Fe -K line Profile and X-ray Spectral Variability of the Seyfert 1.9 Galaxy NGC 7314 Observed with *Suzaku*

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Abstract

We present results from a *Suzaku* observation of the Seyfert 1.9 galaxy NGC 7314. The light curve in the 2-10 keV band shows rapid variability on timescales of ∼1000 sec. The time-averaged spectrum in 0.5-25 keV is explained a model consisting of absorbed and unabsorbed power laws, a reflection continuum and a gaussian at 6.4 keV. The line at 6.4 keV is relatively narrow ($\sigma\sim$50 eV) and does not vary on a timescale of ∼10 years. This narrow line is likely to be primarily from distant matter. We analyze spectra in the time intervals with fluxes higher/lower than the mean. The normalization of the absorbed power law varies by a factor 1.6, while the photon index, the amount of the reflection, and the intensity of the Fe line remains constant.

Key words: — Seyfert galaxy, NGC 7314, variability

1. INTRODUCTION

We observed the Seyfert 1.9 galaxy NGC 7314 with *Suzaku*, which is suitable for analysis of spectral variability thanks to its broad band coverage and good S/N at hard X-rays, on 2007 April 25-26. AGNs often show rapid variability on short timescales (<1000 sec). NGC 7314 is known for variability of an Fe line complex and a continuum on short (∼10 ksec) timescales (Yaqoob et al. 2003) and is one of the best objects to study broad band and emission line variability.

2. RESULTS

2.1. Light Curve

The light curve in the 2-10 keV band obtained with the XIS0 is shown in Figure 1. The 2-10 keV flux varied by a factor of three on timescales of ∼1000 sec. In the following analysis, we use the time intervals where the data from the XIS and HXD/PIN were taken simultaneously and obtained a net exposure time 90.0 ksec.

2.2. Time-averaged Spectrum

We first analyzed the time-averaged spectrum in the 0.5-25 keV band. The spectrum is well reproduced with a model consisting of an unabsorbed power law to represent a soft component, an absorbed power law, a Compton reflection component from neutral matter, and a gaussian at 6.4 keV. We parameterize the reflected continuum from the absorber with the deisk-refction model, PEXRAV, as an approximation to the true scattered continuum. We fixed the cut-off energy of the power law at 300 keV, the cosine of the inclination angle at 0.95, the abundance at the solar value. The photon index was tied to that of the unabsorbed power law. The free parameter for PEXRAV was a scaling factor of the reflection R, where R = 1 corresponds to a plane reflector subtending a solid angle 2π viewed from the illuminating source, and the normalization. All statistical errors quoted are at 90% confidence for one interesting parameter ($\Delta\chi^2 = 2.7$). The PEXRAV component is absorbed by a column density $N_{\rm H} \simeq 8\times10^{21}$ cm^{-2}. The photon index and R were obtained to be $\Gamma = 1.75\pm0.05$ and $R = 0.72\pm^{0.72}_{0.48}$. The best-fit parameters for the gaussian line are E = 6.40±0.02 keV, $\sigma = 54\pm^{18}_{17}$ eV, and equivalent width (EW) = 149±23 eV. The spectrum shows a hint of an emission feature at around 6.9 keV. We added a gaussian to represent this structure with a fixed line center energy (6.95 keV) and a width (10 eV) and obtained EW = $13\pm^{23}_{13}$ eV.

2.3. High and Low-Flux State

In order to study spectral variability, we divided the data into two portions; spectra for the High/Low-flux states were made by using the time intervals with fluxes in the 2-10 keV higher/lower than the mean count rate (0.21 counts s^{-1} per XIS). The spectra in the High/Low-flux states were successfully fitted by the same model as used to describe the time-averaged spectrum. The 2-10 keV flux of the absorbed power-law component changed by a factor of 1.6 between the High and Low-flux states, while the photon index remained constant ($\Gamma = 1.78\pm0.06$ and 9.3×10^{-12} erg s^{-1} cm^{-2} for High flux, $\Gamma = 1.76\pm^{0.09}_{0.10}$ and 5.8×10^{-12} erg s^{-1} cm^{-2} for Low flux). On the other hand, the 2-10 keV flux of the reflection continuum did not vary significantly (4.2×10^{-12} erg s^{-1} cm^{-2} for High flux 4.1×10^{-12} erg s^{-1} cm^{-2} for Low flux), though the errors mainly due to the systematic error of the estimation of the non X-ray background for the HXD/PIN are large ($\sim$30% for High flux, $\sim$40% for Low flux). The normalization of the unabsorbed power-law component and the center energy and the flux of the iron line are consistent with being constant.

