**Abstract**

We report on the results of XMM-Newton observations of two broad absorption line quasars (BAL QSOs), Q1246−057 and SBS 1542+541. The unprecedented sensitivity of XMM-Newton allows spectral analysis of these X-ray–weak sources. The X-ray spectral data of these sources can be fitted by a power law with $\alpha_{X} = 1.0−1.2$ and either a partially covering absorber or an ionized absorber model. Rest-frame UV spectroscopy together with polarimetry favors the model with a partially covering absorber with column density a few times $10^{22} \text{ cm}^{-2}$ and a covering fraction of about 0.80. After correcting for absorption, the X-ray loudness of these BAL QSOs appears to be similar to other, unabsorbed quasars. The mystery of X-ray weakness of BAL QSOs appears to be all but solved, with strong absorption being the primary reason. With the available X-ray data, however, the issue of whether BAL QSOs represent highly accreting/younger population of quasars remains unsettled.

**Key words:** galaxies: active — quasars: general — quasars: individual (Q1246−057, SBS 1542+541)

**1. Introduction**

About 10%−15% of optically selected quasars have rest-frame ultraviolet spectra showing deep broad absorption line (BAL) troughs displaced blueward from the corresponding emission lines. Recently, Hewett & Foltz (2003) found that the intrinsic fraction of BAL quasars (BAL QSOs) is as large as 22% in the $1.5 < z < 3.0$ redshift range. These BALs are seen either in high-ionization transitions, such as $\text{C IV}, \text{Si IV}, \text{N V},$ and $\text{O VI},$ or in low-ionization stages, such as $\text{Al III}$ or $\text{Mg II}$ (Weymann et al. 1991), dividing them into high-ionization and low-ionization BAL QSOs (HiBALs and LoBALs). If the BALs are associated with mass outflows from the nucleus, then outflow velocities of several thousand kilometers per second are inferred (Arav, Shlosman, & Weymann 1997; Crenshaw et al. 2002; but see Branch et al. 2002 for an alternative explanation). If quasar outflows are a result of radiation pressure from the nuclear continuum, the large momentum associated with the BAL QSO outflow causes a serious problem to the quasar energy budget (see Mathur et al. 2001 and references there in). As an alternative, outflows in active galactic nuclei (AGNs) can also be the result of disk-driven hydromagnetic winds (e.g., Emmering, Blandford, & Shlosman 1992; Königl & Kartje 1994; Bottorff et al. 1997; Bottorff, Korista, & Shlosman 2000). BAL QSOs in general show high degrees of polarization, of up to more than 10%, in their absorption troughs (e.g., Schmidt & Hines 1999; Ogle et al. 1999). This argues that part of the nuclear emission is scattered back into our line of sight off a highly asymmetric structure. BAL QSOs may then be normal quasars viewed down the 10%−20% of the lines of sight covered by ubiquitous accelerating wind (e.g., Elvis 2000).

While these properties make BAL QSOs important in their own right, some recent observations suggest that they also occupy a special space in quasar lifetime (e.g., Mathur 2000; Becker et al. 2000). BAL QSOs, together with narrow-line Seyfert 1 galaxies (NLS1’s), occupy one extreme end of the eigenvector 1 for quasars and Seyfert galaxies (Boroson 2002). As such, they appear to be objects accreting at close to the Eddington limit. NLS1’s have been suggested to be AGNs in a young state of their evolution (Grupe 1996; Grupe et al. 1999; Mathur 2000). An analogy between BAL QSOs, especially the LoBALs, and NLS1’s (Brandt & Gallagher 2000; Lawrence et al. 1997; Leighly et al. 1997; Brandt, Mathur, & Elvis 1997) further suggests that BAL QSOs possibly are young quasars (Mathur 2000; Becker et al. 2000). This possibility adds further significance to the study of BAL QSOs.

