Chapter 3

The Absorbing Systems

The analysis of the Mg II systems in the HIRES spectra, based upon the discussion of the previous chapter, is presented. The analysis of each system includes measurements of the equivalent widths (or detection limits), doublet ratios, velocity widths, velocity asymmetries, profile shapes, the integrated apparent column densities, and the number of subfeatures. For each subfeature, the equivalent widths (or detection limits), doublet ratios, velocity widths, velocity asymmetries, profile shapes, and the integrated apparent column densities are also measured. In addition, each subfeature velocity centroid is measured. Formal uncertainties in all quantities are computed. In addition to these direct measurements of the absorption spectra, a full VP decomposition of each system is presented. There are some cases where a VP decomposition is not well suited, such as when the profiles are very saturated and additional information is not available from the Fe II or Mg I transitions. Each absorption system is individually discussed in Section 3.3.

3.1 Absorption Properties of the Observed Systems

The overall Mg II profile and absorption properties are presented in Tables 3.1 and 3.2. Table 3.1 lists (1) the absorber redshift, (2) the uncertainty in the redshift in velocity units, $\sigma(v)$ [km s^{-1}], (3) the velocity width, ω_v, velocity asymmetry, η_v, and rest–frame equivalent width, $\textsc{ew}_{\mathrm{r}}$, of the λ2796 transition, and (4) the Mg II doublet ratio, DR. Not tabulated is a quantity that will be referred to as the profile "shape parameter", η_v/ω_v. This parameter essentially measures the velocity width normalized asymmetry and is more useful for characterizing profile shapes because the asymmetry is simply a higher moment of the velocity width. Thus, a "wide" line with a given profile morphology will necessarily have a larger η_v than will a "narrow" line with the identical morphology. A null shape parameter denotes perfect symmetry about the profile velocity zero point. A negative shape denotes extended blue wings and a positive shape denotes extended red wings.

Table 3.2 lists the 5σ $\textsc{ew}_{\mathrm{r}}$ detection limit for the Mg II λ2796 profile for each system. Also listed are (1) the number of VP components, (2) the integrated VP column density of Mg II λ2796, and (3) the "absolute deviation from the median" of the cloud velocities, given by

$$A(\Delta v) = \frac{1}{N_{\rm c}} \sum_{i=1}^{N_{\rm c}} |\Delta v_i| \, , \tag{3.1}$$

where $\Delta v_i = v_i - \bar{v}$, and $\bar{v}$ is the median cloud velocity. The median is used in lieu of the average because the former is symmetric about the number of clouds and is not sensitive to one or a few large Δv_i clouds. Also tabulated, are the apparent column densities, measured directly from the Mg II λ2796 profiles, and the number of "kinematic subsystems", or profile subfeatures. The last column provides the sample designation for the system (see below).

The number of "kinematic subsystems", and each subfeature velocity centroid, $\langle v \rangle$, velocity width, Mg II λ2796 $\rm EW_r$, and Mg II DR are given in Table 3.3. In Tables 3.6 through 3.54, the absorption properties of each system are presented. Each table lists the adopted integrated apparent column density for Mg II, Fe II, Mg I, Mn II, and Ca II for the kinematic subsystems and for the overall system. If there is a null feature detection for a given ion, then upper limits are given. In the case of unresolved saturation, the lower limit is quoted. Also listed are the rest–frame equivalent widths, $\rm EW_r$, of the transitions listed in Table 2.1. In the case of null detections, the upper limit of $\rm EW_r$ is quoted.

The HIRES spectra of all identified ion transitions given in Table 2.1 are presented for each absorbing system in Figures 3.15–3.62. The MINFIT VP decomposition model spectra are also shown superimposed over the data, where the ticks above the continua give the velocity centroid of each VP component. Recall that all transitions within a system were fit with the same number of components, so that often Fe II, Mg I, or Ca II show no discernible absorption where a VP component has been found based upon Mg II. The column densities of these components were always consistent with zero, and have not been included in the analysis. In Tables 3.55–3.81, the VP velocity centroids, column densities, and Doppler b parameters are given. In the case where the column density is consistent with zero, no entry is given.

Since a deeper appreciation of the uncertainties inherent in the VP decomposition technique was sought, a fairly comprehensive set of simulations were performed. These simulations and the subsequent analysis of the VP decomposition of the simulated spectra are presented in Chapter 4. The limiting detectable column density for Mg II is presented in Figure 4.2. Analysis of the VP components obtained for the HIRES spectra is given in Chapter 5.

3.2 Redshift Distribution and Detection Sensitivity

The redshift distribution of the Mg II systems is illustrated in Figure 3.1. Two samples have been defined based upon the $\rm EW_r$ detection threshold. Sample A includes all 48 systems listed in Table 3.1. Sample B includes only those systems for which the 5σ $\rm EW_r$ detection limit of the Mg II λ2796 transition is less than 0.02 Å. Sample B is shown as the shaded histogram. As illustrated in Figure 3.2, there is a natural break in the $\rm EW_r$ distribution at 0.02 Å, below which 37 of the 48 systems are found. There are two additional reasons this $\rm EW_r$ limit was chosen.

Below the 0.02 Å limit, the redshift distribution in the detection sensitivity does not exhibit a strong trend with redshift. In Figure 3.3, the 5σ $\rm EW_r$ limit is plotted as a function of redshift. Below $\sim$ 7000 Å ($z_{\rm abs} \sim 1.5$ for Mg II), the HIRES efficiency curve decreases steadily with a rapid fall off at $\sim$ 4000 Å ($z_{\rm abs} \sim 0.4$ for Mg II). Below 5100 Å ($z_{\rm abs} \sim 0.8$ for Mg II), the sensitivity is also a strong function of how close to blaze the absorption lines fall on the HIRES echelle format. There are other factors, of course, such as atmospheric conditions, or whether the absorption features are in the wing of a QSO emission feature. Due to these considerations, there is a wide variation in the limiting $\rm EW_r$ below redshift $z = 1$, as seen in Figure 3.3. If all spectra were included in the analysis, great care would be needed to understand any possible biasing effects with redshift.

For the analysis of the absorption properties and of the VP parameters, it is preferable that each system in the survey be observed to some uniform equivalent width threshold. In particular, this gives a well defined upper limit to the sensitivity level probed in each absorbing system. Since, for a given absorption system, the sensitivity remains virtually unchanged across a given absorption profile, it is not necessary to map out the sensitivity of the survey in velocity space (using a function analogous to the redshift path density). Thus, the sample for further study is selected based upon the equivalent width detection threshold. In Figures 2.1–2.24, the 5σ $\rm EW_r$ limit of the Mg II λ2796 transition is presented for each system. The top panels show the feature identifications and the lower panels show the $\rm EW_r$ limits as a function of wavelength. The full velocity spread presented in these figures is nominally ± 500 km s^{-1}.

The second reason for selecting the cutoff at 0.02 Å was based upon the simulations (Chapter 4). Though not presented therein, simulations with a 0.03 Å $\rm EW_r$ cutoff were compared to those with 0.02 Å and 0.01 Å cutoffs. Both the column density completeness limit (for a 99% detection rate) and the accuracy of the resulting VP parameters (following full VP decomposition of the spectra) are strong functions of the limiting $\rm EW_r$.

It would also be preferable if the redshift range observed was sampled uniformly. Achieving this goal is nearly impossible, since the selection criteria of systems is highly dictated by the brightness of the QSOs available on the night of the observations. As seen in Figure 3.1, the distribution of systems in redshift drops rapidly for $z > 1$. Note that all $z > 1$ systems are included in Sample B. In the final analysis, it will be important to understand if measured redshift evolution in any given absorption property is a result of a selection bias. For one, four of the systems at $z > 1.2$ have the four largest equivalent widths ($\rm EW_r > 1.8$ Å). This is a definite selection bias that occured during the course of the observations. The upper left panel of Figure 3.4 shows $\rm EW_r$ verses redshift. It is clear that the $z > 1$ – $\rm EW_r < 1.8$ and the $z < 1$ – $\rm EW_r > 1.8$ quadrants of the diagram have not been sampled. An extension of the current study would be required to better understand how absorption properties obtained from high resolution spectra are distributed with redshift. There are reasons to believe that the $z < 1$ – $\rm EW_r > 1.8$ quadrant is relatively underpopulated (Bergeron et al. 1994; Steidel & Sargent 1992; Petitjean & Bergeron 1990), based upon low and medium resolution studies. It is possible that if clear correlations are found between absorption properties that are not sensitive to spectral resolution (i.e. $\rm EW_r$, DR, and total ω_v) and absorption properties obtained at high resolution (i.e. number of VP components and their velocity clustering), then indirect inferences might be drawn from the available large lower resolution databases.

3.3 Discussion of Individual Systems

3.3.1 Q0002 + 051

Spectra of this QSO, also known as UM 18 and PHL 957, were previously studied by Young, Sargent, & Boksenberg (YSB, 1982), Lanzetta, Turnshek, & Wolfe (LTW, 1987), and Steidel & Sargent (SS92, 1992). An additional Mg II absorber at $z_{\rm abs} = 0.2980$ has been discovered by Steidel, Dickinson, and Persson [SDP, (Steidel, private communication)], but was not observed because it was not covered by the HIRES format. The C IV doublet at $z_{\rm abs} = 1.7444$ reported by YSB has been observed, but is not published here.

$z = 0.591485$ — This system was discovered by SDP (Steidel, private communication). The absorption profile is found to be a single VP component. However, both transitions of the doublet exhibit an asymmetry in the blue wing that is difficult to understand unless the absorbing gas is *extremely* quiescent. The Fe II $\lambda2344$ transition and the Ca II $\lambda\lambda3934, 3969$ doublet were not covered by the HIRES format. The Mn II triplet and all other Fe II transitions showed no absorption to the $\rm EW_r$ limits given in Table 3.6.

$z = 0.851394$ — This system was first reported by SS92, and turns out to be one of the most kinematically intriguing absorption profiles of the entire sample, with a total velocity spread of roughly 475 km s^{-1}. It is difficult to understand this profile in terms of gas gravitationally bound to a single galactic halo. The overall profile was found to have four kinematically distinct features and was fitted with a total of 12 VP components. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\rm EW_r$ limits given in Table 3.7.

Only a single exposure on this QSO was obtained so that removing cosmic rays, especially from the sky, was very problematic. A first–pass QSO spectrum was extracted with no sky subtraction, so that cosmic rays in the sky would not contaminate the resulting spectrum. Then, a second–pass extraction was performed with sky subtraction, in order to obtain the sky spectrum itself. This sky spectrum was then smoothed and the cosmic rays filtered out. This smoothed sky spectrum was then subtracted from the first–pass QSO spectrum. There was a small zero point discrepancy between the "corrected" first–pass and the second–pass QSO spectra. A zero–point offset as a function of wavelength was computed by taking the difference of the first– and second–pass spectra and this offset was used to restore the zero point to the first–pass spectrum, to yield the final spectrum presented here. In the case of the $z_{\rm abs} = 0.8514$ system, zero flux in the saturated line cores of the Mg II transitions was recovered.

3.3.2 Q0058 + 019

Spectra of this QSO, also known as UM 297 and PHL 938, were previously studied by Peterson et al. (1977), Sargent, Boksenberg, & Steidel (SBS, 1988), and SS92. An additional tentative Mg II system at $z_{\rm abs} = 0.5230$ was found by SDP (Steidel, private communication), which was not confirmed to an upper 5σ $\rm EW_r$ limit of ~ 0.05 Å.

z = 0.612672 — This system was first reported by SBS and is likely associated with a damped Lyα absorber (Steidel, private communication). A total of seven VP components were fit to the profiles. The Mg I profile is quite interesting in that it occupies roughly an 80 km s^{-1} region as compared to the 140 km s^{-1} spread of the saturated portion of the Mg II profile. Mn II appears to trace the Mg I, whereas Fe II appears to trace the overall Mg II. It could be inferred that differing ionization and/or chemical conditions are kinematically subclustered (cf. Lanzetta & Bowen 1992). The Ca II $\lambda\lambda$3934, 3969 doublet was not covered by the HIRES format. The Fe II λ 2344, 2374, and 2382 transitions showed no absorption to the EW$_r$ limits given in Table 3.8.

z = 0.725173 — This system has not been reported previously. The absorption profile is found to be a single VP component, based upon the Mg II doublet and a Mg I profile. The Ca II $\lambda\lambda$3934, 3969 doublet was not covered by the HIRES format. The Mn II triplet and the five Fe II transitions given in Table 2.1 showed no absorption to the EW$_r$ limits given in Table 3.9.

3.3.3 Q0117 + 212

A spectrum of this QSO was previously studied by SS92. The four redshifts they reported are confirmed. An additional redshift at $z_{\rm abs} = 0.7291$ discovered by SDP (Steidel, private communication) was also confirmed.

z = 0.576398 — The system exhibits fully saturated Mg II profiles and a Mg I profile with definite variations in strength in velocity space. Weak Ca II λ3936, which is aligned with the peak absorption across the Mg I profile, has also been observed. There is a slight blending in the blue wing of Mg I with the red wing of Fe II λ2600 at $z_{\rm abs} = 0.729055$. The profiles were fit with four VP components. The velocities of the three components in the saturated region were constrained by the Mg I profile. The previously reported Fe II transitions were not covered by the HIRES format. In fact, none of the Fe II transitions, nor the Mn II triplet, nor the Ca II λ3934 transition were covered by the HIRES format. The measured EW$_r$ for the Mg II, Mg I, and Ca II transitions are given in Table 3.10.

z = 0.729055 — This system was discovered by SDP (Steidel, private communication). However, SS92 did flag an unidentified line (15), which is in fact the Mg II for this system. Three kinematic subfeatures were identified and the overall system was fit with five VP components. There is a slight blending in the red wing of Fe II λ2600 with the blue wing of Mg I at $z_{\rm abs} = 0.576398$. The Ca II $\lambda\lambda$3934, 3969 doublet and the Fe II λ2344, 2374, and 2382 transitions were not covered by the HIRES format. The Mn II triplet showed no absorption to the EW$_r$ limits given in Table 3.11.

z = 1.047971 — This system is found to have two kinematic subfeatures separated by roughly $v \sim 100$ km s^{-1}. The overall profile was fit with seven VP components. The Ca II $\lambda\lambda$3934, 3969 doublet was not covered by the HIRES format. The Mn II triplet and the Fe II λ2374 and 2586 transitions showed no absorption to the EW$_r$ limits given in Table 3.12.

$z = 1.325014$ — This weak system is kinematically intriguing in that it is composed of five distinct kinematic subfeatures somewhat uniformly separated in velocity ($\Delta v \sim 30$ km s^{-1}). The overall profile has been fit with six VP components. The Ca II $\lambda\lambda 3934, 3969$ doublet and the Mn II $\lambda 2576$ transition were not covered by the HIRES format. The remaining Mn II transitions and the Fe II $\lambda 2344$, and 2374 transitions showed no absorption to the EW$_r$ limits given in Table 3.13.

$z = 1.342969$ — This is another weak, but kinematically interesting, system. There are four kinematic subfeatures, which are dominated by a narrow asymmetric profile. The overall profile was fit with five VP components. The observed Fe II is associated with this dominate Mg II subfeature. The Ca II $\lambda\lambda 3934, 3969$ doublet and the Fe II $\lambda 2600$ and Mg II $\lambda 2796$ transitions were not covered by the HIRES format. The Mn II triplet and the Mg I transition showed no absorption to the EW$_r$ limits given in Table 3.14.

3.3.4 Q0420 − 014

This QSO was not included in the studies of SSB nor SS92, but was observed by Wills et al. (1980), who first reported the system studied in this work.

$z = 0.633004$ — The overall profile is comprised of two kinematic subfeatures, one broad and complex, separated by $v \sim 200$ km s^{-1}. A total of nine VP components were fit. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet and all but the Fe II $\lambda 2600$ transition showed no absorption to the EW$_r$ limits given in Table 3.15. The spectra are low quality, having signal to noise ranging from two to four, for the Fe II $\lambda 2344$, 2374, and 2382 transitions.

3.3.5 Q0450 − 132

This QSO was discover by C. Hazard (unpublished) and has been previously studied by SBS and SS92. Two systems were studied here. A third and a fourth system at $z_{\rm abs} = 1.2291$ and $z_{\rm abs} = 1.3108$, first identified by SS92, have also been observed in the HIRES spectrum. However, they have not been included in overall statistics of this study due to oversight.

$z = 0.493937$ — This system was first reported by SBS. A single kinematic region was found with a smoothly varying asymmetry in the blue wing. Formally, only two VP components were fit to the overall profiles, but there may be at least two more that could not be distinguished because of the low signal to noise in the spectrum at these wavelengths. In both the Mg I and the Ca II $\lambda 3934$ transitions, there appears to be a double component where a single VP component has been fit ($v = 7.00$ km s^{-1}). Furthermore, there is a small apparent feature in both transitions of the Mg II doublet at $v \sim 60$ km s^{-1}, which was not formally detected by EWREGION. None of the five Fe II transitions listed in Table 3.16 nor the Mn II triplet was covered by the HIRES format. A higher signal to noise spectrum of this system may reveal up to as many as five VP components, and possibly more if detailed structure in Fe II transitions is found.

$z = 1.174615$ — This system was first reported by SBS based upon the Fe II lines, and was later confirmed with Mg II by SS92. The absorption profiles exhibit the "double system" morphology characteristic of strong higher redshift absorbers. The Mg II $\lambda 2803$ was only partially observed because it was cut off at the edge of the CCD. The Ca II $\lambda\lambda 3934, 3969$ doublet, the Mg I transition, and the Fe II $\lambda 2586$ transitions were not covered by the HIRES format. The Mn II triplet showed strong absorption. As such, this was considered to be a damped Ly α system by Lu et al. (1996b), who have presented an independent analysis.

3.3.6 Q0454 + 039

Spectra of this QSO were previously studied by Burbidge et al. (1977), Caulet (1989), SS92, and Steidel et al. (1995). Two systems have been studied in this work. These two systems have been presented in detail by Lu et al. (1996b) for a study of damped Ly α "galaxies".

$z = 0.859565$ — This damped Ly α system was studied by Steidel et al. (1995) and by Lu et al. (1996b). The Mg II $\lambda 2796$ transition and the Ca II $\lambda\lambda 3934, 3969$ doublet were not observed because they were not covered by the HIRES format. The overall Mg II $\lambda 2803$ profile was found to be a single fully saturated feature with a ~ 200 km s^{-1} spread. Beyond the red wing, there is a small absorption profile, which typically accompany profiles with this type of overall shape morphology. The system was fit with a total of 12 VP components. However, the column densities and Doppler b values for components three through nine are not well constrained, and any inferences regarding this system based upon the VP decomposition should be viewed with caution. Based upon the profile fit to the Fe II $\lambda 2344$ transition, there may be an offset in the continuum placement across that profile.

$z = 1.153248$ — This system exhibits a very interesting, and somewhat unique profile. It is the only profile in the sample that has weak high velocity absorption distributed symmetrically about the central main absorption region. However, there is confusion near both the Mg II doublet transitions, in that small unidentified absorption features are seen. Though these features do not fit any obvious pattern expected of low ionization transitions, it is possible they arise from an unidentified redshift system. Additionally, the Fe II $\lambda 2374$ transition is blended with an unidentified absorption line. This is apparent because of the unphysical strength ratios with respect to the other Fe II transitions and is further suggested by another possible nearby unidentified feature. For the overall system, three kinematic subfeatures were found and seven VP components were fit. The Ca II $\lambda\lambda 3934, 3969$ doublet and the Mn II $\lambda 2606$ transition were not covered by the HIRES format.

It should be noted that the accepted apparent column densities for the $z_{\rm abs} = 0.8596$ system, quoted in Table 3.18, are systematically smaller than those quoted by Lu et al. (1996b). This is due to the definition of the optical depth applied in this work. In the case when the flux value in a given pixel is less than the uncertainty in that pixel, the flux value is replaced by the uncertainty. This gives a lower limit on the optical depth, and results in systematically smaller apparent column density values.

3.3.7 Q0454 − 220

Spectra of this QSO were previously studied by Tytler et al. (1987) and by Robertson et al. (1988), and references to the Mg II system discoveries are given in those works.

$z = 0.474410$ — Tytler et al. (1987) studied this system in some detail. A detection of Ca II has been reported by Robertson et al. (1988), and is confirmed with this work. Their tentative report of Mn II λ2584 absorption is not confirmed, however, a small apparent feature is present at about $v = 10$ km s^{-1}. This not taken to be a positive detection of the Mn II transition since the detection threshold of the other Mn II transitions are roughly the same and these transitions show no absorption to the limits given in Table 3.20. A total of 16 VP components were fit to this broad saturated profile. It is most interesting to note the relatively narrow and highly structured Mg I profile and the fact that it is roughly centered on the Mg II profile. The observed Ca II profile is clearly aligned in velocity with the Mg I profile and likely arises in the same spatial region of the absorbing gas. The VP decomposition of this system suffered from a singular curvature matrix during the computation of the uncertainties. Thus, inferences regarding this system based upon the VP parameters should be viewed with suspicion. In fact, this system has been omitted from the statistical studies of VP parameters. The Fe II λ2344, 2374, and 2383 transitions were not covered by the HIRES format and the Ca II λ3934 transition was only partially observed.

$z = 0.483340$ — Tytler et al. (1987) also studied this system in some detail. A null detection of Ca II has been reported by Robertson et al. (1988). However, Ca II absorption is detected in the HIRES spectrum, albeit below the detection threshold of the Robertson et al. spectrum. The profile was fit with a total of seven VP components, which were all well constrained in that they have small fractional errors. The Fe II is aligned in velocity with the maximum Mg II absorption, as is the Ca II absorption. However, the Mg I shows a hint of structure that may span the full velocity spread seen in the Mg II profiles. The Mn II triplet showed no absorption to the EW$_{\rm r}$ limits given in Table 3.21.

3.3.8 Q0823 − 223

This QSO, a luminous BL Lacertae object, has been studied in some detail by Falamo (1990), though its redshift remains quite uncertain, and by Veron–Cetty et al. (1990). A spectrum of this QSO was previously studied by Condon, Hicks, & Jauncey (1977). Falamo reported a strong Mg II doublet at $z_{\rm abs} = 0.9103$. An Mg II system at $z_{\rm abs} = 0.7055$ has been discovered in the HIRES spectrum.

$z = 0.705472$ — There appears to be no prior report of this system in the literature. Except for the Ca II doublet, all the transitions listed in Table 2.1 were observed, though the signal to noise ratio of the Fe II λ2344, 2374, and 2383 transitions was fairly low, ~ 7. Only the Mg II doublet was detected at the limits given in Table 3.22.

The absorption is clearly on the linear part of the curve of growth. The profile has a somewhat asymmetric shape to it, though it was formally fit with a single VP component.

$z = 0.9108$ — This system was first reported by Falamo (1990) and was found to be a "double" system by Veron–Cetty et al. (1990). It is very complex, strong, and kinematically spread out over $\sim$350 km s^{-1}. The profile shapes are suggestive of a scenario proposed by Heahnelt, Steinmetz, & Rauch (1996), in which the absorbing gas may be part of an extended "filamentary" structure that is being probed along the principal axis in the region of a small group of galaxies. This system, in particular, would be interesting to study in detail to see if such a supposition is correct, or if there is only a single associated galaxy [as had been found for the $z_{\rm abs} = 0.8514$ system in the Q0002+051 field (Steidel, private communication)]. J. Surdjen (Veron–Cetty et al. 1990) took an R–band image of the field only to find that an observed companion was a zero redshift star. The Ca II doublet was not observed because it was off the HIRES format. Also, the Mg II λ2803 transition was only partially observed. Three kinematic subsystems were measured, one a single component that could in fact be associated with the larger absorption complex spread over 105–185 km s^{-1}. A total of 18 VP components were fit to the system.

3.3.9 Q1101 − 264

The absorption lines in this QSO spectrum have been the subject of several studies, but those relevant to the Mg II absorbing systems are Carswell et al. (1984) and (again) Carswell et al. (1991). The fully reduced and continuum normalized spectra studied in this work were kindly provided by Max Pettini (Pettini & Hunstead, unpublished). The spectra were obtained with the UCL echelle spectrograph on the AAT, with the IPCS as the detector. The resolution is 6 km s^{-1} FWHM (or approximately 0.07–0.08 Å at the wavelengths covered here); the signal to noise ratio in the region of the Mg II absorbing systems studied in this work is roughly 30. The total integration time was 100,200 seconds!

$z = 0.356286$ — Carswell et al. (1984) claim that this system is not well fit by a single VP component, and in fact they fit six VP components in their high resolution ($\sim$ 9 km s^{-1}) spectrum (Carswell et al. 1991). Actually, it is likely that the Mg II λ2803 transition is blended with a Ly α line, since this system lies just blueward of the Ly α emission line of the QSO. The Mg II λ2796 profile has a weak blueward asymmetry ($\eta_v/\omega_v = -0.58$), and has been well fit by a single VP component. The Mg II λ2803 profile shows a strong redward asymmetry and exhibits absorption that is too strong relative to the Mg II λ2803 profile (also see Figure 3.13). Note that this shape is counter to the blue–wing asymmetry of the doublet discussed by Carswell et al. (1991), who used it to justify their multicomponent VP decomposition. A naive measurement of the doublet ratio yields 1.13, when in fact the measured column density [$\log N(\mathrm{Mg\,II}) = 12.8$ cm^{-2}] is consistent with the linear part of the curve of growth. All things considered, it is unlikely that unresolved saturation of several optically thick narrow components is giving rise to the peculiar aspects of this absorption profile.

$z = 0.359153$ — This system was also first reported by Carswell et al. (1984), who fit the complex profiles with seven VP components. A fit to the UCL/AAT spectra yields six components. The latter fit is virtually identical but for the fit to the saturated portion of the profile (VP component No. 2), where the two components found by Carswell et al. (1991) have been consolidated into a single component. However, they simultaneously fit Fe II $\lambda 2600$ and Mg I, which both show strong absorption aligned with this velocity region of the profile. On the other hand, the shapes of these latter transitions in the Carswell et al. (1990) spectra are not suggestive of multiple components. Other ion transitions were not available for the work presented here.

3.3.10 Q1148 + 384

Spectra of this QSO, also known as 4C 38.31, were previously studied by Boulade et al. (1987), who reported a low redshift Mg II system at $z_{\rm abs} = 0.2130$, and by SS92, who reported a Mg II system at $z_{\rm abs} = 0.5532$. Only the SS92 system has been studied in this work.

