Suzaku broad-band X-ray observation of Narrow-line Seyfert 1 Galaxy Ton S180

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Abstract

We present a Suzaku observation of the narrow-line Seyfert 1 galaxy Ton S180. The hard X-ray spectra above 15 keV is obtained for the first time. Wide band X-ray spectra shows that soft excess and hard excess, and a broad iron emission line are found. The broad iron emission is centered on 6.7 keV and most likely fluorescent X-rays from the ionized matter. We consider that the hard excess is also the reflection from the ionized matter. Possible models to reproduce the soft X-ray excess are examined, and spectral variability is discussed.

Key words: galaxies: active — galaxies: individual (Ton S180) — galaxies: Seyfert

1. Introduction

Ton S180 is the Narrow-Line Seyfert 1 Galaxy, which is located at $z = 0.062$. This target was observed with $ASCA$, $XMM-Newton$, $Chandra$ (Turner et al. 2001, Romano et al. 2001, Vaughan et al. 2002), with particular interest on its EUV to soft X-ray excess component.

2. Time-averaged spectra

We observed this target with $Suzaku$ on 2006 December 9. Fig.1. shows the time-averaged spectra as a spectral ratio to a simple power law model ($\Gamma_{hard} = 2.25$), of which index was determined by fitting the 2.5 keV to 55 keV spectra. We fix the Galactic absorption at $N_H = 1.6 \times 10^{20} cm^{-2}$. This figure shows the excess below the 2.5 keV and above 12 keV, and an emission line at $6 \sim 7$ keV.

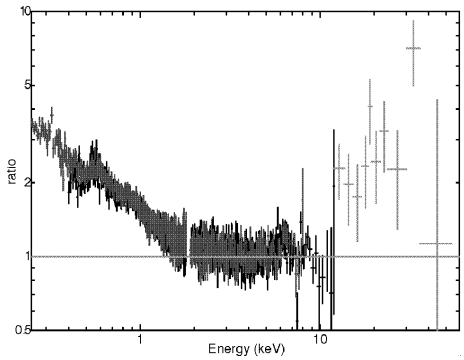

Fig. 1. Spectral ratio (data/model) to a single power-law ($\Gamma = 2.25$) model.

2.1. Broad iron emission line

The emission line feature is fitted with a gaussian model, with the best-fitting line energy (source frame) of $E = 6.74 \pm 0.15$ keV, the line width of $\sigma = 0.43 \pm 0.12$ keV, and $EW = 197$ eV. The broad iron line was implied in the $XMM-Newton$'s observation, but with slightly different energy (7.01 ± 0.31 keV, Vaughan et al. 2002). This iron emission is most likely the fluorescent X-rays from ionized matter at the vicinity of the central black hole. The hard X-ray excess also comes from the same matter as a reflection component.

2.2. Broad Band X-ray Spectra

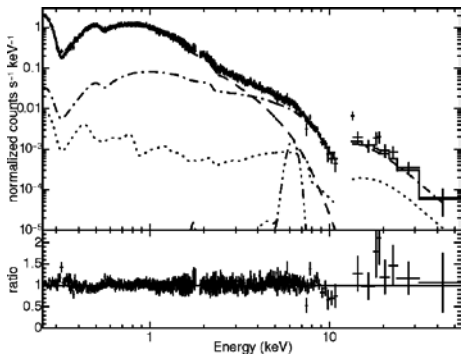

Fig. 2. The Partial-Covering-CUTOFFPL model fit to the $Suzaku$ spectra. The Partial-Covering-CUTOFFPL model consists of CUTOFFPL (dash line), POWERLAW (dash-dot line), PEXRIV (dot line), and ZGAUSS (dash-dot-dot-dot line).

We examined models to reproduce the $0.25 - 55$ keV X-ray spectra. For the hard X-ray excess, we employed

PEXRIV model, which represents a reflected power-law from ionized material. On the other hand, we tested four models for the soft X-ray excess component, i.e., multi-color black body, Comptonized black body, power-law, cutoff-powerlaw (Vaughan et al. 2002, Murashima et al. 2005). Either of these four models provides a reasonable fit, while the model with CUTOFFPL and that with DISKBB give the best ones. Introducing partial covering absorber to the model with the CUTOFFPL, i.e., ZPCFABS*(CUTOFFPL+POWERLAW+PEXRIV+ZGAUSS), reproduces the overall spectra. Hereafter we call this model Partial-Covering-CUTOFFPL model. Fig.2. shows the $0.25 - 55$ keV X-ray spectra fitted with this model. Table.1 shows the best-fit parameter values for it.