X-ray studies of BAL QSOs are important for many reasons. X-ray observations offer direct measurements of the total absorbing column density. In the last decade, the rest-frame UV spectra of BAL QSOs have been extensively investigated. However, using the UV range only, properties such as absorption column density, covering fraction, or temperature are poorly constrained. In fact, absorption columns derived from the UV absorption lines led to values of $N_{H} < 10^{20}–10^{21} \text{ cm}^{-2}$ (Korista et al. 1992). This would suggest only minor intrinsic X-ray absorption in these sources. However, BAL QSOs appear to be highly absorbed in soft X-rays, implying absorbing column densities at least an order of magnitude higher compared with those from the UV studies (Green et al. 2001 and references there in). Scattering into our line of sight, evidenced by polarization (Ogle et al. 1999), turns these measurements into lower limits, and allows consistency with the 10−100 times larger X-ray column densities. Nonblack saturation of absorption lines (e.g., Arav et al. 1997) is a probable cause of the discrepancy between the X-ray and UV studies. Another
motivation behind X-ray observations of BAL QSOs is to
determine the intrinsic spectral shape in the X-ray band and
to compare it with the NLS1 spectra. Are the X-ray spectra
of BAL QSOs similar to those of non-BAL QSOs?

New X-ray missions, *Chandra* and *XMM-Newton*, offer
complementary advantages to BAL QSO studies. *Chandra*,
with its excellent point-spread function and low background
is ideal for detecting faint sources like BAL QSOs. *XMM-
Newton* (Jansen et al. 2001), on the other hand, with its large
collecting area, is ideal for obtaining spectra. In a recent
survey of BAL QSOs with *Chandra*, Green et al. (2001)
detected eight out of the 10 observed BAL QSOs (see also
Gallagher et al. 2002a). In this paper, we report on *XMM-
Newton* observations of two BAL QSOs, Q1246−057 and
SBS 1542+541. Both the objects were previously detected in
X-rays, and given their flux, we expected to obtain a good
signal-to-noise ratio (S/N) spectrum with *Chandra*. Unfor-
unately, QSO Q1246−057 was observed to be a fac-
tor of 2 fainter compared with the epoch of *Chandra*
observation and about half of SBS 1542+541 data were unusable
because of high background radiation. As a result, the spec-
tral quality of both objects is not as good as expected, but
given the rarity of BAL QSO spectra, any spectral informa-
tion is valuable. In the following, we briefly describe the
properties of our two targets and then proceed to a descrip-
tion of the observations (§ 2) and results (§ 3), followed by a
discussion and our conclusions (§ 4).

Q1246−057 (α1200.0 = 12h49m13s9, δ1200.0 = −05°59′19″3,
z = 2.236, and galactic N_H = 2.15 × 10^20 cm⁻²; Dickey
& Lockman 1990) is a HiBAL discovered by Osmer & Smith
(1977). They found strong, broad (5000 km s⁻¹) absorption
lines that were blueshifted by 15,000 km s⁻¹ with respect to
the quasars rest frame. The source was reobserved with
higher spectral resolution by Boksenberg et al. (1978) show-
ing multicomponent structure of the absorption troughs.
In spectropolarimetry measurements, Schmidt & Hines (1999)
and Ogle et al. (1999) found strong polarization in the C iv
λ1550 trough, with increasing degree of polarization toward
the blue, of the order of about 1%−2% (Hutsemékers, Lamy,
&Carrera 2000, 2001; Green et al. 2001) detected the
source but did not yield enough photons to perform
spectral analysis.

SBS 1542+541 (α1200.0 = 15h43m59.4, δ1200.0 = +53°59′03″7,
z = 2.361, and galactic N_H = 1.27 × 10^20 cm⁻²; Dickey
& Lockman 1990) has shown a variety of highly ionized absorption lines in *HST* spectra blueshifted by ≈11,000−12,000 km s⁻¹ and widths of 2000–3000 km s⁻¹ (Telfer et al. 1998). It was detected by *ROSAT* (Yuan et al.
1998) with 7.02 × 10⁻³ counts s⁻¹ (Telfer et al. 1998) in the
Position Sensitive Proportional Counter (PSPC; Pfeffer-
mann et al. 1987). In a later observation with *Chandra*’s
ACIS-S detector, the quasar was clearly detected with a
count rate of 0.019 counts s⁻¹ (Green et al. 2001).

Throughout the paper, we use energy spectral slopes α
defined as F_E ∝ ν⁻α. Luminosities are calculated assuming
a Hubble constant of H₀ = 5 km s⁻¹ Mpc⁻¹ and a deceleration
parameter of q₀ = 0.5 if not noted otherwise.

