We have assembled absorption systems by visually identifying C\textsc{iv} λλ1548, 1551 absorption doublets in the quasar spectra of the Baryon Oscillation Spectroscopic Survey one by one. This paper is the first of the series of work. In this paper, we focus on quasars with relatively low redshifts and high signal-to-noise ratio spectra, and hence we limit our analysis to quasars with $z_{\text{em}} \leq 2.4$ and to doublets with $W_r\lambda1548 \geq 0.2$ Å. Out of the more than 87,000 quasars in Data Release 9, we limit our search to 10,121 quasars that have the appropriate redshifts and spectra with high enough signal-to-noise ratios to identify narrow C\textsc{iv} absorption lines. Among them, 5442 quasars are detected to have at least one C\textsc{iv} λλ1548, 1551 absorption doublet. We obtain a catalog containing 8368 C\textsc{iv} λλ1548, 1551 absorption systems, whose redshifts are within $z_{\text{abs}} = 1.4544–2.2805$. In this catalog, about 33.7\% absorbers have 0.2 Å ≤ $W_r\lambda1548$ < 0.5 Å, about 45.9\% absorbers have 0.5 Å ≤ $W_r\lambda1548$ < 1.0 Å, about 19.2\% absorbers have 1.0 Å ≤ $W_r\lambda1548$ < 2.0 Å, and about 1.2\% absorbers have $W_r\lambda1548 \geq 2.0$ Å.

**Key words:** line; identification – quasars: absorption lines – quasars: general

**Online-only material:** color figures, machine-readable tables

### 1. INTRODUCTION

Absorption lines are often observed in quasar spectra, which are powerful tools for probing the gas in the universe from high redshifts to the present epoch (see Melkinsin 2009 for a review). Quasar absorption lines provide a unique chance to study the gaseous phase (e.g., ionization states, kinematics, metallicities) of distant galaxies that might otherwise be invisible independently of the luminosity of the background quasars. They are also important to understand the star formation and evolution of the ordinary galaxies (e.g., Prochter et al. 2006; Zibetti et al. 2007; Ménard et al. 2011; Chen 2013).

Narrow absorption lines (NALs), with the line width of a few hundred km s$^{-1}$, can be classified into three categories according to the relationship between the absorber and the corresponding quasar; these are intrinsic absorption lines, associated absorption lines, and intervening absorption lines. The intrinsic absorption lines are often believed to be physically related to the quasar wind/outflow (e.g., Narayanan et al. 2004; Misawa et al. 2007; Hamann et al. 2011). The associated absorption lines with $z_{\text{abs}} \approx z_{\text{em}}$ probably arise from the gas in the quasar host galaxy or the galaxy cluster around the quasar (e.g., Weymann et al. 1979; Wild et al. 2008; Vanden Berk et al. 2008). The intervening absorption lines with $z_{\text{abs}} \ll z_{\text{em}}$ are due to the absorption of galaxies along the quasar sightlines located at cosmological distances from the corresponding quasars (e.g., Bahcall & Spitzer 1969; Bergeron 1986; López & Chen 2012). The criteria, determining whether the absorption lines are truly tied to the corresponding quasars, is ambiguous, because there are many factors that can disturb the observed absorption lines such as the signal-to-noise ratio (S/N) of the quasar spectra. The dividing line between the intervening absorption lines and the associated absorption lines is usually derived using statistics (e.g., Richards 2001; Wild et al. 2008). The absorption lines at velocity separations less than ~0.02c–0.04c, when compared to the quasar systems, are classified as associated absorption lines (Vanden Berk et al. 2008; Wild et al. 2008). However, that does not mean that NALs with a velocity separation larger than that value completely belong to the class of intervening absorption lines. Narrow intrinsic absorption lines can be formed in the quasar outflows with velocity separations up to, and even exceeding 0.1c (e.g., Misawa et al. 2007; Tombesi et al. 2011; Chen et al. 2013a; Chen & Qin 2013).

C\textsc{iv} λλ1548, 1551 resonant doublets are observable redward of the Ly$\alpha$1216 emission line, which can be detected over a redshift range of $z \approx 1.5–5.5$ in the optical spectra. These lines are strong transitions and have good profiles. They are valuable absorption lines for studying the intergalactic medium (e.g., Songaila & Cowie 1996; Cowie & Songaila 1998; Songaila 2001; Schaye et al. 2003; Cooke et al. 2010; D’Odorico et al. 2010; Simcoe et al. 2011).

Based on the Sloan Digital Sky Survey (SDSS; York et al. 2000), many previous studies aimed at systematically searching for metal absorption lines have been conducted (e.g., Quider et al. 2011; Qin et al. 2013; Zhu & Ménard 2013; Cooke et al. 2013). We identify absorption doublets, such as C\textsc{iv} λλ1548, 1551 and Mg$\textsc{ii}$ λλ2796, 2803, in the quasar spectra of the Baryon Oscillation Spectroscopic Survey (BOSS), which is a part of the SDSS-III (Eisenstein et al. 2011). In this paper, which is the first in a series of papers on the absorption lines in the BOSS quasar spectra, we identify the C\textsc{iv} λλ1548, 1551 absorption doublet.

