GALEX DISCOVERY OF A DAMPED Lyα SYSTEM AT REDSHIFT z ∼ 1.4

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ABSTRACT

We report the first discovery of a QSO damped Lyα system (DLA) by the Galaxy Evolution Explorer (GALEX) satellite. The system was initially identified as an Mg ii absorption-line system (zabs = 1.028) in the spectrum of Sloan Digital Sky Survey (SDSS) QSO J0203-0910 (zem = 1.58). The presence of unusually strong absorption due to metal lines of Zn ii, Cr ii, Mn ii, and Fe ii clearly suggested that it might be a DLA with N_H > 2 x 10^{20} atoms cm^{-2}. Follow-up GALEX NUV grism spectroscopy confirms that the system exhibits a DLA absorption line, with a measured H i column density of N_H = 1.50 ± 0.45 x 10^{21} atoms cm^{-2}. By combining the GALEX N_H determination with the SDSS spectrum measurements of unsaturated metal-line absorption due to Zn ii, which is generally not depleted onto grains, we find that the system’s neutral-gas-phase metal abundance is [Zn/H] = −0.70 ± 0.22, or ≈20% solar. By way of comparison, although this system has one of the largest Zn+ column densities, its metal abundances are comparable to other DLAs at z ∼ 1. Measurements of the abundances of Cr, Fe, and Mn help to further pin down the evolutionary state of the absorber.

Key words: galaxies: evolution – galaxies: formation – quasars: absorption lines – quasars: individual (SDSS J0203-0910)

1. INTRODUCTION

Since the first survey for damped Lyα systems (DLAs) by Wolfe et al. (1986), it has been recognized that these galaxy-sized columns of neutral hydrogen (N_H > 2 x 10^{20} atoms cm^{-2}) trace the neutral gas content of the universe back to the epoch of the earliest QSOs. Spectroscopic surveys for DLAs rely on only the presence of a background QSO, and therefore probe the universe independently of normal galaxy imaging. As such, they do not depend on the luminosity or spectral energy distribution of any associated galaxies. Only the presence of significant dust in the absorber would cause a bias against the identification of a DLA. Surveys have shown that DLAs trace the bulk of the observable H i gas mass in the universe (Prochaska et al. 2005; Rao et al. 2006, hereafter RTN2006).

Several facets of galaxy formation and evolution can be considered through follow-up studies of DLA properties. Their metal abundances, for example, provide insight into the chemical evolution of the neutral gas over cosmic timescales. Follow-up studies at z > 1.65 generally rely on blind spectroscopic surveys for Lyα, for which the Lyα line is shifted to optical wavelengths accessible from the ground (e.g., Prochaska et al. 2005, and references therein). However, these high-redshift DLAs only provide insight into the cosmic chemical evolution of neutral gas during the first third of the age of the universe (e.g., Pettini et al. 2002; Prochaska et al. 2003, 2007, and references therein).

At redshifts z < 1.65, Hubble Space Telescope (HST)-targeted searches for DLAs in strong Mg ii systems, like those found in Sloan Digital Sky Survey (SDSS) spectra by Nestor et al. (2005), have resulted in significant numbers of lower-redshift DLAs being identified (e.g., RTN2006 and references therein). This has led to a growing sample of DLAs that have been used to determine cosmic neutral gas-phase metallicities at lower redshifts (e.g., Rao et al. 2005; Nestor et al. 2008, and references therein). However, the failure of the Space Telescope Imaging Spectrograph (STIS) onboard the HST in 2004 curtailed further lower-redshift DLA surveys. Moreover, lacking HST UV spectroscopy, follow-up metallicity studies of the lowest redshift population of DLAs have become impossible, given that the weak unsaturated metal lines that must be observed (Cr ii, Fe ii, Mn ii, Si ii, Zn ii) lie in the UV when the redshifts are z < 0.6. Therefore, until the Cosmic Origins Spectrograph (COS) is fully operationally onboard the HST, the best opportunities for measuring individual DLA metallicities at z < 1.65 lie at redshifts z > 0.6, for which the Zn ii λλ2026,2062 lines are shifted into the optical regime. In total, there are currently only about 30 DLAs with 0.6 < z < 1.65 that can be used for individual metallicity studies.

Alternatively, an additional possibility is that DLAs in the redshift interval 0.6 < z < 1.65 might be identified by studying optical spectra and selecting systems which exhibit unusually strong metal-line absorption due to, e.g., Zn ii. Such systems are representative of the highest metal-line column densities in the universe, and are likely to have H i column densities in the DLA regime.

