A Variable Partial Covering Model for the Narrow-Line Seyfert 1 Galaxy 1H0707–495

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\textbf{Abstract}

The Narrow-line Seyfert 1 galaxy 1H0707–495 exhibits significant X-ray spectral variations, and is characterized by a strong soft excess emission and extremely strong iron K-edge structure at \(\sim 7\) keV. We find a Variable Partial Covering model (VPC model in the following), which successfully explains X-ray spectral variations of several Seyfert galaxies with ionized partial covering absorbers, is also successful in explaining the seemingly complex spectral shape and variations of 1H0707–495 observed by Suzaku and XMM-Newton satellites. We also find that the light-curves in the soft energy band below \(\sim 3\) keV are fully reproducible with the VPC model, while the light-curves in the hard band exhibit some additional flare-like features. We propose that the spectral variation of 1H0707–495 consists of two types of variations with different timescales; (1) intrinsic luminosity variation over days, and (2) variation of partial covering fraction over hours.

\textbf{Key words:} galaxies: active — galaxies: individual (1H0707–495) — galaxies: Seyfert — X–rays: galaxies

1. \textbf{Introduction}

1H0707–495 is a narrow line Seyfert 1 galaxy, which is characterized by strong soft excess and a sharp spectral drop at around 7 keV. Several different models have been proposed to explain its unique X-ray energy spectrum. On one hand, in the “relativistic disk-line model”, these features are interpreted as due to relativistically blurred inner-disk reflection around an extreme Kerr black hole (e.g., Fabian et al. 2002). On the other hand, a partial covering model may also explain these spectral features. Gallo et al. (2004) attempted to explain the long-term spectral changes with the partial covering by a neutral single-layer absorber with iron-overabundance (\(\sim 3\times\)solar). Tanaka et al. (2004) used a \textit{double-layer} neutral partial covering model, and suggested that the partial covering cloud is presumably due to either disk instabilities or radiation-driven mass outflow.

Here, we apply a Variable Partial Covering model (VPC model), which has been successful to explain spectral variations of MCG-6-30-15 and other 20 Seyfert 1 galaxies (Miyakawa et al. 2012; Iso et al. in prep.), to 1H0707–495. In the VPC model, intrinsic X-ray luminosity and spectral shape of the central X-ray source are not significantly variable, while variation of the partial covering fraction by intervening absorbers, which are composed of two different ionization layers, is primarily responsible for the observed flux and spectral changes.

2. \textbf{Observation}

We use archival data of Suzaku and XMM-Newton satellites. Suzaku has observed 1H0707–495 once and XMM-Newton has observed fifteen times. In this proceeding, we show only the Suzaku data due to the limited space. The Suzaku observation was carried out on Nov. 1, 2005, for 97 ksec exposure.

3. \textbf{Results}

In the VPC model, two ionized clouds with different ionization states partially cover the constant X-ray source with the same covering fraction. The \textit{xspec} model adopted is written as follows:

\[
F = A_I N (1-\alpha+\alpha W_1 e^{-\tau_1})(1-\alpha+\alpha W_2 e^{-\tau_2})(P+B) \tag{1}
\]

where \(P\) is the intrinsic power-law spectrum, \(B\) is the spectrum from an accretion disk (we adopted \textit{diskbb} in \textit{xspec}), \(N\) is the normalization factor, \(A_I\) is the effect of interstellar absorption (\textit{wabs}), and \(W_1\) and \(W_2\) are respectively high-ionized and low-ionised warm absorbers.
The Fe L- and K-shell edges are mostly explained by $W_1$ and $W_2$, respectively, but additional edge components were introduced as $e^{-\tau_1}$ and $e^{-\tau_2}$ when needed. To model the warm absorbers, we used the absorption table `xout_table.fits` used in Miyakawa et al. (2009) calculated using XSTAR, assuming the solar abundance and the photon index of the ionizing spectrum 2.0. We apply the VPC model to the average spectra and the intensity-sliced spectra respectively. All of the parameters, except for the covering fraction, are the same for all the spectra.

4. Discussion
We find the VPC model can explain the intensity-sliced spectra by only change of the covering fraction, where the luminosity is constant over the observation period for almost three days. Next, we examine if the short time scale variations are explained with the VPC model. We create simulated light-curves via the VPC model for different energy bands, where the covering fraction is the only variable parameter, to compare with the observed light-curves. We calculate the simulated count rates in 0.5-1.0 keV (soft), 1.0-3.0 keV (medium), and 3.0-10.0 keV (hard), and find that the light-curves of the soft and medium bands with typical timescale of hours are almost fully reproducible by the VPC model, while the light-curves of the hard band have additional flare-like features, which are also reported in Leighly (2004). Consequently, we propose that the spectral variation of 1H0707–495 consists of two independent types of the variations with different timescales; (1) intrinsic luminosity variation over days, and (2) variation of the partial covering fraction over hours.

References
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