In Section 2, we show how we construct our C\textsc{iv} λλ1548, 1551 absorption sample and present the spectral analysis. The properties of the absorption lines are presented in Section 3. Section 4 is the discussion, and Section 5 is the summary.

### 2. DATA ANALYSIS

BOSS is the main dark time legacy survey of the third stage of the SDSS (Pâris et al. 2012; Eisenstein et al. 2011), which is a 5 yr program. BOSS aims to obtain over 150,000 quasar spectra with $z_{\text{em}} > 2.15$ using the same 2.5 m telescope (Gunn et al. 2006; Ross et al. 2012) as the SDSS did. The spectra of BOSS span a wavelength range of 3600–10,400 Å at a resolution of 1300 < $R$ < 3000. The first data release of BOSS, SDSS Data
In order to avoid the noisy region of the spectra, we exclude those data shortward of 3800 Å at the observed frame. The pair of O i λ1302 and S ii λ1304 has a wavelength separation similar to that of the C iv λλ1548, 1551 doublet, which could lead to misidentifications of the latter. To avoid confusion arising from the Lyα forest, and O i λ1302 and S ii λ1304 absorption lines, we constrain our analysis to the wavelength range longward of 1310 Å at the rest frame. We also conservatively constrain the upper wavelength limit to 1548 Å × (1 + z em) × \sqrt{(1 - \beta)/(1 + \beta)}), where we adopt \beta = -1/30 to search for intervening C iv λλ1548, 1551 absorption doublets. This cut reduces the quasar sample to 70,336 quasars with z em \gtrsim 1.54.

The noise superposed on the spectra with low S/Ns often confuses the true absorptions. Here, we limit our analysis to sources with high enough S/Ns in the surveyed spectral region. There is a median S/N of the spectrum of each quasar, which can roughly reveal the level of the noise of the observation of the source. Illustrated in Figure 1 is the distribution of the median S/N of these 70,336 quasars. We find that the median value of this distribution is quite close to 4 (see Figure 1). We accordingly adopt this value to limit our analysis. That is, we select only quasars with median S/N \geq 4 in the surveyed spectral region.

As the first paper in this series, here we focus only on quasars with z em \leq 2.4. Taking into account all of the above limitations, we have 10,121 quasars with 1.54 \lesssim z em \leq 2.4 to identify C iv λλ1548, 1551 absorption doublets. The upper cuts of the emission redshift and the median S/N are shown in Figure 2. The distribution of emission redshifts of our final quasar sample is plotted in Figure 4.

We derive a pseudo-continuum for each quasar of our sample by invoking a combination of cubic splines (for underlying continuum; see Willian et al. 1992 for details) and Gaussians (for emission and broad absorption features), which is utilized to normalize the spectral data (fluxes and flux uncertainties). These processes are iterated several times to improve the fittings of both the cubic spline and Gaussian (e.g., Nestor et al. 2005; Quider et al. 2011; Chen et al. 2013a, 2013b). Shown in the left panels of Figure 3 are several quasar spectra (with various values of the median S/N) together with their pseudo-continuum fitting curves. The pseudo-continuum normalized spectra are presented in the right panels of Figure 3.

We search C iv λλ1548, 1551 absorption candidates from the pseudo-continuum normalized spectra. As the first step of the searching (see also Chen et al. 2013a), the 2\sigma curve below the pseudo-continuum fitting is marked, and then those absorption figures located above this curve are ruled out.

In many cases, some very broad troughs appear in the blue wing of C iv and/or Si iv emission lines. Broad absorption line (BAL) is a confusing term. Based on the definition of the balnicity index (BI; Weymann et al. 1991), absorption troughs with a width broader than 2000 km s\(^{-1}\) at depths >10% below the pseudo-continuum fitting curve can be classified as BALs. However, in terms of the absorption index (AI; Hall et al. 2002; Trump et al. 2006), some narrower absorption troughs (>1000 km s\(^{-1}\)) also belong to the BAL population. Knigge et al. (2008) found that the BAL fraction is underestimated in terms of BI, and overestimated in terms of AI. They also found that samples of both BI and AI show bimodal distributions, which cause overlapping of broad NALs and narrow BALs. Therefore, as the second step, we analyze only narrow absorption doublets with a few hundreds of km s\(^{-1}\), and we conservatively disregard those absorption figures with widths broader than 2000 km s\(^{-1}\) and at depths >10% below the pseudo-continuum fitting curve in our program autonmatically.

In the third step, each absorption trough is fitted by a Gaussian component, and the absorption figures with FWHMs greater than 800 km s\(^{-1}\) are ruled out. Then, we search for the candidates of C iv λλ1548, 1551 absorption doublets in the residual absorption figures.

In the fourth step, we measure the equivalent widths (W\(_e\)) of these candidate absorption lines at the rest-frame from the Gaussian fittings, and estimate their uncertainties using

\[
(1 + z)\sigma_w = \sqrt{\sum_i P^2(\lambda_i - \lambda_0)\sigma^2_E(\lambda_i)} / \Delta \lambda, \tag{1}
\]
Figure 3. Quasar spectra with various values of median S/N in the searched spectral region of C IV λλ 1548, 1551 absorption doublets. The red curves in the left panels represent the pseudo-continuum fitting curves. The green lines in the right panels represent the 1σ flux uncertainty levels which have been normalized by the pseudo-continuum. The blue solid lines are the Gaussian fitting curves of the doublets. The red vertical lines in the right panels represent the lower and upper limits, respectively, which are used to cut the spectral region to search for C IV λλ 1548, 1551 absorption doublets. We do not search the C IV λλ 1548, 1551 absorption doublet in the spectra with S/Ns less than 4 (i.e., the first five spectra).

