On the X-ray Baldwin Effect for the Narrow Fe Kα Emission Line

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Abstract. We build a large AGN sample with narrow FeK line measurements by combining the archival Chandra HETG observations of 34 type 1 AGNs with XMM-Newton observations in literature. We find a similar X-ray Baldwin effect as reported earlier by Page et al. in the sample; however, we note that the anti-correlation is dominated by the radio-loud AGN in the sample, whose X-ray spectra might be contaminated by the relativistic jet. Excluding the radio-loud AGN, we find a much weaker anti-correlation. We present Monte Carlo simulations showing that such a weak anti-correlation can be attributed to the relative short time scale variations of the X-ray continuum.

1. Introduction

In 1993, an X-ray Baldwin effect in the iron K lines was found in Ginga observations of 37 AGNs (Iwasawa & Taniguchi 1993). They found the equivalent width (EW) of the iron K line is anti-correlated to the X-ray continuum luminosity. An X-ray Baldwin effect was also reported for the narrow iron Kα line observed by XMM-Newton (Page et al. 2004; Zhou & Wang 2005). A possible explanation is a decrease in the covering factor of the material forming the fluorescence line (such as the torus) with increasing X-ray luminosity.

We revisit this issue by studying archival AGN spectra obtained by Chandra High Energy Transmission Grating Spectrometer (HETGS), which has better spectral resolution in the iron line band for more accurate measurement of the narrow Fe K line. We also combined our Chandra sample with XMM-Newton observations in literature to build a much larger sample of 75 radio-quiet and 26 radio-loud AGNs. We found that the previous reported X-ray Baldwin effect is mainly due to the radio-loud sources in the sample, whose X-ray spectra might be contaminated by the relativistic jet. We found a much weaker X-ray Baldwin effect of the narrow iron Kα line for radio-quiet sample; however, we present simulations showing that such a weak anti-correlation is indistinguishable from an observational bias due to the variation of AGN X-ray continuum.

2. Result

Figure 1 plots the correlation between the EW and luminosity for all objects in the large sample (α = −0.2015 ± 0.0426, Rs = −0.469) and for radio-quiet objects only (α = −0.1019 ± 0.0524, Rs = −0.266). We can clearly see that
Figure 1. Left: including both radio-quiet sources and radio-loud sources; Right: including radio-quiet sources only. The solid lines show the best-fit anti-correlation slopes.

when the RL sources were excluded from the sample the correlation between the line line EW and X-ray luminosity became much weaker (with a confidence level less than 2σ, see Jiang et al. 2006).

Assuming the narrow Fe Kα lines mainly arise from the dust torus, the line should exhibit no significant fluctuations within a timescale of weeks to months, while the behavior of the X-ray continuum is much more active within much shorter timescales. We adopt a toy model to simulate the X-ray continuum variation, while line flux is assumed to be invariable. The observed X-ray luminosity is assumed to be normally distributed with the width of the Gaussian distribution calculated to match the observed excess variance at different luminosities (Markowitz & Edelson 2004). By normalizing the observed line EW for the combined radio-quiet sample (with upper limits) to the best-fit line, we first construct a set of line EW which does not correlate with the X-ray luminosity. Random continuum variations are then added to the luminosities, and the line EW are modified correspondingly since we assume no change to the line flux. We repeated this step to build 1000 artificial samples with different random seed for each time. Finally, 8.4% of the simulations produce anti-correlation slopes steeper than the observed value, and the mean value is $-0.0485 \pm 0.0536$, which is compatible with the observed value ($\alpha = -0.1019 \pm 0.0524$) within the errors.

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References