In this contribution, we successfully employ this second approach. After identifying a strong metal-line system at zabs ≈ 1 in the spectrum of SDSS QSO J0203-0910, we obtained follow-up NUV grism spectroscopy from the NASA Galaxy Evolution Explorer (GALEX) satellite to confirm our hypothesis that it is a DLA. In particular, the damping wings on the Voigt profile of the observed Lyα line are strong and broad enough that N_H is measurable even in the low-resolution GALEX NUV grism spectrum. This represents the first discovery of a DLA by GALEX. Moreover, given that the metal lines of the absorption system are visible and measurable in the SDSS spectrum, our results also lead to a metallicity determination. This adds to the growing number of DLA metallicity measurements at z < 1.65.

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1 Based on observations made with the NASA Galaxy Evolution Explorer (GALEX). GALEX is operated for NASA by the California Institute of Technology under NASA contract NAS5-98034.
2 Based in part on data obtained from the Sloan Digital Sky Survey.
The SDSS QSO J0203-0910 was discovered in SDSS DR1 (Schneider et al. 2003; Richards et al. 2004). The QSO has SDSS u, g, r, i, and z magnitudes of 18.6, 18.3, 18.2, 18.0, and 18.0, respectively. This $z_{\text{em}} = 1.58$ QSO has a strong Mg II system along the sightline at $z_{\text{abs}} = 1.028$, with a rest equivalent width of $W_{\lambda 2796} = 2.66 \pm 0.06$ Å. Since this line is saturated, the equivalent width is in fact an indication of the absorber’s velocity spread, or Δv ≈ 285 km s$^{-1}$. We selected this system as a candidate DLA based on the relatively strong Zn II, Cr II, Mn II, and (some) Fe II absorption lines present in the SDSS spectrum (Section 2.2). It was approved for 31,500 s of observation during Cycle 3 of GALEX (Program ID 0104).

### 2.1. GALEX Data

The GALEX grism spectra of SDSS QSO J0203-0910 (GALEX NUV mag = 19.8) were obtained in 2007 November. The total exposure time of 30,720 s was split between 16 visits. These data were processed, combined, and extracted in the standard pipeline procedure described by Morrissey et al. (2007). The resulting combined FUV-NUV spectrum is shown in Figure 1. The spectrum has a signal-to-noise ratio of $S/N \approx 6$ per pixel in the region of the DLA at $\lambda \approx 2465$ Å, where the resolution of the spectrum is $R \approx 117$ with 6 pixels per resolution element.

In Figure 2, we show the normalized GALEX spectrum in the region of the $z_{\text{abs}} = 1.028$ Lyα absorption line. We fitted a local continuum to the spectral region using standard IRAF$^4$ routines. Since the absorption line lies in the Lyα forest, using a least-squares minimization to fit the line with a Voigt profile is not the best way to proceed. Instead, the line was fitted by eye with a Voigt profile convolved to the instrumental resolution following the procedure described in Rao & Turnshek (2000) and RTN2006. The placement of the continuum in the region of the absorption line is the primary source of $N_{\text{H}}$ uncertainty. To estimate the errors associated with the $N_{\text{H}}$ measurement, we shifted our estimate of the best-fit continuum level upward and downward by the 1σ error array and refit the DLA, as described in Rao & Turnshek (2000). The resulting column density determination is $N_{\text{H}} = 1.5^{+0.4}_{-0.5} \times 10^{21}$ atoms cm$^{-2}$, which we report as 1.5 ± 0.4 × 10$^{21}$ atoms cm$^{-2}$.

### 2.2. The SDSS QSO J0203-0910 Spectrum

The SDSS spectrum of QSO J0203-0910 was fitted using a cubic spline for the continuum and Gaussians for the broad emission features, as described in Nestor et al. (2005). For presentation, portions of the spectrum revealing the relevant metal lines are shifted into the rest frame of the absorber and normalized by the continuum fit; they are shown in the five panels of Figure 3. The figure caption notes which metal-line regions are covered.

### 3. METAL ABSORPTION-LINE MEASUREMENTS

The rest equivalent width measurements of various unsaturated metal absorption lines (e.g., Zn II, Cr II, Mn II, and Fe II) in the $z_{\text{abs}} = 1.028$ system are presented in Table 1 (Column 5). For completeness, Table 1 also includes measurements of saturated lines due to Mg II and Fe II. Note that the Fe II λ2600 rest equivalent width, in combination with the Mg II λ2796 rest equivalent width, makes the absorber a DLA candidate according to the criterion of RTN2006. Details of measuring lines due to Zn II, Cr II, Mn II, and Fe II are discussed below since the results are used to determine metal abundances in Section 4.