(A color version of this figure is available in the online journal.)
where \( P(\lambda_i - \lambda_0) \) is the line profile centered at \( \lambda_0 \), \( \lambda_i \) is the wavelength, and \( \sigma_i \) is the normalized flux uncertainty as a function of pixels (Nestor et al. 2005; Chen et al. 2013b; Chen & Qin 2013). The sum is performed over an integer number of pixels that covers at least \( \pm 3 \) characteristic Gaussian widths. We adopt the method provided by Qin et al. (2013) to evaluate the S/N of the absorption line for the candidates as well. 1σ noise is calculated using

\[
\sigma_N = \sqrt{\frac{\sum_{i=1}^{M} F_{\text{noise}}(\lambda_i)}{M}},
\]

where \( F_{\text{noise}} \) is the flux uncertainty, \( F_{\text{cont}} \) is the flux of the pseudo-continuum fit, and \( i \) represents the pixels in the wavelength range of \( 1548 \, \text{Å} \times (1 + z_{\text{abs}}) - 5 \, \text{Å} < \lambda_{\text{obs}} < 1551 \, \text{Å} \times (1 + z_{\text{abs}}) + 5 \, \text{Å} \). The S/N of the absorption line is determined by

\[
\frac{S/N}{\lambda_i} = \frac{1 - S_{\text{abs}}}{\sigma_N},
\]

where \( S_{\text{abs}} \) is the smallest value of the normalized spectral flux within an absorption trough. Finally, we select only the absorption lines with \( W_r > 0.2 \, \text{Å} \) and \( S/N > 2.0 \) for both \( \lambda_{1548} \) and \( \lambda_{1551} \) lines. In this way, we get 8368 potential intervening \( \lambda_{1548}, 1551 \) absorption doublets. These absorption doublets are presented in Table 1.

### 3. STATISTICAL PROPERTIES OF THE ABSORBERS

In this work, we collect 10,121 quasars to identify \( \lambda_{1548}, 1551 \) absorption doublets, whose emission redshifts are plotted in Figure 4. Of the 10,121 quasar spectra, 5442 are found to have at least one detected \( \lambda_{1548}, 1551 \) absorption doublet. Emission redshifts of these 5442 quasars are also plotted in Figure 4. We identify 8368 \( \lambda_{1548}, 1551 \) absorption doublets from these quasars. These absorption redshifts are also shown in Figure 4.

![Figure 4. Distributions of redshifts. The red line represents the emission redshift of 10,121 quasars that are used to search for \( \lambda_{1548}, 1551 \) absorption doublets. The blue line stands for the emission redshift of the 5442 quasars for which at least one \( \lambda_{1548}, 1551 \) absorption doublet is detected. The black line describes the absorption redshift of all the detected \( \lambda_{1548}, 1551 \) absorption doublets. (A color version of this figure is available in the online journal.)](image1)

![Figure 5. Redshift path covered by our catalog (\( z_{\text{em}} < 2.4 \)), shown as a function of \( S/N^{\lambda_{1548}} \).](image2)

![Figure 6. Distributions of the rest-frame equivalent width of the \( \lambda_{1548} \) absorption line. The black line is for the \( \lambda_{1548} \) absorption, and the red line is for the \( \lambda_{1551} \) absorption. (A color version of this figure is available in the online journal.)](image3)
Table 1
Catalog of C IV λ1548, 1551 Absorption Systems

| SDSS NAME          | PLATEID | MJD   | FIBERID | z_em | z_abs | W_r,1548 | N_r,1548 | W_r,1551 | N_r,1551 | S/N_1548 | S/N_1551 | β      |
|-------------------|---------|-------|---------|------|-------|---------|----------|---------|----------|----------|---------|--------|
| 000027.01+030715.5 | 4296    | 55499 | 0630    | 2.3533 | 1.9833 | 0.22    | 4.40     | 0.22    | 4.40     | 3.9     | 4.4     | 0.11639|
| 000027.01+030715.5 | 4296    | 55499 | 0630    | 2.3533 | 2.1303 | 0.91    | 22.75    | 0.69    | 17.25    | 20.3    | 18.3    | 0.06871|
| 000050.59+010959.1 | 4216    | 55477 | 0746    | 2.3678 | 1.8971 | 0.46    | 7.67     | 0.47    | 5.88     | 7.1     | 5.3     | 0.14942|
| 000050.59+010959.1 | 4216    | 55477 | 0746    | 2.3678 | 1.9184 | 0.19    | 14.14    | 0.86    | 14.33    | 13.6    | 13.0    | 0.02723|
| 000100.27+032801.5 | 4296    | 55499 | 0748    | 2.2195 | 1.7502 | 1.25    | 6.58     | 0.86    | 6.14     | 5.9     | 5.6     | 0.07588|
| 000100.27+032801.5 | 4296    | 55499 | 0748    | 2.2195 | 1.9871 | 0.71    | 7.60     | 0.25    | 6.25     | 5.9     | 5.3     | 0.06939|
| 000027.01+030715.5 | 4296    | 55499 | 0748    | 2.2195 | 1.9871 | 0.71    | 7.60     | 0.25    | 6.25     | 5.9     | 5.3     | 0.06939|
| 000027.01+030715.5 | 4296    | 55499 | 0748    | 2.2195 | 1.9871 | 0.71    | 7.60     | 0.25    | 6.25     | 5.9     | 5.3     | 0.06939|
| 000100.27+030715.5 | 4296    | 55499 | 0748    | 2.2195 | 1.9871 | 0.71    | 7.60     | 0.25    | 6.25     | 5.9     | 5.3     | 0.06939|