$z = 0.553362$ — This system has a very interesting profile that is comprised of eight VP components over a single "kinematic system" spread over 200 km s^{-1}. The striking characteristic of this profile is the well defined and symmetric velocity splitting. In addition, the absorption strengths decrease with increasing velocity, giving the overall absorption "envelope" a Gaussian shape. Qualitatively, this profile appears that it could arise from shells of infalling gas. Interestingly, this profile arises about 15 kpc out in a face–on spiral galaxy (Steidel, private communication), but exhibits the symmetric velocity splittings that are believed to arise out at 20 kpc in the edge–on spiral galaxy at $z_{\rm abs} = 0.7446$ (Churchill, Vogt, & Steidel 1995; Le Brun et al. 1996). The Ca II $\lambda 3934$ transition and the Fe II $\lambda 2344$, 2374, and 2383 transitions were not covered by the HIRES format. The Mn II triplet and the Ca II $\lambda 3969$ transition showed no absorption to the EW$_{\rm r}$ limits given in Table 3.26.

3.3.11 Q1206 + 459

The spectrum of QSO has been studied by SS92 and by Burles & Tytler (1996). SS92 reported a Mg II system at $z_{\rm abs} = 0.9729$. In a search for O VI absorption, Burles & Tytler reported three redshifts, $z_{\rm abs} = 0.7339$, 0.9270, and 1.0827. In the HIRES spectrum, the Mg II doublet was not detected in the $z_{\rm abs} = 0.7339$ nor the 1.0827 system. The 5σ equivalent width upper limits for Mg II are EW$_{\rm r} < 0.015$ Å. These are clearly highly ionized systems. A weak system at $z_{\rm abs} = 0.9343$ was discovered in the HIRES data. Examination of the broad C IV profile in the Key Project FOS spectrum, redward of the very strong C IV absorption, revealed a weak C IV absorber associated with the discovered weak system. Two systems were included in this study.

$z = 0.927602$ — This system is revealed to be a very complex and kinematically spread out system, with a maximum Mg II cloud separation of 500 km s^{-1} (greater than the escape velocity of typical L^* galaxies). It is possible that this is a "double system", one for which a rich complement of low and high ionization species are seen in absorption. If so, the weak system (call it "A", as presented in Table 3.27) would have a measured redshift of $z_{\rm abs} = 0.9266$. It is likely that the bulk of the C IV absorption arises in association with subsystem A, given the lower Mg II absorption strengths that would occur in high ionization gas. Because the FOS data have a resolution of 250 km s^{-1}, it is not possible to precisely discern if the strong high ionization conditions are associated with system A, system B, or both. The average redshift of the high ionization "system" is consistent with being centered on subsystem A within the 1σ (125 km s^{-1}) uncertainty of the measured redshift. However, this is uncertain since the velocity zero point of the FOS data was not addressed by Burles & Tytler. The Mg II profile of system A exhibits the symmetric velocity splittings that are suggestive of shell expansion or radial infall. It is possible that this subset of the profiles could be part of a collisional wind that is also responsible for the O VI, N V, C IV, Si IV, N III, C III, C II, Si II, Lyα, Lyβ, and Lyγ transitions reported by Burles & Tytler. Such a wind could arise from supernovae explosions (Bregman 1980; MacLow & McCray 1988), especially in the low mass potentials of dwarf satellite galaxies (Wang 1993; Wang 1995). Interestingly, there is no Fe II detected to a 5σ EW$_{\rm r}$ limit of 0.008 Å over this velocity interval. The bulk of the Mg II absorption arises in "system B", presented in Table 3.28. It is likely that the ionization conditions are lower than in system A. Also detected is the Mg I transition and several Fe II transitions. The overall system (A+B) was fit with 12 VP components (six each) over a total of five subfeatures. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the EW$_{\rm r}$ limits given in Tables 3.27 and 3.28.

$z = 0.934283$ — This "weak" Mg II system was discovered in the HIRES spectrum. Only the Mg II doublet was detected to the EW$_{\rm r}$ limits quoted in Table 3.29. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. It is unlikely that this system is associated with the $z = 0.9276$ system(s), given that the velocity separation is 2000 km s^{-1}.

For the "double system", the low ionization gas kinematics and the large absorption strengths of the higher ions are suggestive of an active system, or multiple systems with different gaseous phases. A great deal can be learned by comparing the relative line of sight kinematics, spatial separations, individual morphologies, and stellar content of the matter traced by stars, i.e. galaxies. Such detail requires the high spatial resolution imaging provided by WFPC2/HST, both for obtaining morphologies of galaxies and for identifying faint dwarf galaxies in the environment. Three galaxies have been identified in the ground–based image of Kirhakos et al. (1992) at 5.6″, 8.6″, and 9.0″ from the quasar. Additionally, Thimms (1995) has measured [O II] emission using Fabry–Perot imaging at a redshift of 0.93 (crude), corresponding to the 8.6″ galaxy.

3.3.12 Q1213 − 003

Spectra of this QSO were previously studied by LTW and SS92. The two very strong systems studies in this work were both discovered by LTW. They both exhibit remarkable absorption profiles. In fact, these systems were selected with a bias toward large equivalent widths and high redshifts.

z = 1.320059 — This system exhibits a large double saturated trough like that seen along the line of sight to SN 1993J, which is embedded in the disk of M81. Its line of sight samples half of the halo and disk of M81 and half of the halo and disk of the Galaxy (Bowen, Blades, & Pettini 1995). It is tempting to speculate that this absorption system may be passing through two different galaxies that are separated by about 200 km s^{-1} along the line of sight. Once again, the low ionization profile exhibit symmetric velocity splittings with $v \sim 30$ km s^{-1} separations. A total of 24 VP components were fit to the system. Even though this is a large number of components, it should be noted that the number is probably an underestimate because strong blending is occuring (see Chapter 4). This is also illustrated in Figure 3.6— if the linear relation between the system $\mathrm{EW_r}$ and $N_{\rm cl}$ holds for all systems. Note that the VP column densities and b parameters are not well constrained for components 7, and 14–17. The inverted $N_a(v)$ profiles for the Mg II doublet and the richly structured Mg I transition are illustrated in Figure 3.13. The Mn II $\lambda2594$ transition and the Ca II $\lambda\lambda3934, 3969$ doublet were not covered by the HIRES format.

$z = 1.554148$ — As noted by SS92: "It is surprising that two such strong low–ionization, apparently unrelated absorption systems should be found in the QSO spectrum[.]" This system is quite similar to the $z_{\rm abs} = 1.3201$ system, except that the double–like saturated trough is not as prominent. On the other hand, this system shows the asymmetric profiles in the low ionization species characteristic of the damped Ly α systems thought to be thick disks sampled at high inclination (Prochaska & Wolfe 1996; Prochaska & Wolfe 1997). Though the full complement of Fe II transitions are very strong, the Mn II triplet shows no absorption to a 5σ $\mathrm{EW_r}$ limit of 0.085 Å over the full velocity range of the Mg II profiles. However, at roughly $v = 10$ km s^{-1} there is what may be a very weak feature in the Mn II $\lambda2577$. As such, this system may not be a damped (Lu et al. 1996b). The overall profile was fit with a total of 17 VP components. The only component for which the column density and Doppler b parameter are highly uncertain is number 13, which is centered in the saturated trough. The Mn II $\lambda2576$ transition and the Ca II $\lambda\lambda3934, 3969$ doublet were not covered by the HIRES format.

3.3.13 Q1222 + 228

Spectra of this QSO, also known as TON 1530, were previously studied by YSB, SBS, and SS92. Several strong C IV systems at $z_{\rm abs}$ = 1.4867, 1.5239, 1.9372, 1.9805, and 2.0555 were reported by YSB and SBS. These systems have been observed in the HIRES spectrum and will be reported elsewhere (Churchill et al. 1997). SS92 tentatively reported the possible discovery of Mg II doublets at $z_{\rm abs}$ = 1.4867 and 1.5239 associated with the C IV reported by YSB and SBS. The HIRES spectrum does not cover the expected wavelengths of these Mg II transitions. However, a search was made for associated Fe II transitions for both redshifts. The expected wavelengths of the $\lambda2587$ and 2600 transitions were not covered by the HIRES format, but the expected regions of the $\lambda2383$ transition were. No Fe II $\lambda 2383$ was detected for either redshift to a 5σ EW$_r$ of ~ 0.01 Å. Only the $z_{abs} = 0.6681$ Mg II system is included in this work.

$z = 0.668052$ — This system was tentatively reported by YSB, and later confirmed by SBS. The profile is characterized by a central strong absorption and what classifies as a "high velocity" cloud at $v \sim 230$ km s^{-1}. Velocities less than -100 km s^{-1} were not observed for the Mg II $\lambda 2796$ transitions, but were for the $\lambda 2803$ transition. There is no detectable absorption at those velocities. A total of five VP components were fit to the central absorption profile and a single component was fit to the high velocity subsystem. The Fe II $\lambda 2374$ transition and the Mn II triplet showed no absorption to the EW$_r$ limits given in Table 3.32. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format.

3.3.14 Q1225 + 317

Spectra of this QSO were previously studied by SYBT, YSB, Pettini, Sargent, & Boksenberg (1981, unpublished), York et al. (1984), Bechtold, Green, & York (1987), Caulet (1989), and SS92. The last authors provide a nice description of the history of study of this QSO spectrum. A single system is studied for this work. As with the Q1213 − 003 systems, this system was selected for its large equivalent width, reported multiple Fe II transitions, and high redshift. As such it is not an unbiased member of the sample.

$z = 1.794833$ — This system is very similar to the $z_{abs} = 1.3201$ absorber in the Q1213 − 003 spectrum. It also exhibits a large double saturated trough like that seen along the line of sight to SN 1993J (Bowen, Blades, & Pettini 1995). However, based upon the a study of the relative profile shapes of both high and low ionization species, Bechtold, Green, & York conclude that the data "favor the interpretation that the system is a single large galaxy halo, rather than the superposition of absorption arising in overlapping halos of galaxies in a cluster". A total of 18 VP components were fit to the system. Even though this is a large number of components, it should be noted that the number is probably an underestimate because strong blending is occuring (see Chapter 4). This is also illustrated in Figure 3.6— provided the linear relation between the system EW$_r$ and N_{cl} holds for all systems. The Fe II $\lambda 2587$ and the Mn II $\lambda 2594$ transitions, and the Ca II $\lambda\lambda 3934, 3969$ doublet were not covered by the HIRES format. The two other Mn II transitions showed no absorption to the EW$_r$ limits given in Table 3.33. Though the strong broad absorption system is suggestive of a damped Ly α system, this system may not be a damped (Lu et al. 1996b).

The Mg II $\lambda 2803$ transition was cut off by the CCD edge at $v = 300$ km s^{-1}. Because the signal to noise in this region is somewhat reduced and because of the large spread in the absorption system, accurate continuum normalization for $v \geq +100$ km s^{-1} was difficult. As can be seen by the VP model spectra, the continuum placement appears to have been too low by several percent. The reduction of this system was further plagued by a several pixel shift in the cross disperser position between frames. There was no arc image for the shifted images, and thus combining the frames in order to improve the spectral signal to noise was problematic. There may be some systematic errors in the resulting analysis.

3.3.15 Q1241 + 174

The only spectrum from which a weak Mg II system at $z_{\rm abs} = 0.5507$ was reported, was presented by SS92. The system is verified in the HIRES spectrum, including the detection of Fe II and Ca II.

$z = 0.550482$ — This system exhibits an asymmetric rotating disk–like profile with a high velocity subsystem at $v = 145$ km s^{-1}. Weak neutral Mg I and the low ionization Ca II λ 3639 transition are present and are aligned in velocity with the central optically thick portion of the Mg II profile. Fe II is not detected in the high velocity subsystem. A total of four VP components was fit to the system. The Fe II λ 2344, 2374, and 2383 transitions and the Ca II λ 3934 transition (partially) were not covered by the HIRES format. The Mn II triplet showed no absorption to the EW$_{\rm r}$ limits given in Table 3.34.

3.3.16 Q1248 + 401

The only spectrum from which a weak Mg II system at $z_{\rm abs} = 0.7728$ was reported, was presented by SS92. The HIRES spectrum also revealed a previously unreported system at $z_{\rm abs} = 0.8546$.

$z = 0.772953$ — The Mg II profiles exhibit the classic "double horn" shape that Lanzetta & Bowen (1992) derived for a simple infall kinematic halo model. The velocity separation of the two main absorbing regions is ~ 50 km s^{-1}. The blue "horn" is comprised of three VP components, which give rise to an asymmetry in the overall profile. This central profile is quite similar to the Q1101−264 system at $z_{\rm abs} = 0.3590$. At $v = +225$ km s^{-1}, there is an outlying high velocity optically thin subsystem. This outlier exhibits a small redward asymmetry; it is not a pure Voigt profile, though the VP LSF did not yield multiple VP components. The region of the spectrum where Mg II has been observed is of excellent quality, so that the VP fitting of even these small subsystems should be fairly accurate. Several Fe II transitions (λ2344, 2374, 2383, 2587, and 2600) have been detected. The high velocity subsystem is detected in the λ2600 transition, but is not detected to 5σ in the other Fe II transitions (even the stronger, yet noisier, λ2383 transition). A clear detection of Mg I is also present in the high velocity system. Normally, these optically thin high velocity systems are not seen to exhibit neutral absorption. It could be that this "cloud" is in a well shielded environment. The Ca II $\lambda\lambda$3934, 3969 doublet was not covered by the HIRES format and the Mg I transition was only partially observed toward negative velocities. The Mn II triplet showed no absorption to the EW$_{\rm r}$ limits given in Table 3.35.

$z = 0.854562$ — This system is characterized by a central asymmetric absorbing subfeature that is fit with two VP components. There are three absorbing subsystems, the others being optically thin and having high velocities. There is broad shallow absorption that stretches approximately 100 km s^{-1} from the main absorbing subsystem. There is also a set of two distinct high velocity, $v > 200$ km s^{-1}, "clouds". Interestingly, there is Fe II detected only in the main absorbing subsystem. A total of eight VP components were fit to the system. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet and the Mg I transition showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.36.

3.3.17 Q1254 + 044

Again, the only spectrum from which weak Mg II systems at $z_{\rm abs} = 0.5193$ and 0.9341 were reported, was presented by SS92.

$z = 0.519389$ — The spectrum in the range of the Mg II doublet is somewhat confused by unidentified weak absorption lines. Only absorption features that were common in velocity to both the $\lambda 2796$ and 2803 transitions were included in the VP decomposition. This system likely exhibits low ionization conditions in the main subsystem, given that it has strong absorption in Mg I and in Ca II. This main feature has been fit with three VP components and shows a typical rotating disk shape as can especially can be seen in the Mg I transitions. There are three high velocity optically thin single VP component subsystems at negative velocities. The total system velocity spread is upward of 400 km s^{-1}, which is difficult to understand in terms of a relaxed system of gas in a galaxy potential. The Fe II $\lambda 2344$, 2374, and 2383 transitions were not covered by the HIRES format. The Mn II triplet showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.37. It might be worth obtaining a higher signal to noise spectrum of this system because of the confusion and because there may be undetected weak subsystems present.

$z = 0.934232$ — The Mg II profiles exhibit the classic "double horn" shape that Lanzetta & Bowen (1992) derived for a simple infall kinematic halo model. The velocity separation of the two main absorbing regions is ~ 40 km s^{-1}. A total of two VP components, one modeling each of the "horns", were fit to the profiles. The Fe II is prominent only in one of the components. Mg I is also present in this particular component, but is not detected in the other. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.38.

3.3.18 Q1317 + 274

A very high signal to noise spectrum of this QSO has been studied by SS92. They report two Mg II system, at $z_{\rm abs} = 0.2887$ and 0.6596. The observed wavelengths of the former were not covered by the HIRES format. Based upon FOS/HST spectra, the latter absorber was reported to have Lyman limit absorption with $\log N(\mathrm{H\,I}) = 17.76$ cm^{-2} (Bahcall et al. 1993).

$z = 0.660051$ — SS92 reported weak, but definite, Mg II and Fe II. The HIRES spectrum has revealed that this system is spread over ~ 150 km s^{-1} with a main subsystem that has a full width of ~ 50 km s^{-1} and an asymmetric profile. Three subsystems were found and a total of eight VP components were fit. The higher velocity subsystems are optically thin and are suggestive of "cloud" blends or differential streaming motion along the line of sight. Fe II has been detected in the main and next strongest subsystems only. These subsystems have each been fit with three VP components. The Mg I transition has been detected aligned with the highest $N_a(v)$ portion of the main subsystem only. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.39.

3.3.19 Q1329 + 412

Spectra of this QSO have been studied by SBS and SS92. The line of sight has six reported absorption systems, including C IV. The SS92 spectrum is redward of the wavelength range covering the $z_{\mathrm{abs}} = 0.5009$ Mg II system reported by SBS. The HIRES spectrum has low signal to noise (in fact, the observed systems from it were not included in Sample B). Still, two new low redshift systems at $z_{\mathrm{abs}} = 0.8933$ and 0.9984, that have not been reported elsewhere, have been found. These systems are in the Mg II redshift path not covered by the SBS spectrum (0.339 – 0.761), nor by the SS92 spectrum (1.125 – 1.875). A systematic search of the Mg II redshift path covered by the HIRES spectrum has not yet been done.

$z = 0.500785$ — This systems was reported as a "probable" Mg II doublet detection by SBS. Because of the low signal to noise of the HIRES spectrum, only the Mg II doublet was detected to the 5σ significance level. However, there is a very weak suggestion of absorption from the Mn II $\lambda2577$ transition. The overall profile was fit with four VP components. Though signal to noise is known to be a factor in determining the number of VP components, the overall shape of the profile in the HIRES spectrum is not suggestive of hidden components. If there are higher velocity subsystems with $\mathrm{EW_r} < 0.04$ Å, they remain undetected (there is a hint of a subsystem at $v \sim -180$ km s^{-1}). The Fe II $\lambda2344$, 2374, and 2383 transitions and the Ca II $\lambda\lambda3934, 3969$ doublet were not covered by the HIRES format. The Mg I transition, and all other Mn II and Fe II transitions showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.40.

$z = 0.893337$ — There are no previous reports of a Mg II system at this redshift. The $\lambda2796$ $\mathrm{EW_r}$ (0.39 Å) is above the detection thresholds of both the SBS and SS92 survey, so it is likely that had this wavelength range been observed, these authors would have discovered this system. It is found to have two subsystems separated by ~ 100 km s^{-1}. One has been fit with two VP components and the other has been fit with a single VP component. However, there may be one or more additional components in the asymmetric blue wings of both. If so, both subsystems would exhibit similar asymmetries that are characteristic of organized motion with a density gradient along the line of sight. There are what appear to be two spurious absorption features between these subsystems at $v = 20$ and 80 km s^{-1} in the $\lambda2796$ profile that are not present in the $\lambda2803$ profile. They have not been included in the computation of the $\mathrm{EW_r}$ nor other measured absorption quantities. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet and all but the Fe II $\lambda2383$ and 2600 transitions showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.41.

$z = 0.998358$ — There are no previous reports of a Mg II system at this redshift. As stated above, SBS and SS92 likely would have discovered the system had their spectra covered the appropriate wavelength range. This system was fit by a single VP component and showed absorption in the Fe II $\lambda2344$, 2383, and 2600 transitions. Though there is no suggestion of a red wing asymmetry in the $\lambda2796$ transition, the Fe II and $\lambda2803$ transitions appear to have a common redward asymmetry. That the ratio of the Doppler b parameters is unphysical may be indicative of an unresolved VP component. However, it is not uncommon to obtain unphysical ratios even for unblended lines with a similar signal to noise ratio (see Chapter 4). The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet and the remaining Fe II transitions showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.42.

3.3.20 Q1354 + 193

Optical spectra of this QSO have been studied by Weymann et al. (1979) and by SS92. Weymann et al. first reported a Mg II system at $z_{\rm abs} = 0.457$, which was confirmed at $z_{\rm abs} = 0.4564$ by SS92. A Lyman limit system roughly at this redshift with $\log N(\mathrm{H\,I}) = 17.17$ cm^{-2} was reported by Bahcall et al. (1993). The HIRES spectrum of this system has a relatively low signal to noise ratio, $S/N \sim 20$ per resolution element. This field has been studied in some detail and several galaxies in a cluster have been found by C. Steidel (private communication) and by K. Lanzetta (private communication) in this redshift range. However, there appears to be only a "single" Mg II system to a 5σ limit of $\mathrm{EW_r} \sim 0.03$ Å in the HIRES spectrum (there are no breaks in the redshift coverage until $z = 0.82$). It could be that the reported system is arising in multiple galaxy halos, though the profiles are not suggestive of kinematic complexity. High resolution spectra of high ionization transitions may be instrumental in a deeper appreciation of this line of sight.

$z = 0.456588$ — This system is seen to have two subsystems separated by $v \sim 80$ km s^{-1}. The main subsystem is broad and exhibits hidden components, based upon the discrepancy of the $N_a(v)$ profiles from the Mg II doublet. This is likely due to the low signal to noise, though it is interesting that the Fe II components are quite narrow, which may suggest that the system is comprised of many quiescent clouds. A total of seven VP components were fit, where the constraint on the cloud velocities was primarily the $\lambda2803$ transition profile. The higher velocity subsystem has been fit with a single VP component. Mg I has been detected aligned with the strongest Mg II component. The Fe II $\lambda2600$ transition was detected, but the spectrum is very noisy. The Fe II $\lambda2344$, 2374, 2383, and 2587 transitions, the Mn II $\lambda2587$ transition, and the Ca II $\lambda\lambda3934, 3969$ doublet were not covered by the HIRES format. The other Mn II transitions show no absorption to the $\mathrm{EW_r}$ limits given in Table 3.43.

3.3.21 Q1421 + 331

This QSO has been the subject of several studies (Weymann et al. 1979; Uomoto 1984; Foltz et al. 1986; Caulet 1989; SS92), which are described in SS92. The HIRES spectrum confirms complex C IV systems at $z_{\rm abs} = 1.584$, 1.717, (Caulet 1989) and 1.759 (Foltz et al. 1986). They will be published elsewhere (Churchill et al. 1997). A previously unreported Mg II doublet at $z = 0.8431$ was discovered in the HIRES spectrum. Though the $z_{\rm abs} = 0.4564$ absorber was clearly detected in the HIRES spectrum, it was badly affected by poor signal to noise at the detector edge. It has not been included in this work.

$z = 0.843247$ — There is no previous report of this system in the literature. However, Uomoto (1984) reported an unidentified "moderate, broad" line and an unidentified "weak" line in his spectrum. These two lines correspond to Fe II $\lambda2600$ and $\lambda2374$ at this redshift, respectively. The system was fit with a single VP component. Absorption was seen in all observed Fe II transitions and also in the Mg I transition. The Mg II/Fe II ratio of both the apparent column densities and the VP column densities is less than unity, which is not common. This may be indicative of an enhancement of iron group (SN I origins) relative to α group (SN II origins) elements. Alternatively, the observed ratio $\log N$(Mg II/Fe II) $= -0.35$, and the ratio $\log N$(Mg II/Mg I) $= 1.52$, are somewhat consistent with collisionally ionized gas with $T \sim 3 \times 10^4$ K, assuming solar abundances (cf. Tytler et al. 1987). Thus, it is possible that the absorption arises in an H II region not unlike those found in the Galaxy. Depletion in H I photoionized gas, on the other hand, tends to *increase* the Mg II/Fe II column density ratio, which is 1.2 for solar abundances in the case of no depletion (cf. Tytler et al. 1987). High resolution spectra of highly ionized species, especially C IV, N V, and O VI, and of the neutral hydrogen column density, could be very instrumental for obtaining a better appreciation of this absorption system. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\rm EW_r$ limits given in Table 3.44.

$z = 0.902871$ — This system was first reported by Uomoto (1984). The full profile was fit with a total of ten VP components. Fe II was present in each, whereas VP components of Mg I were found only in components six and seven. There are two subsystems based upon the EWREGION algorithm, though the profile is more suggestive of three. In the strongest subsystem, the Fe II transitions reveal a "disk–like" profile, or the characteristic of organized motion with a density gradient along the line of sight. Mg I absorption is seen only in this subsystem, and it also exhibits a blueward asymmetry. The Mn II $\lambda2594$ transition, tentatively reported by Uomoto (1984), is not seen in the HIRES spectrum, nor is a nearby unidentified absorption feature seen. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\rm EW_r$ limits given in Table 3.45.

$z = 1.172609$ — This system was also first reported by Uomoto (1984). The full profile was fit with a total of seven VP components over a single system (no subsystems). The profile is quite symmetric, though exhibits three strong centers of higher column density gas. Mg I has been detected in these three regions. The Ca II $\lambda\lambda3934, 3969$ doublet and the Mn II $\lambda2594$ transition were not covered by the HIRES format. The Mn II triplet showed no absorption to the $\rm EW_r$ limits given in Table 3.46.

3.3.22 Q$1548+093$

A spectrum of this QSO has been studied by SBS. They reported a weak, but unambiguous, Mg II absorbing system at $z_{\rm abs} = 0.7708$, which has been observed in the HIRES spectrum. This spectrum also has three C IV absorbers at $z > 2$, which will be presented elsewhere (Churchill et al. 1997). The HIRES spectrum also covers the Ly α forest below 4600 Å. Unfortunately, the signal to noise in the HIRES spectrum is quite low, ~ 9, at the Mg II $\lambda 2796$ transition. Thus, this system has not been included in Sample B of this study.

$z = 0.770300$ — The HIRES spectrum is noisy and the detected absorption profiles suffer from unresolved saturation. The full width of the Mg II profile is ~ 40 km s^{-1}. A single VP component has been fit to the observed profiles. However, the residuals are systematically positive for $v < 0$ km s^{-1}, which may indicate a redward asymmetry (a hidden VP component). If there are subsystems with $\rm EW_r \leq 0.05$ Å, they cannot be detected. However, there is a suggestion of narrow depressions in both doublet transitions at $v \sim 80$ km s^{-1} and at $-90 \leq v \leq -60$ km s^{-1}, but neither of these can be distinguished from noise. The Mg I transition and the Fe II $\lambda 2600$ transition have been detected. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet and all other Fe II transitions showed no absorption to the $\rm EW_r$ limits given in Table 3.47. These $\rm EW_r$ limits are not very stringent.

3.3.23 Q$1622+235$

This QSO field has been exhaustively studied by Steidel et al. (1997), who built upon the work of Steidel & Dickinson (1992) and SS92. Steidel et al. reported six definite absorbing systems (with associated galaxies) at $z_{\rm abs} = 0.3181$, 0.3675, 0.4721, 0.6563, 0.7973, and 0.8912, and three potential absorbing galaxies at $z_{\rm abs} = 0.5652$, 0.6352, and 0.7016. The HIRES spectrum of this QSO ranges in signal to noise from 2–20 per resolution element. Thus, the absorption profiles are not without their ambiguity. Four of the six definite systems have been detected in the HIRES spectrum, $z_{\rm abs} = 0.4721$, 0.6563, 0.7973, and 0.8912. The spectrum was searched for the potential absorbers (upon request of C. Steidel), and only the 0.7016 system turned up a tentative detection using a 5σ $\rm EW_r$ limit (see Steidel et al. for details). The $z_{\rm abs} = 0.4721$ Mg II profiles, though clearly detected because they are broad and fully saturated, are not included in this work because of the very low signal to noise. Three systems are included in this work. The VP decomposition of only the 0.7973 system is robust.

