The X-ray properties of Type II Quasars from SDSS

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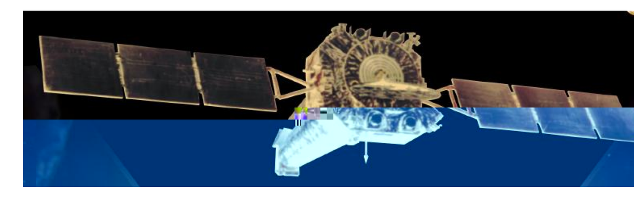


Abstract

We present the X-ray properties of 65 Type II quasars optically selected from Sloan Digital Sky Survey (SDSS) by correlating with *Chandra* and *XMM* archival data. Spectra were fitted to characterize the spectral properties of each source, and were studied statistically.

※ Mean of column density N_H=2.65 x 10^{23} cm^{-2}, photon index Γ=1.79

※ The observed hard X-ray / [OIII] luminosity ratios imply that N_H is underestimated in spectral fits

※ N_H implied by simulations of obscuration are about 1 order higher than the fitted values

※ Fe line luminosities are correlated with [OIII] luminosities

Introduction

※ Type 2 AGNs are expected to be heavily obscured due to the edge-on geometry but are difficult to observe at high redshifts due to their faintness.

※ Quantifying the amount and frequency of obscuration in AGN and its dependency on intrinsic luminosity is important for understanding the structure of AGN in general.

※ Open questions:

- ◆ Half of the XRB above 6 keV remains unresolved, is this due to star-forming galaxies, low-luminosity AGN or emission from luminous AGN?
- ◆ The fraction of obscured sources is not well known at high luminosities.
- ◆ The true number of the most obscured (Compton-thick) objects is poorly constrained.

※ Why use [OIII] selection?

- ◆ SDSS has a large survey volume. The sample of Type 2 QSOs has been greatly expanded as SDSS progressed.
- ◆ It can avoid the selection effect from X-ray surveys. Unlike the X-ray emission, [OIII]λ5007 line is formed in the narrow line region, and is not affected by the obscuration.

Sample selection & data reduction

※ 887 type 2 quasars with redshifts z<0.83 were selected optically from SDSS (Reyes et al, 2008):

- ◆ [OIII]5007 luminosity: $10^{8.3}L_{sun}<L_{[OIII]}<10^{10}L_{sun}$
- ◆ no broad emission line
- ◆ hard ionizing emission

※ 65 objects were found to have *Chandra* and *XMM* archival data available, while data for the other 8 objects were proprietary.

※ Data pipeline: XAssist associated with CIAO and XMMSAS

※ Spectral fits:

- ◆ Single absorbed power-law: a power-law continuum absorbed by the Galactic column density and an absorber surrounding the source
- ◆ Two-absorber power-law: In case of partial covering. Two power-law indices tied
- ◆ Absorbed power-law plus Gaussian Fe-K emission line: Fe-K emission line (6.4 keV) added to the continuum power-law profile

χ^2-stat: 10 counts per bin for sources with sufficient counts

C-stat: 1 count per bin for sources with insufficient counts

5σ upper limit: if no good fit given by spectral fitting

ΛCMD: h=0.7, Ω_M=0.3, Ω_Λ=0.7

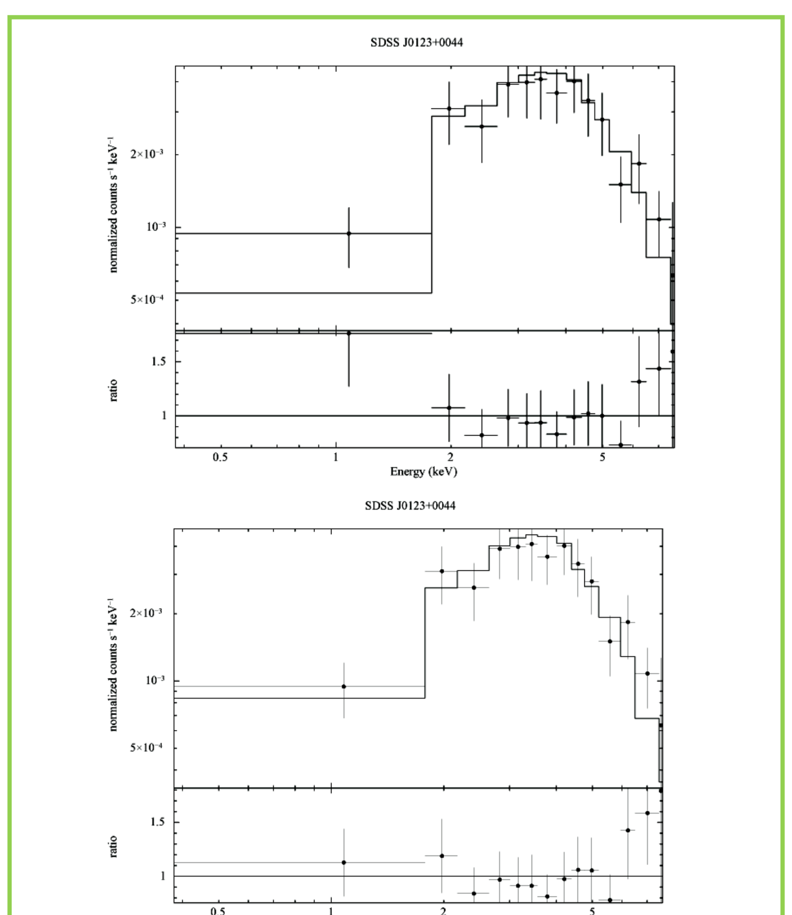
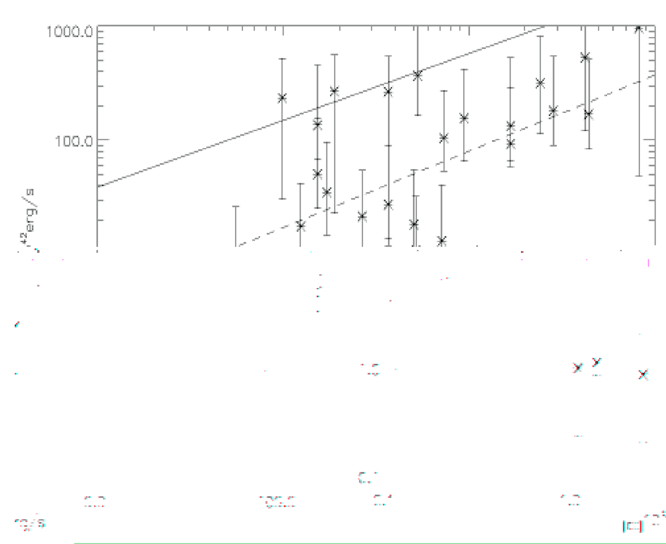