Note. \(N_\sigma = (W_r/\sigma_W)\) represents the significance level of the detection, \(\beta = v/c = ((1 + z_{em})^2 - (1 + z_{abs})^2)/((1 + z_{em})^2 + (1 + z_{abs})^2)\).

(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)

Figure 7. Distribution of the ratio of the rest-frame equivalent widths of the C IV doublet. The red curve is the fitting Gaussian with center = 1.18 and FWHM = 0.80. The red dashed lines are the theoretical limits for completely saturated \((W_r,1548/W_r,1551 = 1.0)\) and unsaturated \((W_r,1548/W_r,1551 = 2.0)\) absorptions, respectively.

(A color version of this figure is available in the online journal.)

Figure 8. Plot of the detection frequency as a function of S/N. The upper (red) line represents the count of the spectral data point, the middle (blue) line represents the count of the detected C IV absorption system, and the bottom (black) line stands for the frequency of NALs detected in this work, calculated by Equation (5).

(A color version of this figure is available in the online journal.)

In order to estimate the false positives/negatives of the C IV absorption system, we wish to look at the frequency of the detected C IV absorption systems \((f_{NALs})\) as a function of S/N, which can be computed via

\[
f_{NALs} = \lim_{\Delta S/N \to 0} \frac{\Delta N_{abs}}{\Delta N_{sdp}}
\]

where \(\Delta N_{abs}\) and \(\Delta N_{sdp}\) are the count of the detected C IV absorption systems and the count of the spectral data points in the S/N bin \(\Delta S/N\), respectively. The resulting \(f_{NALs}\) as a function of the S/N, is displayed in Figure 8. It exhibits a platform in the range of \(S/N > 4\), suggesting that the detection of C IV absorption systems would likely be complete when the S/N is larger than 4.

In Figure 7 we plot the distribution of the \(W_r\) ratio of the two lines \((W_r,1548/W_r,1551)\). We invoke a Gaussian function to fit this distribution, which yields a center value of 1.18 and FWHM = 0.80. The maximum and minimum values of the \(W_r\) ratio are 4.5 and 0.2, respectively. The \(W_r\) ratio reflects the degree of saturation (Strömgren 1948). The \(W_r\) ratio of the C IV λ1548, 1551 doublet can be changed from completely saturated absorption, \(DR = 1.0\), to completely unsaturated absorption, \(DR = 2.0\) (e.g., Sargent et al. 1988; Steidel 1990). The boundaries of the completely saturated absorption (\(DR = 1.0\)) and completely unsaturated absorption (\(DR = 2.0\)) are marked in Figure 7. Most of the absorbers of this catalog satisfy \(1.0 < W_r,1548/W_r,1551 < 2.0\), occupying nearly 72.9% (6007/8638) of the total. About 22.0% (1839/8638) of absorbers have \(W_r,1548/W_r,1551 < 1.0\), and about 62.2% (522/8638) of absorbers have \(W_r,1548/W_r,1551 > 2.0\). We guess that the C IV λ1548, 1551 absorption systems that lie outside the theoretical limits of the \(W_r\) ratio \((W_r,1548/W_r,1551 < 1.0\) or \(W_r,1548/W_r,1551 > 2.0\)) might originate mainly from line blending.

4. DISCUSSION

In order to estimate the false positives/negatives of the C IV absorption system, we wish to look at the frequency of the detected C IV absorption systems \((f_{NALs})\) as a function of S/N, which can be computed via

\[
f_{NALs} = \lim_{\Delta S/N \to 0} \frac{\Delta N_{abs}}{\Delta N_{sdp}}
\]

5
Table 2
Missing Rate of Absorption Systems with \( S/N^{\lambda1548} \leq 4 \)

| S/N Bin | [2.0,2.5] | [2.5,3.0] | [3.0,3.5] | [3.5,4.0] |
|---------|-----------|-----------|-----------|-----------|
| \( f_{MR} \) | 0.91 | 0.67 | 0.62 | 0.20 |