$z = 0.656114$ — This system is a damped Ly α system (Steidel et al.). The Mg II profiles have full widths ~ 150 km s^{-1} and are fully saturated with some component structure in both wings. Fe II $\lambda 2587$ is blended with Fe II $\lambda 2383$ at $z_{\rm abs} = 0.7971$. It is likely that the Fe II from the 0.7971 system is negligible, given the null detection of all other observed Fe II transitions in that system. The Fe II $\lambda 2587$ transition may exhibit a double "horn" shape, but the signal to noise is poor and the elevated flux in the profile may be nothing but noise fluctuations. The VP profile fits are shown with the spectrum (three VP components were fit), but they are not to be believed.

Damped systems usually exhibit Mn II absorption (Lu et al. 1996b), but none is seen to 5σ $\mathrm{EW_r} = 0.18$ Å, though higher signal to noise may reveal absorption, especially in the $\lambda2594$ transition. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.48. It is interesting to note that SS92 and Steidel & Dickinson (1992) both reported an unphysical Mg II doublet ratio and suggested the presence of a second Mg II absorber at $\sim +800$ km s^{-1} from which the $\lambda2796$ is blended with the measured $\lambda2803$ transition. In the HIRES spectrum the doublet ratio of this system was measured to be 1.10 ± 0.03

$z = 0.797107$ — This system, at first, was an unidentified transition in the HIRES spectrum. C. Steidel (private communication) suggested a search for the Mg II doublet at this redshift based upon a C IV detection in his FOS/HST spectrum. The unidentified transition was then seen to be the $\lambda2803$ line of the doublet, the $\lambda2796$ line having been lost due to the ink mark on the HIRES Tektronics CCD. The profile is comprised of three subsystems evenly split by ~ 75 km s^{-1} to which a total of four VP components were fit. The total velocity spread is ~ 140 km s^{-1}. The Mn II $\lambda2576$ transition and the Ca II $\lambda\lambda3934, 3969$ doublet were not covered by the HIRES format. The Mn II triplet showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.49. Note that Fe II $\lambda2382$ is blended with the Fe II $\lambda2587$ transition at $z_{\mathrm{abs}} = 0.6561$. Given the null detection of all other observed Fe II transitions in the 0.7971 system, it is likely that the Fe II $\lambda2382$ transition is also a null detection.

$z = 0.891253$ — This is a highly saturated system with a full velocity spread of ~ 200 km s^{-1}. The blue wing shows some component structure, and, interestingly, the Mg I absorption is not observed over the same velocity where this structure in the Mg II is seen. The Fe II transitions are saturated as well, but with some structure in the $\lambda2587$ transition. An attempt at VP decomposition was deemed a failure, but the "best" fit is presented with the absorption profiles. The only real constraint for the component velocities was the Mg I profile. Steidel et al. report a possible high gas phase iron abundance in this system and a relatively small H I column density [$17.9 \leq N(\mathrm{H\,I}) \leq 19.4$ cm^{-2}]. They suggest that the absorption in this system may arise in H II regions. Based upon the integrated apparent column densities, N_a, the lower limit for $\log N(\mathrm{Mg\,II})$–$\log N(\mathrm{Mg\,I})$ is 1.67, which implies a lower limit to the collisionally ionized gas temperature of 3×10^4 K (cf. Tytler et al. 1987). This in turn implies a negative $\log N(\mathrm{Mg\,II})$–$\log N(\mathrm{Fe\,II})$. Unfortunately, the measured column densities of both the Mg II and the Fe II ions are poorly determined, and so the supposition that the gas arises in H II regions cannot be addressed with confidence.

3.3.24 Q1634 + 706

The optical spectrum of this very bright QSO has been studied by SS92, who reported two Mg II absorbers at $z_{\mathrm{abs}} = 0.6694$, and 0.9903. It has long since been known that the 0.6694 system was a misidentification, but is mentioned here because it appears that no such report has made its way into the literature. Womble (1995) obtained a very high quality HIRES spectrum in June of 1994, but it remains unpublished. Womble reported five Mg II systems with $\mathrm{EW_r} \geq 0.015$ Å and one system with $\mathrm{EW_r} \geq 0.3$ Å over the redshift range $0.52 \leq z \leq 1.334$. Bahcall et al. (1995) have presented a UV HST spectrum of this QSO. The HIRES spectrum for this work had an 5σ $\mathrm{EW_r}$ limit of ~ 0.01 Å or smaller for most of the redshift coverage, but no systematic search has been conducted with redshift. However, a single obvious system, in addition to the 0.9903 system, is reported at $z_{\mathrm{abs}} = 0.9056$.

$z = 0.905556$ — This system is a single profile that is likely unresolved, having a doublet ratio of 1.41 for $\mathrm{EW_r}(\mathrm{Mg\,II}) = 0.064$ Å. It has not been previously reported in the literature. The Mg I transition and the Ca II $\lambda\lambda 3934, 3969$ doublet were not covered by the HIRES format. The Mn II triplet and all other Fe II transitions showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.51.

$z = 0.990239$ — This system was first reported by SS92. It is a single system (no subsystems) and has been fit by five VP components. The total velocity spread is ~ 80 km s^{-1}. Examination of the Mg II doublet $N_a(v)$ profiles reveals a $\sim 2\sigma$ discrepancy in 4–5 pixels over the velocity interval $0 \leq v \leq 10$ km s^{-1}, indicating that there may be a "hidden" component. The Fe II profiles exhibit the classic "double horn" shape, characteristic of infalling gas. The Ca II $\lambda\lambda 3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the $\mathrm{EW_r}$ limits given in Table 3.52.

3.3.25 Q2128 − 123

Spectra of this low redshift QSO have been studied by Weymann et al. (1979), Tytler et al. (1987), and at higher resolution by Petitjean & Bergeron (1990).

$z = 0.429735$ — This system was first reported by Weymann et al. (1979). The Mg II profiles are found to be a single feature based upon the EWREGION algorithm. However, there is a "double–like" characteristic to the profiles. The system has been fit with a total of four VP components. Mg I and Ca II absorption is found associated with the two strongest Mg II components. Detection of the Ca II $\lambda\lambda 3934, 3969$ confirms the 1σ Ca II $\lambda 3934$ detection reported by Petitjean & Bergeron. An IUE spectrum reveals a Lyman limit cutoff and large Ly α absorption, suggesting $N(\mathrm{H\,I}) \geq 2 \times 10^{19}$ cm^{-2} (Tytler 1982; Bergeron & Knuth 1983). Taken at face value, the strong neutral component (the ionization potential of Ca II is 0.87 Ryd) of the absorption suggests that the H is not mostly ionized. Given the measured Mg II column density ($\log N = 13.47$), a supersolar magnesium abundance is not required to explain the column density ratio $N(\mathrm{Mg\,II})/N(\mathrm{H\,I})$ [see Tytler et al. 1987]. Unfortunately, none of the Fe II transitions in were covered by the HIRES format, so the Fe II lines reported by Tytler et al. and Petitjean & Bergeron were not observed.

3.3.26 Q2145 + 064

Optical spectra of this QSO have been studied by Wills et al. (1980), SSB, Petitjean & Bergeron (1990), and SS92. Measurements of higher ionization species and of Ly α absorption from a FOS/HST UV spectrum have been reported by Bergeron et al. (1994).

$z = 0.790777$ — This system was first reported by Wills et al., and was later verified by SSB. Petitjean & Bergeron observed the Mg II at a resolution of 0.55 Å (three times that of SSB) and found the profiles were a blend of at least three components. In the HIRES spectrum, each of these three components have been resolved and two of them are clearly seen to be blends. Thus, the profile has been divided into three subsystems, which were fit by one, three, and two VP components, respectively. These subsystems are each separated by ~ 90 km s^{-1}. It is possible that they do not arise under the same chemical or ionization conditions (cf. Bergeron et al. 1994). The Fe II $\lambda2587$ transition was not included in the analysis because it was positioned near the pen mark on the HIRES Tektronics CCD. The Ca II $\lambda\lambda3934, 3969$ doublet was not covered by the HIRES format. The Mn II triplet showed no absorption to the EW$_{\rm r}$ limits given in Table 3.54.

3.4 Exploring the Absorption Properties

Trends of gas absorption properties with other system properties (i.e. cloud velocities, internal velocity spreads of the blended "cloud" components, or system redshifts) provide new clues to the physical nature of the absorbing gas. Monotonic "correlations" between properties determined solely from high resolution spectra may reveal fundamentally new information about the absorbing gas. On the other hand, correlations of properties that are roughly independent of the spectral resolution with properties determined from high resolution spectra may provide long sought insights into or confirmations of inferences based upon larger low resolution surveys.

There is a great deal of scatter in the absorption properties. Furthermore, the probability distribution functions from which the properties can be thought to have been drawn are unknown. Thus, when searching for possible relationships between various quantities, it is best to perform simple non–parametric tests for trends. Then, statistically significant trends can be further investigated for possibly having been drawn from an assumed and well defined probability distribution function, which can be parameterized (i.e a linear relationship).

3.4.1 Spearman and Kendall Non–Parametric Tests

The Spearman rank order coefficient, $r_{\rm s}$, and the Kendall Tau, $\tau_{\rm k}$, are both quantities computed from the ranks or relative ranks of data pairs. The probability distribution functions from which these ranks are drawn are well understood, so that the significance level to which the hypothesis of no correlation (null hypothesis) is satisfied can be computed. These two statistical tests are described in (Press et al. 1986).

For the Spearman test, each data point, x_i, is replaced by the value of its rank among all other x_i's in the sample. The same is done for the y_i. The resulting list of ranks is thus drawn uniformly from the integers between 1 and N, where N is the number of data points. The significance level, $P_{\rm s}$, is computed from the number of standard deviations,

N_σ, by which the sum–squared difference of x and y ranks deviate from the computed null hypothesis value. The sum–squared difference of ranks is approximately normally distributed. Thus, the significance level is the complementary error function evaluated at $N_\sigma/\sqrt{2}$.

The Kendall test actually invokes *relative* ranking of the data. The data are broken into pairs; a pair is "concordant" if the relative ranking of the two x's is the same as the relative ranking of the two y's. A pair is discordant if the relative ranking of the x's is opposite that of the y's. The Kendall Tau is computed from the number of concordant and discordant data pairs. Kendall's Tau has a zero expectation value for the null hypothesis, and its variance is also approximately normally distributed. The confidence level, $P_{\rm k}$, is also given by the complementary error function evaluated at $N_\sigma/\sqrt{2}$, where N_σ is the number of standard deviations by which $\tau_{\rm k}$ deviates from zero.

3.4.2 Overall Absorption Properties

Spearman and Kendall non–parametric rank correlation tests were performed on all Sample B quantities presented in Tables 3.1 and 3.2. In the upper portion of Table 3.4, the tests for correlations of absorbing properties with redshift are presented. In the lower portion of Table 3.4, selected tests for correlations between absorbing properties are tabulated. Also tabulated are tests for correlations of the system redshift, number of subfeatures, and number of VP components with the $\rm EW_r$ of the spectrum. These latter tests are to discern if the non–uniform sensitivity of the spectra is introducing bias into the other tests.

The tests are listed in order of increasing $P_{\rm k}$, that is in order of decreasing likelihood that the null hypothesis is *not* satisfied. If the criterion that the data are inconsistent with the null hypothesis to the 99.9% confidence level is adopted, then "clear" correlations can be claimed only if $P \leq 0.001$. For data that exhibit the level of scatter seen in absorption properties shown in Figures 3.3 through 3.12, such a stringent criterion is required, especially for fewer than 50 data points.

Note that the tests yield $P = (P_{\rm s}, P_{\rm k}) = (0.025, 0.014)$ for the limiting $\rm EW_r$ verses redshift. As illustrated in Figure 3.3, the Sample B limiting equivalent widths do not show a clear trend with redshift apart from a few points that are driving the correlation coefficients to the $N_\sigma \sim 2.4$ level. The same test on a sample for which the less stringent cutoff limit 0.03 Å was applied yielded $P = (0.001, 0.001)$. It is probable that an $\rm EW_r$ cutoff at 0.03 Å would have resulted in biased results with redshift.

In Figure 3.4, the selected absorption properties are plotted against absorber redshift. Plotted are rest–frame equivalent width, $\rm EW_r$, the median deviation of VP cloud velocities, $A(\Delta v)$, the absolute value of the shape parameter, $|\eta_v/\omega_v|$, and the number of clouds per system, $N_{\rm cl}$. It is important to remember that the $z > 1$ portion of the diagrams are under sampled with respect to the $z < 1$ portions, and that there is a biasing toward large $\rm EW_r$ at $z > 1.3$. Even so, the correlation tests do not allow a rejection of the null hypothesis to the adopted confidence level. Except for $|\eta_v/\omega_v|$, the same tests on the full sample, Sample A, yielded probabilities more suggestive of correlations, but none yield $P < 0.01$. The lowest probability is for $A(\Delta v)$, which is accentuated by the weakest systems ($N_{\rm cl} = 1, A(\Delta v) = 0$) at $z < 1$. The interesting data are the two $z < 1$ systems with $A(\Delta v) \sim 150$ km s^{-1}. These are the Q1206 + 459 at $z_{\rm abs} = 0.9276$ system and the Q1254 + 044 at $z_{\rm abs} = 0.5194$ system, respectively. Both systems exhibit a high velocity kinematic subsystem. That two out of 27 systems are seen with these characteristics crudely implies that less than 10% of all $z < 1$ systems will be observed to have these very high velocity kinematic subsystems to a limiting $\rm EW_r$ of 0.02 Å.

In Figure 3.5, a small selection of overall absorption properties is presented. These quantities are taken from Table 3.4 to illustrate a range of correlation significance levels. It was important to verify that the number of VP components, $N_{\rm cl}$, shows no correlation with the equivalent width limit of the spectra. Indeed, this was verified to a high degree as can be seen in the last entry of Table 3.4 and in the lower left panel of Figure 3.5. Had a correlation been found, it would place serious doubts on the results of the VP decompositions. It is also found that the number of subfeatures, or subsystems, is not correlated to the equivalent width limit of the spectra. With little doubt, it can be claimed that any conclusions based upon the subsystems or the number of clouds are not weakened non–uniformity in the signal to noise.

The highest confidence levels (lowest values of the probabilities) that the null hypothesis can be ruled out, are seen for the $N_{\rm cl}$ verses $\rm EW_r$ test and for the $A(\Delta v)$ verses $N_{\rm cl}$ test. Not surprisingly, $A(\Delta v)$ is correlated with $\rm EW_r$ to the required confidence level. Note also, that the Mg II doublet ratio is anti–correlated with $\rm EW_r$ (this is confirmation that the correlation tests are fairly useful, since this particular test had better come up with a non–null result). Illustrated in Figure 3.6 is a correlation of the number of clouds with $\rm EW_r$. This correlation was first recognized by Wolfe (1986) and by York et al. (1986), and later demonstrated by Petitjean & Bergeron (1990) and Churchill, Steidel, & Vogt (1996). Following those authors, a linear relation has been fit to the data, excluding the cross hatched points. These points are Q0450 − 132 at $z_{\rm abs} = 1.1746$, Q1213 − 003 at $z_{\rm abs} = 1.5541$, Q1225 + 317 at $z_{\rm abs} = 1.7948$, and Q1213 − 003 at $z_{\rm abs} = 1.3201$, in increasing number of VP components. It is likely that $N_{\rm cl}$ has been underestimated for these systems, possibly by as much as a factor of ~ 1.5 (see Figure 4.13). A correction factor of this magnitude would place these points closer to the fitted line. An effect due to the signal to noise in the spectra can be seen, as well. Note the open circles, which have $\rm EW_r > 0.02$ Å limits (corresponding to a signal to noise ratio $S/N \sim 22$ per three pixel resolution element). It is likely that the number of VP components has also been underestimated for these systems.

In Figure 3.6, two linear fits to the Sample B data are shown. The dash–dot line is a maximum likelihood fit with slope $m = 0.076 \pm 0.004$ and the dotted line is a χ^2 minimizing fit with slope $m = 0.093 \pm 0.007$, where the reduced $\chi^2 = 0.9$. Errors in both $\rm EW_r$ and $N_{\rm cl}$ were included in the χ^2 fit, which likely explains the large slope in view of the assumed $\sqrt{N}$ uncertainties in the cloud numbers (which is not very appropriate because the uncertainties in the $N_{\rm cl}$ are not normally distributed— the $N_{\rm cl}$ are systematically underestimated due to component blending). Thus, the maximum likelihood slope is probably a more realistic result. In addition, this value is comparable to the value 0.070 found by Churchill, Steidel, & Vogt (1996). This slope is significantly smaller than the value ~ 0.35 obtained from the Petitjean & Bergeron (1990) fit to 30 km s^{-1} resolution spectra.

It is useful to ask if the internal velocity spread can be inferred from the value of $\mathrm{EW_r}$, which can be measured in low resolution spectra. A maximum likelihood linear fit was obtained to the $A(\Delta v)$ verses $N_{\rm cl}$ data, for which a slope of 6.72 ± 0.76 was obtained. However, as can be seen in Figure 3.4, the data exhibit increased scatter for $A(\Delta v) \geq 40$ and $N_{\rm cl} \geq 10$. The systems with $N_{\rm cl}$ greater than 15 are dominated by the broad saturated systems. For these, $N_{\rm cl}$ is likely a *lower* limit, based upon the VP fitting simulations (see Chapter 4). A system for which $N_{\rm cl}$ is underestimated would properly occupy a position down and to the left of where it has been plotted; this tends to *increase* the scatter with respect to the "correlation line". It is clear that $A(\Delta v)$ is sensitive to somewhat extreme kinematics that cannot be discerned simply from the number of VP components. Since the $\mathrm{EW_r}$ is correlated with $N_{\rm cl}$, it follows that the average kinematic spread cannot be inferred from $\mathrm{EW_r}$ with confidence. Primarily, this is due to saturation/blending on one extreme and due to the chance presence of high velocity subsystems that do not contribute much to the value of $\mathrm{EW_r}$ on the other.

In Figure 3.7, the histogram distributions of $N_{\rm cl}$, $\mathrm{EW_r}$, ω_v, and $|\eta_v/\omega_v|$ are presented. The shaded distributions are the Sample B systems, and the unshaded distributions are the full sample presented in Table 3.1. What is apparent is that the Sample B distributions are fairly flat and that the low signal to noise systems cluster at smaller $N_{\rm cl}$, $\mathrm{EW_r}$, ω_v, and $|\eta_v/\omega_v|$. In the case of $\mathrm{EW_r}$, these systems are clustered at low redshift, and this may be an artifact of the redshift–$\mathrm{EW_r}$ distribution. For the other absorption properties, it appears that some information from the absorption profiles is truly "missed" for the limit $\mathrm{EW_r} > 0.02$ Å. In these systems there may be lurking undetected undulations in the profile shapes (i.e. asymmetries, VP components) and/or kinematic subsystems (also see Figure 3.12, from which one can infer that there are roughly as many subsystems in the range $0.01 \leq \mathrm{EW_r} \leq 0.02$ Å as there are in the range $0.02 \leq \mathrm{EW_r} \leq 0.03$ Å).

3.4.3 Subfeature Absorption Properties

Just exactly what are the absorbing subfeatures, or kinematic subsystems, as they have been defined for this work? Is it meaningful to segregate the overall profiles into distinct absorption subsystems simply based on there being a stretch of continuum between two absorption profiles within a predefined velocity range that are detectable down to some predefined sensitivity level? Can the notion of subsystems be taken a step further— can they be treated as a population of absorption systems in their own right from which a deeper appreciation of the overall systems can be gleaned? If this line of questioning is affirmed, then it may be that these subsystems will provide insights into the ionization conditions, spatial distributions and kinematics of different sub–populations of absorbing clouds (i.e perhaps optically thin clouds can be inferred to be located in galactic halos, etc). In particular, trends of subsystem absorption properties with their velocities, or with the galaxy properties [when these become available for a larger sample than that studied by Churchill, Vogt, & Steidel (1996)], may provide clues for answering the above questions. Perhaps these subsystems may actually be isolated absorbing "clouds" or spatially separated absorbing regions within galaxies.

Recall that the velocity zero point for all systems is the optical depth mean of the Mg II $\lambda 2796$ profile. Thus, the subsystems at small velocities will tend to have the largest optical depths and will systematically have larger $\mathrm{EW_r}$, smaller DR, and greater ω_v. These can be understood entirely in terms of the definition of the velocity zero point. However, it is not clear how these absorption properties will be distributed , nor how they will be distributed in velocity space.

In Figure 3.8, the subfeature DR, $\mathrm{EW_r}$, ω_v, and $|\eta_v/\omega_v|$ are presented verses velocity in a scatter plot. These properties are listed in Table 3.3. Spearman and Kendall non–parametric rank correlation tests were performed for all Sample B subfeature quantities. In the upper portion of Table 3.4, the tests for correlations of absorbing properties with velocity are presented. At first glance it looks as if all tested properties, except the shape parameter, show significant trends with increasing velocity. However, there is an over representation of subsystems with $v = 0$ km s^{-1}. In fact, for every absorption system, there is a subsystem with $v = 0$ km s^{-1} because of the velocity zero point definition. The non–null result for the correlation tests occur because these subsystems cluster, as predicted.

The histogram distributions of selected subfeature absorption properties are presented in Figure 3.9. The upper left panel shows the doublet ratios, the lower left shows the equivalent widths, the upper right shows the subfeature shape parameters, and the lower right shows the subfeature velocity widths. It is interesting to compare these distributions with those of the full features in Figure 3.7. What is most striking is how peaked the the equivalent widths and the velocity widths are at small values for the subsystems.

In Figure 3.10, the histogram distribution of the number of subsystems in each 20 km s^{-1} velocity bin is given. As mentioned, for each full system there is one subsystem in the smallest velocity bin. However, out of 33 systems, there are 39 subsystems with velocities greater than 20 km s^{-1}. Higher velocity subsystems are quite common, and in fact, on average there is likely to be one or more per system with $\mathrm{EW_r} < 0.2$ Å. Apart from four systems, the maximum width of these subsystems is ~ 45 km s^{-1}. These four systems, Q0450 − 132 at $z_{\mathrm{abs}} = 1.1746$, Q0823 − 223 at $z_{\mathrm{abs}} = 0.91102$, Q1213 − 003 at $z_{\mathrm{abs}} = 1.5541$, and Q1225 + 317 at $z_{\mathrm{abs}} = 1.7948$, are either at high redshift and or exhibit extreme kinematic conditions. These four systems may be "double systems". Either they are associated with two galaxies with line of sight velocity differences ~ 200 km s^{-1}, as suggested by the M81–Galaxy profile from SN 1993J (Bowen, Blades, & Pettini 1995), or they are suggestive of a scenario proposed by Heahnelt, Steinmetz, & Rauch (1996), in which the absorbing gas may be part of an extended "filamentary" structure that is being probed along the principal axis in the region of a small group of galaxies. Given the known $\mathrm{EW_r}$ evolution of Mg II absorption systems (Petitjean & Bergeron 1990; Steidel & Sargent 1992), it may be that absorbers that can be characterized by a "central" or "main" subsystem with a velocity width greater then ~ 50 km s^{-1} are the type of systems that are decreasing in numbers by $z \sim 1$.

All subsystems with $v > 40$ km s^{-1} have been culled into a separate sample. The histogram distributions of the subsystem DR, $\mathrm{EW_r}$, ω_v, and $|\eta_v/\omega_v|$, are again illustrated in Figure 3.11. However, this figure includes only Sample B (grey shade). The black shaded histogram is the population of $v > 40$ km s^{-1} subsystems. Though DR greater than two is unphysical, the doublet ratios of the $v > 40$ km s^{-1} subsystems are suggestive of optically thin gas for the most part. Roughly 80% of subsystems with $\mathrm{EW_r} \leq 0.2$ Å are accounted for by $v > 40$ km s^{-1} subsystems. Most of these $v > 40$ km s^{-1} subsystems have $\omega_v < 10$ km s^{-1}. Taken together, these results are suggestive that these subsystems are a subpopulation characterized first and foremost by their velocity with respect to the optical depth mean of the overall system.

As illustrated in Figure 3.12, there is no clear turnover in the EW_r distribution of the $v > 40$ km s^{-1} subsystems. As Figure 3.12 is presented, the counts in each bin have not been corrected for partial contributions [a system with a 5σ detection limit of 0.0075 Å samples only 50% of the smallest bin (0.005–0.01 Å)]. That there are no counts in this smallest bin is consistent with no turnover in the distribution once a correction is applied. Of the observed 33 systems, 13 have 5σ detection limits that partially sample this smallest bin (one of them samples the entire bin). If these 13 are weighted by the fraction of the bin each samples, then there are effectively ~ 5 systems. If the distribution is flat, the expected number of counts in any bin is given by the average counts in bins with $\text{EW}_\text{r} > 0.02$ Å, where the sample is complete. The average number of counts between $0.02 \leq \text{EW}_\text{r} \leq 0.05$ Å is ~ 2. Thus, $2(5/33) = 0.3$ counts, which is consistent with the observed null detection, are predicted in the 0.005–0.01 Å bin.

3.5 Comparing Integrated AOD and VP Column Densities

The apparent optical depth method (Savage & Sembach 1991) for obtaining the $N_a(v)$ profiles is well suited for quantifying the degree of unresolved saturation at each velocity location along the absorption profiles. It also provides a very useful technique for obtaining the integrated column density, N_a, especially for doublets or transitions of a given ion for which the $f\lambda$ are a factor of two different. An example of inverted profiles are presented in Figure 3.13 for three systems. These profiles illustrate the technique presented in Section 2.5. Shown are the $N_a(v)$ profiles for the Mg I transition and the Mg II doublet from the Q1213 − 003 at $z_\text{abs} = 1.3201$ system. Also shown are the Mg II doublets from the Q1101 − 264 at $z_\text{abs} = 0.3563$ system, and from the Q0117 + 212 at $z_\text{abs} = 1.0479$ system. Note the heavy saturation in Mg II for the Q1213 − 003 system, where the $\lambda 2803$ data give a more accurate lower limit of $N_a(v)$. Also note the discrepancy in the data for the Q1101 − 264 system. The $\lambda 2803$ transition is likely blended with a Ly α absorption line, given the level of confusion in the spectrum over the observed wavelength region.