# 2. Observations

## 2.1. XMM-Newton Observations

Q1246−057 was observed by *XMM-Newton* for 41.5 ks in
orbit 291. SBS 1542+541 was observed twice in orbits 294
and 396 for 11 and 36 ks, respectively. The observations
of both sources were performed with *XMM-Newton*’s EPIC
PN and MOS cameras (Strüder et al. 2001 and Turner et al.
2001, respectively) in full-frame mode using thin filters
(Table 1). For Q1246−057, the whole lengths of the obser-
vations could be used. Due to high background radiation
in some parts of the observations of SBS 1542+541, only part
of these observations were used. Only times with high
energy (greater than 10 keV) background count rate CR < 10 counts s⁻¹ were accepted and screened into good
time intervals (GTIs). These GTIs were used to create new
event file lists that contain only acceptable data. In the end,
the two GTI event files were merged into one, which
was used to derive spectra. This results in total observing time of
25,176 s for the PN and 37,303 s for the MOS detectors.

Source photons were selected in a circle with a radius of
22.5′ and 25.0′ in the PN and MOS, respectively. Back-
ground photons were selected for a circular region of 50″
radius close to the source on the same CCD. Only good
quality events, with single and double patterns for the EPIC
PN (PATTERN ≤ 4) and single, double, and triple events
for the EPIC MOS (PATTERN ≤ 12), were selected for
spectral analysis. The count rates of both sources are too
low to be affected by pileups (See § 3.1 and 3.2).

The data were reduced by using the *XMM-Newton*
Science Analysis Software (XMMMSAS) version 5.3.3 and
the X-ray spectra were analyzed with XSPEC 11.2.0. The
data were grouped by tool GRPPHA 3.0.0 in bins of at
leasts 20 counts per bin. For the count-rate conversions
between different X-ray missions, PIMMS 3.2 has been
used.

## 2.2. ROSAT Observations

Q1246−057 and SBS 1542+541 were both targets for
pointed *ROSAT* Trümpner (1982) observations using the

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**TABLE 1**

| Source       | Obs ID   | Instr. | Obsstart       | Obsend       | T obs |
|--------------|----------|--------|----------------|--------------|-------|
| Q1246−057    | 0060370201 | PN     | 2001 Jul 11, 15:59:38 | 2001 Jul 12, 02:40:56 | 38008 |
|              |          | MOS    | 2001 Jul 11, 15:21:40 | 2001 Jul 12, 02:39:54 | 40514 |
| SBS 1542+541 | 0060370101 | PN     | 2002 Feb 3, 04:15:32 | 2002 Feb 3, 06:45:48 | 8546a |
|              |          | MOS    | 2002 Feb 3, 03:41:54 | 2002 Feb 3, 06:47:05 | 10822a|
|              | 0060370901 | PN     | 2002 Feb 6, 20:57:59 | 2002 Feb 7, 06:31:35 | 33946a|
|              |          | MOS    | 2002 Feb 6, 20:24:21 | 2002 Feb 6, 06:31:03 | 36222a|

* Please note that parts of the observations could not be used for spectral analysis due to high background radiation. The actual times used are given in § 2.1.
PSPC. Q1246−057 was observed serendipitously in an observation of NGC 4697 on 1993 June 22 to 1993 July 7 (rp600262a02) for a total of 45 ks (Green & Mathur 1996; Page et al. 2000, 2001). SBS 1542+541 was observed on 1993 August 14 (rp701436) for a total of 5.6 ks (Telfer et al. 1993). Long-term Light Curve

The mean count rates measured for Q1246−057 by the EPIC PN, MOS-1, and MOS-2 are (1.21 ± 0.15) × 10^{-2} counts s^{-1}, (3.86 ± 0.41) × 10^{-3} counts s^{-1}, and (4.18 ± 0.70) × 10^{-3} counts s^{-1}, respectively, resulting in 460, 160, and 170 photons. Due to the low count rate of the source no reliable light curve could be derived.

We measured the ROSAT PSPC count rate to be (1.30 ± 0.29) × 10^{-3} counts s^{-1}, consistent with that reported by Page et al. (2000). Using the EPIC PN count rate and the best-fit model (Table 2) we calculated the ROSAT PSPC count rate for Q1246−057.

