The New Primary Radiation from Seyfert 1 AGNs

Katsuma Miyake[1], Hirofumi Noda[2], Shin'ya Yamada[3],
and Kazuo Makishima[1,2]

[1] University of Tokyo, 7-3-1 Bunkyo, Tokyo, Japan
[2] RIKEN, 2-1 Hirosawa, Wako city, Saitama, Japan
[3] Tokyo Metropolitan University, 1-1 Minami Osawa, Hachioji city, Tokyo, Japan
E-mail(KM): miyake@juno.phys.s.u-tokyo.ac.jp

Abstract

A bright variable Seyfert 1 AGN, IC4329A was observed by Suzaku 6 times in 2007 and 2013, with a 2–10 keV fluxes of 7.0×10^{-11} erg cm^{-2} s^{-1}. Difference spectra among these observations revealed that the source variability is carried by a primary power-law (PL) component with a photon index of $\Gamma \sim 2.1$. The time averaged spectra cannot be reproduced by this PL plus an appropriate reflection component, and require another harder primary component with $\Gamma \sim 1.5$ which remained constant over a month. The primary emission from this AGN is a mixture of the variable steeper PL and the less variable flatter PL.

Key words: galaxies: active — galaxies: individual (IC4329A) — galaxies: Seyfert — X-rays: galaxies

1. Introduction

X-ray spectra of AGNs were so far considered to consist of a single power-law (PL) like primary component and a reflection component accompanied by an Fe Kα line (Fabian & Miniutti 2005). However, it is difficult to properly distinguish the primary and reflection components without some assumptions, because they are mixed in an observed spectrum (Cerruti et al. 2011). In particular, the assumption of "single primary component" has not been confirmed observationally.

Noda et al. (2011, 2013) showed that X-ray spectra of many AGNs harbor two distinct primary components. Let us examine another AGN for the same possibility.

IC4329A is a highly variable (Perola et al. 1999) Seyfert 1 AGN, with a redshift of $z = 0.016$ (Willmer et al. 1991) and an estimated mass of $1.3 \times 10^7 M_\odot$ (Markowitz 2009). This AGN was observed by Suzaku 5 times in 2007 and once in 2012. As shown in Fig. 1, we observed clear variability in soft X-rays, around a mean 2-10 keV flux of 7.0×10^{-11} erg cm^{-2} s^{-1}.

2. Data Reduction

We analysed publicly available XIS 0, XIS 3, and HXD-PIN data of the 6 Suzaku observations of IC4329A. XIS 0 and 3 data were co-added and are referred to as XIS FI. On-source XIS FI events were extracted from a circular region of $3'$ radius, and background events from an annular region of $4'.8 - 7'.8$. From the HXD-PIN data, we subtracted Non X-ray Background (NXB) estimated by the NXB model (Fukazawa et al. 2009) and Cosmic X-ray Background (Boldt 1987).

3. Data Analysis

3.1. Light Curves and Spectra

Figure 1 shows the background subtracted and dead-time corrected XIS FI and HXD-PIN light curves in 2007 and 2012. The 2–10 keV continuum varied by a factor ~ 2 among the 5 observations in 2007 and ~ 1.5 during 216 ks observation in 2012. In the 2012 observation, we defined a period from 36 ks to 72 ks as a 'high phase', and from 180 ks to 216 ks as a 'low phase'.

Figure 2 shows the background subtracted time averaged spectra in the form of their ratios to a PL model of $\Gamma = 2$. They exhibit Fe Kα line and edge at 6.4 keV and 7.2 keV in the rest frame, respectively. We can see

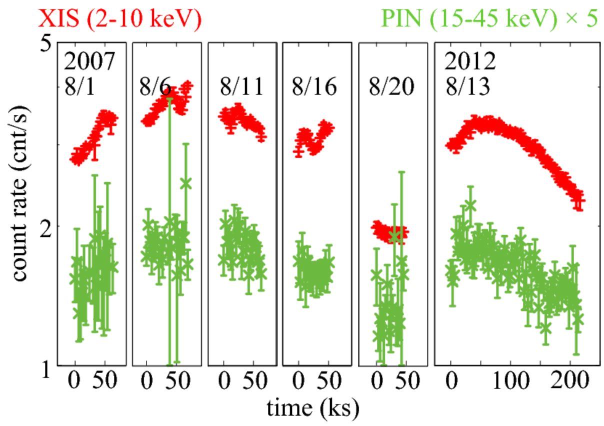

Fig. 1. Background subtracted and dead-time corrected light curves of IC4329A with XIS FI in 2–10 keV (red) and HXD-PIN in 15–45 keV (green). The latter is multiplied by a factor of 5.