It is also interesting to compare N_a with the integrated VP column densities, N_vp. In Figure 3.14, $\log N_a$(Mg II) is plotted verses $\log N_\text{vp}$(Mg II). Though the number of data points is small, it appears that column density regimes at which these two methods break down from the tight correlation are not identical. In other words, small fractional errors are still obtained for the $\log N_\text{vp}$(Mg II) up to 14.0 cm^{-2} or higher when the $\log N_a$(Mg II) are only lower limits at 13.5 cm^{-2}. A deeper appreciation of this figure would require studying this relationship for simulated spectra. This particular issue was not studied in Chapter 4. Clearly, however, a power law fit to the distribution of system column densities would result in a relatively steeper power if one were fitting the N_a. Thus, inferring the system integrated column density distribution from the VP column densities is likely to recover a power law slope more commensurate with the true distribution.

Table 3.1. Mg II Absorbing Systems: Profile Properties

QSO	$z_{\rm abs}$	$\sigma(v)$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_{\rm r}$ [Å]	DR
$0002+051$	0.591485	0.34	4.9 ± 0.7	-3.4 ± 2.5	0.102 ± 0.008	1.56 ± 0.25
	0.851394	3.33	97.1 ± 4.6	103.1 ± 7.7	1.086 ± 0.016	1.15 ± 0.03
$0058+019$	0.612672	0.26	50.8 ± 0.3	-23.4 ± 1.7	1.625 ± 0.013	1.05 ± 0.01
	0.725173	0.28	8.3 ± 0.4	-4.9 ± 1.9	0.235 ± 0.011	1.22 ± 0.11
$0117+212$	0.576398	1.03	26.9 ± 1.0	12.7 ± 5.4	0.906 ± 0.010	1.07 ± 0.02
	0.729055	1.34	46.8 ± 1.4	-18.7 ± 11.9	0.237 ± 0.008	1.72 ± 0.15
	1.047971	0.68	39.1 ± 0.7	-39.3 ± 0.9	0.415 ± 0.009	1.63 ± 0.06
	1.325014	1.16	74.5 ± 1.1	56.4 ± 2.3	0.280 ± 0.007	1.56 ± 0.10
	1.342969[a]	3.38	45.1 ± 3.5	-53.2 ± 3.6	0.148 ± 0.009	···
$0420-014$	0.633004	2.90	60.7 ± 3.3	-79.8 ± 3.5	0.871 ± 0.017	1.35 ± 0.05
$0450-132$	0.493937	2.17	26.2 ± 3.7	-10.0 ± 29.6	0.720 ± 0.069	1.26 ± 0.16
	1.174615[b]	1.60	60.1 ± 1.6	39.7 ± 4.4	1.818 ± 0.016	···
$0454+039$	0.859565[a]	1.33	42.8 ± 1.3	9.7 ± 29.5	···	···
	1.153248	0.53	30.2 ± 1.7	20.0 ± 3.6	0.432 ± 0.012	1.43 ± 0.07
$0454-220$	0.474410	1.01	40.8 ± 1.0	-16.6 ± 6.9	1.382 ± 0.009	1.10 ± 0.01
	0.483340	0.33	15.5 ± 0.5	-14.6 ± 0.7	0.431 ± 0.007	1.34 ± 0.04
$0823-223$	0.705472	0.54	9.0 ± 0.8	-6.8 ± 1.7	0.090 ± 0.007	1.80 ± 0.37
	0.911017	1.10	89.9 ± 1.1	73.3 ± 2.1	1.276 ± 0.016	1.81 ± 0.06
$1101-264$	0.356286	0.56	16.0 ± 0.9	-9.4 ± 3.3	0.220 ± 0.010	1.13 ± 0.08
	0.359002	1.04	24.6 ± 1.1	18.8 ± 2.3	0.550 ± 0.015	1.31 ± 0.06
$1148+384$	0.553362	1.21	44.9 ± 1.3	14.7 ± 14.6	0.638 ± 0.030	1.61 ± 0.16
$1206+459$	0.927602	4.38	116.2 ± 4.8	-141.1 ± 5.4	0.878 ± 0.016	1.39 ± 0.04
	0.934283	0.59	7.8 ± 0.8	-5.1 ± 2.5	0.051 ± 0.005	2.35 ± 0.58
$1213-003$	1.320059	1.98	90.9 ± 1.9	-40.2 ± 11.2	2.794 ± 0.018	1.11 ± 0.01
	1.554148	1.40	82.1 ± 1.6	-75.2 ± 2.3	1.987 ± 0.026	1.35 ± 0.04

Table 3.1—Continued

QSO	$z_{\rm abs}$	$\sigma(v)$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_{\rm r}$ [Å]	DR
$1222+228$	0.668052	5.29	75.9 ± 4.9	99.4 ± 4.4	0.494 ± 0.014	1.47 ± 0.07
$1225+317$	1.794833	1.43	70.4 ± 1.4	46.2 ± 4.0	2.014 ± 0.020	1.27 ± 0.03
$1241+174$	0.550482	2.57	33.9 ± 4.1	47.2 ± 4.6	0.481 ± 0.019	1.33 ± 0.09
$1248+401$	0.772957	1.88	53.6 ± 2.6	75.3 ± 2.7	0.694 ± 0.009	1.26 ± 0.03
	0.854558	7.68	62.1 ± 9.0	76.6 ± 9.8	0.265 ± 0.017	1.71 ± 0.26
$1254+044$	0.519389	15.4	90.0 ± 20.7	-122.7 ± 23.2	0.554 ± 0.018	1.35 ± 0.08
	0.934232	0.65	21.1 ± 0.7	-17.3 ± 1.1	0.346 ± 0.010	1.50 ± 0.10
$1317+274$	0.660051	2.00	45.0 ± 2.2	51.0 ± 2.7	0.338 ± 0.011	1.59 ± 0.10
$1329+412$	0.500785	4.19	23.7 ± 11.0	14.1 ± 39.0	0.245 ± 0.083	1.36 ± 0.99
	0.893337	3.07	55.0 ± 2.8	53.6 ± 3.6	0.400 ± 0.023	1.99 ± 0.30
	0.998358	0.43	6.6 ± 0.7	-3.3 ± 4.1	0.139 ± 0.010	1.62 ± 0.30
$1354+193$	0.456588	1.67	31.9 ± 1.7	-27.1 ± 3.2	0.751 ± 0.023	1.30 ± 0.06
$1421+331$	0.843247	0.27	2.3 ± 1.0	-3.6 ± 1.3	0.094 ± 0.008	1.10 ± 0.13
	0.902871	1.31	51.5 ± 1.4	-19.4 ± 11.8	1.048 ± 0.018	1.37 ± 0.04
	1.172609	0.54	24.2 ± 0.7	-13.4 ± 2.3	0.517 ± 0.012	1.41 ± 0.08
$1548+092$	0.770646	2.16	17.0 ± 6.1	-13.6 ± 11.3	0.299 ± 0.074	1.21 ± 0.49
$1622+235$	0.656114	2.30	44.7 ± 2.3	-16.5 ± 20.4	1.449 ± 0.029	1.10 ± 0.03
	0.797107[a]	2.94	45.2 ± 2.8	9.9 ± 75.6	0.274 ± 0.029	···
	0.891253	2.09	50.7 ± 2.0	-30.0 ± 7.1	1.534 ± 0.025	1.12 ± 0.03
$1634+704$	0.905554	0.27	4.0 ± 0.6	-4.3 ± 1.1	0.064 ± 0.004	1.41 ± 0.16
	0.990240	0.09	17.8 ± 0.2	10.3 ± 0.7	0.558 ± 0.005	1.32 ± 0.02
$2128-123$	0.429735	0.29	15.8 ± 0.4	-16.1 ± 0.7	0.406 ± 0.014	1.16 ± 0.06
$2145+064$	0.790777	0.97	75.1 ± 1.1	-42.2 ± 3.6	0.483 ± 0.015	1.36 ± 0.08

[a]The $\lambda 2796$ transition was not observed. Quoted quantites are the $\lambda 2803$ transition.

[b]The $\lambda 2803$ transition was either not observed or was only partially observed.

Table 3.2. Mg II Absorbing Systems: Absorption Properties

QSO	$z_{\rm abs}$	$\rm EW_{r,lim}$ 5σ [Å]	$N_{\rm cl}$	$\log N_{\rm vp}$ [$\rm cm^{-2}$]	$A(\Delta v)$ [$\rm km\ s^{-1}$]	$N_{\rm reg}$	$\log N_a$ [$\rm cm^{-2}$]	Smpl
$0002+051$	0.591485	0.016	1	12.63 ± 0.01	0.0	1	12.59 ± 0.01	B
	0.851394	0.012	14	> 15.77	101.8	4	> 13.93	B
$0058+019$	0.612672	0.024	7	15.18 ± 0.39	51.5	1	> 14.10	
	0.725173	0.025	1	13.43 ± 0.01	0.0	1	13.09 ± 0.01	
$0117+212$	0.576398	0.010	4	> 14.77	33.6	1	> 14.08	B
	0.729055	0.007	5	13.04 ± 0.01	45.0	3	12.93 ± 0.01	B
	1.047971	0.008	7	13.18 ± 0.06	37.6	2	> 13.17	B
	1.325014	0.005	6	13.13 ± 0.01	60.1	4	13.00 ± 0.01	B
	1.342969[a]	0.007	5	13.09 ± 0.02	50.6	4	13.02 ± 0.01	B
$0420-014$	0.633004	0.014	9	13.84 ± 0.10	68.4	2	> 13.77	B
$0450-132$	0.493937	0.042	2	13.89 ± 0.07	16.8	1	> 13.75	
	1.174615[b]	0.012	13	> 16.85	63.7	2	> 14.07	B
$0454+039$	0.859565[a]	0.013	12	> 15.23	46.4	1	> 14.32	B
	1.153248	0.009	7	13.44 ± 0.02	45.4	3	13.42 ± 0.01	B
$0454-220$	0.474410	0.010	16	> 14.94	43.5	1	> 14.27	B
	0.483340	0.007	7	13.70 ± 0.49	18.5	1	> 13.53	B
$0823-223$	0.705472	0.010	1	12.40 ± 0.02	0.0	1	12.40 ± 0.02	B
	0.911017	0.007	18	13.85 ± 0.01	83.3	3	> 13.84	B
$1101-264$	0.356286	0.012	1	12.83 ± 0.01	0.0	1	12.89 ± 0.01	B
	0.359002	0.014	6	13.65 ± 0.03	29.9	1	> 13.62	B
$1148+384$	0.553362	0.015	8	13.47 ± 0.02	44.1	1	13.43 ± 0.02	B
$1206+459$	0.927602	0.008	12	13.82 ± 0.02	141.5	5	> 13.74	B
	0.934283	0.008	2	12.08 ± 0.02	6.9	1	12.10 ± 0.02	B
$1213-003$	1.320059	0.011	24	16.04 ± 0.18	83.8	1	> 14.53	B
	1.554148	0.011	17	> 15.42	91.6	2	> 14.19	B

Table 3.2—Continued

QSO	$z_{\rm abs}$	EW$_{\rm r,lim}$ 5σ [Å]	$N_{\rm cl}$	$\log N_{\rm vp}$ [cm^{-2}]	$A(\Delta v)$ [km s^{-1}]	$N_{\rm reg}$	$\log N_a$ [cm^{-2}]	Smpl
$1222+228$	0.668052	0.014	6	13.36 ± 0.03	51.1	2	13.34 ± 0.01	B
$1225+317$	1.794833	0.013	18	> 14.75	68.0	2	> 14.29	B
$1241+174$	0.550482	0.016	4	13.68 ± 0.11	48.1	2	> 13.51	B
$1248+401$	0.772957	0.008	8	13.75 ± 0.03	47.0	2	> 13.73	B
	0.854558	0.009	8	13.02 ± 0.01	65.6	3	12.95 ± 0.01	B
$1254+044$	0.519389	0.018	6	> 15.50	138.0	4	> 13.66	B
	0.934232	0.011	2	13.23 ± 0.01	20.9	1	13.26 ± 0.02	B
$1317+274$	0.660051	0.008	8	13.12 ± 0.02	44.9	4	13.10 ± 0.01	B
$1329+412$	0.500785	0.042	4	13.08 ± 0.03	20.8	1	12.97 ± 0.03	
	0.893337	0.033	3	13.10 ± 0.05	43.7	2	13.17 ± 0.01	
	0.998358	0.024	1	12.75 ± 0.01	0.0	1	12.71 ± 0.01	
$1354+193$	0.456588	0.024	7	15.53 ± 0.18	27.0	2	> 13.75	
$1421+331$	0.843247	0.014	1	13.10 ± 0.10	0.0	1	12.79 ± 0.04	B
	0.902871	0.013	10	14.52 ± 0.70	51.7	2	> 13.88	B
	1.172609	0.012	7	13.45 ± 0.02	26.1	1	13.43 ± 0.02	B
$1548+092$	0.770646	0.052	1	13.34 ± 0.01	0.0	1	13.17 ± 0.02	
$1622+235$	0.656114	0.085	3	14.13 ± 0.04	38.2	1	> 14.07	
	0.797107[a]	0.026	4	13.15 ± 0.03	41.3	3	13.24 ± 0.03	
	0.891253	0.028	6	15.90 ± 0.58	48.5	1	> 14.17	
$1634+704$	0.905554	0.008	1	12.47 ± 0.01	0.0	1	12.35 ± 0.01	B
	0.990240	0.007	5	13.54 ± 0.05	13.9	1	> 13.52	B
$2128-123$	0.429735	0.022	4	15.25 ± 0.50	19.3	1	> 13.47	
$2145+064$	0.790777	0.014	6	13.62 ± 0.04	61.4	3	13.28 ± 0.01	B

[a]The $\lambda 2796$ transition was not observed. Quoted quantites are the $\lambda 2803$ transition.

[b]The $\lambda 2803$ transition was either not observed or was only partially observed.

Table 3.3. Mg II Absorbing Kinematic Subsystems

No.	$\langle v \rangle$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_r$ [Å]	DR
		Q0002 + 051	z_{abs} = 0.851394		
1	-10.9 ± 0.14	18.4 ± 0.2	15.2 ± 0.7	0.634 ± 0.009	1.10 ± 0.03
2	169.4 ± 0.20	16.4 ± 0.3	-12.7 ± 0.7	0.380 ± 0.010	1.23 ± 0.06
3	296.9 ± 0.81	4.6 ± 1.4	-3.4 ± 4.3	0.038 ± 0.006	1.79 ± 0.80
4	407.9 ± 0.68	4.0 ± 1.2	3.3 ± 2.9	0.035 ± 0.006	1.12 ± 0.34
		Q0117 + 212	z_{abs} = 0.729055		
1	-76.6 ± 0.30	8.7 ± 0.5	7.5 ± 0.9	0.111 ± 0.005	1.64 ± 0.20
2	10.2 ± 0.29	7.7 ± 0.5	-8.6 ± 0.8	0.114 ± 0.005	1.74 ± 0.24
3	66.6 ± 0.96	3.1 ± 1.7	-3.7 ± 2.3	0.012 ± 0.003	2.45 ± 0.68
		Q0117 + 212	z_{abs} = 1.047971		
1	-86.4 ± 0.29	5.4 ± 0.6	3.4 ± 3.0	0.095 ± 0.005	1.76 ± 0.16
2	3.4 ± 0.26	15.6 ± 0.5	-8.9 ± 1.8	0.320 ± 0.008	1.60 ± 0.07
		Q0117 + 212	z_{abs} = 1.325003		
1	-60.6 ± 0.33	9.6 ± 0.7	-7.4 ± 1.6	0.094 ± 0.005	1.50 ± 0.19
2	-4.8 ± 0.23	3.1 ± 0.7	3.7 ± 1.1	0.051 ± 0.003	1.51 ± 0.21
3	47.4 ± 0.15	3.4 ± 0.4	-4.1 ± 0.6	0.075 ± 0.003	1.57 ± 0.15
4	142.8 ± 0.22	4.3 ± 0.5	-1.8 ± 5.4	0.060 ± 0.003	1.69 ± 0.22

Table 3.3—Continued

No.	$\langle v \rangle$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_r$ [Å]	DR
		Q0117 + 212 $z_{abs} = 1.342969$[a]			
1	-136.5 ± 1.02	4.0 ± 1.7	-2.2 ± 9.2	0.013 ± 0.004	···
2	-103.5 ± 0.78	6.1 ± 1.0	3.0 ± 5.7	0.022 ± 0.004	···
3	-62.2 ± 4.36	5.5 ± 12.3	-9.9 ± 8.3	0.007 ± 0.006	···
4	1.4 ± 0.17	5.1 ± 0.4	3.4 ± 1.5	0.106 ± 0.004	···
		Q0420 − 014 $z_{abs} = 0.633004$			
1	-222.0 ± 0.49	5.7 ± 0.9	3.9 ± 2.6	0.086 ± 0.009	1.50 ± 0.24
2	-6.3 ± 1.21	30.9 ± 1.2	-25.9 ± 2.1	0.785 ± 0.015	1.34 ± 0.04
		Q0450 − 132 $z_{abs} = 1.174615$[b]			
1	-3.2 ± 1.59	57.3 ± 1.5	29.8 ± 6.7	1.760 ± 0.014	···
2	159.0 ± 0.50	4.8 ± 0.8	-3.8 ± 2.1	0.058 ± 0.007	···
		Q0454 + 039 $z_{abs} = 1.153254$			
1	-96.1 ± 0.57	1.7 ± 2.6	-1.9 ± 6.9	0.027 ± 0.005	1.53 ± 0.43
2	2.0 ± 0.39	14.8 ± 0.8	18.6 ± 1.2	0.372 ± 0.010	1.38 ± 0.06
3	99.4 ± 0.60	2.5 ± 2.0	4.6 ± 1.7	0.032 ± 0.005	2.15 ± 0.69
		Q0823 − 223 $z_{abs} = 0.911017$[b]			
1	-36.0 ± 0.71	50.9 ± 0.7	-28.2 ± 2.6	0.944 ± 0.014	1.34 ± 0.05
2	145.8 ± 0.21	13.4 ± 0.3	4.2 ± 4.0	0.307 ± 0.006	···
3	214.3 ± 0.68	5.3 ± 0.9	-4.9 ± 1.6	0.026 ± 0.004	···

Table 3.3—Continued

No.	$\langle v \rangle$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_r$ [Å]	DR
		Q1206 + 459	$z_{abs} = 0.927602$		
1	-404.8 ± 0.75	4.3 ± 1.5	-4.8 ± 2.1	0.030 ± 0.005	1.71 ± 0.54
2	-339.3 ± 0.57	12.2 ± 0.7	5.8 ± 3.5	0.080 ± 0.007	1.58 ± 0.25
3	-257.3 ± 0.34	3.8 ± 0.9	-4.0 ± 1.7	0.064 ± 0.005	1.70 ± 0.26
4	-184.1 ± 0.61	5.9 ± 1.2	3.9 ± 4.1	0.049 ± 0.005	2.63 ± 0.83
5	5.9 ± 0.93	34.1 ± 0.9	26.4 ± 1.9	0.656 ± 0.012	1.29 ± 0.04
		Q1213 − 003	$z_{abs} = 1.554148$		
1	-255.4 ± 0.69	5.5 ± 1.2	-3.4 ± 4.5	0.043 ± 0.006	2.09 ± 0.83
2	-17.8 ± 1.29	79.0 ± 1.3	-69.7 ± 2.0	1.944 ± 0.025	1.34 ± 0.04
		Q1222 + 228	$z_{abs} = 0.668052$		
1	-1.8 ± 0.48	15.8 ± 0.6	5.8 ± 4.9	0.417 ± 0.012	1.48 ± 0.07
2	232.3 ± 0.53	6.6 ± 0.7	-5.2 ± 1.7	0.076 ± 0.008	1.44 ± 0.23
		Q1225 + 317	$z_{abs} = 1.794833$		
1	-14.6 ± 1.39	65.4 ± 1.3	27.3 ± 8.7	1.899 ± 0.017	1.21 ± 0.03
2	164.4 ± 0.72	12.2 ± 0.9	-4.2 ± 9.0	0.115 ± 0.011	5.51 ± 4.41
		Q1241 + 174	$z_{abs} = 0.550482$		
1	0.4 ± 0.51	18.3 ± 0.9	16.2 ± 1.2	0.448 ± 0.017	1.33 ± 0.09
2	146.0 ± 0.99	4.5 ± 1.4	2.5 ± 6.2	0.033 ± 0.007	1.45 ± 0.59

Table 3.3—Continued

No.	$\langle v \rangle$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_r$ [Å]	DR
			Q1248 + 401 $z_{abs} = 0.772957$		
1	7.1 ± 0.69	25.9 ± 0.7	16.8 ± 1.8	0.632 ± 0.007	1.26 ± 0.03
2	225.9 ± 0.38	5.4 ± 0.7	4.1 ± 2.0	0.062 ± 0.005	1.29 ± 0.19
			Q1248 + 401 $z_{abs} = 0.854558$		
1	20.5 ± 1.49	39.4 ± 1.5	40.0 ± 1.8	0.243 ± 0.016	1.67 ± 0.27
2	210.8 ± 0.93	2.3 ± 1.9	-3.0 ± 2.3	0.011 ± 0.004	2.44 ± 0.81
3	233.9 ± 0.82	2.3 ± 1.4	-3.5 ± 1.2	0.010 ± 0.003	2.24 ± 0.74
			Q1254 + 044 $z_{abs} = 0.519389$		
1	-398.0 ± 0.91	4.2 ± 1.0	-4.0 ± 1.5	0.018 ± 0.008	2.28 ± 0.96
2	-261.9 ± 0.69	5.3 ± 1.0	-3.5 ± 3.6	0.060 ± 0.009	2.87 ± 1.68
3	-159.6 ± 0.87	5.2 ± 1.1	-1.3 ± 26.9	0.042 ± 0.008	3.64 ± 0.71
4	1.6 ± 0.74	13.4 ± 0.7	6.6 ± 3.5	0.433 ± 0.011	1.17 ± 0.06
			Q1317 + 274 $z_{abs} = 0.660051$		
1	-3.3 ± 0.19	9.1 ± 0.3	5.5 ± 1.3	0.225 ± 0.006	1.44 ± 0.08
2	47.6 ± 0.92	3.3 ± 1.4	3.1 ± 2.4	0.013 ± 0.004	2.71 ± 0.87
3	89.1 ± 0.62	10.0 ± 0.9	5.4 ± 3.9	0.075 ± 0.007	1.66 ± 0.36
4	142.7 ± 0.90	7.3 ± 0.9	5.6 ± 2.1	0.024 ± 0.005	3.97 ± 0.79

Table 3.3—Continued

No.	$\langle v \rangle$ [km s^{-1}]	ω_v [km s^{-1}]	η_v [km s^{-1}]	EW$_r$ [Å]	DR
		Q1329 + 412	$z_{\rm abs} = 0.893337$		
1	-8.8 ± 0.55	13.6 ± 0.7	-10.4 ± 1.6	0.296 ± 0.017	2.00 ± 0.33
2	120.2 ± 0.71	6.7 ± 0.9	-6.3 ± 1.5	0.104 ± 0.016	1.95 ± 0.64
		Q1354 + 193	$z_{\rm abs} = 0.456588$		
1	-77.6 ± 0.57	4.7 ± 0.8	-3.8 ± 1.7	0.070 ± 0.012	2.03 ± 0.74
2	2.5 ± 1.49	25.2 ± 1.4	-7.9 ± 17.5	0.681 ± 0.020	1.25 ± 0.06
		Q1421 + 331	$z_{\rm abs} = 0.902871$		
1	-19.9 ± 1.38	41.4 ± 1.3	-35.8 ± 2.1	0.887 ± 0.015	1.36 ± 0.04
2	82.4 ± 0.34	8.6 ± 0.7	-7.8 ± 1.1	0.161 ± 0.010	1.42 ± 0.15
		Q1622 + 235	$z_{\rm abs} = 0.797107^{\rm a}$		
1	-66.8 ± 1.26	7.9 ± 1.4	5.8 ± 3.6	0.077 ± 0.015	···
2	-1.5 ± 1.49	14.3 ± 1.5	-13.9 ± 2.2	0.147 ± 0.021	···
3	63.7 ± 1.07	4.9 ± 1.7	4.2 ± 3.9	0.050 ± 0.013	···
		Q2145 + 064	$z_{\rm abs} = 0.790777$		
1	-105.1 ± 0.21	5.3 ± 0.5	-4.9 ± 0.9	0.148 ± 0.006	1.24 ± 0.10
2	1.2 ± 0.41	8.7 ± 0.7	3.3 ± 6.6	0.139 ± 0.008	1.46 ± 0.19
3	67.2 ± 0.45	11.9 ± 0.8	4.1 ± 8.7	0.196 ± 0.011	1.39 ± 0.15

[a]The $\lambda 2796$ transition was not been observed. Quoted quantites are based upon the $\lambda 2803$ transition.

[b]The $\lambda 2803$ transition was either not observed or was only partially observed.

Table 3.4. Spearman–Kendall Tests of Overall Profile Properties

Tested Quantities			Spearman			Kendall		
A (1)	B (2)	N (3)	$r_{\rm s}$ (4)	$P_{\rm s}$ (5)	N_σ (6)	$\tau_{\rm k}$ (7)	$P_{\rm k}$ (8)	N_σ (9)
$\rm EW_{limit}$	$z_{\rm abs}$	36	−0.41	0.025	2.24	−0.29	0.014	2.45
$A(\Delta v)$	$z_{\rm abs}$	36	0.29	0.076	1.77	0.23	0.045	2.00
$N_{\rm cl}$	$z_{\rm abs}$	36	0.28	0.075	1.78	0.22	0.058	1.90
ω_v	$z_{\rm abs}$	36	0.25	0.133	1.50	0.19	0.108	1.61
$N_{\rm reg}$	$z_{\rm abs}$	36	−0.05	0.161	1.40	0.18	0.116	1.57
DR	$z_{\rm abs}$	33	0.22	0.222	1.22	0.16	0.193	1.30
$\rm EW_r$	$z_{\rm abs}$	34	0.22	0.216	1.24	0.15	0.208	1.26
η_v	$z_{\rm abs}$	36	0.15	0.367	0.90	0.12	0.313	1.01
$\log N_a({\rm Mg\,II})$	$z_{\rm abs}$	36	0.11	0.522	0.64	0.06	0.614	0.50
η_v/ω_v	$z_{\rm abs}$	36	−0.09	0.584	0.55	−0.07	0.531	0.63
$\log N_{vp}({\rm Mg\,II})$	$z_{\rm abs}$	36	0.07	0.676	0.42	0.03	0.827	0.22
Selected Spearman-Kendall Tests								
$N_{\rm cl}$	$\rm EW_r$	34	0.81	$2\cdot10^{-6}$	4.75	0.67	$2\cdot10^{-8}$	5.56
$A(\Delta v)$	$N_{\rm cl}$	36	0.71	$1\cdot10^{-5}$	4.35	0.58	$5\cdot10^{-7}$	5.00
$A(\Delta v)$	$\rm EW_r$	34	0.67	$9\cdot10^{-5}$	3.91	0.49	$4\cdot10^{-5}$	4.08
DR	$\rm EW_r$	33	−0.49	0.006	2.75	−0.39	0.001	3.19
η_v/ω_v	$N_{\rm reg}$	36	0.11	0.020	2.33	0.30	0.011	2.54
$\rm EW_{limit}$	$N_{\rm reg}$	36	−0.56	0.220	1.23	−0.16	0.175	1.36
η_v/ω_v	$\rm EW_r$	34	−0.20	0.251	1.15	−0.14	0.230	1.20
η_v/ω_v	$N_{\rm cl}$	36	−0.17	0.390	0.86	−0.11	0.346	0.94
$N_{\rm cl}$	DR	33	−0.17	0.430	0.79	−0.11	0.369	0.90
$\rm EW_{limit}$	$N_{\rm cl}$	36	−0.08	0.874	0.16	−0.04	0.747	0.32

Note. — Columns 1 and 2 list the properties for which the rank correlation tests were performed. Column 3 gives the number of data points used in each test. Columns 4 and 7 tabulate $r_{\rm s}$ and $\tau_{\rm k}$, the Spearman correlation coefficient and the Kendall τ, respectively. The probabilities, $P_{\rm s}$ and $P_{\rm k}$, and the number of standard deviations N_σ by which the rank coefficients deviate from their null hypothesis values are listed in columns 5, 8, 6, and 9, respectively.