Table 3
Sources of the Randomly Selected Quasar Sample

| SDSS NAME | PLATEID | MID | FIBERID | \( z_{em} \) | S/N |
|-----------|---------|-----|---------|------------|-----|
| 000525.86+030813.5 | 4296 | 55499 | 0908 | 2.1802 | 3.4 |
| 00063.085+031327.1 | 4296 | 55499 | 0962 | 2.3788 | 3.9 |
| 002059.05+030633.3 | 4300 | 55528 | 0761 | 2.1935 | 3.4 |
| 004616.50+011343.0 | 3589 | 55186 | 0864 | 2.1632 | 1.5 |
| 005623.89+021253.2 | 4308 | 55565 | 0740 | 2.2631 | 2.1 |
| 010618.39+101247.8 | 4551 | 55569 | 0598 | 2.2872 | 1.3 |
| 011927.05+000008.0 | 4227 | 55481 | 0036 | 2.3571 | 1.7 |
| 02059.05+030633.3 | 4300 | 55528 | 0761 | 2.1935 | 3.4 |
| 030813.5 | 4296 | 55499 | 0908 | 2.1802 | 3.4 |

Note. \( S/N \) is the median \( S/N \) of the quasar in the surveyed spectral region.
(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)

The incompleteness of the detection of \( \text{C} \text{IV} \) absorption systems is obvious within the range of \( S/N^{\lambda1548} \leq 4 \). As suggested by Figure 8, we find that, within the range of \( S/N^{\lambda1548} \leq 4 \), when the \( S/N \) tends to be smaller, more \( \text{C} \text{IV} \) absorption systems tend to be missed by our analysis. To roughly estimate the significance of the incompleteness, we compute the missing rate (\( f_{MR} \)) of the detection of \( \text{C} \text{IV} \) absorption systems in several bins of the \( S/N \) via

\[
f_{MR} = \frac{f_{\text{NALS}} - f_{\text{NALS}}}{f_{\text{NALS}}},
\]

where \( f_{\text{NALS}} \) is the average frequency of NALs in the range of \( S/N^{\lambda1548} > 4 \), and \( f_{\text{NALS}} \) is the frequency of NALs in the corresponding \( S/N \) bin. The results are presented in Table 2.

To refine the quasar sample to search the \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption system, we perform our analysis under the condition that the spectra examined must have a median \( S/N \) greater than or equal to 4. It is possible that some \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption doublets, which satisfy our criteria of selecting absorption lines, may be imprinted in the spectra with a median \( S/N \) less than 4, and they will be missed.

To have a look at these possibly missed doublets, we randomly select 100 quasars from those located in the left lower region of Figure 2 (below the horizontal red line and on the left-hand side of the vertical red line), to detect \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption doublets with the same criteria described in Section 2. These quasars are listed in Table 3. 15 \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption doublets are detected from these quasar spectra, which are presented in Table 4. For this randomly selected quasar sample, the redshift path computed using Equation (4) and the frequency of NALs calculated by Equation (5) are displayed in Figures 9 and 10, respectively.

8368 \( \text{C} \text{IV} \) absorption systems in the spectra of the 10,121 quasars with their median \( S/N \)s being greater than 4. The value of 8368/10,121 is several times larger than that of 15/100, which shows that many real absorption lines cannot be identified in the spectra with lower \( S/N \)s.

5. SUMMARY

As the first effort in our series of papers on identifying absorption lines in the quasar spectra of BOSS, we search for quasars with \( z_{em} \leq 2.4 \) and identify potential intervening \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption doublets with \( W_{r,\lambda1548} \geq 0.2 \text{ Å} \). Our sample contains 10,121 quasars, from which we identify 8368 \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption systems which covers the absorption redshift range of \( z_{abs} = 1.4544 \pm 2.2805 \). Of 10,121 quasars, 5442 are detected to have at least one \( \text{C} \text{IV} \lambda\lambda1548,1551 \) absorption doublet. We find that about 33.7% of absorbers have \( 0.2 \text{ Å} \leq W_{r,\lambda1548} < 0.5 \text{ Å} \), about 45.9% of absorbers have \( 0.5 \text{ Å} \leq W_{r,\lambda1548} < 1.0 \text{ Å} \), about 19.2% of absorbers have \( 1.0 \text{ Å} \leq W_{r,\lambda1548} < 2.0 \text{ Å} \), and
Table 4
C IV λλ1548, 1551 Absorption Systems of the Randomly Selected Quasar Sample

| SDSS NAME                | PLATEID | MJD   | FIBERIN | z_em | z_abs | Wλ1548 | N_{δ1548} | Wλ1551 | N_{δ1551} | S/N_{1548} | S/N_{1551} | β    |
|-------------------------|---------|-------|---------|------|-------|--------|-----------|--------|-----------|------------|------------|------|
| 075343.86+182204.9      | 4490    | 55629 | 0734    | 2.1708 | 1.9708 | 0.38   | 2.53      | 0.56    | 2.55       | 2.3        | 2.4        | 0.06506 |
| 114931.76+360338.8      | 4653    | 55622 | 0042    | 2.2658 | 1.7910 | 0.79   | 2.39      | 1.21    | 3.67       | 2.2        | 3.4        | 0.15582 |
| 014848.55+145729.2      | 4658    | 55592 | 0948    | 2.1370 | 1.8690 | 0.31   | 2.38      | 0.44    | 2.44       | 2.2        | 2.3        | 0.08907 |
| 152155.41+310942.3      | 4719    | 55736 | 0322    | 2.1108 | 1.8242 | 0.88   | 5.18      | 0.39    | 2.79       | 4.4        | 2.7        | 0.09611 |
| 080354.70+422136.2      | 4856    | 55712 | 0230    | 2.3698 | 2.0359 | 0.88   | 3.03      | 1.19    | 3.31       | 2.9        | 3.1        | 0.10397 |
| 074256.10+481730.0      | 3675    | 55183 | 0520    | 2.2775 | 1.9637 | 1.14   | 3.93      | 0.99    | 3.41       | 3.6        | 3.2        | 0.10030 |
| 081937.46+302718.3      | 4447    | 55542 | 0070    | 2.0307 | 2.0699 | 0.58   | 2.76      | 0.65    | 2.83       | 2.7        | 2.7        | 0.06331 |
| 014848.55+145729.2      | 4658    | 55592 | 0948    | 2.1370 | 1.8690 | 0.31   | 2.38      | 0.44    | 2.44       | 2.2        | 2.3        | 0.08907 |
| 104647.31+382734.8      | 4634    | 55626 | 0932    | 2.2235 | 2.1045 | 0.81   | 2.84      | 0.71    | 2.84       | 2.9        | 2.7        | 0.07165 |