### 3. RESULTS

#### 3.1. Q1246−057

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### TABLE 2

**Spectral Fit Parameters of Q1246−057**

| Detector  | \(N_{\text{H,gal}}\) (10^{20} cm^{-2}) | \(N_{\text{H,inn}}\) (10^{22} cm^{-2}) | Covering Fraction | \(\xi\) | \(\alpha_X\) | \(\chi^2\) (DOF) |
|-----------|-----------------------------------|-----------------------------------|------------------|-------|---------|------------------|
| PN\textsuperscript{a}              | 2.15 (fixed)                      | 92.0 ± 157                        | ...              | 0.32   | 4.56    | 6.9 (12)         |
| PN\textsuperscript{b}              | 4.78 ± 3.50                      | 2.15 (fixed)                      | 2.11 ± 5.07      | 0.42   | 3.74    | 22.1 (33)        |
| MOS-1\textsuperscript{c}           | 6.41 ± 7.85                      | 2.15 (fixed)                      | 15.05 ± 9.13     | 0.80   | 4.05    | 21.8 (34)        |
| MOS-2\textsuperscript{d}           | 3.70 ± 10.95                     | 2.15 (fixed)                      | 10.60 ± 11.39    | 0.60   | 3.65    | 2.2 (5)          |
| PSPC\textsuperscript{e} (0.2−1.45 keV) | 3.65 ± 5.82                    | 2.15 (fixed)                      | 0.47 ± 13.50     | 0.48   | 3.48    | 11.4 (13)        |
| MOS-1\textsuperscript{c} + MOS-2\textsuperscript{d} | 3.65 ± 5.82                    | 2.15 (fixed)                      | 4.170 ± 540      | 0.48   | 4.05    | 11.1 (13)        |
| PN\textsuperscript{b} + MOS-1\textsuperscript{c} + MOS-2\textsuperscript{d} | 5.52 ± 3.48                    | 2.15 (fixed)                      | 11.12 ± 4.90     | 0.74   | 3.65    | 14.9 (14)        |
| PN\textsuperscript{b} + MOS-1\textsuperscript{c} + MOS-2\textsuperscript{d} + PSPC\textsuperscript{e} | 4.98 ± 3.26                    | 2.15 (fixed)                      | 9.11 ± 2.95      | 0.80   | 2.54    | 38.9 (47)        |

\textsuperscript{a} EPIC PN; observed energy range used, 1.5−7.5 keV.

\textsuperscript{b} EPIC PN; observed energy range used, 0.2−7.5 keV.

\textsuperscript{c} EPIC MOS-1; observed energy range used, 0.2−7.5 keV.

\textsuperscript{d} EPIC MOS-2; observed energy range used, 0.2−4.0 keV.

\textsuperscript{e} ROSAT PSPC; observed energy range used, 0.2−1.45 keV.

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Notes.—Spectral fit parameters of Q1246−057 for a power-law model with galactic absorption (\(N_{\text{H,gal}} = 2.15 \times 10^{20} \text{ cm}^{-2}\)) and redshifted partial coverer and ionized absorption for the intrinsic absorption. The ionization state is given by \(\xi\) (Done et al. 1992).
PSPC count rate using PIMMS and found it to be the same as observed. This suggests that the source did not vary significantly between the ROSAT and XMM-Newton observations. However, a comparison to the Chandra ACIS-S count rate of \( \text{CR} = (8.1 \pm 1.2) \times 10^{-3} \text{ counts s}^{-1} \) (Green et al. 2001) suggests that the source was about a factor of 2 brighter during the Chandra observation compared with the ROSAT and XMM-Newton observations. Converting the EPIC PN count rate into an ACIS-S count rate gives \( \text{CR} = (4.9 \pm 0.5) \times 10^{-3} \text{ counts s}^{-1} \). From the quality of the data, it is not clear if this is due to intrinsic variability in luminosity of the source or caused by a change in the absorber property, either column density, covering fraction, or the ionization parameter. The Chandra observation was performed on 2000 February 8, so the Chandra and XMM-Newton observations were 520 days apart, which converts to 161 days in the rest frame of the quasar. From the ROSAT observation, the Chandra and XMM-Newton observations were 2596 and 2934 days apart, respectively, which converts to 802 and 907 days in Q1246–057’s rest frame, respectively.

3.1.2. Spectral Analysis

Figure 1 shows the observed XMM-Newton spectrum of the source in the 0.2–7 keV range (~0.6–21 keV rest frame). What is immediately apparent is lack of low-energy cutoff. This is completely contrary to the expectation, based on earlier work, that BAL QSOs are highly absorbed in X-rays (Mathur et al. 2001; Green et al. 2001). A simple power-law model with only Galactic absorption fits the data with \( \chi^2 = 6.9 \) for 12 degrees of freedom (Table 2). If the absorbing column density is allowed to vary, the fit yields \( \alpha_X = 1.28 \pm 0.94 \), and \( N_H \) is unconstrained (PN data only). If the source is not intrinsically X-ray–weak and is absorbed in X-rays like other BAL QSOs, then the observed flux in the soft-energy range can be explained if (1) the absorber only partially covers the source, or (2) the absorber is ionized. We examine these two alternatives below.