Table 3.5. Spearman–Kendall Tests of Profile Subfeature Properties

Tested Quantities			Spearman			Kendall		
A	B	N	r_s	P_s	N_σ	τ_k	P_k	N_σ
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
				Velocity				
EW_r	$\langle v\rangle$	67	−0.59	$1\cdot10^{-5}$	4.81	−0.39	$3\cdot10^{-5}$	4.63
DR	$\langle v\rangle$	65	0.46	$2\cdot10^{-4}$	3.66	0.32	$7\cdot10^{-4}$	3.78
ω_v	$\langle v\rangle$	72	−0.45	$1\cdot10^{-4}$	3.79	−0.30	$2\cdot10^{-4}$	3.68
η_v	$\langle v\rangle$	72	−0.44	$2\cdot10^{-4}$	3.72	−0.27	$7\cdot10^{-4}$	3.37
η_v/ω_v	$\langle v\rangle$	72	0.14	0.252	1.14	0.09	0.247	1.16
				Velocity Width				
η_v	ω_v	72	0.86	$<1\cdot10^{-10}$	7.27	0.67	$<1\cdot10^{-10}$	8.36
EW_r	ω_v	67	0.91	$<1\cdot10^{-10}$	7.37	0.75	$<1\cdot10^{-10}$	8.99
DR	ω_v	65	−0.53	$2\cdot10^{-5}$	4.21	−0.37	$1\cdot10^{-5}$	4.39
η_v/ω_v	ω_v	72	−0.47	$7\cdot10^{-5}$	3.96	−0.33	$4\cdot10^{-5}$	4.12
				Velocity Asymmetry				
EW_r	η_v	67	0.82	$2\cdot10^{-10}$	6.69	0.64	$<1\cdot10^{-10}$	7.61
DR	η_v	65	−0.54	$2\cdot10^{-5}$	4.29	−0.37	$1\cdot10^{-5}$	4.34
η_v/ω_v	η_v	72	−0.01	0.907	0.12	0.00	0.953	0.06
				Strengths and Shapes				
DR	EW_r	65	−0.71	$1\cdot10^{-8}$	5.67	−0.53	$5\cdot10^{-10}$	6.21
η_v/ω_v	EW_r	67	−0.38	0.002	3.11	−0.26	0.002	3.06
η_v/ω_v	DR	65	0.12	0.322	0.99	0.10	0.262	1.12

Note. — Columns 1 and 2 list the properties for which the rank correlation tests were performed. Column 3 gives the number of data points used in each test. Columns 4 and 7 tabulate r_s and τ_k, the Spearman correlation coefficient and the Kendall τ, respectively. The probabilities, P_s and P_k, and the number of standard deviations N_σ by which the rank coefficients deviate from their null hypothesis values are listed in columns 5, 8, 6, and 9, respectively.

Table 3.6. $Q0002+051$ $z_{\rm abs}=0.591485$

Ion/Tran	(v_1^-, v_1^+)
	$(-18, 21)$
Apparent Column Density[a] [cm^{-2}]	
Mg II	12.588 ± 0.012
Fe II	< 11.724
Mg I	< 10.802
Mn II	< 11.495
Rest Frame Equivalent Width[a] [Å]	
Fe II 2374	< 0.047
Fe II 2383	< 0.029
Mn II 2577	< 0.019
Fe II 2587	< 0.023
Mn II 2594	< 0.023
Fe II 2600	< 0.019
Mn II 2606	< 0.019
Mg II 2796	0.102 ± 0.008
Mg II 2803	0.065 ± 0.009
Mg I 2853	< 0.017

[a]ACD and $\mathrm{EW_r}$ limits are 1σ.

Table 3.7. Q0002 + 051 $z_{\rm abs} = 0.851394$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	(v_4^-, v_4^+)	System
	$(-55, 60)$	$(125, 219)$	$(282, 314)$	$(393, 423)$	$(-55, 423)$
			Apparent Column Density [$\rm cm^{-2}$]		
Mg II	13.773 ± 0.001	13.379 ± 0.003	12.001 ± 0.035	12.028 ± 0.031	13.931 ± 0.001
Fe II	13.753 ± 0.003	12.801 ± 0.024	< 11.300	< 11.279	13.802 ± 0.004
Mg I	12.188 ± 0.024	< 10.874	< 10.655	< 10.642	12.232 ± 0.022
Mn II	< 11.482	< 11.438	< 11.212	< 11.200	< 11.954
			Rest Frame Equivalent Width [Å]		
Fe II 2344	0.225 ± 0.022	0.047 ± 0.025	0.025 ± 0.010	< 0.010	0.297 ± 0.035
Fe II 2374	0.077 ± 0.025	< 0.023	< 0.010	< 0.009	0.077 ± 0.025
Fe II 2383	0.347 ± 0.016	0.082 ± 0.019	< 0.009	< 0.008	0.429 ± 0.025
Mn II 2577	< 0.029	< 0.025	< 0.010	< 0.010	< 0.074
Fe II 2587	0.170 ± 0.025	< 0.025	< 0.011	< 0.011	0.170 ± 0.025
Mn II 2594	< 0.027	< 0.023	< 0.009	< 0.009	< 0.068
Fe II 2600	0.349 ± 0.014	0.070 ± 0.017	< 0.007	< 0.008	0.419 ± 0.022
Mn II 2606	< 0.024	< 0.021	< 0.009	< 0.008	< 0.061
Mg II 2796	0.634 ± 0.009	0.380 ± 0.010	0.038 ± 0.006	0.035 ± 0.006	1.086 ± 0.016
Mg II 2803	0.579 ± 0.013	0.310 ± 0.013	0.021 ± 0.009	0.031 ± 0.008	0.940 ± 0.022
Mg I 2853	0.166 ± 0.027	< 0.027	< 0.012	< 0.011	0.116 ± 0.027

Table 3.8. Q0058 + 019 $z_{\rm abs} = 0.612672$

Ion/Tran	(v_1^-, v_1^+)
	$(-114, 97)$
Apparent Column Density [cm^{-2}]	
Mg II	14.097 ± 0.002
Fe II	14.400 ± 0.005
Mg I	12.548 ± 0.017
Mn II	13.114 ± 0.038
Rest Frame Equivalent Width [Å]	
Fe II 2344	1.230 ± 0.416
Fe II 2374	0.460 ± 0.592
Fe II 2383	< 5.357
Mn II 2577	0.203 ± 0.113
Fe II 2587	1.043 ± 0.057
Mn II 2594	0.102 ± 0.136
Fe II 2600	1.274 ± 0.037
Mn II 2606	0.110 ± 0.120
Mg II 2796	1.625 ± 0.013
Mg II 2803	1.540 ± 0.015
Mg I 2853	0.300 ± 0.062

Table 3.9. Q0058 + 019 $z_{\rm abs} = 0.725173$

Ion/Tran	(v_1^-, v_1^+)
	$(-26, 25)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	13.093 ± 0.007
Fe II	< 11.837
Mg I	11.604 ± 0.096
Mn II	< 11.646
Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.049
Fe II 2374	< 0.039
Fe II 2383	< 0.036
Mn II 2577	< 0.030
Fe II 2587	< 0.024
Mn II 2594	< 0.026
Fe II 2600	< 0.034
Mn II 2606	< 0.030
Mg II 2796	0.235 ± 0.011
Mg II 2803	0.193 ± 0.015
Mg I 2853	0.041 ± 0.024

Table 3.10. Q0117 + 212 $z_{\rm abs} = 0.576398$

Ion/Tran	(v_1^-, v_1^+)
	$(-62, 91)$
Apparent Column Density [cm^{-2}]	
Mg II	> 14.080
Mg I	12.144 ± 0.019
Ca II	11.905 ± 0.071
Rest Frame Equivalent Width [Å]	
Mg II 2796	0.906 ± 0.010
Mg II 2803	0.844 ± 0.012
Mg I 2853	0.155 ± 0.023
Ca II 3969	0.033 ± 0.020

Table 3.11. Q0117 + 212 $z_{\rm abs} = 0.729055$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	System
	$(-99, -46)$	$(-22, 33)$	$(55, 79)$	$(-99, 79)$
Apparent Column Density [$\rm cm^{-2}$]				
Mg II	12.576 ± 0.009	12.652 ± 0.011	11.422 ± 0.071	12.930 ± 0.007
Fe II	12.436 ± 0.049	12.481 ± 0.045	12.060 ± 0.074	12.839 ± 0.030
Mg I	< 10.404	11.144 ± 0.083	< 10.225	11.259 ± 0.064
Mn II	< 11.121	< 11.130	< 10.966	< 11.556
Rest Frame Equivalent Width [Å]				
Mn II 2577	< 0.008	< 0.008	< 0.004	< 0.020
Fe II 2587	< 0.010	0.070 ± 0.010	< 0.005	0.070 ± 0.010
Mn II 2594	< 0.012	< 0.013	< 0.010	< 0.036
Fe II 2600	0.040 ± 0.009	0.037 ± 0.009	0.017 ± 0.005	0.094 ± 0.013
Mn II 2606	< 0.009	< 0.010	< 0.005	< 0.024
Mg II 2796	0.111 ± 0.005	0.114 ± 0.005	0.012 ± 0.003	0.237 ± 0.008
Mg II 2803	0.068 ± 0.008	0.065 ± 0.008	< 0.005	0.133 ± 0.011
Mg I 2853	< 0.008	0.015 ± 0.008	< 0.004	0.015 ± 0.008

Table 3.12. $Q0117+212$ $z_{\rm abs}=1.047971$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-109, -63)$	$(-46, 51)$	$(-109, 51)$
		Apparent Column Density [cm^{-2}]	
Mg II	12.486 ± 0.010	13.075 ± 0.005	13.174 ± 0.004
Fe II	12.038 ± 0.045	12.616 ± 0.018	12.718 ± 0.017
Mg I	11.006 ± 0.077	11.065 ± 0.097	11.337 ± 0.063
Mn II	< 10.978	< 11.140	< 11.368
		Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.006	0.016 ± 0.012	0.022 ± 0.012
Fe II 2374	< 0.006	< 0.012	< 0.018
Fe II 2383	0.018 ± 0.005	0.061 ± 0.009	0.080 ± 0.011
Mn II 2577	< 0.007	< 0.013	< 0.020
Fe II 2587	< 0.006	< 0.012	< 0.019
Mn II 2594	< 0.006	< 0.011	< 0.016
Fe II 2600	0.014 ± 0.005	0.051 ± 0.009	0.065 ± 0.010
Mn II 2606	< 0.006	< 0.011	< 0.017
Mg II 2796	0.095 ± 0.005	0.320 ± 0.008	0.415 ± 0.009
Mg II 2803	0.054 ± 0.004	0.200 ± 0.007	0.254 ± 0.008
Mg I 2853	0.012 ± 0.005	0.015 ± 0.010	0.027 ± 0.011

Table 3.13. Q0117 + 212 $z_{\rm abs} = 1.325003$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	(v_4^-, v_4^+)	System
	$(-95, -24)$	$(-22, 14)$	$(28, 66)$	$(125, 163)$	$(-95, 163)$
			Apparent Column Density [$\rm cm^{-2}$]		
Mg II	12.539 ± 0.008	12.221 ± 0.011	12.460 ± 0.008	12.290 ± 0.010	12.998 ± 0.005
Fe II	11.795 ± 0.085	11.759 ± 0.065	12.144 ± 0.028	< 10.933	12.427 ± 0.028
Mg I	< 10.246	10.779 ± 0.092	< 10.125	< 10.131	11.020 ± 0.053
Mn II	< 11.128	< 10.979	< 10.990	< 10.992	< 11.629
			Rest Frame Equivalent Width [Å]		
Fe II 2344	< 0.009	< 0.005	< 0.005	< 0.005	< 0.024
Fe II 2374	< 0.009	< 0.005	< 0.005	< 0.006	< 0.025
Fe II 2383	0.009 ± 0.007	0.006 ± 0.004	0.018 ± 0.004	< 0.004	0.033 ± 0.009
Fe II 2587	< 0.008	< 0.005	0.010 ± 0.005	< 0.005	0.010 ± 0.005
Mn II 2594	< 0.007	< 0.004	< 0.004	< 0.004	< 0.019
Fe II 2600	0.008 ± 0.006	0.010 ± 0.003	0.018 ± 0.003	< 0.003	0.036 ± 0.007
Mn II 2606	< 0.007	< 0.004	< 0.004	< 0.004	< 0.019
Mg II 2796	0.094 ± 0.005	0.051 ± 0.003	0.075 ± 0.003	0.061 ± 0.003	0.280 ± 0.007
Mg II 2803	0.063 ± 0.007	0.033 ± 0.004	0.048 ± 0.004	0.036 ± 0.004	0.179 ± 0.010
Mg I 2853	< 0.006	0.008 ± 0.003	< 0.004	< 0.004	0.008 ± 0.003

Table 3.14. Q0117 + 212 $z_{\rm abs} = 1.342969$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	(v_4^-, v_4^+)	System
	$(-149, -121)$	$(-119, -86)$	$(-84, -32)$	$(-20, 26)$	$(-149, 26)$
			Apparent Column Density [$\rm cm^{-2}$]		
Mg II	11.819 ± 0.063	12.034 ± 0.040	11.593 ± 0.134	12.922 ± 0.011	13.021 ± 0.011
Fe II	< 10.961	< 10.999	< 11.091	12.437 ± 0.020	12.484 ± 0.018
Mg I	< 10.130	< 10.136	< 10.250	< 10.212	< 10.787
Mn II	< 10.791	< 10.831	< 10.917	< 10.891	< 11.463
			Rest Frame Equivalent Width [Å]		
Fe II 2344	< 0.003	< 0.003	< 0.005	0.016 ± 0.004	0.016 ± 0.004
Fe II 2374	< 0.006	< 0.007	< 0.009	< 0.009	< 0.031
Fe II 2383	< 0.003	< 0.003	< 0.005	0.031 ± 0.004	0.031 ± 0.004
Mn II 2577	< 0.003	< 0.004	< 0.005	< 0.005	< 0.017
Fe II 2587	< 0.003	< 0.004	< 0.005	0.013 ± 0.005	0.013 ± 0.005
Mn II 2594	< 0.004	< 0.004	< 0.006	< 0.006	< 0.019
Mn II 2606	< 0.004	< 0.005	< 0.007	< 0.006	< 0.022
Mg II 2796[a]	...	...	...	...	...
Mg II 2803	0.013 ± 0.004	0.022 ± 0.004	0.007 ± 0.006	0.106 ± 0.004	0.148 ± 0.009
Mg I 2853	< 0.003	< 0.004	< 0.005	< 0.005	< 0.017

[a]Transition not observed.

Table 3.15. Q0420 − 014 $z_{\rm abs} = 0.633004$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-241, -201)$	$(-96, 51)$	$(-241, 51)$
	Apparent Column Density [cm^{-2}]		
Mg II	12.456 ± 0.019	> 13.753	13.774 ± 0.001
Fe II	< 11.806	12.840 ± 0.081	12.879 ± 0.075
Mg I	< 10.517	11.745 ± 0.057	11.770 ± 0.054
Mn II	< 11.468	< 11.762	< 11.940
	Rest Frame Equivalent Width [Å]		
Fe II 2344	< 0.073	< 0.229	< 0.302
Fe II 2374	< 0.049	< 0.153	< 0.202
Fe II 2383	< 0.051	< 0.174	< 0.225
Mn II 2577	< 0.019	< 0.059	< 0.078
Fe II 2587	< 0.027	< 0.097	< 0.124
Mn II 2594	< 0.017	< 0.055	< 0.071
Fe II 2600	< 0.018	0.076 ± 0.054	0.076 ± 0.054
Mn II 2606	< 0.019	< 0.065	< 0.084
Mg II 2796	0.086 ± 0.009	0.785 ± 0.015	0.871 ± 0.017
Mg II 2803	0.057 ± 0.007	0.586 ± 0.016	0.643 ± 0.017
Mg I 2853	< 0.009	0.062 ± 0.031	0.062 ± 0.031

Table 3.16. Q0450 − 132 $z_{\rm abs} = 0.493937$

Ion/Tran	(v_1^-, v_1^+)
	$(-91, 80)$
Apparent Column Density [cm^{-2}]	
Mg II	> 13.752
Mg I	11.883 ± 0.087
Ca II	11.763 ± 0.095
Rest Frame Equivalent Width [Å]	
Mg II 2796	0.720 ± 0.069
Mg II 2803	0.569 ± 0.048
Mg I 2853	0.078 ± 0.068
Ca II 3934	0.049 ± 0.047
Ca II 3969	0.021 ± 0.040

Table 3.17. Q0450 $-$ 132 $z_{\rm abs} = 1.174615$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-119, 135)$	$(143, 176)$	$(-119, 176)$
	Apparent Column Density [cm^{-2}]		
Mg II	> 14.061	12.216 ± 0.029	> 14.067
Fe II	14.984 ± 0.031	11.640 ± 0.149	14.985 ± 0.031
Mn II	12.859 ± 0.022	< 11.103	12.867 ± 0.021
	Rest Frame Equivalent Width [Å]		
Fe II 2261	0.126 ± 0.044	< 0.008	0.126 ± 0.044
Fe II 2344	0.765 ± 0.020	< 0.005	0.765 ± 0.020
Fe II 2374	0.485 ± 0.033	< 0.007	0.485 ± 0.033
Fe II 2383	1.072 ± 0.019	< 0.006	1.072 ± 0.019
Mn II 2577	0.143 ± 0.046	< 0.008	0.143 ± 0.046
Mn II 2594	0.094 ± 0.039	< 0.007	0.094 ± 0.039
Fe II 2600	1.131 ± 0.019	0.014 ± 0.006	1.146 ± 0.020
Mn II 2606	0.055 ± 0.040	< 0.007	0.055 ± 0.040
Mg II 2796	1.761 ± 0.014	0.058 ± 0.007	1.818 ± 0.016
Mg II 2803[a]	...	...	...

[a]Transition only partially observed.

Table 3.18. Q0454 + 039 $z_{\rm abs} = 0.859565$

Ion/Tran	(v_1^-, v_1^+)
	$(-95, 121)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	> 14.323
Fe II	15.068 ± 0.028
Mg I	12.453 ± 0.009
Mn II	12.947 ± 0.017
Rest Frame Equivalent Width [Å]	
Fe II 2261	0.159 ± 0.042
Fe II 2344	0.978 ± 0.015
Fe II 2374	0.719 ± 0.021
Fe II 2383	1.144 ± 0.018
Mn II 2577	0.177 ± 0.039
Fe II 2587	1.007 ± 0.016
Mn II 2594	0.125 ± 0.030
Fe II 2600	1.232 ± 0.014
Mn II 2606	0.057 ± 0.041
Mg II 2796[a]	···
Mg II 2803	1.445 ± 0.014
Mg I 2853	0.306 ± 0.022

[a]Transition not observed.

Table 3.19. Q0454 + 039 $z_{\rm abs} = 1.153254$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	System
	$(-109, -79)$	$(-35, 81)$	$(83, 115)$	$(-109, 115)$
		Apparent Column Density [$\rm cm^{-2}$]		
Mg II	11.933 ± 0.028	13.391 ± 0.008	11.943 ± 0.028	13.421 ± 0.008
Fe II	11.804 ± 0.108	12.773 ± 0.020	< 11.126	12.826 ± 0.020
Mg I	< 10.186	11.271 ± 0.072	< 10.195	11.338 ± 0.061
Mn II	< 10.992	< 11.288	< 11.004	< 11.594
		Rest Frame Equivalent Width [Å]		
Fe II 2344	< 0.005	0.048 ± 0.017	< 0.006	0.048 ± 0.017
Fe II 2374	< 0.004	0.019 ± 0.014	< 0.005	0.019 ± 0.014
Fe II 2383[a]	···	0.056 ± 0.020	< 0.007	0.056 ± 0.020
Mn II 2577	< 0.006	< 0.017	< 0.006	< 0.029
Fe II 2587	< 0.004	0.014 ± 0.013	< 0.004	0.014 ± 0.013
Mn II 2594	< 0.004	< 0.015	< 0.005	< 0.024
Fe II 2600	0.009 ± 0.005	0.075 ± 0.014	< 0.005	0.084 ± 0.015
Mg II 2796	0.027 ± 0.005	0.372 ± 0.010	0.032 ± 0.005	0.432 ± 0.012
Mg II 2803	0.018 ± 0.004	0.270 ± 0.010	0.015 ± 0.004	0.302 ± 0.011
Mg I 2853	< 0.004	0.026 ± 0.012	< 0.004	0.026 ± 0.012

[a]Transition only partially observed.

Table 3.20. Q0454 − 220 $z_{\rm abs} = 0.474410$

Ion/Tran	(v_1^-, v_1^+)
	$(-98, 106)$
Apparent Column Density [cm^{-2}]	
Mg II	> 14.272
Fe II	> 14.515
Mg I	12.532 ± 0.005
Mn II	< 12.196
Ca II	12.096 ± 0.026
Rest Frame Equivalent Width [Å]	
Mn II 2577	< 0.137
Fe II 2587	0.677 ± 0.067
Mn II 2594	< 0.130
Fe II 2600	0.975 ± 0.029
Mn II 2606	< 0.116
Mg II 2796	1.382 ± 0.009
Mg II 2803	1.260 ± 0.009
Mg I 2853	0.333 ± 0.014
Ca II 3969	0.051 ± 0.013

Table 3.21. Q0454 − 220 $z_{\rm abs} = 0.483340$

Ion/Tran	(v_1^-, v_1^+)
	$(-60, 41)$
Apparent Column Density [cm^{-2}]	
Mg II	> 13.527
Fe II	13.384 ± 0.051
Mg I	11.849 ± 0.018
Mn II	12.466 ± 0.086
Ca II	11.409 ± 0.046
Rest Frame Equivalent Width [Å]	
Mn II 2577	< 0.073
Fe II 2587	0.069 ± 0.028
Mn II 2594	0.056 ± 0.031
Fe II 2600	0.162 ± 0.043
Mn II 2606	< 0.057
Mg II 2796	0.431 ± 0.007
Mg II 2803	0.321 ± 0.008
Mg I 2853	0.070 ± 0.010
Ca II 3935	0.020 ± 0.007

Table 3.22. Q0823 − 223 $z_{\rm abs} = 0.705472$

Ion/Tran	(v_1^-, v_1^+)
	$(-26, 24)$
Apparent Column Density [cm^{-2}]	
Mg II	12.396 ± 0.017
Fe II	< 11.630
Mg I	< 10.543
Mn II	< 11.353
Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.034
Fe II 2374	< 0.027
Fe II 2383	< 0.031
Mn II 2577	< 0.014
Fe II 2587	< 0.015
Mn II 2594	< 0.017
Fe II 2600	< 0.015
Mn II 2606	< 0.014
Mg II 2796	0.090 ± 0.007
Mg II 2803	0.050 ± 0.009
Mg I 2853	< 0.010

Table 3.23. Q0823 − 223 $z_{\rm abs} = 0.911017$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	System
	$(-157, 75)$	$(105, 185)$	$(199, 230)$	$(-157, 230)$
		Apparent Column Density [$\rm cm^{-2}$]		
Mg II	> 13.752	13.072 ± 0.007	11.827 ± 0.038	13.839 ± 0.001
Fe II	13.470 ± 0.007	12.987 ± 0.012	11.513 ± 0.198	13.597 ± 0.006
Mg I	12.234 ± 0.016	11.411 ± 0.057	< 10.305	12.299 ± 0.016
Mn II	< 11.433	< 11.193	< 10.990	< 11.720
		Rest Frame Equivalent Width [Å]		
Fe II 2344	0.123 ± 0.050	0.048 ± 0.020	< 0.010	0.171 ± 0.054
Fe II 2374	0.006 ± 0.054	< 0.022	< 0.011	0.006 ± 0.054
Fe II 2383	0.371 ± 0.039	0.123 ± 0.014	< 0.007	0.494 ± 0.041
Mn II 2577	< 0.035	< 0.013	< 0.006	< 0.054
Fe II 2587	0.118 ± 0.026	0.037 ± 0.009	< 0.005	0.155 ± 0.028
Mn II 2594	< 0.028	< 0.010	< 0.005	< 0.043
Fe II 2600	0.298 ± 0.024	0.111 ± 0.009	0.007 ± 0.005	0.416 ± 0.026
Mn II 2606	< 0.039	< 0.015	< 0.008	< 0.061
Mg II 2796	0.944 ± 0.014	0.307 ± 0.006	0.026 ± 0.005	1.276 ± 0.016
Mg II 2803[a]	0.705 ± 0.022	···	···	> 0.705
Mg I 2853	0.189 ± 0.029	0.034 ± 0.011	< 0.005	0.224 ± 0.031

[a]Transition only partially observed.

Table 3.24. Q1101 − 264 $z_{\rm abs} = 0.356286$

Ion/Tran	(v_1^-, v_1^+)
	$(-48, 49)$
Apparent Column Density [cm^{-2}]	
Mg II	12.894 ± 0.011
Rest Frame Equivalent Width [Å]	
Mg II 2796	0.220 ± 0.010
Mg II 2803[a]	< 0.195

[a]Blended with Lyα forest.

