

## ***XMM-Newton* Observations of Luminous Narrow-Line Seyfert 1 Galaxies**

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We observed four optically-luminous narrow-line Seyfert 1 galaxies (NLS1s) with *XMM-Newton*. All the four NLS1s were detected. The observed X-ray spectra were rather steep ( $\Gamma = 2-3$ ), as is typical among NLS1s. Utilizing simultaneous UV observations by the *XMM-Newton* optical monitor (OM), we also investigate the spectral energy distributions in the UV-X-ray band. One object (RX J1225.7+2055) of the four was found to be X-ray weak ( $\alpha_{\text{ox}} \sim 2.0$ ) during our observations. Compiling values of  $\alpha_{\text{ox}}$  from a larger NLS1s, we find that, although the sample is small, the  $\alpha_{\text{ox}}$  distribution suggests that X-ray weakness may occur more frequently among more luminous NLS1s.

### **§1. Introduction**

The extreme spectral and variability properties of NLS1s have been the subject of intensive study by virtually every X-ray satellite during the past decade, and are now well established. They frequently show a strong soft excess component, their hard X-ray spectrum tends to be steeper than in similar broad-line Seyfert 1 galaxies, and they show enhanced X-ray variability (e.g. Boller et al. 1996). The most promising explanation for this behavior is that NLS1s have a higher mass accretion rate compared with the Eddington value.

Luminous AGNs with narrow emission lines are of special interest, because they should have particularly high  $L/L_{\text{Edd}}$  based on the reverberation mapping argument (e.g., Laor 2000). While many NLS1s with lower, Seyfert-level luminosity have been studied using *ASCA* and *ROSAT*, only a few very luminous ( $M_V < -25$ ) NLS1s have been observed in the X-ray band. Recently, in the VLA FIRST radio survey, a new, extremely bright and quite luminous ( $M_V = -26.5$ ) quasar, PHL 1811, was discovered. Optically classified as a NLS1, it is remarkable because it was not a known X-ray source, being undetected in the *ROSAT* all-sky survey (RASS). Followup *BeppoSAX* observations detected the quasar in the X-rays, but discovered that it is remarkably X-ray weak (Leighly et al. 2001a). During followup *Chandra* observations in 2001, it was again observed to be X-ray weak. Significant variability was observed between the two observations separated by 12 days, and an observed steep X-ray spectrum shows that it is not absorbed (Leighly et al. 2002; Leighly et al. in prep.). These observations revealed that PHL 1811 is intrinsically X-ray weak.

### **§2. Results**

In order to characterize X-ray and broad-band properties of optically-luminous NLS1s, we carried out *XMM-Newton* observations of four such NLS1s in 2003. The observation date and fundamental informations of the sources are summarized in

Table I. All the four NLS1s were detected. We performed spectral fits to the X-ray spectra with Galactic absorbed power-law model in two energy bands: 0.3–10 keV and 2–10 keV. The photon-indices and the 2–10 keV fluxes are listed in Table I. The observed X-ray spectra are rather steep, as is typical among NLS1s.

We investigated UV–X-ray spectral slopes of our targets using  $\alpha_{\text{ox}}$ , defined as the point-to-point power-law energy-index between 2500 Å and 2 keV (rest frame). Fluxes at 2500 Å are estimated from the simultaneous UV observations by the *XMM-Newton* OM. The obtained  $\alpha_{\text{ox}}$  values are also listed in Table I. RX J1225.7+2055 was found to be X-ray weak ( $\alpha_{\text{ox}} \sim 2.0$ ; see Fig. 1) during our observation.

To investigate  $\alpha_{\text{ox}}$  distribution among luminous NLS1s in general, we compiled a heterogeneous sample of rather luminous AGNs ( $M_V < -23$ ) with narrow H $\beta$  line from the literatures. The 2500 Å flux ( $l_o$ ) was estimated from optical photometry by extrapolating a power law of  $f_\nu \propto \nu^{-0.5}$ . The 2 keV fluxes were estimated from the count rates or upper limits obtained from RASS, assuming that the X-ray spectrum can be represented by Galactic absorbed power law with photon-index of 2.75. The resulting values of  $\alpha_{\text{ox}}$  are plotted as a function of monochromatic luminosity at 2500 Å in Fig. 1. We discovered four additional X-ray weak objects in relatively luminous regime ( $\log l_o > 30.5$ ). Although it is not statistically clear, it is suggested that X-ray weak objects might be found more frequently in more luminous regime.

Table I. Results from the *XMM-Newton* observations of luminous NLS1s.

Object Name	$z$	$M_V$	$m$	$N_{\text{H}}^{\text{a}}$	Obs. Date	$\Gamma_{0.3-10\text{keV}}$	$\Gamma_{2-10\text{keV}}$	$F_{2-10\text{keV}}^{\text{a}}$	$\alpha_{\text{ox}}$
RX J2241.8–4405	0.545	–26.9	15.8	1.8	5/28 15–18	(2.64±0.10) <sup>b</sup>	2.4±0.4	4.2×10 <sup>–13</sup>	1.53
PG 1543+489	0.400	–25.6	16.0	1.6	2/08 20–24	2.74±0.07	2.6±0.5	1.5×10 <sup>–13</sup>	1.59
PG 2233+134	0.325	–25.2	16.0	4.8	5/17 17–20	(2.56±0.04) <sup>b</sup>	2.2±0.2	5.4×10 <sup>–13</sup>	1.56
RX J1225.7+2055	0.335	–25.1	15.9	2.4	6/12 16–20	2.73 <sup>+0.29</sup> <sub>–0.25</sub>	...	0.2×10 <sup>–13</sup>	1.97

a) The unit of Galactic column density is 10<sup>20</sup> cm<sup>–2</sup>, and that of the 2–10 keV flux is erg cm<sup>–2</sup> s<sup>–1</sup>.

b) The  $\chi^2$  value of this fit was not acceptable at 90% confidence level, and the fit was improved significantly by the addition of a soft excess component.

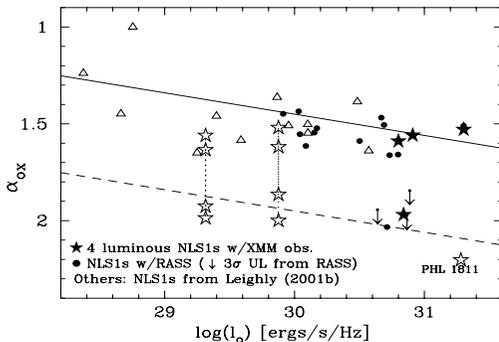


Fig. 1.  $\alpha_{\text{ox}}$  as a function of monochromatic luminosity at 2500 Å from a heterogeneous sample of NLS1s. The solid line represents the regression among radio quiet quasars (Vignali et al. 2003), and the dashed line is parallel to the solid one, ( $\Delta\alpha_{\text{ox}} = 0.5$ ; the sources at the dashed line have are 20 times X-ray weaker than the sources at the solid line), and is shown to guide the eye.

## References

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