#### 3.1. Zn II and Cr II

We measured the equivalent widths of the metal lines in the normalized SDSS spectrum by fitting Gaussians to the absorption features using the ratios of relevant transition oscillator strengths, as presented by Nestor et al. (2003; see their Table 2). We adopted the oscillator strengths from Table 1 of Rao et al. (2005), who compiled them from the references given in Columns 3 and 4 of our Table 1.

The blends of Zn II and Mg II at 2026 Å$^5$ and Cr II and Zn II at 2062 Å are unresolved and were fitted by single Gaussians. The
Figure 3. These portions of the normalized spectrum of SDSS QSO J0203-0910 show selected absorption lines due to metals in the rest frame of the $z = 1.028$ absorber. See Table 1 for the rest wavelengths of the various absorption lines marked by vertical dashed lines. The spectra are unsmoothed, and the horizontal dashed curves show the 1σ error array. The two panels on the left side show the regions containing the strong Mg ii doublet and the Mg i line (top panel) and the Zn ii, Mg i, and Cr ii lines (bottom panel). The three panels on the right side show the regions containing Mn ii and strong Fe ii lines (top panel), other strong Fe ii lines (middle panel), and weak Fe ii lines (bottom panel).

Table 1
Absorption Lines in SDSS QSO J0203-0910, $z = 1.028$

| Ion | $\lambda_{\text{rest}}$ (Å) | $f$ | Ref. | $W_0$ (mÅ) | $\log N$ (cm$^{-2}$) | [X/H] | [X/Fe] |
|-----|----------------------------|----|------|-----------|----------------|------|--------|
| H i | 1215.67                    |    |      |           | 21.18$^{+0.11}_{-0.16}$ | ... | ...    |
| Zn ii | 2026.14                    | 0.489 | 1 | (298 ± 91)$^b$ | 13.15 ± 0.15 | −0.70 ± 0.22 | 0.33 ± 0.15 |
|      | 2062.66                    | 0.256 | 1 | (92 ± 65)$^c$ | 13.78 ± 0.07$^d$ | −1.07 ± 0.18 | −0.04 ± 0.07 |
| Cr ii | 2056.25                    | 0.105 | 1 | 235 ± 50 | 175 ± 37$^e$ | 381 ± 63 |
|      | 2062.23                    | 0.078 | 1 | 2066.16 | 0.0515 | ... |
| Fe ii | 2249.88                    | 0.00182100 | 2 | 371 ± 53 | 15.65 ± 0.03$^f$ | −1.03 ± 0.16 | ... |
|      | 2260.78                    | 0.00244 | 2 | 396 ± 44 | ... |
|      | 2344.21                    | 0.114 | 3 | 1287 ± 35 | 381 ± 63 |
|      | 2374.46                    | 0.0313 | 3 | 1108 ± 34 | 381 ± 63 |
|      | 2382.77                    | 0.320 | 3 | 1791 ± 33 | 381 ± 63 |
|      | 2586.65                    | 0.0691 | 3 | 1430 ± 46 | 381 ± 63 |
|      | 2600.17                    | 0.239 | 3 | 1780 ± 45 | 381 ± 63 |
| Mn ii | 2576.88                    | 0.3508 | 4 | 337 ± 44 | 13.23 ± 0.05 | −1.48 ± 0.17 | −0.45 ± 0.16 |
|      | 2594.50                    | 0.271 | 4 | (335 ± 58)$^g$ | 13.23 ± 0.05 | −1.48 ± 0.17 | −0.45 ± 0.16 |
|      | 2606.46                    | 0.1927 | 4 | 176 ± 45 | 13.23 ± 0.05 | −1.48 ± 0.17 | −0.45 ± 0.16 |
| Mg ii | 2026.48                    | 0.1120 | 4 | (35 ± 5)$^h$ | 12.93 ± 0.06 | 12.93 ± 0.06 |
|      | 2852.96                    | 1.810 | 4 | 890 ± 56 | 12.93 ± 0.06 |
| Mg i | 2796.35                    | 0.6123 | 5 | 2665 ± 56 | 12.93 ± 0.06 |
|      | 2803.53                    | 0.3054 | 5 | 2450 ± 62 | 12.93 ± 0.06 |

Notes.

a Parentheses denote inferred or estimated values.
b Zn ii $\lambda$2026 is blended with Mg i $\lambda$2026.
c Zn ii $\lambda$2062 is blended with Cr ii $\lambda$2062.
d Calculated from Cr ii $\lambda$2056.
e Inferred from Cr ii $\lambda$2056, blended with Zn ii $\lambda$2062.
f Calculated from Fe ii $\lambda$$\lambda$2249.2260.
g Blend with weak Fe ii $\lambda$2374 line at $z_{\text{abs}} = 1.217$.
h Estimated from Mg i $\lambda$2852 as described in the text.