Note. See Table 1 for the meanings of each column.

about 1.2% of absorbers have \( W_{\lambda 1548} \geq 2.0 \) Å. Most of the C IV \( \lambda\lambda 1548, 1551 \) absorption doublets (72.9%) lie within the theoretical limits of the completely saturated and unsaturated absorptions (1.0 \( \leq W_{\lambda 1548}/W_{\lambda 1551} < 2.0 \)).

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ERRATUM: “CATALOG OF NARROW C IV ABSORPTION LINES IN BOSS. I. FOR QUASARS WITH z_{em} ≤ 2.4” (2014, ApJS, 210, 7)

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ABSTRACT

Online-only material: color figures, machine-readable table

In this paper, spectra of some quasars that meet our criteria for detecting narrow C IV absorption lines were not analyzed. This mistake gives rise to some errors in the provided figures and tables. In Paper I (2014, ApJS, 210, 7), we limited our search to 10,121 quasars that have the appropriate redshifts and spectra with high enough S/Ns to identify narrow C IV absorption lines. However, the number of quasars that satisfy the same criteria should be 15,278. Due to this mistake, the following corrections should be made.

Figures 4–8 and 10 in Paper I should be replaced by Figures 4–8 and 10 given here. Tables 1 and 2 in Paper I should be replaced by Tables 1 and 2 given here.

In the abstract (on page 1), “Out of the more than 87,000 quasars in Data Release 9, we limit our search to 10,121 quasars that have the appropriate redshifts and spectra with high enough S/Ns to identify narrow C IV absorption lines. Among them, 5,442 quasars are detected to have at least one C IV λλ1548, 1551 absorption doublet. We obtain a catalog containing 8368 C IV λλ1548, 1551 absorption systems, whose redshifts are within \( z_{abs} = 1.4544–2.2805 \). In this catalog, about 33.7% absorbers have \( 0.2 \AA \leq W_r \lambda 1548 < 0.5 \AA \), about 45.9% absorbers have \( 0.5 \AA \leq W_r \lambda 1548 < 1.0 \AA \), about 19.2% absorbers have \( 1.0 \AA \leq W_r \lambda 1548 < 2.0 \AA \), and about 12% absorbers have \( W_r \lambda 1548 \geq 2.0 \AA \)” should be replaced by “Out of the more than 87,000 quasars in Data Release 9, we limit our search to 15,278 quasars that have the appropriate redshifts and spectra with high enough S/Ns to identify narrow C IV absorption lines. Among them, 6291 quasars are detected to have at least one C IV λλ1548, 1551 absorption doublet. We obtain a catalog containing 9417 C IV λλ1548, 1551 absorption systems, whose redshifts are within \( z_{abs} = 1.4544–2.2805 \). In this catalog, about 34.1% absorbers have \( 0.2 \AA \leq W_r \lambda 1548 < 0.5 \AA \), about 45.8% absorbers have \( 0.5 \AA \leq W_r \lambda 1548 < 1.0 \AA \), about 18.8% absorbers have \( 1.0 \AA \leq W_r \lambda 1548 < 2.0 \AA \), and about 12% absorbers have \( W_r \lambda 1548 \geq 2.0 \AA \)”.

In Section 2, paragraph 4 (on page 2), “Taking into account all the above limitations, we have 10,121 quasars with \( 1.54 \leq z_{em} < 2.4 \) to identify C IV λλ1548, 1551 absorption doublets” should be replaced by “Taking into account all the above limitations, we have 15,278 quasars with \( 1.54 \leq z_{em} \leq 2.4 \) to identify C IV λλ1548, 1551 absorption doublets.”

In Section 2, the last two sentences (on page 4), “In this way, we get 8368 potential intervening C IV λλ1548, 1551 absorption doublets. These absorption doublets are presented in Table 1” should be replaced by “In this way, we get 9417 potential intervening C IV λλ1548, 1551 absorption doublets. These absorption doublets are presented in Table 1.”