We then attempted to fit the data with an absorbed power-law model, partially covering the continuum source. Such a model was motivated by our earlier work on BAL QSOs (Mathur et al. 2001). The S/N in the spectrum is not good enough to perform complex spectral fits, and leaving the spectral slope parameter free results in fits where no parameter can be constrained (see Table 2). Restricting the EPIC PN data in the observed 1.5–7.5 keV energy range yields \( \alpha_X = 1.28 \) when \( N_H \) is free (Table 2). This energy range converts to 4.85–24.3 keV in the rest frame of Q1246–057, which is insensitive to absorption with column densities smaller than \( \approx N_H = 10^{23} \text{ cm}^{-2} \), and therefore the X-ray spectral slope \( \alpha_X \) in this range is likely the intrinsic unaffected power-law slope of the source. We therefore fixed the power-law slope to \( \alpha_X = 0.80, 1.0, 1.28 \) (to match the best fit), and 1.5 (see Table 2).

Fitting all three XMM-Newton EPIC detectors simultaneously results in a partially covering absorber with \( N_H = (4.49 \pm 2.36) \times 10^{22} \text{ cm}^{-2} \) with a covering fraction of 58% ± 9% (Table 2) for \( \alpha_X = 1.0 \) (fixed) and \( N_H = (7.4 \pm 2.1) \times 10^{22} \text{ cm}^{-2} \) with a covering fraction of 79% (Table 2) for \( \alpha_X = 1.5 \) (fixed). Addition of the ROSAT data do not contribute significantly to the fit. However, Table 2 shows that the ROSAT PSPC spectrum can be fitted with the same parameters as the EPIC PN and MOS data, providing a consistency check.

The rest-frame UV spectrum of Q1246–057 shows absorption lines of Si iv \( \lambda 1397 \) and C iv \( \lambda 1549 \) (Boksenberg et al. 1978, their Fig. 2) in which the flux in troughs do not reach zero intensity. If this is due to nonblack saturation resulting from partial covering of the continuum source, then the estimated covering fraction is 0.8. This is consistent with covering fraction determined with the X-ray spectral fitting, for \( \alpha_X = 1.5 \) (Table 2).

As discussed above, an ionized absorber can also be transparent in the soft X-ray region. To test this possibility, we fitted the spectrum with an ionized absorber model in XSPEC, and the results are given in Table 2. Again, because the data quality is not good enough to fit all the parameters simultaneously, we fixed the power-law slope to \( \alpha_X = 1.0 \) and then to \( \alpha_X = 1.5 \) to fit the absorber parameters. As shown in Figure 2, the column density and ionization parameter of the absorber are not well constrained, but the best-fit values are \( N_H = (6.5 \pm 1.9) \times 10^{22} \text{ cm} \) and the ionization state (Done et al. 1992) \( \xi = 609 \pm 175 \) for \( \alpha_X = 1.0 \). For \( \alpha_X = 1.5 \), the best-fit values are \( N_H = 6.9 \times 10^{22} \text{ cm}^{-2} \).
and $\xi = 1000$. In terms of the more familiar representation of the ionization parameter $U$ (Ferland et al. 1998), these best-fit values correspond to $U = 30$ and 50, respectively, using the conversion given in Figure 1 in George et al. (1998). This compares well with the ionization parameter $U$ suggested by Sabra & Hamann (2001) for the BAL QSO PG 1254+047 derived from Chandra observations.

3.2. SBS 1542+541

3.2.1. Long-term Light Curve

In the EPIC PN and MOS-1 and MOS-2 observations, SBS 1542+541 detected count rates of $(4.51 \pm 0.21) \times 10^{-2}$ counts s$^{-1}$, $(1.38 \pm 0.08) \times 10^{-2}$ counts s$^{-1}$, and $(1.30 \pm 0.09) \times 10^{-2}$ counts s$^{-1}$, resulting in 1135, 515, and 485 total photons, respectively. Due to the presence of high background during part of the observation, the observed data quality is not as good as expected, and it is impossible to perform reliable temporal analysis. We did not detect any significant change in count rate between the two observations 4 days apart.

