inner disk out to the Broad Line Region and the molecular torus (see review Reynolds & Nowak 2003; Fabian & Miniutti 2005). Recently, narrow spectral features in the 5–6 keV energy range were discovered with *XMM-Newton* and *Chandra* in a few AGN: NGC 3516 (Turner et al., 2002); NGC 7314 (Yaqoob et al., 2003); Mrk 766 (Turner et al., 2004, 2005); IC 4329A (McKernan & Yaqoob, 2004); AX J0447-0627 (Della Ceca et al., 2005). Localized spots or narrow annuli which occur on the surface of an accretion disk following its illumination by flares has been proposed to explain these features (e.g., Nayakshin & Kazanas 2001; Turner et al. 2002; Dovčiak et al. 2004). An alternative scenario has been proposed by Turner et al. (2004) for Mrk 766 for which the first evidence for a significant line energy shift has been observed over a few tens of ks. They proposed that this shift could be also interpreted as deceleration of an ejected blob of gas traveling close to the escape velocity.

2. THE CASE OF ESO 113-G010

This intermediate Seyfert 1.8 has been observed for the first time above 2 keV by XMM-Newton on May 2001 during a PN net exposure of 4 ks (Porquet et al., 2004). The spectrum shows a significant positive deviation near 5.4 keV (Fig. 1). The line is detected at 99% confidence from performing Monte Carlo simulations which fully account for the range of energies where a narrow iron line is likely to occur. For our null hypothesis, we assumed that the spectrum is simply an absorbed power-law continuum, with the same parameters as the absorbed power-law model fitted to the real data. We used the XSPEC FAKEIT command to create 1000 fake EPIC-pn spectra corresponding to this model, with photon statistics expected from the 4 ks exposure, and grouped each spectrum to a maximum of 20 counts per bin. Following the procedure used to test the real data for the presence of a narrow line, we fitted each fake spectrum with an absorbed power-law (absorption fixed at Galactic, but power-law photon index and normalisation left free to vary), to obtain a χ^2 value. We then added a narrow line ($\sigma = 0.1$ keV) to the fit, restricting the line energy to be between 4–7 keV. Furthermore we stepped the line over

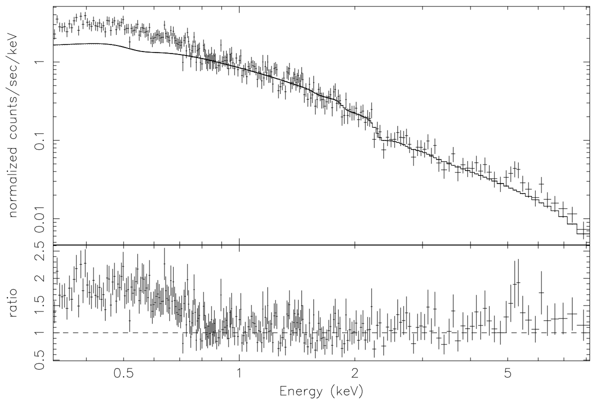

Figure 1. PN spectrum of ESO 113-G010 (observer frame). A power-law has been fitted to the 1–4 keV energy band and extrapolated to lower and higher energies. A soft X-ray excess is clearly seen extending to about 0.7 keV, as well as a positive deviation near 5.4 keV (quasar frame).

the 4–7 keV energy range in increments of 0.1 keV, whilst fitting separately each time to ensure the lowest χ^2 value was found. We then recorded the minimum χ^2 obtained from these multiple line fits for each fake spectrum, and compared with the corresponding χ^2 of the null hypothesis fits, to obtain 1000 simulated values of the $\Delta\chi^2$, which we used to construct a cumulative frequency distribution of the $\Delta\chi^2$ expected for a blind line search in the 4–7 keV range, assuming the null hypothesis of a simple power-law with no line is correct. We find only 1.4% of fake power-law spectra fitted with a line show a larger $\Delta\chi^2$ than observed in the real data, implying that the line detection is significant at approximately 99% confidence (see Fig. 4. in Porquet et al. 2004).

Fitting the data above 1 keV with a Gaussian line (σ=0.1 keV) we obtain a good fit for the feature with: E=5.38±0.11 keV and EW=265^{+147}_{-145} eV. Figure 2 shows the confidence contour plot for the rest-energy of the line.

2.1. Possible origins for this highly red-shifted Fe Kα line

• Emission from relativistic (v $\sim$ 0.17–0.23 c) ejected matter moving away from the observer.

• Emission from an annulus at the surface of the accretion disk BUT a very small inclination angle, less than 10 degrees, is required to explain the line in this intermediate Seyfert galaxy !

• Emission from a small, localized hot-spot of the disk, occurring within a fraction of a complete disk orbit (see modelisation e.g., by Nayakshin & Kazanas 2001 and Dovčiak et al. 2004).

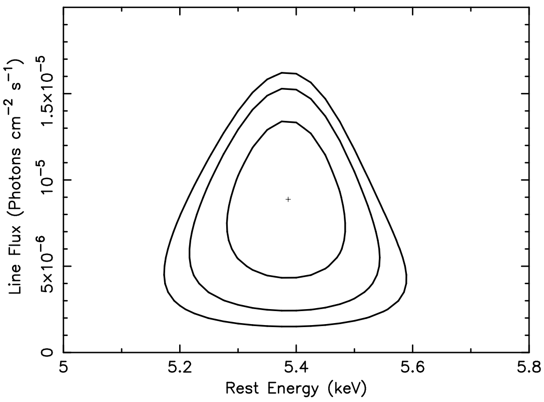

Figure 2. Contour plot showing the 68%, 90% and 95% (from the inner to outer curves) confidence level for values of line rest-energy (keV) and line flux.

• A longer X-ray observation is necessary to disentangle between these possible origins of this highly red-shifted line. This will be done with a 103 ks XMM-Newton observation (AO4, PI: D. Porquet) in order to perform time-resolved spectroscopy.

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