Note that the above model is not the unique solution. In fact, we found that the relativistically blurred reflection from ionized accretion disk model (Ross & Fabian et al. 2005) fits the observed spectra well ($\chi^2/d.o.f = 2897.74/2861$).

Table 1. The best-fit parameters of Partial-Covering-CUTOFFPL model

component	parameter	value
partial covering	$N_H(10^{22}cm^{-2})$	4.90 ± 0.04
	covering fraction	0.5 ± 0.04
soft excess	Γ_{soft}	2.61 ± 0.05
	$E_{cutoff}(keV)$	2.41 ± 0.54
power-law	Γ_{hard}	1.60 ± 0.25
broad iron line	$E(keV)$	$6.66^{+0.15}_{-0.18}$
	$\sigma(keV)$	$0.39^{+0.24}_{-0.23}$
	$EW(eV)$	131
	$\chi^2/d.o.f$	3053.46/2860

3. Spectral Variability

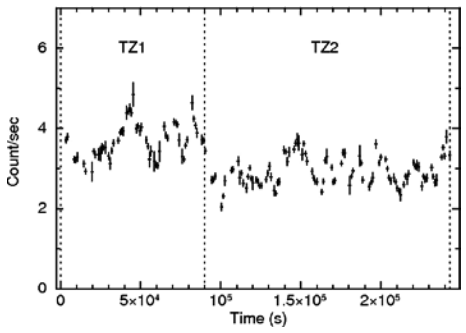

Fig. 3. The light curve in the $0.2 - 12$ keV band obtained with the XIS, using a bin size of 1024 sec. The data from the three XIS sensors (XIS0, 1, 3) are combined.

Fig.3. shows the XIS light curve of this source. We divided time span into TZ1 and TZ2, each exposure time of 46 ks and 80 ks, respectively. We made the spectra in each time zone, and fitted with the Partial-Covering-CUTOFFPL model. We fixed E_{cutoff}, line energy, and σ at 2.41, 6.66, 0.39, respectively. We made only the covering fraction of each time zone different and others common and free. As shown in Fig.4, the spectral variability is explained by slight change in the covering fraction, 0.37 ± 0.05 (TZ1) and 0.51 ± 0.04 (TZ2). We also examined RMS variability of the source, which indicates small energy dependence of the variability.

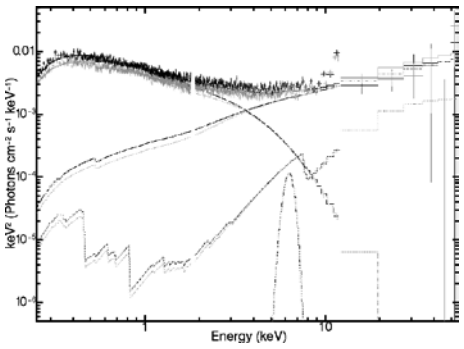

Fig. 4. The result of simultaneous fitting using Partial-Covering-CUTOFFPL model. The black spectrum is TZ1 and the light gray one is TZ2. The Partial-Covering-CUTOFFPL model is composed of CUTOFFPL (dash line), POWERLAW (dash-dot line), PEXRIV (dot line), ZGAUSS (dash-dot-dot-dot line). The spectral variability can be explained by the change of the covering fraction.

4. Summary

We observed Ton S180 with Suzaku and detected the hard X-ray emission above 15 keV for the first time. From the wide band spectra, we found the soft X-ray excess, the hard X-ray excess, and a broad iron line which peak is 6.73 keV. This line is most likely radiated from the ionized matter near the central black hole. The hard X-ray excess is considered as the reflection component from the same ionized matter. We showed the Partial-Covering-CUTOFFPL model provides a reasonable fit for the $0.25 - 55$ keV X-ray spectra. Using this model, the spectral variability could be explained by slightly change in the covering fraction.

References

Murashima,M.et al.2005,PASJ.,57,279
Romano,P. et al 2002, ApJ., 564, 162
Ross & Fabian, 2005, MNRAS, 358. p.211
Turner T.J. et al 2001, ApJ., 548, L13.
Vaughan S. et al 2002, MNRAS., 337, 247