References.
(1) Bergeson & Lawler 1993; (2) Bergeson et al. 1994; (3) D. Morton 1994, private communication; (4) Morton 1991; (5) Verner et al. 1994.
rest equivalent width of Zn II λ2026 was found by subtracting the contribution attributed to Mg I λ2026, which in turn was inferred from the measurement of the stronger Mg I λ2852 line as follows. Since it has a rest equivalent width of $W_{\lambda=2852} = 890 \pm 56$ mÅ, this line is slightly displaced from the linear part of the curve of growth, and a saturation correction is necessary. In their study of metal-strong DLAs at higher redshifts, Herbert-Fort et al. (2006) compared the Mg I λ2852 lines measured in SDSS spectra to higher resolution observations and found little evidence for heavy saturation. They determined that only a slight increment of 0.1 dex to log $N_{\text{Mg}^+}$ was warranted. Our data are similar, and our measured $W_{\lambda=2852}$ lies near the middle of the range of values reported by Herbert-Fort et al. (2006).

We therefore adopted their procedure to infer an estimated rest equivalent width of the Mg I λ2026 line to be $W_{\lambda=2026} = 35 \pm 5$ mÅ. The quoted error reflects an uncertainty of 0.05 dex in the increment to the column density. Subtraction of this value from the measured blend at λ2026 indicates that the contribution from Zn II λ2026 is $W_{\lambda=2026} = 298 \pm 91$ mÅ.

The rest equivalent width of Cr II λ2062 was inferred from the fit to Cr II λ2056; it was subtracted from the measurement of the Cr II and Zn II 2062 Å blend, resulting in the reported Zn II λ2062 value. We note that the relatively large measured rest equivalent width of Cr II λ2066 (oscillator strength $f = 0.0515$) seems anomalous given that it should be weaker than Cr II λ2056 and Cr II λ2064. Therefore, we have not used the Cr II λ2066 measurement for the Cr+ column density and abundance determinations reported in Section 4.

3.2. Mn II and Fe II

Measurements of some of the Mn II absorption lines at $z = 1.028$ are slightly complicated by Fe II absorption lines in a weaker Mg II system ($W_{\lambda=2796} = 0.442 \pm 0.057$ Å) at $z_{\text{obs}} = 1.217$. The Mn II λ2576 line ($z = 1.028$) is unaffected; however, Mn II λ2594 ($z = 1.028$) is blended with Fe II λ2374 ($z = 1.217$), and Mn II λ2606 ($z = 1.028$) falls near Fe II λ2382 ($z = 1.217$).

After measuring the absorption feature at the position of the Mn II λ2594 ($z = 1.028$) and Fe II λ2374 ($z = 1.217$) blend, we evaluated the contribution from Fe II as follows. We first measured the Fe II λ2344 and Fe II λ2600 lines in the $z = 1.217$ system, and used the relevant oscillator strengths to infer the Fe II λ2374 ($z = 1.217$) rest equivalent width; its contribution is estimated to be $50 \pm 15$ mÅ. We then subtracted this value from the total measured rest equivalent width of the Mn II and Fe II blend to obtain $W_{\lambda=2594} = 335 \pm 58$ mÅ ($z = 1.028$).

The Mn II λ2606 line has the lowest oscillator strength of the three Mn II lines, $f = 0.1927$. Our measured value of this line, $W_{\lambda=2606} = 175 \pm 44$ mÅ ($z = 1.028$), is in agreement with the value predicted from the isolated Mn II λ2576 line, $W_{\lambda=2576} = 185$ mÅ. Also, the Fe II λ2382 line ($z = 1.217$) and the Mn II λ2606 line ($z = 1.028$) should be approximately resolved, given their $\approx 4$ Å separation in the observed frame. We conclude, therefore, that the contribution of Fe II λ2382 to the Mn II λ2606 measurement is negligible.