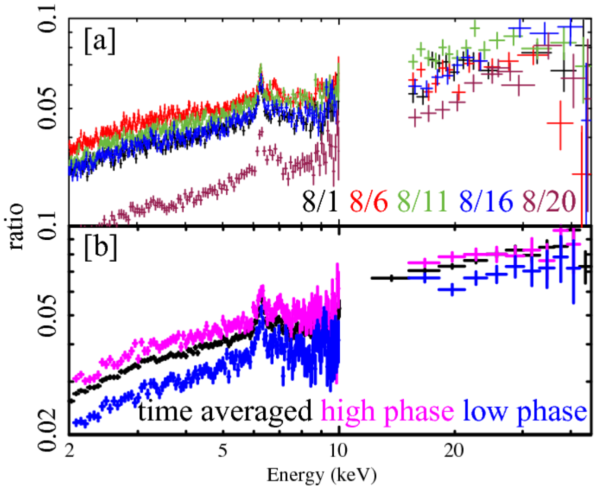

Fig. 2. Background subtracted spectra of IC4329A. [a] Time averaged spectrum of each observation in 2007. [b] Time averaged spectrum in 2012 (black), compared with those extracted from the high phase (magenta) and low phase (blue).

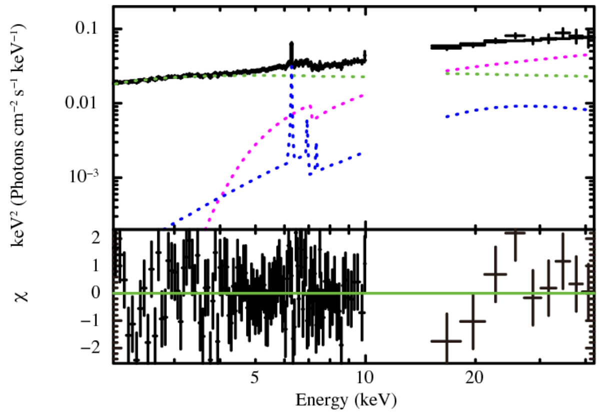

Fig. 3. The time averaged spectrum of 2007 August 20 (black), fitted with the $\Gamma = 2.1$ PL, its reflection (blue), and the additional PL component with $\Gamma = 1.3$ (magenta).

that neither the shape of the hard X-ray hump nor the Fe Kα line intensity changed significantly.

3.2. Difference Spectra

To extract the spectral component which is responsible for the source variation, we made difference spectra among the observations in 2007, and within the observation in 2012. The obtained difference spectra can be well reproduced by an absorbed PL model, `wabs*powerlaw`. Any pair of the 2007 observations yielded a PL photon index of $\Gamma = 2.1 \pm 0.1$. From the difference spectrum between the high and low phase in 2012, $\Gamma = 2.0 \pm 0.1$ was obtained.

3.3. Decomposition of the Time-Averaged Spectra

Although we inferred that the reflection component is stationary while a $\Gamma = 2.1$ PL carries the variability, the time averaged spectrum of each observation in 2007 cannot be reproduced (with $\chi^2/\mathrm{d.o.f.} \gtrsim 2.6$), by a model which consists of a PL component with $\Gamma = 2.1$ and a reflection component with an abundance fixed in 1 solar, `wabs[0]*(powerlaw[0]+pexmon[0])`. The fitting became succesful with $\chi^2/\mathrm{d.o.f.} \lesssim 1.4$ by including an additional component, `wabs[1]*powerlaw[1]`. This additional PL has a harder slope with $\Gamma = 1.3 \pm 0.1$, and is strongly absorbed with a hydrogen column density $N_\mathrm{H} = (5 \pm 1) \times 10^{23}$ atoms cm^{-2}. It is accompanied by an Fe Kα edge at 7.2 keV, but no emission feature is seen.

Similarly, the fitting to the time averaged spectrum in 2012 was improved from $\chi^2/\mathrm{d.o.f.} = 7.2$ to 1.7, by the additional component with $\Gamma = 1.3 \pm 0.2$ and $n_\mathrm{H} = (5 \pm 1) \times 10^{23}$ atoms cm^{-2}.

4. Discussion and Conclusion

Spectra of AGNs were so far interpreted to include a partially absorbed or relativistically reflected PL component, in addition to a single primary PL component and its reflection with Fe Kα line. However, the fitting to the time average spectrum of 2007 August 20 degraded from $\chi^2/\mathrm{d.o.f.} = 1.1$ to 1.3 or 1.4, respectively, by replacing the harder new PL with a partially absorbed $\Gamma = 2.1$ (fixed) PL, or by a relativistic reflection. Moreover, a partially absorbed PL or a relativistic reflection component should vary on the same time scale as the $\Gamma \sim 2.1$ primary PL component, and would not emerge as (nearly) stationary signals.

As a result of the above discussion, the additional PL component is unlikely to be a secondary component, and should be regarded as a new primary component that is different from the $\Gamma \sim 2.1$ PL. Thus, like the case of NGC 3516 (Noda et al. 2013), the broad-band spectra of IC4329A have been found to consist of two distinct primary components; a steeper ($\Gamma \sim 2.1$) variable one and a flatter ($\Gamma = 1.5 - 1.8$) one. This new finding may apply to other Seyferts also.

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