We measured the ROSAT PSPC count rate $CR = (5.19 \pm 1.15) \times 10^{-3}$ counts s$^{-1}$. Using PIMMS and a power-law model with partial covering with all parameters free, as given in Table 4, results in a similar count rate $(5.06 \times 10^{-3}$ counts s$^{-1}$). Using the same data to derive a count rate for the Chandra ACIS-S results in $0.016 \pm 0.001$ counts s$^{-1}$, which agrees with the measured value $(0.019 \pm 0.002$ counts s$^{-1}$; Green et al. 2001). The Chandra and XMM-Newton observations were separated by 2412 and 3097 days from the ROSAT observation, which converts to 718 and 921 days in the rest frame. The Chandra and XMM-Newton observations were separated by 686 days in the observed frame or 204 days in the rest frame.

3.2.2. Spectral Analysis

Spectral analysis of SBS 1542+541 was performed the same way as discussed above for Q1246–057, and the results are summarized in Table 4. When leaving all parameters free (except the Galactic absorption), the X-ray slope $\alpha_X$ is of the order of 1.0 in all the fits, and the covering fraction is of the order of 0.70. The absorption column is constrained to lie between about $(2.7-6.4) \times 10^{22}$ cm$^{-2}$ (see also Fig. 3). A combined fit to the spectra from all the EPIC detectors results in power-law slope $\alpha_X = 1.04$ with an intrinsic absorption column $N_H \approx 4 \times 10^{22}$ cm$^{-2}$ and a covering fraction of $\approx 0.70$. Fixing the power-law slope to $\alpha_X = 1.5$, as in Q1246–057, results in column density $N_H \approx 6 \times 10^{22}$ cm$^{-2}$ and a covering fraction of $\approx 0.8$. 

**TABLE 3**

| Property                  | Q1246–057   | SBS 1542+541 |
|---------------------------|-------------|--------------|
| $z$                        | 2.236       | 2.361        |
| $D$                       | 11500       | 12222        |
| log $L_X$ (0.2–2.0 keV)    | 44.70       | 45.13        |
| log $L_X$ (2.0–10.0 keV)   | 44.64       | 45.10        |
| $\alpha_X$                | 1.50$^b$    | 1.48$^b$     |

**Notes.**—The table contains the redshifts, distances (in megaparsecs), unabsorbed rest-frame X-ray luminosities (in units of ergs per second), the rest-frame luminosity density $l_{2500}$ (in units of ergs per second), and X-ray loudness.

$^a$ The X-ray loudness is defined by $\alpha_X = -0.384 \log (l_{2keV}/l_{2500})$.

$^b$ Assuming partial covering model.
which converts to an ionization parameter $U$ through of O\textseven consistent with spectral fitting results with $/C11$. From these, we estimate the covering fraction to be 0.80, $N$ data with $\gamma = 3.0$. Fig. 3 displays the contour plot between the column density of the ionized absorber and the ionization state $\xi$; neither parameters are very well constrained.

The optical spectrum of SBS 1542+541 shows absorption troughs of O\textseven $\lambda 1032$ and Ly$\alpha$ (Fig. 2 in Telfer et al. 1998). From these, we estimate the covering fraction to be 0.80, consistent with spectral fitting results with $\alpha_X = 1.5$. An ionized absorber model fit to the EPIC PN and MOS data with $N_{H,gal}$ fixed to the galactic value (1.27 x $10^{20}$ cm$^{-2}$) and $\alpha_X = 1.0$ resulted in $N_H \approx (5.1 \pm 1.4) \times 10^{22}$ cm$^{-2}$ and the ionization state $\xi = 375 \pm 145$ (Table 4), which converts to an ionization parameter $U = 21.0 \pm 8.7$. The fits to the spectra; right, the confidence levels of the column density of the partial coverer vs. the photon index (see Table 4).