There are five Fe II lines that can be measured in the SDSS spectrum, although only two of them, Fe II λ2249 and Fe II λ2260, appear to have equivalent widths placing them on the linear part of the curve of growth. Thus, these are the two most useful Fe II lines for column density determinations. It should be noted that the $z = 1.217$ Cr II lines at 2056 Å and 2066 Å are potential contaminants of the $z = 1.028$ Fe II lines at 2249 Å and 2260 Å, respectively. However, inspection of the SDSS spectrum indicates no evidence for Zn II λ2026 absorption or a Zn II λ2062 and Cr II λ2062 absorption blend at $z = 1.217$. Given this, we conclude that any Zn II or Cr II features at $z = 1.217$ are too weak to produce a significant detection in the SDSS spectrum; they would certainly lie well within the reported measurement errors for the Fe II λ2249 and Fe II λ2260 lines at $z = 1.028$.

4. COLUMN DENSITIES AND ELEMENT ABUNDANCE DETERMINATIONS

With the exception of the Cr II λ2066 measurement described above, but which we ignore, the other rest equivalent width measurements appear to be in reasonable agreement. The rest equivalent widths of the weak lines due to Zn II, Cr II, Mn II, and two of the Fe II lines can be converted directly into column densities since they are unsaturated and lie on the linear part of the curve of growth.

Column density results for these ions are presented in Table 1 (Column 6) next to the first transition of each ion; the results are weighted averages derived from all of the relevant rest equivalent widths in Column 5, unless otherwise noted. For example, in the case of the Cr II lines, since $W_{\lambda=2056} = 0.0515$ was inferred from $W_{\lambda=2056}^{0}$, the quoted $N_{\text{Cr}^+}$ was determined solely from the $W_{\lambda=2056}^{0}$ measurement. We also remind the reader that some of the column densities rely on inferred equivalent widths. In particular, $N_{\text{Zn}^+}$ is determined from the Zn II λλ2026, 2062 lines, and these equivalent widths were both estimated from blends as described in Section 3.1.

Table 1 also lists the $N_{\text{H}^+}$ value determined from the GALEX spectrum. The various column densities are used to derive the element abundance results discussed below. When we quote abundances relative to solar values, we use the solar values of Grevesse & Sauval (1998) as compiled in Table 2 of Rao et al. (2005).

It is generally agreed that most of the Zn and Cr is singly ionized in the neutral DLA regions (Howk & Sembach 1999); this should hold for singly ionized Fe and Mn as well. Under this assumption, we have converted the Zn++, Cr++, Mn++, and Fe++ column densities into neutral gas-phase abundances. We find that $[\text{Zn/}H] = -0.70 \pm 0.22$, or $\approx$20% solar; $[\text{Cr/}H] = -1.07 \pm 0.18$ and $[\text{Fe/}H] = -1.03 \pm 0.16$, both $\approx$9% solar; and $[\text{Mn/}H] = -1.48 \pm 0.17$, or $\approx$3% solar. These results are given in Table 1 (Column 7).

Also in Table 1 (Column 8), we give the elemental abundances of Zn, Cr, and Mn relative to Fe, expressed as [X/Fe]. We find $[\text{Zn/Fe}] = 0.33 \pm 0.15$ and $[\text{Cr/Fe}] = -0.04 \pm 0.07$. The value $[\text{Cr/}Zn] = -0.37 \pm 0.17$ is typically taken as an indication of the presence of dust, given that Cr is expected to be readily depleted onto grains, whereas Zn is not (Pettini et al. 1990). The same holds for the inferred value of [Fe/Zn]. Thus, from the measurements we can infer that $\approx$60% of the Cr (and Fe) is depleted onto grains. This value is comparable to $[\text{Cr/}Zn] \approx -0.5$ found for the Milky Way halo (Savage & Sembach 1996). Nestor et al. (2003) found $[\text{Cr/}Zn] = -0.64 \pm 0.13$ in a composite SDSS spectrum for a sample of Mg II absorbers with $W_{\lambda=2796} \geq 1.3$ Å and $0.9 \leq z \leq 1.3$. With regard to Mn, we also find that $[\text{Mn/}Fe] = -0.45 \pm 0.16$. This result is similar to that found in previous DLA metallicity studies (e.g., Pettini et al. 2000; Ledoux et al. 2002; Rao et al. 2005); it has been suggested that this is due to metallicity-dependent production of Mn (see Section 5).
5. SUMMARY AND DISCUSSION

Based on the presence of unusually strong metal lines (Zn ii, Cr ii, Mn ii, and two low-oscillator-strength Fe ii lines) at z_{abs} = 1.028 in the SDSS spectrum of QSO J0203-0910, we selected the system as a DLA absorber candidate. We obtained a GALEX NUV grism spectrum to confirm the presence of the DLA, and found N_{HI} = 1.5^{+0.5}_{-0.5} \times 10^{21} \text{ atoms cm}^{-2}. This marks the first discovery of a DLA by GALEX. Using the existing SDSS spectrum, we determined the system’s metal-line column densities from measurements of the unsaturated metal lines.