Table 3.25. Q1101 − 264 $z_{\rm abs} = 0.359002$

Ion/Tran	(v_1^-, v_1^+)
	$(-57, 94)$
Apparent Column Density [cm^{-2}]	
Mg II	> 13.621
Rest Frame Equivalent Width [Å]	
Mg II 2796	0.550 ± 0.015
Mg II 2803	0.419 ± 0.013

Table 3.26. Q1148 + 384 $z_{\rm abs} = 0.553362$

Ion/Tran	(v_1^-, v_1^+)
	$(-96, 101)$
Apparent Column Density [cm^{-2}]	
Mg II	13.433 ± 0.019
Fe II	13.186 ± 0.046
Mg I	< 11.077
Mn II	< 11.887
Ca II	< 11.341
Rest Frame Equivalent Width [Å]	
Mn II 2577	< 0.085
Fe II 2587	0.065 ± 0.081
Mn II 2594	< 0.110
Fe II 2600	0.151 ± 0.071
Mn II 2606	< 0.073
Mg II 2796	0.638 ± 0.030
Mg II 2803	0.397 ± 0.035
Mg I 2853	< 0.063
Ca II 3969	< 0.039

Table 3.27. Q1206 + 459 $z_{\rm abs} = 0.927602$ A

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	(v_4^-, v_4^+)[a]
	$(-421, -386)$	$(-366, -310)$	$(-275, -236)$	$(-204, -160)$
Apparent Column Density [$\rm cm^{-2}$]				
Mg II	11.910 ± 0.031	12.384 ± 0.014	12.304 ± 0.015	12.099 ± 0.022
Fe II	< 11.140	< 11.242	< 11.156	< 11.187
Mg I	< 10.262	< 10.366	< 10.286	< 10.306
Mn II	< 10.970	< 11.072	< 10.988	< 11.011
Rest Frame Equivalent Width [Å]				
Fe II 2344	< 0.006	< 0.009	< 0.007	< 0.007
Fe II 2374	< 0.006	< 0.009	< 0.007	< 0.007
Fe II 2383	< 0.006	< 0.009	< 0.007	< 0.008
Mn II 2577	< 0.005	< 0.008	< 0.006	< 0.006
Fe II 2587	< 0.006	< 0.010	< 0.008	< 0.008
Mn II 2594	< 0.006	< 0.009	< 0.006	< 0.007
Fe II 2600	< 0.006	< 0.008	< 0.006	< 0.006
Mn II 2606	< 0.005	< 0.008	< 0.006	< 0.006
Mg II 2796	0.030 ± 0.005	0.080 ± 0.007	0.064 ± 0.005	0.049 ± 0.006
Mg II 2803	0.018 ± 0.005	0.050 ± 0.007	0.037 ± 0.005	0.019 ± 0.005
Mg I 2853	< 0.005	< 0.007	< 0.005	< 0.006

[a]This system has been divided into two sub–systems, A and B, for presentation purposes. It may be that these sub–systems are physically "distinct". The total system (A+B) quantities are given on the following table (Table 3.28) with sub–system B.

Table 3.28. Q1206 + 459 $z_{\rm abs} = 0.927602$ B

Ion/Tran	(v_5^-, v_5^+)	System[a]
	$(-80, 89)$	$(-421, 89)$
Apparent Column Density [cm^{-2}]		
Mg II	> 13.683	13.738 ± 0.001
Fe II	12.870 ± 0.019	12.905 ± 0.017
Mg I	11.535 ± 0.053	11.627 ± 0.041
Mn II	< 11.308	< 11.789
Rest Frame Equivalent Width [Å]		
Fe II 2344	0.033 ± 0.024	0.033 ± 0.024
Fe II 2374	0.018 ± 0.024	0.018 ± 0.024
Fe II 2383[b]	0.098 ± 0.026	0.098 ± 0.026
Mn II 2577	< 0.021	< 0.046
Fe II 2587	0.030 ± 0.030	0.030 ± 0.030
Mn II 2594	< 0.023	< 0.052
Fe II 2600	0.077 ± 0.020	0.077 ± 0.020
Mn II 2606	< 0.021	< 0.046
Mg II 2796	0.656 ± 0.012	0.878 ± 0.016
Mg II 2803	0.508 ± 0.013	0.632 ± 0.017
Mg I 2853	0.042 ± 0.020	0.042 ± 0.020

[a]See notes for Table 3.27.

[b]In this region this transition is blended with Fe II λ 2374 transition at $z = 0.9343$. Based upon the 1σ EW$_{\rm r}$ limits on the other Fe II transitions from that system, the absorption contributed by the Fe II λ 2374 transition is negligible.

Table 3.29. Q1206 + 459 $z_{\rm abs} = 0.934283$

Ion/Tran	(v_1^-, v_1^+)
	$(-21, 22)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	12.096 ± 0.021
Fe II	< 11.178
Mg I	< 10.293
Mn II	< 11.056
Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.008
Fe II 2374[a]	...
Fe II 2383	< 0.009
Mn II 2577	< 0.009
Fe II 2587	< 0.007
Mn II 2594	< 0.006
Fe II 2600	< 0.006
Mn II 2606	< 0.006
Mg II 2796	0.051 ± 0.005
Mg II 2803	0.022 ± 0.005
Mg I 2853	< 0.006

[a]Transition blended with the $z = 0.9276$ Fe II λ 2383 transition in region five. None of the Fe II transitions for this system show absorption. It can be assumed that the 1σ $\rm EW_r$ limits for this transition are consistent with the others.

Table 3.30. Q1213 − 003 $z_{\rm abs} = 1.320059$

Ion/Tran	(v_1^-, v_1^+)
	$(-221, 175)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	> 14.532
Fe II	14.529 ± 0.018
Mg I	12.837 ± 0.008
Mn II	< 11.766
Rest Frame Equivalent Width [Å]	
Fe II 2344	1.073 ± 0.091
Fe II 2374	0.417 ± 0.067
Fe II 2383	1.668 ± 0.057
Mn II 2577	< 0.083
Fe II 2587	0.875 ± 0.066
Fe II 2600	1.585 ± 0.031
Mn II 2606	< 0.066
Mg II 2796	2.794 ± 0.018
Mg II 2803	2.509 ± 0.021
Mg I 2853[a]	0.686 ± 0.054

[a]Transition blended with the $z = 1.5541$ Mn II λ 2594 transition from region one. The Mn II λ 2606 transition from that system shows no absorption. It can be assumed that the Mn II blend is negligible.

Table 3.31. Q1213 − 003 $z_{\rm abs} = 1.554148$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-273, -235)$	$(-218, 155)$	$(-273, 155)$
		Apparent Column Density [cm^{-2}]	
Mg II	12.071 ± 0.030	> 14.185	> 14.189
Fe II	< 11.224	14.404 ± 0.013	14.404 ± 0.013
Mg I	< 10.564	12.306 ± 0.027	12.314 ± 0.026
Mn II	< 11.538	< 11.764	< 12.182
		Rest Frame Equivalent Width [Å]	
Fe II 2261	< 0.006	0.019 ± 0.051	0.019 ± 0.051
Fe II 2344	< 0.008	0.499 ± 0.060	0.499 ± 0.060
Fe II 2374	< 0.007	0.278 ± 0.049	0.278 ± 0.049
Fe II 2383	< 0.008	0.849 ± 0.046	0.849 ± 0.046
Fe II 2587	< 0.010	0.464 ± 0.064	0.464 ± 0.064
Mn II 2594[a]	$\cdots$	< 0.058	< 0.058
Fe II 2600	< 0.008	0.853 ± 0.047	0.853 ± 0.047
Mn II 2606	< 0.009	< 0.076	< 0.085
Mg II 2796	0.043 ± 0.006	1.944 ± 0.026	1.987 ± 0.026
Mg II 2803	0.021 ± 0.008	1.456 ± 0.038	1.476 ± 0.039
Mg I 2853	< 0.010	0.215 ± 0.075	0.215 ± 0.075

[a]In region one, this transition is blended with the $z = 1.3201$ Mg I λ 2853 transition. The Mn II λ 2606 transition in region one from this system shows no absorption. It can be assumed that the Mn II blend is negligible. Region two of the Mn II λ 2594 spectrum may exhibit very weak absorption in the velocity interval $\sim 10-40$ km s^{-1}, where the Mg II and Fe II are most severly saturated, but the measured EW$_{\rm r}$ was consistent with a null detection to the given limit over the full velocity range of the region.

Table 3.32. Q1222 + 228 $z_{\rm abs} = 0.668052$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-43, 42)$	$(213, 253)$	$(-43, 253)$
	Apparent Column Density [cm^{-2}]		
Mg II	13.290 ± 0.010	12.412 ± 0.019	13.344 ± 0.009
Fe II	12.988 ± 0.030	12.518 ± 0.055	13.115 ± 0.026
Mg I	11.477 ± 0.068	< 10.509	11.521 ± 0.061
Mn II	< 11.458	< 11.285	< 11.681
	Rest Frame Equivalent Width [Å]		
Fe II 2344	0.063 ± 0.045	< 0.024	0.063 ± 0.045
Fe II 2374	< 0.035	< 0.018	< 0.052
Fe II 2383	0.113 ± 0.035	0.028 ± 0.021	0.140 ± 0.041
Mn II 2577	< 0.021	< 0.011	< 0.032
Fe II 2587	< 0.027	< 0.015	< 0.042
Mn II 2594	< 0.030	< 0.014	< 0.044
Fe II 2600	0.119 ± 0.022	0.047 ± 0.011	0.166 ± 0.025
Mn II 2606	< 0.022	< 0.011	< 0.033
Mg II 2796	0.417 ± 0.012	0.076 ± 0.008	0.494 ± 0.014
Mg II 2803	0.282 ± 0.010	0.053 ± 0.006	0.335 ± 0.012
Mg I 2853	0.038 ± 0.016	< 0.009	0.038 ± 0.016

Table 3.33. Q1225 + 317 $z_{\rm abs} = 1.794833$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-147, 136)$	$(136, 195)$	$(-147, 195)$
	Apparent Column Density [$\rm cm^{-2}$]		
Mg II	> 14.280	12.455 ± 0.021	> 14.286
Fe II	13.880 ± 0.007	< 11.327	13.881 ± 0.007
Mg I	12.387 ± 0.016	< 10.593	12.394 ± 0.016
Mn II	12.055 ± 0.169	< 11.328	12.130 ± 0.142
	Rest Frame Equivalent Width [Å]		
Fe II 2344	0.300 ± 0.043	< 0.013	0.300 ± 0.043
Fe II 2374	0.086 ± 0.035	< 0.009	0.086 ± 0.035
Fe II 2383	0.661 ± 0.025	< 0.009	0.661 ± 0.025
Mn II 2577[a]	0.035 ± 0.058	< 0.014	0.035 ± 0.058
Fe II 2600	0.620 ± 0.050	< 0.016	0.620 ± 0.050
Mn II 2606	< 0.037	< 0.009	< 0.046
Mg II 2796	1.899 ± 0.017	0.115 ± 0.011	2.014 ± 0.020
Mg II 2803	1.564 ± 0.030	0.021 ± 0.017	1.585 ± 0.034
Mg I 2853	0.275 ± 0.046	< 0.013	0.275 ± 0.046

[a]The equivalent width of this transition is not significant, but the value is still quoted.

Table 3.34. Q1241 + 174 $z_{\rm abs} = 0.550482$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-49, 62)$	$(133, 161)$	$(-49, 161)$
	Apparent Column Density [cm^{-2}]		
Mg II	> 13.497	11.941 ± 0.049	13.509 ± 0.001
Fe II	> 13.728	< 11.825	< 13.734
Mg I	11.964 ± 0.042	< 10.634	11.984 ± 0.040
Mn II	< 11.821	< 11.503	< 11.992
Ca II	11.987 ± 0.062	< 10.845	12.018 ± 0.058
	Rest Frame Equivalent Width [Å]		
Mn II 2577	< 0.057	< 0.019	< 0.076
Fe II 2587	0.096 ± 0.047	< 0.017	0.096 ± 0.047
Mn II 2594	< 0.061	< 0.019	< 0.080
Fe II 2600	0.236 ± 0.048	< 0.018	0.236 ± 0.048
Mn II 2606	< 0.049	< 0.015	< 0.064
Mg II 2796	0.448 ± 0.017	0.033 ± 0.007	0.481 ± 0.019
Mg II 2803	0.338 ± 0.018	0.023 ± 0.008	0.361 ± 0.020
Mg I 2853	0.098 ± 0.030	< 0.011	0.098 ± 0.030
Ca II 3969	0.039 ± 0.018	< 0.006	0.039 ± 0.018

Table 3.35. Q1248 + 401 $z_{\rm abs} = 0.772957$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-52, 69)$	$(207, 248)$	$(-52, 248)$
		Apparent Column Density [cm^{-2}]	
Mg II	> 13.710	12.304 ± 0.015	13.726 ± 0.001
Fe II	13.544 ± 0.017	11.707 ± 0.178	13.550 ± 0.017
Mg I	11.620 ± 0.058	11.141 ± 0.088	11.744 ± 0.049
Mn II	< 11.399	< 11.196	< 11.610
		Rest Frame Equivalent Width [Å]	
Fe II 2344	0.105 ± 0.026	< 0.011	0.105 ± 0.026
Fe II 2374	0.045 ± 0.026	< 0.011	0.045 ± 0.026
Fe II 2383	0.241 ± 0.021	< 0.010	0.241 ± 0.021
Mn II 2577	< 0.021	< 0.008	< 0.030
Fe II 2587	0.116 ± 0.019	< 0.008	0.116 ± 0.019
Mn II 2594[a]	< 0.032	$\cdots$	< 0.032
Fe II 2600	0.233 ± 0.018	0.014 ± 0.008	0.247 ± 0.020
Mn II 2606	< 0.021	< 0.008	< 0.029
Mg II 2796	0.632 ± 0.007	0.062 ± 0.005	0.694 ± 0.009
Mg II 2803	0.501 ± 0.009	0.048 ± 0.006	0.549 ± 0.011
Mg I 2853	0.049 ± 0.021	0.016 ± 0.007	0.065 ± 0.022

[a]Transition only partially observed.

Table 3.36. Q1248 + 401 $z_{\rm abs} = 0.854558$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	System
	$(-26, 116)$	$(202, 221)$	$(225, 243)$	$(-26, 243)$
		Apparent Column Density [cm^{-2}]		
Mg II	12.928 ± 0.009	11.377 ± 0.091	11.368 ± 0.085	12.952 ± 0.009
Fe II	12.480 ± 0.049	< 11.093	11.433 ± 0.194	12.533 ± 0.046
Mg I	< 10.706	< 10.263	< 10.236	< 10.936
Mn II	< 11.359	< 10.929	< 10.916	< 11.597
		Rest Frame Equivalent Width [Å]		
Fe II 2344	0.025 ± 0.027	< 0.006	< 0.005	0.025 ± 0.027
Fe II 2374	< 0.027	< 0.005	< 0.005	< 0.037
Fe II 2383	0.040 ± 0.028	< 0.006	< 0.006	0.040 ± 0.028
Mn II 2577	< 0.027	< 0.005	< 0.005	< 0.037
Fe II 2587	0.012 ± 0.025	< 0.005	< 0.004	0.012 ± 0.025
Mn II 2594	< 0.020	< 0.004	< 0.003	< 0.027
Fe II 2600	0.033 ± 0.020	< 0.004	< 0.004	0.033 ± 0.020
Mn II 2606	< 0.020	< 0.004	< 0.004	< 0.028
Mg II 2796	0.243 ± 0.016	0.011 ± 0.004	0.010 ± 0.003	0.264 ± 0.017
Mg II 2803	0.145 ± 0.022	< 0.005	< 0.004	0.145 ± 0.022
Mg I 2853	< 0.022	< 0.004	< 0.004	< 0.031

Table 3.37. Q1254 + 044 $z_{\rm abs} = 0.519389$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	(v_4^-, v_4^+)	System
	$(-407, -388)$	$(-277, -244)$	$(-173, -143)$	$(-33, 40)$	$(-407, 40)$
		Apparent Column Density [$\rm cm^{-2}$]			
Mg II	11.639 ± 0.105	12.219 ± 0.038	11.970 ± 0.057	> 13.625	13.655 ± 0.002
Fe II	< 11.740	< 11.881	< 11.832	> 13.948	> 13.957
Mg I	< 10.589	< 10.728	< 10.674	12.313 ± 0.041	12.342 ± 0.038
Mn II	< 11.477	< 11.596	< 11.555	< 11.764	< 12.213
Ca II	< 10.517	< 10.638	< 10.613	12.046 ± 0.028	12.090 ± 0.025
		Rest Frame Equivalent Width [Å]			
Mn II 2577	< 0.015	< 0.022	< 0.021	< 0.041	< 0.099
Fe II 2587	< 0.013	< 0.018	< 0.016	0.185 ± 0.029	0.185 ± 0.029
Mn II 2594	< 0.019	< 0.028	< 0.025	< 0.048	< 0.120
Fe II 2600	< 0.015	< 0.021	< 0.018	0.298 ± 0.024	0.298 ± 0.024
Mn II 2606	< 0.013	< 0.020	< 0.016	< 0.036	< 0.085
Mg II 2796	0.018 ± 0.008	0.060 ± 0.010	0.042 ± 0.008	0.433 ± 0.011	0.554 ± 0.018
Mg II 2803	< 0.008	0.021 ± 0.012	< 0.012	0.371 ± 0.016	0.392 ± 0.020
Mg I 2853	< 0.009	< 0.013	< 0.012	0.169 ± 0.019	0.169 ± 0.019
Ca II 3934	< 0.006	< 0.009	< 0.008	0.077 ± 0.017	0.077 ± 0.017
Ca II 3969	< 0.006	< 0.009	< 0.008	0.048 ± 0.015	0.048 ± 0.015

Table 3.38. Q1254 + 044 $z_{\rm abs} = 0.934232$

Ion/Tran	(v_1^-, v_1^+)
	$(-61, 32)$
Apparent Column Density [cm^{-2}]	
Mg II	13.261 ± 0.024
Fe II	12.699 ± 0.030
Mg I	10.585 ± 0.569
Mn II	< 11.341
Rest Frame Equivalent Width [Å]	
Fe II 2344	0.021 ± 0.022
Fe II 2374	< 0.023
Fe II 2383	0.056 ± 0.022
Mn II 2577	< 0.021
Fe II 2587	0.040 ± 0.020
Mn II 2594	< 0.017
Fe II 2600	0.051 ± 0.015
Mn II 2606	< 0.017
Mg II 2796	0.346 ± 0.010
Mg II 2803	0.231 ± 0.014
Mg I 2853	0.005 ± 0.019

Table 3.39. Q1317 + 274 $z_{\rm abs} = 0.660051$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	(v_4^-, v_4^+)	System
	$(-33, 30)$	$(36, 58)$	$(62, 118)$	$(126, 158)$	$(-33, 158)$
			Apparent Column Density [cm^{-2}]		
Mg II	12.991 ± 0.008	11.398 ± 0.085	12.314 ± 0.017	11.703 ± 0.050	13.100 ± 0.007
Fe II	12.992 ± 0.019	< 11.218	12.380 ± 0.051	< 11.309	13.100 ± 0.018
Mg I	11.341 ± 0.063	< 10.247	< 10.450	< 10.328	11.457 ± 0.048
Mn II	< 11.261	< 11.032	< 11.227	< 11.115	< 11.770
			Rest Frame Equivalent Width [Å]		
Fe II 2344	0.060 ± 0.021	< 0.010	< 0.021	< 0.015	0.060 ± 0.021
Fe II 2374	< 0.028	< 0.013	< 0.028	< 0.018	< 0.087
Fe II 2383	0.104 ± 0.014	< 0.007	0.049 ± 0.013	< 0.009	0.153 ± 0.020
Mn II 2577	< 0.013	< 0.006	< 0.011	< 0.008	< 0.038
Fe II 2587	0.028 ± 0.010	< 0.005	< 0.009	< 0.006	0.028 ± 0.010
Mn II 2594	< 0.012	< 0.005	< 0.011	< 0.007	< 0.034
Fe II 2600	0.099 ± 0.011	< 0.006	0.027 ± 0.012	< 0.008	0.126 ± 0.016
Mn II 2606	< 0.017	< 0.008	< 0.016	< 0.010	< 0.051
Mg II 2796	0.225 ± 0.006	0.012 ± 0.004	0.075 ± 0.007	0.024 ± 0.005	0.338 ± 0.011
Mg II 2803	0.156 ± 0.008	< 0.005	0.045 ± 0.009	< 0.006	0.202 ± 0.012
Mg I 2853	0.026 ± 0.009	< 0.004	< 0.008	< 0.006	0.026 ± 0.009

Table 3.40. Q1329 + 412 $z_{\rm abs} = 0.500785$

Ion/Tran	(v_1^-, v_1^+)
	$(-94, 69)$
Apparent Column Density [cm^{-2}]	
Mg II	12.974 ± 0.029
Mg I	< 11.369
Mn II[a]	...
Rest Frame Equivalent Width [Å]	
Mn II 2577	< 0.264
Fe II 2587	< 0.288
Mn II 2594	< 0.431
Fe II 2600	< 0.262
Mn II 2606	< 0.201
Mg II 2796	0.245 ± 0.083
Mg II 2803	0.181 ± 0.118
Mg I 2853	< 0.115

[a]Spectra of the Mn II triplet were of too poor quality to obtain an adopted limiting column density.

Table 3.41. Q1329 + 412 $z_{\rm abs} = 0.893337$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-45, 25)$	$(102, 139)$	$(-45, 139)$
	Apparent Column Density [$\rm cm^{-2}$]		
Mg II	13.053 ± 0.012	12.533 ± 0.029	13.167 ± 0.011
Fe II	12.687 ± 0.047	12.398 ± 0.066	12.867 ± 0.038
Mg I	< 11.043	< 10.913	< 11.284
Mn II	< 11.667	< 11.528	< 11.904
	Rest Frame Equivalent Width [Å]		
Fe II 2344	< 0.037	< 0.022	< 0.058
Fe II 2374	< 0.030	< 0.016	< 0.046
Fe II 2383	0.069 ± 0.021	0.032 ± 0.013	0.101 ± 0.025
Mn II 2577	< 0.035	< 0.019	< 0.054
Fe II 2587	< 0.034	< 0.021	< 0.054
Mn II 2594	< 0.037	< 0.023	< 0.060
Fe II 2600	0.051 ± 0.031	0.029 ± 0.018	0.080 ± 0.035
Mn II 2606	< 0.035	< 0.020	< 0.055
Mg II 2796	0.296 ± 0.017	0.104 ± 0.016	0.399 ± 0.023
Mg II 2803	0.148 ± 0.023	0.053 ± 0.016	0.201 ± 0.028
Mg I 2853	< 0.033	< 0.022	< 0.055

Table 3.42. Q1329 + 412 $z_{\rm abs} = 0.998358$

Ion/Tran	(v_1^-, v_1^+)
	$(-20, 21)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	12.712 ± 0.015
Fe II	12.708 ± 0.035
Mn II	< 11.499
Rest Frame Equivalent Width [Å]	
Fe II 2344	0.043 ± 0.018
Fe II 2374	< 0.018
Fe II 2383	0.062 ± 0.013
Mn II 2577	< 0.020
Fe II 2587	< 0.020
Mn II 2594	< 0.017
Fe II 2600	0.061 ± 0.018
Mn II 2606	< 0.022
Mg II 2796	0.139 ± 0.010
Mg II 2803	0.086 ± 0.015

Table 3.43. Q1354 + 193 $z_{\rm abs} = 0.456588$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-90, -61)$	$(-51, 56)$	$(-90, 56)$
		Apparent Column Density [cm^{-2}]	
Mg II	12.385 ± 0.053	> 13.727	13.747 ± 0.002
Fe II	< 12.441	> 13.543	> 13.543
Mg I	< 10.574	11.530 ± 0.097	11.575 ± 0.087
Ca II	< 10.578	< 10.855	< 11.039
		Rest Frame Equivalent Width [Å]	
Mn II 2594	< 0.044	< 0.128	< 0.172
Fe II 2600	< 0.033	0.149 ± 0.088	0.149 ± 0.088
Mn II 2606	< 0.025	< 0.092	< 0.117
Mg II 2796	0.069 ± 0.012	0.682 ± 0.020	0.751 ± 0.023
Mg II 2803	0.034 ± 0.011	0.544 ± 0.019	0.579 ± 0.022
Mg I 2853	< 0.009	0.038 ± 0.028	0.038 ± 0.028
Ca II 3934	< 0.008	< 0.022	< 0.029
Ca II 3969	< 0.007	< 0.020	< 0.027

Table 3.44. Q1421 + 331 $z_{\rm abs} = 0.843247$

Ion/Tran	(v_1^-, v_1^+)
	$(-16, 20)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	12.791 ± 0.040
Fe II	13.143 ± 0.034
Mg I	11.269 ± 0.079
Mn II	< 11.270
Rest Frame Equivalent Width [Å]	
Fe II 2344	0.042 ± 0.016
Fe II 2374	0.034 ± 0.018
Fe II 2383	0.069 ± 0.012
Mn II 2577	< 0.010
Fe II 2587	0.052 ± 0.009
Mn II 2594	< 0.013
Fe II 2600	0.069 ± 0.015
Mn II 2606	< 0.012
Mg II 2796	0.094 ± 0.008
Mg II 2803	0.085 ± 0.007
Mg I 2853	0.022 ± 0.008

Table 3.45. Q1421 + 331 $z_{\mathrm{abs}} = 0.902871$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	System
	$(-118, 46)$	$(50, 112)$	$(-118, 112)$
	Apparent Column Density [cm^{-2}]		
Mg II	> 13.827	12.914 ± 0.030	13.877 ± 0.003
Fe II	13.699 ± 0.026	11.928 ± 0.157	13.706 ± 0.026
Mg I	11.631 ± 0.071	< 10.632	11.673 ± 0.065
Mn II	< 11.558	< 11.344	< 11.765
	Rest Frame Equivalent Width [Å]		
Fe II 2344	0.163 ± 0.030	< 0.014	0.163 ± 0.030
Fe II 2374	0.063 ± 0.028	< 0.012	0.063 ± 0.028
Fe II 2383	0.309 ± 0.027	0.022 ± 0.015	0.331 ± 0.031
Mn II 2577	< 0.037	< 0.016	< 0.053
Fe II 2587	0.121 ± 0.045	< 0.022	0.121 ± 0.045
Mn II 2594	< 0.041	< 0.016	< 0.057
Fe II 2600	0.223 ± 0.034	< 0.016	0.223 ± 0.034
Mn II 2606	< 0.039	< 0.016	< 0.055
Mg II 2796	0.887 ± 0.015	0.160 ± 0.010	1.048 ± 0.018
Mg II 2803	0.650 ± 0.018	0.113 ± 0.010	0.763 ± 0.021
Mg I 2853	0.048 ± 0.032	< 0.014	0.048 ± 0.032

Table 3.46. Q1421 + 331 $z_{\mathrm{abs}} = 1.172609$

Ion/Tran	(v_1^-, v_1^+)
	$(-60, 53)$
Apparent Column Density [cm^{-2}]	
Mg II	13.429 ± 0.018
Fe II	13.049 ± 0.014
Mg I	11.688 ± 0.061
Mn II	< 11.432
Rest Frame Equivalent Width [Å]	
Fe II 2344	0.058 ± 0.020
Fe II 2374	< 0.022
Fe II 2383	0.140 ± 0.018
Mn II 2577	< 0.021
Fe II 2587	< 0.031
Fe II 2600	0.131 ± 0.018
Mn II 2606	< 0.020
Mg II 2796	0.517 ± 0.012
Mg II 2803	0.367 ± 0.018
Mg I 2853	0.057 ± 0.026

Table 3.47. Q1548 + 092 $z_{\rm abs} = 0.770646$

Ion/Tran	(v_1^-, v_1^+)
	$(-63, 63)$
Apparent Column Density [cm^{-2}]	
Mg II	13.166 ± 0.021
Fe II	12.932 ± 0.091
Mg I[a]	...
Mn II	< 11.774
Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.465
Fe II 2374	< 1.200
Fe II 2383	< 1.997
Mn II 2577	< 0.050
Fe II 2587	< 0.058
Mn II 2594	< 0.075
Fe II 2600	0.103 ± 0.075
Mn II 2606	< 0.070
Mg II 2796	0.300 ± 0.074
Mg II 2803	0.248 ± 0.080
Mg I 2853	0.038 ± 0.184

[a]The data for the Mg I transition were of too low quality to adopt a column density.