### Table 4

| Detector | $N_{H,gal}$ ($10^{20}$ cm$^{-2}$) | $N_{H,ion}$ ($10^{20}$ cm$^{-2}$) | Covering Fraction | $\xi$ | $\alpha_X$ | $\chi^2$ (DOF) |
|----------|-------------------------------|-----------------------------|-------------------|-----|---------|----------------|
| PN$^a$ | 1.27 (fixed) | ... | ... | ... | 1.126 $\pm$ 0.220 | 30.7 (26) |
| PN$^b$ | 0.00 $\pm$ 1.70 | ... | ... | ... | 1.044 $\pm$ 0.574 | 31.0 (25) |
| PN$^b$ | 8.43 $\pm$ 1.98 | ... | ... | ... | 0.965 $\pm$ 0.119 | 68.0 (67) |
| MOS-1$^c$ | 10.91 $\pm$ 4.10 | ... | ... | ... | 0.962 $\pm$ 0.188 | 27.4 (26) |
| MOS-2$^d$ | 6.50 $\pm$ 3.76 | ... | ... | ... | 0.813 $\pm$ 0.181 | 21.3 (23) |
| MOS-1$^c$ + MOS-2$^d$ | 8.89 $\pm$ 2.83 | ... | ... | ... | 0.894 $\pm$ 0.266 | 20.0 (22) |
| PN$^b$ + MOS-1$^c$ + MOS-2$^d$ | 8.43 $\pm$ 1.64 | ... | ... | ... | 0.923 $\pm$ 0.088 | 118.3 (120) |

Notes.—Spectral fit parameters of SBS 1542+541 for a power-law model with galactic absorption ($N_{H,gal} = 1.27 \times 10^{20}$ cm$^{-2}$) and redshifted partial coverer or ionized absorption for the intrinsic absorption.

$^a$ EPIC PN; observed energy range used, 1.5–10.0 keV.
$^b$ EPIC PN; observed energy range used, 0.2–12.0 keV.
$^c$ EPIC MOS-1; observed energy range used, 0.2–9.0 keV.
$^d$ EPIC MOS-2; observed energy range used, 0.2–7.0 keV.
1542+541. The Fe Kα line is barely detected with 1σ significance, and we measured the equivalent widths in the range between 70 and 90 eV in the observed frame corresponding to 210–270 eV in the rest frame. This agrees with what is expected from Figure 3 in Nandra et al. (1997) for an object to 210–270 eV in the rest frame. This agrees with what is expected for a radio-quiet source with an optical luminosity density of log L 2500Å = 31.6 (ergs s⁻¹; Yuan et al. 1998).

As a class, LoBALs tend to be more X-ray–weak compared to that derived by Telfer et al. (1998) to model the UV spectrum of SBS 1542+541. A partially covering absorber and an ionized absorber both fit the data well. However, significant polarization observed in Q1246–057 and nonblack saturation of UV absorption lines observed in both sources suggest that a part of continuum radiation is scattered back in our line of sight, favoring the model with a partially covering absorber. It is possible that the absorber is both warm and partially covering. In Q1246–057, the Fe Kα and Si iv troughs are reported to be variable (Smith & Penston 1988). Comparison of observations from 1977, 1979, and 1984 found variability of the order of up to 10%. The observed X-ray variability may then be a result of change in absorber property.

The power-law slope could not be well constrained, making comparison with spectral shape of NLS1’s impossible. The absorption-corrected, intrinsic loudness of both the objects is within the normal range observed for non–BAL QSOs. Chandra and XMM-Newton observations now offer spectra for a handful of BAL QSOs (e.g., Gallagher et al. 2002a; Green et al. 2001; Hasinger et al. 2002; Clavel, Schartel, & Tomas 2003). In Table 5, we list the column densities, covering fractions, and spectral slopes of published spectra of BAL QSOs. In many of these, a partially covering absorber is the best-fit spectral model. The detection of these sources, however, is not only because of the part of the unabsorbed continuum in our line of sight. The BAL QSOs detected in X-rays, and for which a reasonable spectrum could be obtained, tend to have lower absorbing columns. As a class, LoBALs tend to be more X-ray–weak compared with the HiBALs (Green et al. 2001), but not all HiBALs are the brighter members of the population either. The HiBAL LBQS 2212–1759 is undetected in a 172 ks

4. DISCUSSION AND CONCLUSION

The XMM-Newton observations of BAL QSOs Q1246–057 and SBS 1542+541 show that the X-ray spectra can be represented by a power law and intrinsic partially covering absorption. The column density of the absorber is of the order of 4 × 10²² cm⁻², with a covering fraction of the order of 0.8. The observed column density is comparable to that derived by Telfer et al. (1998) to model the UV spectrum of SBS 1542+541. A partially covering absorber and an ionized absorber both fit the data well. However, significant polarization observed in Q1246–057 and nonblack saturation of UV absorption lines observed in both sources suggest that a part of continuum radiation is scattered back in our line of sight, favoring the model with a partially covering absorber. It is possible that the absorber is both warm and partially covering. In Q1246–057, the Fe Kα and Si iv troughs are reported to be variable (Smith & Penston 1988). Comparison of observations from 1977, 1979, and 1984 found variability of the order of up to 10%. The observed X-ray variability may then be a result of change in absorber property.