Fig. 1. Spectral plots of SDSS J0123+0044 with the model of single (upper) and double (lower) absorbed power-law

Results

$L_{2-10keV}/L_{[OIII]}$ is a proxy of intrinsic obscuration

Hard X-ray and [OIII] luminosities are correlated for both type 1 and 2 QSOs (H05). Fig. 2 shows such relationship for our sample, and indicates they are significantly obscured. We simulated unobscured $L_{2-10keV}$ estimates based on the observed $L_{[OIII]}$ for each source and the the Sy 1 $L_{2-10keV}$/ $L_{[OIII]}$ ratio. The difference between the observed and simulated $L_{2-10keV}$ is then likely due to absorption and we estimated the amount of absorption by varying N_H in a partial-covering model. This shows that the N_H from fitting the observed spectra are likely underestimates of the 'true' N_H(Fig. 3).



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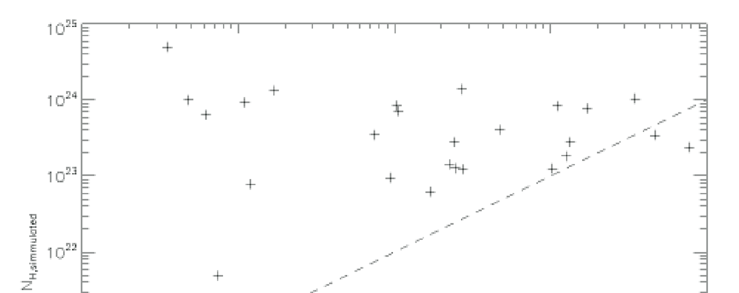

Fig. 3. $N_{H,simulated}$ V.S. $N_{H,fittted}$. The dashed line indicates where the two values are equal. It shows that the $N_{H,fitted}$ less than 10^{22} cm^{-2} are underestimated.

Fe line EW

7 targets were found to have visually-detected Fe emission lines. The Fe Gaussian line was added to the double power-law continuum in spectral fitting. EW of Fe line lacks correlation with $L_{2-10keV}/L_{[OIII]}$ (Fig. 4). In Fig. 5, Fe V.S. N_H is consistent with the relationship by Krolik & Kallman (1987) (if N_H is from single power-law fit, the data will be above the line).

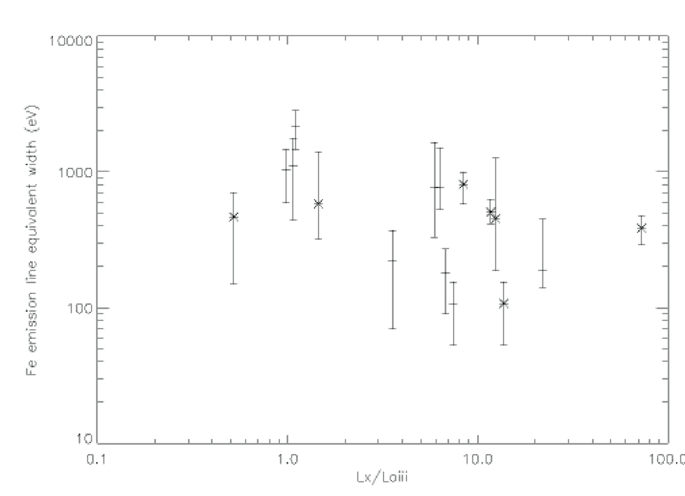

Fig. 4. Equivalent width of Fe emission line V.S. $L_{2-10keV}/L_{[OIII]}$. The points with asterisks are from our sample, others are from LaMassa et al (2009).