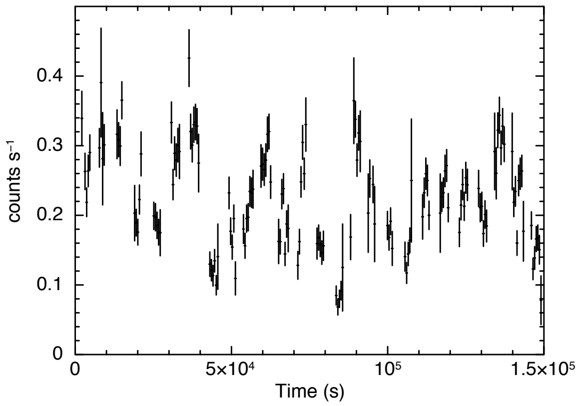

Fig. 1. *Suzaku* XIS0 light curve of NGC 7314 in the 2-10 keV band binned at 512 s.

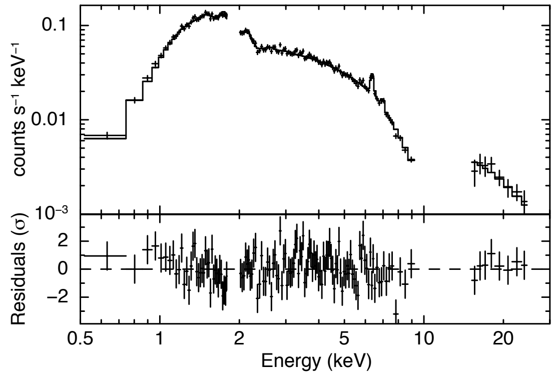

Fig. 2. *Upper*: Time-averaged spectrum along with the best-fit model in the 0.5-25 keV band. The XIS1 data are not shown for clarity. *Lower*: Residuals in units of sigma.

3. DISCUSSION

3.1. Spectral Variability of NGC 7314

The 2-10 keV flux of the power-law component varied by a factor of $\sim$1.6 between the High and Low-flux states, while the photon index remained constant. Although the best-fit fluxes of the reflection continuum were almost the same between the two states, it is not clear whether the reflection continuum varied by a large amount or not because of the large errors. Since the Fe Kα line at 6.4 keV and the reflection continuum are likely to be reprocessed by the same matter, the constant Fe line flux implies that the reflection continuum might be expected to be constant, and the data are consistent with this. Such spectral behavior would be in concordance with idea of the two-component model, in which a combination of a soft variable component and a constant hard component explains the spectral variability (Fabian and Vaughan 2003).

We compared our results with previous observations of NGC 7314 (*ASCA* in 1994, Yaqoob et al. 1996; *XMM − Newton* in 2001, Dewangan and Griffiths 2005; *Chandra* in 2002, Yaqoob et al. 2003). The power-law flux changed by a factor of $\sim$3 on a long timescale ($\sim$10 years). The line energy at 6.4 keV appeared to vary on a short timescale (<12.5 ksec) in the Chandra observation (Yaqoob et al. 2003), although it did not vary on long timescales. The best-fit intensity of the Fe XXVI line obtained in our observation ($1.3\pm^{1.5}_{1.3}\times10^{-6}$ photons cm^{-2} s^{-1}) is smaller than that in the Chandra observation ($1.9\pm^{1.0}_{0.7}\times10^{-5}$ photons cm^{-2} s^{-1}) by a factor of $\sim$10, though the 90% confidence contours between intensity and energy for the two observations overlap with each other.

3.2. Origin of the Fe Emission Line

Since the intensity of Fe Kα emission line at 6.4 keV did not change on long timescales ($\sim$10 years) and its width is relatively narrow, it is likely to be from distant matter. If there is an additional variable Fe Kα component that responds to continuum variability on short timescales, the EW of such component would be at most $\sim$20 eV, because the errors on the EW of the neutral Fe Kα emission line in the High/Low-flux spectral fits are about 15%. Therefore, if a small inclination angle is assumed (Yaqoob et al. 2003), the reprocessor near the central source would subtend a solid angle of at most $\Omega = 2\pi\times20/150$, since EW $\simeq$ 150 eV is expected for a face-on slab with $\Omega = 2\pi$ (George and Fabian 1991). If we assume that the X-ray source is located at a height $h = 10\ R_{\rm s}$ above the center of the disc, the inner radius of the disk is estimated to be $\sim$75 $R_{\rm s}$.

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