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Table 5

| Source     | Mission       | Intrinsic N_H | Covering Fraction | α_X | Reference |
|------------|---------------|---------------|-------------------|-----|-----------|
| Q1246–057  | XMM-Newton, EPIC PN | 2.47 ± 3.62   | 0.43 ± 0.27       | 0.80 | 1         |
| SBS 1542+541 | XMM-Newton, EPIC PN | 3.58 ± 1.26   | 0.73 ± 0.08       | 1.12 | 1         |
| Q0000–263  | XMM-Newton, PN + MOS | 0.0           | ...               | 1.1  | 2         |
| APM 08279+5255 | Chandra, ACIS-S | 6.0 ± 3.5     | ...               | 0.86 | 3         |
| APM 08279+5255 | XMM-Newton, PN + MOS | 6.9 ± 0.3     | ...               | 1.04 | 4         |
| RX J0914.1+0551 | Chandra, ACIS-S | 19 ± 28       | 0.71 ± 0.20       | 0.87 | 5         |
| PG 1115+080 | Chandra, ACIS-S | 3.8 ± 2.5     | 0.64 ± 0.12       | 0.99 | 3         |
| Mkn 231    | Chandra, ACIS-S | 2.1 ± 0.8     | ...               | 1.1  | 6         |
| H1413+117  | Chandra, ACIS-S | 20 ± 18       | ...               | 0.39 | 3         |
| PG 1411+442 | Chandra, ACIS-S | 19 ± 7.5      | 0.97 ± 0.02       | 1.20 | 7         |
| PG 1535+547 | Chandra, ACIS-S | 12 ± 8        | 0.97 ± 0.07       | 1.02 | 8         |
| PG 2112+059 | Chandra, ACIS-S | 1.1 ± 0.5     | ...               | 0.97 | 8         |
| LBQS 2212–1759 | XMM-Newton, EPIC PN | >3000         | ...               | 0.9  | 9         |
| PHL 5200   | XMM-Newton, EPIC PN | 10            | ...               | 1.0  | 10        |

*In units of 10²² cm⁻².

References.—(1) This paper; (2) Ferrero & Brinkmann 2003; (3) Chartas et al. 2002; (4) Hasinger et al. 2002; (5) Chartas et al. 2001; (6) Gallagher et al. 2002b; (7) Gallagher et al. 2002a; (8) Gallagher et al. 2002c; (9) Clavel et al. 2003; (10) Brinkmann, Ferrero, & Gliozzi 2002.
observation with *XMM-Newton*, yielding observed $\alpha_{\text{ox}} \geq 2.55$ (Clavel et al. 2003). Thus, even the HiBALs must have a range of absorbing column density, plausibly related to the strength of the C iv BAL (Brandt & Gallagher 2000).

The issue of whether BAL QSOs represent highly accreting/younger population of quasars remains unsettled. For the spectra presented here, the power-law slope could not be constrained, making comparison with spectral shape of NLS1's impossible. However, it is necessary to note that relatively steep X-ray spectra are required for our objects ($\alpha_{\text{ox}} \sim 1.5$), if the covering fraction is to be the same as observed in the UV. (Note, however, that accretion rate close to Eddington on to a high-mass black hole may not result in a steep X-ray power-law slope as in lower luminosity NLS1's with lower mass black holes [see the accretion disk/corona models of Witt, Czerny, & Zyki 1997 and also Kuraszkiewicz et al. 2000]). Comparison of rest-frame optical spectra of BAL and non-BAL quasars would be useful in deciding whether the two classes are intrinsically similar.

We would like to thank Gary Schmidt and Dean Hines for discussions on the UV spectrum of Q1246–057, and Norbert Schartel for providing the information about the *XMM-Newton* observation on LBQS 2212–1759. This research has made use of the NASA/IPAC Extragalactic Database (NED), which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. The ROSAT project is supported by the Bundesministerium für Bildung und Forschung (BMBF/DR) and the Max Planck Society. This work is supported in part by NASA grant NAG 5-9936.

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