Table 3.48. Q1622 + 235 $z_{\rm abs} = 0.656114$

Ion/Tran	(v_1^-, v_1^+)
	$(-91, 89)$
Apparent Column Density [cm^{-2}]	
Mg II	> 14.072
Fe II	> 14.386
Mn II[a]	···
Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.130
Fe II 2374	0.447 ± 0.152
Fe II 2383	< 0.155
Mn II 2577	< 0.155
Fe II 2587[b]	0.700 ± 0.090
Mn II 2594	< 0.139
Fe II 2600	1.015 ± 0.050
Mn II 2606	< 0.182
Mg II 2796	1.449 ± 0.029
Mg II 2803	1.317 ± 0.032

[a]Spectra of the Mn II triplet were of too poor quality to obtain an adopted limiting column density.

[b]This transition is blended with Fe II $\lambda 2383$ in the $z_{\rm abs} = 0.7971$ system. The latter transition does not contribute to the quoted values.

Table 3.49. Q1622 + 235 $z_{\rm abs} = 0.797107$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	System
	$(-83, -46)$	$(-40, 26)$	$(47, 80)$	$(-83, 80)$
		Apparent Column Density [cm^{-2}]		
Mg II	12.631 ± 0.051	13.001 ± 0.050	12.509 ± 0.065	13.243 ± 0.034
Fe II	< 12.044	< 12.108	< 11.961	< 12.519
Mg I	< 10.910	< 11.297	< 11.380	< 11.715
Mn II	< 11.974	< 12.009	< 11.829	< 12.421
		Rest Frame Equivalent Width [Å]		
Fe II 2344	< 0.055	< 0.068	< 0.042	< 0.166
Fe II 2374	< 0.049	< 0.070	< 0.038	< 0.157
Fe II 2383[a]	⋯	⋯	⋯	⋯
Fe II 2587	< 0.024	< 0.038	< 0.021	< 0.083
Mn II 2594[b]	< 0.058	< 5.592	⋯	< 5.650
Fe II 2600	< 0.027	< 0.040	< 0.024	< 0.092
Mn II 2606	< 0.020	< 0.029	< 0.015	< 0.064
Mg II 2803	0.077 ± 0.015	0.147 ± 0.021	0.050 ± 0.013	0.274 ± 0.029
Mg I 2853	< 0.021	< 0.035	< 0.198	< 0.254

[a]This transition is blended with Fe II $\lambda 2587$ in the $z_{\rm abs} = 0.7971$ system. The latter transition completely dominates the absorption.

[b]Transition only partially observed.

Table 3.50. Q1622 + 235 $z_{\rm abs} = 0.891253$

Ion/Tran	(v_1^-, v_1^+)
	$(-114, 95)$
Apparent Column Density [cm^{-2}]	
Mg II	> 14.174
Fe II	> 14.729
Mg I	12.491 ± 0.014
Mn II	< 11.903
Rest Frame Equivalent Width [Å]	
Fe II 2344	0.659 ± 0.102
Fe II 2374	0.431 ± 0.089
Fe II 2383	1.517 ± 1.587
Mn II 2577	< 0.069
Fe II 2587	0.754 ± 0.344
Mn II 2594	< 0.100
Fe II 2600	1.080 ± 0.421
Mn II 2606	< 0.089
Mg II 2796	1.534 ± 0.025
Mg II 2803	1.369 ± 0.024
Mg I 2853	0.307 ± 0.033

Table 3.51. Q1634 + 704 $z_{\rm abs} = 0.905554$

Ion/Tran	(v_1^-, v_1^+)
	$(-17, 19)$
Apparent Column Density [cm^{-2}]	
Mg II	12.352 ± 0.010
Fe II	< 11.338
Mn II	< 11.111
Rest Frame Equivalent Width [Å]	
Fe II 2344	< 0.011
Fe II 2374	< 0.012
Fe II 2383	< 0.021
Mn II 2577	< 0.009
Fe II 2587	< 0.008
Mn II 2594	< 0.008
Fe II 2600	< 0.007
Mn II 2606	< 0.006
Mg II 2796	0.064 ± 0.004
Mg II 2803	0.045 ± 0.004

Table 3.52. Q1634 + 704 $z_{\rm abs} = 0.990240$

Ion/Tran	(v_1^-, v_1^+)
	$(-48, 59)$
Apparent Column Density [$\rm cm^{-2}$]	
Mg II	13.519 ± 0.001
Fe II	13.059 ± 0.010
Mg I	11.684 ± 0.024
Mn II	< 11.290
Rest Frame Equivalent Width [Å]	
Fe II 2344	0.069 ± 0.037
Fe II 2374	< 0.033
Fe II 2383	0.135 ± 0.018
Mn II 2577	< 0.022
Fe II 2587	0.042 ± 0.015
Mn II 2594	< 0.014
Fe II 2600	0.127 ± 0.011
Mn II 2606	< 0.015
Mg II 2796	0.558 ± 0.005
Mg II 2803	0.421 ± 0.006
Mg I 2853	0.058 ± 0.010

Table 3.53. Q2128 − 123 $z_{\rm abs} = 0.429735$

Ion/Tran	(v_1^-, v_1^+)
	$(-54, 35)$
Apparent Column Density [cm^{-2}]	
Mg II	13.471 ± 0.003
Mg I	12.248 ± 0.023
Ca II	11.938 ± 0.034
Rest Frame Equivalent Width [Å]	
Mg II 2796	0.406 ± 0.014
Mg II 2803	0.352 ± 0.015
Mg I 2853	0.162 ± 0.026
Ca II 3934	0.070 ± 0.017
Ca II 3969	0.028 ± 0.017

Table 3.54. Q2145 + 064 $z_{\rm abs} = 0.790777$

Ion/Tran	(v_1^-, v_1^+)	(v_2^-, v_2^+)	(v_3^-, v_3^+)	System
	$(-127, -82)$	$(-23, 30)$	$(32, 105)$	$(-127, 105)$
		Apparent Column Density [cm^{-2}]		
Mg II	12.860 ± 0.006	12.681 ± 0.011	12.845 ± 0.009	13.279 ± 0.005
Fe II	12.688 ± 0.035	...	12.401 ± 0.149	12.869 ± 0.056
Mg I	< 10.558	< 10.597	< 10.660	< 11.084
Mn II	< 11.359	< 11.387	< 11.461	< 11.882
		Rest Frame Equivalent Width [Å]		
Fe II 2344	0.008 ± 0.016	< 0.019	< 0.026	0.008 ± 0.016
Fe II 2374	< 0.017	< 0.019	< 0.026	< 0.063
Fe II 2383	0.053 ± 0.019	< 0.026	0.034 ± 0.032	0.087 ± 0.038
Mn II 2577	< 0.017	< 0.017	< 0.023	< 0.057
Fe II 2587[a]	...	...	...	...
Mn II 2594	< 0.013	< 0.014	< 0.019	< 0.047
Fe II 2600	0.041 ± 0.014	< 0.019	< 0.023	0.041 ± 0.014
Mn II 2606	< 0.016	< 0.018	< 0.023	< 0.057
Mg II 2796	0.148 ± 0.006	0.139 ± 0.008	0.196 ± 0.011	0.483 ± 0.015
Mg II 2803	0.119 ± 0.009	0.095 ± 0.011	0.141 ± 0.013	0.356 ± 0.019
Mg I 2853	< 0.011	< 0.012	< 0.015	< 0.038

[a]Area of spectrum compromised by the pen mark on the HIRES CCD.

Table 3.55: Q0002 + 051: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.591485$		Mg II					
1	0.0	12.63 ± 0.01	6.78 ± 0.22				
$z_{\rm abs} = 0.851394$		Mg II		Fe II		Mg I	
1	-39.5	12.39 ± 1.13	4.47 ± 3.10	...	...	...	...
2	-30.9	13.69 ± 0.14	5.90 ± 2.96	13.31 ± 0.01	3.94 ± 0.11	11.66 ± 0.23	6.03 ± 3.07
3	-12.9	15.76 ± 2.79	5.99 ± 0.45	13.72 ± 0.01	5.68 ± 0.16	11.74 ± 0.15	4.22 ± 1.38
4	5.2	13.64 ± 0.07	4.87 ± 0.30	13.18 ± 0.02	3.43 ± 0.18	11.55 ± 0.18	4.97 ± 1.89
5	28.2	12.31 ± 0.26	5.81 ± 1.37	12.04 ± 0.12	1.38 ± 1.21	...	...
6	36.6	12.06 ± 1.97	14.5 ± 26.1	11.32 ± 1.00	11.9 ± 27.6	...	...
7	142.8	12.92 ± 0.02	3.03 ± 0.17	12.43 ± 0.05	1.86 ± 0.55	...	...
8	149.4	12.39 ± 0.06	9.41 ± 0.79	11.39 ± 0.52	8.15 ± 10.9	...	...
9	172.4	13.42 ± 0.03	3.44 ± 0.14	12.30 ± 0.06	5.59 ± 1.14	...	...
10	182.6	13.20 ± 0.01	4.48 ± 0.17	12.42 ± 0.04	3.58 ± 0.56	...	...
11	296.0	12.04 ± 0.03	6.70 ± 0.70	...	...	...	...
12	407.4	12.05 ± 0.03	5.23 ± 0.54	...	...	...	...

Table 3.56: Q0058 + 019: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.612672$		Mg II		Fe II		Mg I		Mn II	
1	-96.3	12.79 ± 0.01	6.30 ± 0.30	12.95 ± 0.05	8.46 ± 1.38	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	-64.0	13.74 ± 0.28	10.2 ± 1.36	14.53 ± 1.01	3.48 ± 2.05	11.46 ± 0.21	15.22 ± 6.67	$\cdots$	$\cdots$
3	-40.1	14.22 ± 1.81	17.0 ± 19.5	14.57 ± 0.04	18.8 ± 0.78	12.44 ± 0.04	15.97 ± 1.18	13.07 ± 0.36	15.9 ± 3.72
4	-14.3	14.26 ± 0.85	18.1 ± 58.2	14.53 ± 0.10	12.1 ± 1.53	12.07 ± 0.09	18.26 ± 3.72	12.41 ± 0.31	7.67 ± 3.44
5	22.0	14.18 ± 0.06	19.2 ± 1.35	14.40 ± 0.01	12.8 ± 0.62	$\cdots$	$\cdots$	12.68 ± 0.33	23.0 ± 9.57
6	61.1	13.35 ± 0.02	7.24 ± 0.46	13.81 ± 0.03	9.28 ± 0.59	$\cdots$	$\cdots$	$\cdots$	$\cdots$
7	77.1	14.96 ± 0.53	3.23 ± 0.43	13.86 ± 0.07	4.79 ± 0.44	$\cdots$	$\cdots$	11.98 ± 1.29	15.6 ± 24.8
$z_{\rm abs} = 0.725173$		Mg II		Mg I					
1	-1.4	13.43 ± 0.01	8.89 ± 0.14	11.69 ± 0.06	7.38 ± 1.49				

Table 3.57: Q0117 + 212: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.576398$		Mg II		Mg I		Ca II	
1	-27.6	13.73 ± 0.09	12.0 ± 0.56	10.62 ± 0.32	1.79 ± 4.04	...	...
2	-10.0	14.50 ± 9.99	3.91 ± 16.5	11.90 ± 0.03	11.1 ± 0.92	11.65 ± 0.09	10.5 ± 2.48
3	19.8	14.34 ± 0.07	13.6 ± 0.36	11.71 ± 0.07	20.7 ± 4.07	...	...
4	77.2	11.60 ± 0.06	4.56 ± 1.11	...	...	...	...
$z_{\rm abs} = 0.729055$		Mg II		Fe II		Mg I	
1	-81.6	12.50 ± 0.01	4.06 ± 0.15	12.18 ± 0.06	5.05 ± 1.30	...	...
2	-64.0	12.07 ± 0.02	3.51 ± 0.30	11.77 ± 2.99	3.35 ± 2.56	...	...
3	-9.0	11.67 ± 0.04	4.05 ± 0.70	12.07 ± 9.99	0.24 ± 89.16	...	...
4	12.2	12.76 ± 0.02	3.64 ± 0.12	12.57 ± 0.03	3.36 ± 0.50	11.17 ± 0.08	1.41 ± 0.95
5	67.3	11.50 ± 0.06	4.87 ± 1.23	12.21 ± 0.21	13.5 ± 8.87	...	...
$z_{\rm abs} = 1.047971$		Mg II		Fe II		Mg I	
1	-97.0	11.55 ± 0.09	2.98 ± 1.21	11.32 ± 0.39	9.76 ± 11.3	...	...
2	-85.8	12.46 ± 0.01	5.28 ± 0.26	12.00 ± 0.05	4.56 ± 0.71	...	...
3	-23.3	12.20 ± 0.06	10.8 ± 1.26	...	...	...	...
4	-0.2	12.74 ± 0.13	10.3 ± 1.93	12.40 ± 0.09	12.5 ± 1.96	11.02 ± 0.12	14.43 ± 5.26
5	6.0	12.21 ± 0.28	4.44 ± 1.26	11.70 ± 0.17	1.61 ± 2.35	9.12 ± 5.83	1.01 ± 29.30
6	17.4	12.38 ± 0.11	6.44 ± 0.94	11.65 ± 0.29	4.24 ± 2.48	10.40 ± 9.99	$0.04 \pm \cdots$
7	33.5	11.91 ± 0.08	9.05 ± 1.66	11.84 ± 0.44	12.5 ± 6.33	9.87 ± 0.60	1.32 ± 6.55
$z_{\rm abs} = 1.325014$		Mg II		Fe II		Mg I	
1	-81.6	11.62 ± 0.06	1.30 ± 0.62	...	...	...	...
2	-58.8	12.69 ± 0.02	2.75 ± 0.08	11.83 ± 0.04	2.01 ± 0.95	...	...
3	-34.6	11.22 ± 0.06	1.41 ± 1.18	...	...	...	...
4	-5.1	12.31 ± 0.01	2.82 ± 0.14	11.80 ± 0.04	3.67 ± 0.89	10.73 ± 0.08	4.45 ± 1.49
5	47.8	12.60 ± 0.01	3.29 ± 0.09	12.18 ± 0.02	1.98 ± 0.42	...	...
6	143.0	12.32 ± 0.01	4.07 ± 0.14	...	...	...	...
$z_{\rm abs} = 1.342969$		Mg II		Fe II			
1	-136.7	11.82 ± 0.05	4.13 ± 0.95	...	...		
2	-103.9	12.01 ± 0.04	6.40 ± 0.84	...	...		
3	-59.3	11.61 ± 0.10	7.64 ± 2.40	...	...		
4	0.9	12.98 ± 0.02	3.97 ± 0.16	12.49 ± 0.02	2.31 ± 0.20		
5	11.3	11.83 ± 0.06	3.79 ± 1.08	11.72 ± 0.45	0.46 ± 0.18		

Table 3.58: Q0420 − 014: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.633004$		Mg II		Fe II		Mg I	
1	-225.0	12.34 ± 0.06	4.13 ± 0.80	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	-215.8	11.95 ± 0.14	3.47 ± 1.53	$\cdots$	$\cdots$	$\cdots$	$\cdots$
3	-82.3	11.91 ± 0.12	4.15 ± 1.25	$\cdots$	$\cdots$	$\cdots$	$\cdots$
4	-62.2	12.47 ± 0.07	15.1 ± 2.96	$\cdots$	$\cdots$	$\cdots$	$\cdots$
5	-39.5	12.62 ± 0.01	5.99 ± 0.60	$\cdots$	$\cdots$	$\cdots$	$\cdots$
6	-22.5	13.05 ± 0.04	15.7 ± 1.34	$\cdots$	$\cdots$	$\cdots$	$\cdots$
7	5.4	13.22 ± 0.41	2.24 ± 0.61	12.13 ± 0.28	6.93 ± 6.05	11.01 ± 1.16	28.9 ± 61.1
8	16.1	13.37 ± 0.05	8.83 ± 0.70	12.64 ± 0.09	5.94 ± 1.89	11.57 ± 0.15	11.1 ± 3.37
9	30.9	12.80 ± 0.03	3.97 ± 0.41	12.20 ± 0.15	1.79 ± 3.27	10.99 ± 0.27	3.74 ± 2.80

Table 3.59: Q0450 − 132: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.493937$		Mg II		Mg I		Ca II	
1	-26.6	12.93 ± 0.15	18.62 ± 4.01	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	7.0	13.84 ± 0.08	17.82 ± 1.13	11.78 ± 0.07	12.64 ± 2.44	11.7 ± 0.05	12.44 ± 1.91
$z_{\rm abs} = 1.174615$		Mg II		Fe II		Mn II	
1	-104.1	$12.36 \pm \cdots$	$2.92 \pm \cdots$	12.46 ± 0.05	1.74 ± 0.42	$\cdots$	$\cdots$
2	-81.9	$13.07 \pm \cdots$	$10.4 \pm \cdots$	13.23 ± 0.03	6.38 ± 0.38	$\cdots$	$\cdots$
3	-66.8	$15.90 \pm \cdots$	$3.88 \pm \cdots$	15.27 ± 0.62	2.16 ± 0.38	12.39 ± 0.07	4.00 ± 0.70
4	-51.7	$16.66 \pm \cdots$	$7.41 \pm \cdots$	14.80 ± 0.20	11.1 ± 0.40	12.50 ± 0.14	11.1 ± 0.76
5	-19.2	$13.01 \pm \cdots$	$9.77 \pm \cdots$	12.87 ± 0.11	5.94 ± 0.40	$\cdots$	$\cdots$
6	20.6	$16.21 \pm \cdots$	$64.5 \pm \cdots$	13.82 ± 0.09	4.49 ± 0.77	$\cdots$	$\cdots$
7	21.5	$13.70 \pm \cdots$	$13.9 \pm \cdots$	13.62 ± 0.48	15.7 ± 3.47	$\cdots$	$\cdots$
8	40.8	$13.74 \pm \cdots$	$29.7 \pm \cdots$	13.47 ± 0.65	13.3 ± 6.12	$\cdots$	$\cdots$
9	50.0	$13.43 \pm \cdots$	$9.43 \pm \cdots$	13.80 ± 0.05	2.43 ± 0.53	12.01 ± 0.09	1.70 ± 1.12
10	74.2	$12.61 \pm \cdots$	$9.37 \pm \cdots$	12.01 ± 0.21	5.48 ± 2.95	$\cdots$	$\cdots$
11	87.3	$14.10 \pm \cdots$	$3.58 \pm \cdots$	12.60 ± 0.08	5.16 ± 0.74	$\cdots$	$\cdots$
12	113.1	$12.38 \pm \cdots$	$10.1 \pm \cdots$	11.73 ± 0.16	6.61 ± 3.40	$\cdots$	$\cdots$
13	159.5	12.23 ± 0.03	3.91 ± 0.43	12.12 ± 0.09	1.75 ± 1.53	$\cdots$	$\cdots$

Table 3.60: Q0454 + 039: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.859565$		Mg II		Fe II		Mg I		Mn II	
1	-72.2	13.03 ± 0.07	6.25 ± 0.51	12.73 ± 0.03	3.00 ± 0.36	10.34 ± 0.46	7.00 ± 10.4	$\cdots$	$\cdots$
2	-53.8	14.50 ± 2.91	6.50 ± 7.67	14.51 ± 0.05	6.50 ± 0.33	11.74 ± 0.04	6.50 ± 0.72	12.16 ± 0.07	6.50 ± 1.27
3	-42.5	$13.94 \pm \cdots$	$5.00 \pm \cdots$	13.33 ± 0.21	5.00 ± 1.46	11.19 ± 0.16	5.00 ± 1.81	11.60 ± 0.22	5.00 ± 3.33
4	-26.9	$13.87 \pm \cdots$	$8.75 \pm \cdots$	13.51 ± 0.06	8.75 ± 1.64	11.12 ± 0.22	8.75 ± 5.72	12.13 ± 0.05	5.00 ± 1.01
5	-10.4	$14.22 \pm \cdots$	$5.50 \pm \cdots$	13.77 ± 0.19	5.25 ± 0.99	11.47 ± 0.16	5.50 ± 1.27	11.43 ± 0.34	5.50 ± 5.67
6	4.2	$14.51 \pm \cdots$	$10.8 \pm \cdots$	14.31 ± 0.13	10.5 ± 3.49	11.75 ± 0.17	10.8 ± 4.13	12.34 ± 0.11	7.25 ± 1.59
7	21.2	$14.62 \pm \cdots$	$8.00 \pm \cdots$	14.73 ± 0.14	8.00 ± 1.62	11.86 ± 0.10	8.00 ± 1.26	12.66 ± 0.07	9.25 ± 1.75
8	39.6	$13.99 \pm \cdots$	$6.75 \pm \cdots$	13.88 ± 0.14	6.75 ± 2.21	11.24 ± 0.21	6.75 ± 3.90	11.65 ± 0.57	6.75 ± 9.22
9	53.8	$13.87 \pm \cdots$	$5.50 \pm \cdots$	13.51 ± 0.54	5.50 ± 5.30	11.12 ± 0.57	5.50 ± 6.16	11.53 ± 0.84	5.50 ± 10.9
10	60.8	$14.05 \pm \cdots$	4.00 ± 59.7	13.68 ± 0.29	4.25 ± 0.68	11.30 ± 0.30	3.50 ± 1.40	11.71 ± 0.38	3.50 ± 2.26
11	73.6	12.73 ± 0.79	7.00 ± 4.26	12.73 ± 0.04	4.50 ± 0.54	10.34 ± 0.47	7.50 ± 11.3	$\cdots$	$\cdots$
12	106.2	12.04 ± 0.06	3.00 ± 1.06	12.04 ± 0.05	3.00 ± 0.90	10.48 ± 0.20	3.00 ± 3.64	11.19 ± 0.25	3.00 ± 4.45
$z_{\rm abs} = 1.153248$		Mg II		Fe II		Mg I			
1	-96.3	12.00 ± 0.02	2.86 ± 0.36	11.97 ± 0.06	2.02 ± 1.14	$\cdots$	$\cdots$		
2	-11.5	12.57 ± 0.08	9.22 ± 0.53	12.06 ± 0.08	3.86 ± 1.20	$\cdots$	$\cdots$		
3	-1.2	13.24 ± 0.02	8.46 ± 0.42	12.54 ± 0.03	4.07 ± 0.50	10.87 ± 0.12	3.56 ± 1.66		
4	12.4	12.58 ± 0.04	9.35 ± 0.49	12.02 ± 0.09	9.25 ± 2.27	10.18 ± 0.67	2.53 ± 6.37		
5	41.8	11.63 ± 0.06	7.42 ± 1.37	11.32 ± 0.25	3.25 ± 1.48	$\cdots$	$\cdots$		
6	67.7	11.62 ± 0.05	6.35 ± 1.13	11.49 ± 0.18	6.60 ± 3.94	$\cdots$	$\cdots$		
7	99.0	11.99 ± 0.02	3.27 ± 0.35	$\cdots$	$\cdots$	$\cdots$	$\cdots$		