In Section 3, the first paragraph (on page 4), “In this work, we collect 10,121 quasars to identify C IV λλ1548, 1551 absorption doublets, whose emission redshifts are plotted in Figure 4. Of the 10,121 quasar spectra, 5,442 are found to have at least one detected C IV λλ1548, 1551 absorption doublet. Emission redshifts of these 5,442 quasars are also plotted in Figure 4. We identify 8368 C IV λλ1548, 1551 absorption doublets from these quasars” should be replaced by “In this work, we collect 15,278 quasars to identify C IV λλ1548, 1551 absorption doublets, whose emission redshifts are plotted in Figure 4. Of the 15,278 quasar spectra, 6291 are found to have at least one detected C IV λλ1548, 1551 absorption doublet. Emission redshifts of these 6291 quasars are also plotted in Figure 4.”

In Section 3, paragraph 3 (on pages 4 and 5), “In this catalog, about 33.7% (2823/8368) absorbers have \( 0.2 \AA \leq W_r \lambda 1548 < 0.5 \AA \), about 45.9% (3842/8368) absorbers have \( 0.5 \AA \leq W_r \lambda 1548 < 1.0 \AA \), about 19.2% (1603/8368) absorbers have \( 1.0 \AA \leq W_r \lambda 1548 < 2.0 \AA \), and about 12% (100/8368) absorbers have \( W_r \lambda 1548 \geq 2.0 \AA \)” should be replaced by “In this catalog, about 33.1% (3215/9417) absorbers have \( 0.2 \AA \leq W_r \lambda 1548 < 0.5 \AA \), about 45.8% (4315/9417) absorbers have \( 0.5 \AA \leq W_r \lambda 1548 < 1.0 \AA \), about 18.8% (1775/9417) absorbers have \( 1.0 \AA \leq W_r \lambda 1548 < 2.0 \AA \), and about 12% (112/9417) absorbers have \( W_r \lambda 1548 \geq 2.0 \AA \)”.

In Section 3, the last paragraph (on page 5), “Most of the absorbers of this catalog satisfy \( 1.0 \leq W_r \lambda 1548/W_r \lambda 1551 \leq 2.0 \), occupying nearly 72.9% (6007/8368) of the total. About 22.0% (1839/8368) absorbers have \( W_r \lambda 1548/W_r \lambda 1551 < 1.0 \), and about 6.2% (522/8368) absorbers have \( W_r \lambda 1548/W_r \lambda 1551 > 2.0 \)” should be replaced by “Most of the absorbers of this catalog satisfy \( 1.0 \leq W_r \lambda 1548/W_r \lambda 1551 \leq 2.0 \), occupying nearly 71.5% (6731/9417) of the total. About 22.4% (2114/9417) absorbers have \( W_r \lambda 1548/W_r \lambda 1551 < 1.0 \), and about 6.1% (572/9417) absorbers have \( W_r \lambda 1548/W_r \lambda 1551 > 2.0 \)”.

In Section 4, the last paragraph (on page 6), “However, we detect 8368 C IV absorption systems in the spectra of the 10,121 quasars with their median S/Ns being greater than 4. The value of 8368/10,121 is several times larger than that of 15/100, which manifests that many real absorption lines cannot be identified in the spectra with lower S/Ns” should be replaced by “However, we detect 9417 C IV absorption systems in the spectra of the 15,278 quasars with their median S/Ns being greater than 4. The value of 9417/15,278
Figure 4. Distributions of redshifts. The red line represents the emission redshift of 15,278 quasars that are used to search for C\textsc{iv} \( \lambda \lambda 1548, 1551 \) absorption doublets. The blue line stands for the emission redshift of the 6291 quasars for which at least one C\textsc{iv} \( \lambda \lambda 1548, 1551 \) absorption doublet is detected. The black line describes the absorption redshift of all the detected C\textsc{iv} \( \lambda \lambda 1548, 1551 \) absorption doublets.

(A color version of this figure is available in the online journal.)

Figure 5. Redshift path covered by our catalog \( (z_{\text{em}} \leq 2.4) \), shown as a function of \( S/N_{1548} \).

### Table 1

| SDSS Name          | Plateid | MJD | Fiberid | \( z_{\text{em}} \) | \( z_{\text{abs}} \) | \( W_{\lambda 1548} \) | \( N_{\lambda 1548} \) | \( W_{\lambda 1551} \) | \( N_{\lambda 1551} \) | \( S/N_{1548} \) | \( S/N_{1551} \) | \( \beta \) |
|--------------------|---------|-----|---------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|----------------|---------|
| 000003.17+011510.6 | 4296    | 55499 | 0364    | 2.3543          | 1.8863          | 0.29            | 2.90            | 0.36            | 2.57            | 2.7            | 2.5            | 0.14915 |
| 000027.01+030715.5 | 4296    | 55499 | 0630    | 2.3533          | 1.9833          | 0.22            | 4.40            | 0.22            | 4.40            | 3.9            | 4.4            | 0.11639 |
| 000027.01+030715.5 | 4296    | 55477 | 0630    | 2.3533          | 2.1303          | 0.91            | 22.75           | 0.69            | 17.25           | 20.3           | 18.3           | 0.06871 |
| 000050.59+010959.1 | 4216    | 55477 | 0746    | 2.3678          | 1.8971          | 0.46            | 7.67            | 0.47            | 5.88            | 7.1            | 5.3            | 0.14942 |
| 000050.59+010959.1 | 4216    | 55506 | 0746    | 2.3678          | 1.9184          | 0.99            | 14.14           | 0.86            | 14.33           | 13.6           | 13.0           | 0.14225 |
| 000120.27+030731.9 | 4277    | 55506 | 0098    | 2.1082          | 1.8898          | 0.38            | 7.60            | 0.25            | 6.25            | 6.6            | 5.3            | 0.07273 |
| 000146.95+01428.9 | 4216    | 55477 | 0860    | 2.1567          | 1.9256          | 0.39            | 3.90            | 0.38            | 6.33            | 3.8            | 5.6            | 0.07588 |
| 000202.33+002648.4 | 4216    | 55477 | 0154    | 2.1761          | 1.9382          | 0.59            | 3.47            | 0.35            | 3.18            | 3.3            | 2.9            | 0.0777 |
| 000207.61+032801.5 | 4296    | 55499 | 0748    | 2.2195          | 1.7502          | 1.25            | 6.58            | 0.86            | 6.14            | 6.2            | 5.9            | 0.15626 |
| 000223.32+010101.2 | 4216    | 55477 | 0876    | 2.2931          | 2.1549          | 0.32            | 2.91            | 0.45            | 3.21            | 2.6            | 3.1            | 0.04285 |