As discussed further below, the Zn + column density in this system is among the highest known. Therefore, prior to our GALEX observation, we also thought that this system might be a good candidate for a solar or super-solar metallicity DLA. However, we found [Zn/H] = −0.70 ± 0.22, or ≈20% solar, which is within the normal range for DLAs at this redshift.

Measurements of absorption lines due to Cr ii and Fe ii in this system indicate that the gas-phase abundance of Cr and Fe is lower than Zn, with ≈60% of the Cr and Fe depleted onto grains. In addition, measurements of the Mn ii lines indicate that, relative to solar, the gas-phase abundance of Mn is even less than that of Cr and Fe. This may be due to a combination of depletion and an early stage of chemical evolution for the absorbing gas. In particular, it is known that [Mn/Fe] is clearly underabundant (e.g., [Mn/Fe] ≲−2) in low-metallicity stars (e.g., [Fe/H] < −1), but then [Mn/Fe] starts to increase with increasing [Fe/H] (McWilliam et al. 2003, and references therein). However, the details of the origin of Mn production, and the roles of SNe Ia and SNe II enrichment, are still debated (e.g., Feltzing et al. 2007; Bergemann & Gehren 2008, and references therein).

Our value for the Zn + column density, log N_{Zn} ≈ 13.15 ± 0.15, places it right at the empirical threshold of log N_{Zn} < 13.15 on a plot of [Zn/H] versus log N_{HI}, above which DLAs have generally not been found (Boissey et al. 1998; Meiring et al. 2006). Herbert-Fort et al. (2006) have classified DLAs above this threshold, i.e., with log N_{Zn} ≳ 13.15, as “metal-strong.” This soft limit has been suggested as being due to obscuration by dust (e.g., Boissey et al. 1998); however, more recent results suggest that the lack of systems above this limit is due more to their inherent rarity (Herbert-Fort et al. 2006, and references therein).

The strong metal lines in this system, nevertheless, are not indicative of an unusually large metallicity compared to other DLAs at z ≈ 1. For example, Kulkarni et al. (2007) found ([Zn/H]) = −0.82 ± 0.15 for 20 DLAs with 0.1 < z < 1.2, which is consistent with our result. Rather, the strong metal lines in this system can be attributed to its large H i column density. As noted above, this DLA does have a relatively high metallicity in comparison to systems with similar N_{HI}.

Our metallicity results may also be compared to those determined at z > 0.6 from SDSS composite spectra. For example, in an analysis of one composite created from 90 Mg ii absorbers with W_{0,2796} > 1.3 Å and 0.9 < z < 1.35, many of which should be DLAs (Rao & Turnshek 2000; RTN2006), Nestor et al. (2003) estimated a metallicity of [Zn/H] = −0.56 ± 0.19. Turnshek et al. (2005) reported an extension of this analysis using a much large sample of strong Mg ii absorbers with 1 < z < 2, and parameterized [Zn/H] = −0.4 − 0.0043e^{(6−W_{2796})/0.88} for 0.6 Å < W_{2796} ≤ 6.0 Å. Using our measured value of W_{0,2796} = 2.66 Å for the Mg ii absorber corresponding to the DLA in SDSS QSO J0203-0910, this paramaterization would predict [Zn/H] = −0.59, in agreement with our measured value of [Zn/H] = −0.70 ± 0.22.

Candidate DLA selection based on strong lines of Zn ii remains the best chance for finding solar or super-solar metallicity DLAs at z ≈ 1. We suspect that such a system might exhibit a Zn + column density similar to the z_{abs} = 1.028 system, but have N_{Zn} ≲ 2 \times 10^{20} \text{ atoms cm}^{-2}, i.e., right at the DLA N_{HI} lower threshold. The presence of other normally weak lines may also provide a clue, but many of the other elements are subject to depletion. Alternatively, one could argue that searches for strong Zn ii systems may offer a way to find the highest N_{HI} systems, providing a potential way to explore the high end of the H i column density distribution at low redshifts. Larger surveys using HST COS will permit an evaluation of the success of this technique at 0.6 < z < 1.65.

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