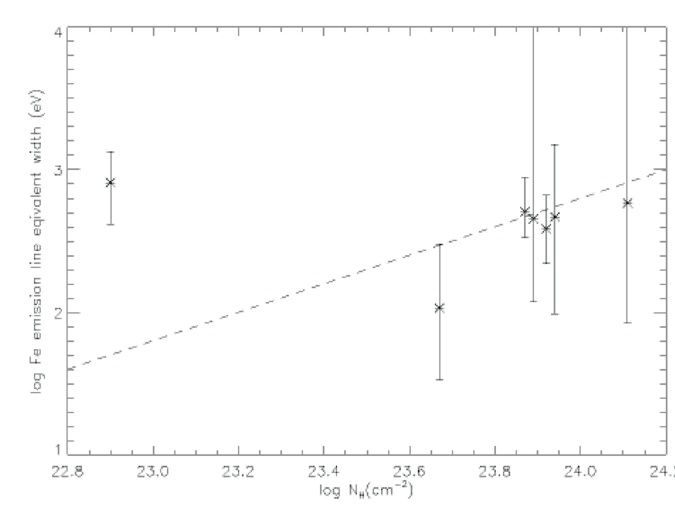

Fig. 5. Fe line EW V.S. fitted column densities. Dashed line represents the relationship from Krolik & Kallman (1987).

The spectral fits for 16 sources with sufficient photon counts were performed by a double power-law model with two absorbers, which gave much higher values of obscuration than those from single power-law fits. The results are consistent with the simulated values based on the correlation of hard X-ray and [OIII] luminosities (H05).

The correlation between Fe line luminosities and [OIII] luminosities is consistent with that in the cases of heavily obscured AGN (Ptak et al 2003).

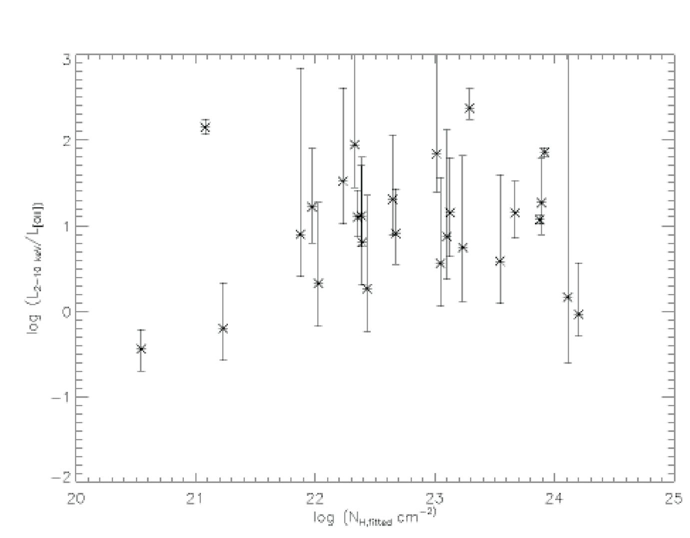

Fig. 6. $L_{2-10keV}/L_{[OIII]}$ V.S. fitted column density, not correlated, indicating the $N_{H,fitted}$ do not represent the actual values.

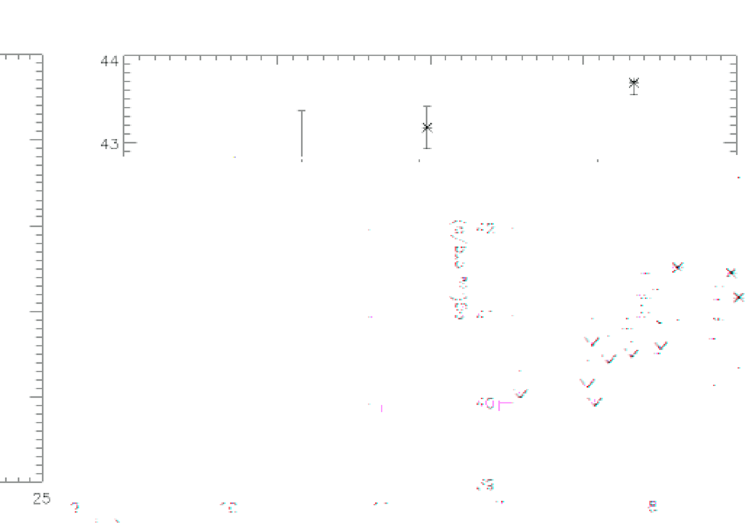

Fig. 7. Fe line luminosities V.S. $L_{[OIII]}$, points with asterisks are from this sample, others from LaMassa et al. (2009)

References:

Heckman, T., et al. 2005, ApJ, 634, 161 (H05);Krolik, J. & Kallman, T. 1987, ApJ, 320, L5;

LaMassa, S. et al. 2009, Submitted to ApJ; Ptak, A. et al. 2003, ApJ 592, 782

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Chandra's First Decade of Discovery