Notes. \( N_{\sigma} = \frac{W_{\sigma}}{\sigma} \) represents the significant level of the detection. \( \beta = \frac{\left(1+z_{\text{em}}\right)^2 - \left(1+z_{\text{abs}}\right)^2}{\left(1+z_{\text{em}}\right)^2 + \left(1+z_{\text{abs}}\right)^2} \).

(This table is available in its entirety in a machine-readable form in the online journal. A portion is shown here for guidance regarding its form and content.)
Table 2
Missing Rate of Absorption Systems with S/N_1548 ≤ 4

| S/N Bin   | [2.0, 2.5] | [2.5, 3.0] | [3.0, 3.5] | [3.5, 4.0] |
|-----------|------------|------------|------------|------------|
| f_MR      | 0.92       | 0.71       | 0.64       | 0.23       |

Figure 6. Distributions of the rest-frame equivalent width of the CIV absorption line. The black line is for the λ1548 absorption and the red line is for the λ1551 absorption.

(A color version of this figure is available in the online journal.)

Figure 7. Distribution of the ratio of the rest-frame equivalent widths of the C IV doublet. The red curve is the fitting Gaussian with center = 1.18 and FWHM = 0.80. The red dashed lines are the theoretical limits for completely saturated (W_rλ1548/W_rλ1551 = 1.0) and unsaturated (W_rλ1548/W_rλ1551 = 2.0) absorptions, respectively.

(A color version of this figure is available in the online journal.)

is several times larger than that of 15/100, which manifests that many real absorption lines cannot be identified in the spectra with lower S/Ns."

In Section 5, on pages 6 and 7, “Our sample contains 10,121 quasars, from which we identify 8368 C IV λλ1548, 1551 absorption systems which covers the absorption redshift range of z_{abs} = 1.4544–2.2805. Of 10,121 quasars, 5442 are detected to have at least one C IV λλ1548, 1551 absorption doublet. We find that about 33.7% absorbers have 0.2 Å ≤ W_rλ1548 < 0.5 Å, about 45.9% absorbers have 0.5 Å ≤ W_rλ1548 < 1.0 Å, about 19.2% absorbers have 1.0 Å ≤ W_rλ1548 < 2.0 Å, and about 1.2% absorbers have W_rλ1548 ≥ 2.0 Å. Most of the C IV λλ1548, 1551 absorption doublets (72.9%) lie within the theoretical limits of the completely saturated and unsaturated absorptions (1.0 ≤ W_rλ1548/W_rλ1551 ≤ 2.0)” should be replaced by “Our sample contains 15,278 quasars, from which we identify 9417 C IV λλ1548, 1551 absorption systems which covers the absorption redshift range of z_{abs} = 1.4544–2.2805. Of 15,278 quasars, 6291 are detected to have at least one C IV λλ1548, 1551 absorption doublet.
Figure 8. Plot of the detection frequency as a function of S/N. The upper (red) line represents the count of the spectral data point, the middle (blue) line represents the count of the detected C iv absorption system, and the bottom (black) line stands for the frequency of NALs detected in this work, calculated by Equation (5).

(A color version of this figure is available in the online journal.)

Figure 10. Plot of the detection frequency as a function of S/N for the randomly selected quasar sample. See Figure 8 for the meanings of each solid line. The dashed lines are the solid lines shown in Figure 8 with the same colors.

(A color version of this figure is available in the online journal.)

We find that about 34.1% absorbers have $0.2 \AA \leq W_r \lambda 1548 < 0.5 \AA$, about 45.8% absorbers have $0.5 \AA \leq W_r \lambda 1548 < 1.0 \AA$, about 18.8% absorbers have $1.0 \AA \leq W_r \lambda 1548 < 2.0 \AA$, and about 1.2% absorbers have $W_r \lambda 1548 \geq 2.0 \AA$. Most of the C iv $\lambda \lambda 1548, 1551$ absorption doublets (71.5%) lie within the theoretical limits of the completely saturated and unsaturated absorptions ($1.0 \leq W_r \lambda 1548/W_r \lambda 1551 \leq 2.0$).

None of the main conclusions of Paper I are affected by this correction.