Table 3.61: Q0454 − 220: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.474410$		Mg II		Fe II		Mg I		Ca II	
1	−83.1	$12.43 \pm \cdots$	$1.33 \pm \cdots$	$\cdots$	$\cdots$	$10.63 \pm \cdots$	$5.20 \pm \cdots$	$\cdots$	$\cdots$
2	−77.3	$12.28 \pm \cdots$	$2.99 \pm \cdots$	$11.11 \pm \cdots$	$6.56 \pm \cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
3	−64.2	$12.51 \pm \cdots$	$7.39 \pm \cdots$	$11.80 \pm \cdots$	$3.97 \pm \cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
4	−57.0	$12.47 \pm \cdots$	$3.68 \pm \cdots$	$12.15 \pm \cdots$	$7.17 \pm \cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
5	−48.3	$12.90 \pm \cdots$	$4.81 \pm \cdots$	$12.71 \pm \cdots$	$2.60 \pm \cdots$	$11.05 \pm \cdots$	$2.61 \pm \cdots$	$\cdots$	$\cdots$
6	−39.1	$14.06 \pm \cdots$	$3.67 \pm \cdots$	$12.47 \pm \cdots$	$5.19 \pm \cdots$	$11.02 \pm \cdots$	$5.98 \pm \cdots$	$\cdots$	$\cdots$
7	−24.9	$14.44 \pm \cdots$	$2.81 \pm \cdots$	$13.10 \pm \cdots$	$1.99 \pm \cdots$	$10.91 \pm \cdots$	$12.4 \pm \cdots$	$\cdots$	$\cdots$
8	−15.6	$12.99 \pm \cdots$	$2.24 \pm \cdots$	$15.68 \pm \cdots$	$2.34 \pm \cdots$	$11.93 \pm \cdots$	$7.75 \pm \cdots$	$11.60 \pm \cdots$	$6.10 \pm \cdots$
9	−3.7	$14.09 \pm \cdots$	$4.05 \pm \cdots$	$13.97 \pm \cdots$	$39.4 \pm \cdots$	$11.59 \pm \cdots$	$3.79 \pm \cdots$	$11.62 \pm \cdots$	$5.59 \pm \cdots$
10	5.8	$13.48 \pm \cdots$	$12.9 \pm \cdots$	$14.77 \pm \cdots$	$10.1 \pm \cdots$	$11.95 \pm \cdots$	$7.99 \pm \cdots$	$11.19 \pm \cdots$	$1.17 \pm \cdots$
11	16.9	$12.95 \pm \cdots$	$5.09 \pm \cdots$	$12.63 \pm \cdots$	$8.19 \pm \cdots$	$11.67 \pm \cdots$	$4.63 \pm \cdots$	$11.43 \pm \cdots$	$10.0 \pm \cdots$
12	27.1	$14.39 \pm \cdots$	$2.54 \pm \cdots$	$14.87 \pm \cdots$	$1.29 \pm \cdots$	$11.50 \pm \cdots$	$6.53 \pm \cdots$	$\cdots$	$\cdots$
13	40.1	$13.38 \pm \cdots$	$8.84 \pm \cdots$	$13.22 \pm \cdots$	$6.89 \pm \cdots$	$10.78 \pm \cdots$	$12.9 \pm \cdots$	$\cdots$	$\cdots$
14	52.1	$13.33 \pm \cdots$	$6.29 \pm \cdots$	$13.63 \pm \cdots$	$4.59 \pm \cdots$	$11.33 \pm \cdots$	$9.76 \pm \cdots$	$\cdots$	$\cdots$
15	64.3	$12.76 \pm \cdots$	$7.02 \pm \cdots$	$12.21 \pm \cdots$	$3.92 \pm \cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
16	84.3	$11.84 \pm \cdots$	$8.06 \pm \cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
$z_{\rm abs} = 0.483340$		Mg II		Fe II		Mg I		Ca II	
1	−46.4	11.73 ± 0.04	1.78 ± 0.69	$\cdots$	$\cdots$	10.47 ± 0.23	5.69 ± 4.93	$\cdots$	$\cdots$
2	−33.0	12.32 ± 0.01	3.81 ± 0.24	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
3	−20.9	11.94 ± 0.03	2.16 ± 0.66	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
4	−7.7	12.96 ± 0.12	4.74 ± 0.82	13.16 ± 0.19	4.32 ± 1.07	10.93 ± 0.21	7.15 ± 4.51	$\cdots$	$\cdots$
5	1.6	13.43 ± 0.90	3.33 ± 2.80	14.55 ± 3.62	3.22 ± 4.36	11.68 ± 0.10	4.98 ± 0.98	11.39 ± 0.13	6.16 ± 1.57
6	6.2	12.89 ± 0.12	5.89 ± 1.06	$\cdots$	$\cdots$	11.18 ± 0.23	1.76 ± 1.74	$\cdots$	$\cdots$
7	21.2	12.35 ± 0.03	4.28 ± 0.38	$\cdots$	$\cdots$	10.47 ± 0.16	2.76 ± 3.23	$\cdots$	$\cdots$

Table 3.62: Q0823 – 223: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.705472$		Mg II					
1	-0.3	12.40 ± 0.02	13.30 ± 0.62				
$z_{\rm abs} = 0.911017$		Mg II		Fe II		Mg I	
1	-139.2	12.49 ± 0.01	1.53 ± 0.12	12.21 ± 0.01	1.97 ± 0.68	10.76 ± 5.56	5.64 ± 4.65
2	-119.3	12.35 ± 0.01	4.23 ± 0.29	12.22 ± 0.01	4.23 ± 0.77	...	...
3	-117.7	12.44 ± 0.01	27.5 ± 2.05	...	...	...	...
4	-67.5	13.25 ± 0.01	7.17 ± 0.15	13.04 ± 0.01	6.56 ± 0.20	11.93 ± 0.01	6.90 ± 0.44
5	-52.4	12.80 ± 0.01	3.51 ± 0.32	12.33 ± 0.01	1.02 ± 0.17	11.47 ± 0.04	3.32 ± 0.72
6	-43.2	12.27 ± 0.02	3.00 ± 0.50	11.98 ± 0.01	3.74 ± 1.16	...	...
7	-29.3	12.02 ± 0.01	5.01 ± 0.54	11.53 ± 0.01	1.09 ± 0.87	10.69 ± 0.46	11.3 ± 10.7
8	-2.2	12.27 ± 0.01	0.95 ± 0.20	11.92 ± 0.02	0.85 ± 0.21	10.90 ± 0.09	5.74 ± 5.62
9	6.3	12.62 ± 0.04	2.58 ± 0.44	12.55 ± 0.01	0.96 ± 0.22	11.32 ± 0.34	11.5 ± 8.76
10	8.2	12.98 ± 0.01	17.8 ± 0.65	...	...	...	...
11	13.8	12.49 ± 0.01	3.22 ± 0.60	12.36 ± 0.01	3.57 ± 0.69	...	...
12	46.2	12.53 ± 0.01	9.92 ± 0.40	12.43 ± 0.01	10.3 ± 0.97	10.18 ± 0.22	5.51 ± 16.7
13	62.9	11.45 ± 0.03	0.77 ± 0.14	...	...	...	...
14	131.2	12.48 ± 0.08	9.78 ± 1.08	12.37 ± 0.09	8.26 ± 1.70	11.09 ± 0.33	18.8 ± 12.1
15	140.3	12.40 ± 0.11	3.53 ± 0.89	12.31 ± 0.11	1.96 ± 1.15	...	...
16	150.1	12.68 ± 0.09	10.3 ± 2.05	12.62 ± 0.09	8.84 ± 2.03	...	...
17	166.1	12.30 ± 0.05	3.93 ± 0.43	12.19 ± 0.05	1.88 ± 0.87	...	...
18	216.5	11.79 ± 0.03	3.64 ± 0.59	12.01 ± 0.12	1.56 ± 0.98	...	...

Table 3.63: Q1101 − 264: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.356286$		Mg II	
1	0.4	12.83 ± 0.01	24.5 ± 0.66
$z_{\rm abs} = 0.359002$		Mg II	
1	−37.4	11.91 ± 0.05	10.4 ± 1.75
2	−8.0	13.48 ± 0.04	7.92 ± 0.30
3	14.0	12.18 ± 0.05	5.03 ± 1.03
4	30.2	12.98 ± 0.02	6.26 ± 0.40
5	46.6	12.42 ± 0.03	5.40 ± 0.48
6	71.4	11.57 ± 0.07	3.99 ± 1.28

Table 3.64: Q1148 + 384: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.553362$		Mg II		Fe II	
1	-79.8	12.56 ± 0.04	2.90 ± 0.27	12.23 ± 0.90	1.08 ± 0.96
2	-49.4	12.78 ± 0.02	6.02 ± 0.24	12.61 ± 0.07	5.29 ± 1.34
3	-6.0	12.64 ± 0.04	7.15 ± 0.74	12.32 ± 0.15	5.85 ± 3.01
4	6.6	12.91 ± 0.04	4.11 ± 0.37	12.62 ± 0.08	3.16 ± 1.21
5	25.6	12.41 ± 0.03	3.62 ± 0.34	11.88 ± 0.29	3.99 ± 5.13
6	49.7	12.43 ± 0.03	3.79 ± 0.41	11.93 ± 0.24	2.91 ± 4.45
7	63.6	12.09 ± 0.04	4.94 ± 0.83	···	···
8	85.5	11.85 ± 0.05	3.52 ± 0.90	···	···

Table 3.65: Q1206 + 456: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.927602$		Mg II		Fe II		Mg I	
1	-403.5	11.92 ± 0.03	5.98 ± 0.55	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	-350.7	12.16 ± 0.02	2.89 ± 0.26	$\cdots$	$\cdots$	$\cdots$	$\cdots$
3	-327.7	12.12 ± 0.02	2.98 ± 0.28	$\cdots$	$\cdots$	$\cdots$	$\cdots$
4	-256.8	12.35 ± 0.01	4.77 ± 0.20	$\cdots$	$\cdots$	$\cdots$	$\cdots$
5	-188.0	12.01 ± 0.02	3.10 ± 0.37	$\cdots$	$\cdots$	$\cdots$	$\cdots$
6	-174.2	11.60 ± 0.05	3.69 ± 0.89	$\cdots$	$\cdots$	$\cdots$	$\cdots$
7	-62.8	11.72 ± 0.07	16.3 ± 3.54	$\cdots$	$\cdots$	$\cdots$	$\cdots$
8	-29.0	13.44 ± 0.04	5.67 ± 0.15	12.75 ± 0.02	6.19 ± 0.27	11.03 ± 0.10	5.09 ± 1.51
9	-13.3	11.53 ± 0.08	1.07 ± 0.26	$\cdots$	$\cdots$	$\cdots$	$\cdots$
10	6.0	13.29 ± 0.01	7.38 ± 0.14	12.21 ± 0.06	8.52 ± 1.26	11.30 ± 0.10	10.4 ± 1.89
11	30.4	12.60 ± 0.01	12.7 ± 0.49	$\cdots$	$\cdots$	$\cdots$	$\cdots$
12	66.0	12.82 ± 0.01	5.08 ± 0.10	12.07 ± 0.05	2.85 ± 0.76	10.81 ± 0.29	12.3 ± 6.50
$z_{\rm abs} = 0.934283$		Mg II					
1	-13.0	10.87 ± 0.15	0.45 ± 0.26				
2	0.8	12.05 ± 0.02	7.52 ± 0.52				

Table 3.66: Q1213 – 003: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 1.320059$		Mg II		Fe II		Mg I	
1	-202.8	12.57 ± 0.02	3.80 ± 0.19	11.73 ± 0.11	3.23 ± 2.12	$\cdots$	$\cdots$
2	-179.0	12.28 ± 0.02	5.79 ± 0.38	11.41 ± 0.26	4.09 ± 4.82	$\cdots$	$\cdots$
3	-157.8	12.54 ± 0.03	3.44 ± 0.31	12.23 ± 0.05	7.52 ± 1.25	10.94 ± 0.13	4.18 ± 2.18
4	-128.5	13.37 ± 0.01	25.2 ± 0.01	12.84 ± 0.03	6.59 ± 0.46	11.41 ± 0.12	10.4 ± 2.54
5	-117.6	14.52 ± 0.01	8.06 ± 0.01	13.42 ± 0.02	5.41 ± 0.35	11.85 ± 0.05	10.3 ± 1.23
6	-95.0	15.95 ± 0.01	8.68 ± 0.01	13.51 ± 0.02	11.9 ± 0.92	11.56 ± 0.08	5.69 ± 1.12
7	-84.4	$14.03 \pm \cdots$	$2.59 \pm \cdots$	13.28 ± 0.05	6.84 ± 1.14	11.48 ± 0.12	8.79 ± 2.84
8	-65.0	14.09 ± 0.01	9.21 ± 0.01	14.04 ± 0.02	9.19 ± 0.38	12.07 ± 0.03	7.99 ± 0.55
9	-46.9	13.18 ± 0.01	5.40 ± 0.11	13.20 ± 0.04	3.05 ± 0.38	11.53 ± 0.04	3.02 ± 0.82
10	-39.4	12.95 ± 0.85	1.76 ± 1.16	12.10 ± 0.12	1.54 ± 1.22	$\cdots$	$\cdots$
11	-26.6	12.72 ± 0.03	3.43 ± 0.20	12.29 ± 0.04	2.85 ± 0.66	10.48 ± 0.62	7.80 ± 12.3
12	2.3	12.79 ± 0.01	47.4 ± 0.01	12.32 ± 0.12	2.51 ± 0.76	$\cdots$	$\cdots$
13	15.0	14.95 ± 0.46	7.44 ± 0.79	13.14 ± 0.57	5.63 ± 2.23	11.84 ± 0.13	3.34 ± 0.82
14	24.6	$11.64 \pm \cdots$	$3.20 \pm \cdots$	13.44 ± 0.37	10.2 ± 7.15	11.23 ± 0.80	6.48 ± 14.1
15	36.9	$14.05 \pm \cdots$	2.89 ± 58.6	13.15 ± 0.24	3.60 ± 1.94	11.73 ± 0.12	4.29 ± 1.41
16	44.7	$13.83 \pm \cdots$	$1.63 \pm \cdots$	12.94 ± 0.19	3.25 ± 1.83	10.30 ± 2.50	4.12 ± 28.5
17	54.9	$13.69 \pm \cdots$	$4.49 \pm \cdots$	13.30 ± 0.04	3.53 ± 0.63	11.53 ± 0.13	4.01 ± 1.66
18	63.3	14.27 ± 4.59	2.53 ± 4.71	13.12 ± 0.06	2.03 ± 0.46	11.42 ± 0.14	4.23 ± 1.81
19	73.2	13.40 ± 4.45	2.32 ± 9.98	13.05 ± 0.06	5.75 ± 1.42	11.33 ± 0.10	3.00 ± 1.62
20	87.2	13.68 ± 0.91	7.51 ± 6.87	13.65 ± 0.03	4.43 ± 0.44	12.07 ± 0.03	4.87 ± 0.56
21	96.7	13.19 ± 4.09	12.6 ± 68.73	12.98 ± 0.07	2.71 ± 0.64	11.66 ± 7.30	3.53 ± 5.48
22	106.8	13.10 ± 2.63	11.5 ± 3.24	12.70 ± 0.06	6.74 ± 1.10	11.26 ± 0.13	8.37 ± 3.03
23	128.1	13.01 ± 0.02	4.30 ± 0.42	12.66 ± 0.03	4.67 ± 0.46	11.12 ± 0.12	5.39 ± 2.05
24	140.2	12.36 ± 0.02	3.87 ± 0.39	12.02 ± 0.04	3.43 ± 0.88	$\cdots$	$\cdots$

Table 3.67: Q1213 − 003: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 1.554148$		Mg II		Fe II		Mg I	
1	-255.1	12.09 ± 0.03	7.87 ± 0.65	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	-201.3	12.32 ± 0.02	7.39 ± 0.40	11.16 ± 0.37	3.97 ± 6.96	$\cdots$	$\cdots$
3	-173.2	12.92 ± 0.01	6.39 ± 0.19	12.24 ± 0.01	4.68 ± 0.57	$\cdots$	$\cdots$
4	-152.3	11.92 ± 0.11	8.70 ± 2.13	13.44 ± 0.01	1.02 ± 0.01	$\cdots$	$\cdots$
5	-138.4	12.98 ± 0.01	11.7 ± 0.45	12.60 ± 0.01	13.2 ± 0.01	$\cdots$	$\cdots$
6	-111.0	11.87 ± 0.08	7.68 ± 1.84	$\cdots$	$\cdots$	$\cdots$	$\cdots$
7	-87.8	12.13 ± 0.06	9.28 ± 1.46	11.61 ± 0.16	6.82 ± 3.68	$\cdots$	$\cdots$
8	-63.5	12.39 ± 0.04	2.61 ± 0.52	12.38 ± 0.07	1.41 ± 0.40	11.13 ± 3.21	20.8 ± 34.4
9	-50.1	12.84 ± 0.07	17.7 ± 2.29	12.47 ± 0.14	12.4 ± 3.83	$\cdots$	$\cdots$
10	-31.4	13.20 ± 0.04	8.03 ± 0.56	13.19 ± 0.03	8.11 ± 0.55	11.40 ± 0.36	10.4 ± 2.77
11	-15.7	12.78 ± 0.12	9.18 ± 2.26	12.46 ± 0.06	5.06 ± 0.85	10.50 ± 0.85	2.74 ± 8.81
12	11.0	13.71 ± 0.06	13.7 ± 1.27	14.05 ± 0.03	7.92 ± 0.26	12.04 ± 0.11	11.8 ± 1.27
13	28.0	15.39 ± 7.39	4.17 ± 7.83	14.03 ± 0.03	9.56 ± 0.57	11.69 ± 1.72	25.7 ± 35.9
14	41.7	13.74 ± 0.03	20.2 ± 0.50	13.54 ± 0.01	20.5 ± 0.52	11.55 ± 0.06	3.39 ± 0.63
15	88.3	12.39 ± 0.02	6.52 ± 0.37	11.70 ± 0.11	2.74 ± 1.89	$\cdots$	$\cdots$
16	116.2	12.11 ± 0.02	3.95 ± 0.40	11.86 ± 0.07	2.82 ± 1.32	$\cdots$	$\cdots$
17	135.7	12.31 ± 0.02	5.21 ± 0.32	12.16 ± 0.04	4.21 ± 0.76	$\cdots$	$\cdots$

Table 3.68: Q1222 + 228: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.668052$		Mg II		Fe II		Mg I	
1	-28.2	12.05 ± 0.10	4.79 ± 1.22	11.89 ± 0.15	1.94 ± 3.20	$\cdots$	$\cdots$
2	-15.4	12.73 ± 0.07	5.51 ± 1.12	12.11 ± 0.21	5.32 ± 3.74	10.91 ± 0.49	8.80 ± 13.76
3	-4.9	12.70 ± 0.07	3.83 ± 1.02	12.58 ± 0.07	4.35 ± 1.20	10.66 ± 0.56	1.98 ± 5.81
4	5.2	12.62 ± 0.04	3.65 ± 0.66	12.65 ± 0.14	1.52 ± 0.57	10.93 ± 0.18	4.70 ± 3.03
5	19.7	12.68 ± 0.02	6.50 ± 0.41	12.27 ± 0.08	6.68 ± 1.89	10.94 ± 0.17	7.64 ± 4.01
6	233.4	12.40 ± 0.02	5.19 ± 0.31	14.94 ± 0.01	2.30 ± 0.20	$\cdots$	$\cdots$

Table 3.69: Q1225 + 317: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 1.794833$		Mg II		Fe II		Mg I	
1	-127.1	12.84 ± 0.01	9.00 ± 0.28	12.19 ± 0.04	5.65 ± 0.78	···	···
2	-83.0	13.63 ± 0.49	14.5 ± 1.57	12.97 ± 0.02	9.30 ± 0.46	11.83 ± 0.04	10.5 ± 1.23
3	-67.5	13.41 ± 1.68	15.8 ± 54.0	13.21 ± 0.02	3.88 ± 0.28	11.38 ± 0.10	3.35 ± 1.25
4	-52.9	14.19 ± 5.81	7.30 ± 21.1	13.25 ± 0.12	7.01 ± 0.90	11.59 ± 0.06	8.14 ± 1.64
5	-42.3	12.92 ± 0.18	23.7 ± 10.6	12.93 ± 0.25	11.2 ± 2.78	···	···
6	-38.2	13.16 ± 0.27	5.82 ± 1.23	12.27 ± 0.13	1.64 ± 1.51	11.02 ± 0.12	1.95 ± 2.60
7	13.8	13.14 ± 1.26	14.6 ± 10.7	12.39 ± 0.96	15.6 ± 12.9	11.14 ± 3.64	6.02 ± 6.83
8	16.4	13.94 ± 0.72	6.85 ± 3.23	12.97 ± 0.11	4.49 ± 0.74	11.10 ± 3.91	4.06 ± 10.2
9	30.7	13.40 ± 0.90	3.96 ± 4.04	12.79 ± 0.19	4.65 ± 1.12	11.22 ± 0.52	7.41 ± 6.35
10	41.2	13.06 ± 0.16	3.71 ± 2.55	12.04 ± 0.19	0.82 ± 0.29	···	···
11	52.5	14.19 ± 2.42	3.32 ± 3.01	12.87 ± 0.02	3.90 ± 0.25	11.02 ± 0.49	3.37 ± 4.32
12	65.0	12.78 ± 0.72	8.11 ± 14.5	11.68 ± 0.13	1.39 ± 3.40	···	···
13	73.3	12.51 ± 0.56	2.94 ± 2.04	12.24 ± 0.05	2.67 ± 0.90	···	···
14	84.6	12.66 ± 0.08	4.97 ± 0.68	12.03 ± 0.10	8.56 ± 2.42	···	···
15	112.3	12.21 ± 0.07	5.23 ± 1.10	···	···	···	···
16	121.9	12.44 ± 0.04	2.89 ± 0.53	···	···	···	···
17	150.5	11.98 ± 0.04	4.72 ± 0.82	···	···	···	···
18	171.6	12.29 ± 0.03	10.5 ± 0.98	···	···	···	···

Table 3.70: Q1241 + 174: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.550482$		Mg II		Fe II		Mg I		Ca II	
1	-8.4	13.07 ± 0.02	19.41 ± 0.58	12.92 ± 0.08	2.08 ± 0.40	11.29 ± 0.21	17.8 ± 8.42	$\cdots$	$\cdots$
2	1.6	13.52 ± 0.15	5.90 ± 0.57	13.57 ± 0.05	7.59 ± 0.68	11.74 ± 0.06	5.79 ± 0.93	11.66 ± 0.13	7.54 ± 2.15
3	40.5	12.31 ± 0.03	8.05 ± 0.65	12.19 ± 0.18	4.05 ± 3.34	11.42 ± 0.24	26.7 ± 18.87	$\cdots$	$\cdots$
4	145.2	11.96 ± 0.05	6.54 ± 1.13	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$

Table 3.71: Q1248 + 401: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.772957$		Mg II		Fe II		Mg I	
1	-29.6	12.66 ± 0.02	8.48 ± 0.43	12.27 ± 0.07	9.81 ± 2.05	...	...
2	-13.1	12.80 ± 0.16	5.66 ± 1.27	12.62 ± 0.15	5.31 ± 1.47	10.91 ± 0.48	7.77 ± 7.24
3	-5.2	13.33 ± 0.04	7.41 ± 0.34	13.54 ± 0.03	3.39 ± 0.20	11.45 ± 0.17	1.12 ± 0.64
4	12.6	12.31 ± 0.02	3.54 ± 0.40	12.04 ± 0.11	8.32 ± 3.06	...	...
5	23.8	11.70 ± 0.07	1.35 ± 0.88	...	...	...	...
6	39.7	13.26 ± 0.02	6.51 ± 0.23	12.87 ± 0.02	4.22 ± 0.33	11.23 ± 0.48	5.80 ± 2.92
7	52.2	11.89 ± 0.15	5.34 ± 1.31	11.70 ± 0.18	3.85 ± 3.43	...	...
8	225.2	12.30 ± 0.01	5.53 ± 0.24	11.98 ± 0.10	4.15 ± 1.98	11.16 ± 0.07	7.66 ± 1.89
$z_{\rm abs} = 0.854558$		Mg II		Fe II			
1	-6.8	12.77 ± 0.02	4.30 ± 0.19	12.44 ± 0.03	2.49 ± 0.44		
2	3.6	12.10 ± 0.03	2.23 ± 0.50	11.72 ± 0.11	0.84 ± 0.36		
3	45.0	11.95 ± 0.07	16.3 ± 2.79	...	...		
4	59.0	11.02 ± 0.29	1.58 ± 7.07	...	...		
5	80.6	11.88 ± 0.04	5.74 ± 0.83	...	...		
6	98.8	11.98 ± 0.03	5.85 ± 0.64	...	...		
7	211.4	11.50 ± 0.07	3.26 ± 1.30	...	...		
8	235.1	11.49 ± 0.07	3.35 ± 1.41	...	...		

Table 3.72: Q1254 + 044: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.519389$		Mg II		Fe II		Mg I		Ca II	
1	-396.6	11.77 ± 0.10	2.04 ± 1.72	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	-262.4	12.25 ± 0.04	3.31 ± 0.52	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
3	-159.4	12.05 ± 0.05	6.28 ± 1.12	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
4	-9.3	13.51 ± 0.12	7.17 ± 0.52	13.81 ± 0.11	5.43 ± 0.56	12.12 ± 0.05	6.29 ± 0.72	12.00 ± 0.03	5.92 ± 0.52
5	7.2	$15.49 \pm \cdots$	$2.15 \pm \cdots$	13.39 ± 0.41	10.87 ± 4.24	11.82 ± 0.11	21.3 ± 4.32	11.29 ± 0.33	5.87 ± 3.06
6	11.8	13.21 ± 0.05	10.9 ± 0.71	12.07 ± 7.35	11.43 ± 28.9	11.07 ± 2.19	0.77 ± 7.38	10.98 ± 0.61	2.97 ± 3.71
$z_{\rm abs} = 0.934232$		Mg II		Fe II		Mg I			
1	-37.6	12.72 ± 0.01	9.68 ± 0.27	11.90 ± 0.12	11.5 ± 4.10	$\cdots$	$\cdots$		
2	4.3	13.07 ± 0.01	7.57 ± 0.16	12.66 ± 0.02	4.41 ± 0.34	11.92 ± 0.11	4.77 ± 2.01		

Table 3.73: Q1317 + 274: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.660051$		Mg II		Fe II		Mg I	
1	-10.4	12.63 ± 0.04	7.29 ± 0.49	12.60 ± 0.04	6.53 ± 0.90	$\cdots$	$\cdots$
2	0.0	12.69 ± 0.04	4.55 ± 0.36	12.81 ± 0.04	2.49 ± 0.37	$\cdots$	$\cdots$
3	11.6	12.02 ± 0.05	6.02 ± 0.77	11.99 ± 0.06	2.05 ± 1.50	10.82 ± 0.56	19.65 ± 32.44
4	47.5	11.50 ± 0.07	3.68 ± 1.21	$\cdots$	$\cdots$	$\cdots$	$\cdots$
5	77.6	11.81 ± 0.11	6.98 ± 1.89	$\cdots$	$\cdots$	$\cdots$	$\cdots$
6	89.7	11.92 ± 0.08	4.65 ± 1.04	12.00 ± 0.15	5.04 ± 2.52	$\cdots$	$\cdots$
7	100.2	11.77 ± 0.08	10.2 ± 2.22	11.88 ± 0.11	1.57 ± 3.20	$\cdots$	$\cdots$
8	140.4	11.75 ± 0.05	9.01 ± 1.48	$\cdots$	$\cdots$	$\cdots$	$\cdots$

Table 3.74: Q1329 + 412: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.500785$		Mg II			
1	-38.2	12.69 ± 0.03	5.54 ± 0.61		
2	-20.7	12.06 ± 0.08	3.84 ± 1.53		
3	3.8	12.45 ± 0.09	8.11 ± 2.12		
4	20.4	12.51 ± 0.07	6.83 ± 1.37		
$z_{\rm abs} = 0.893337$		Mg II		Fe II	
1	-7.8	12.88 ± 0.07	18.4 ± 2.30	12.66 ± 0.07	22.7 ± 3.93
2	5.6	12.33 ± 0.18	5.10 ± 2.02	12.12 ± 0.12	3.01 ± 1.94
3	123.3	12.46 ± 0.05	4.39 ± 0.95	12.45 ± 0.05	5.60 ± 1.02
$z_{\rm abs} = 0.998358$		Mg II		Fe II	
1	-0.1	12.75 ± 0.01	7.42 ± 0.29	12.83 ± 0.03	14.1 ± 1.45

Table 3.75: Q1354 + 193: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.456588$		Mg II		Fe II		Mg I	
1	-77.4	12.42 ± 0.04	3.68 ± 0.50	···	···	···	···
2	-30.8	15.52 ± 0.18	2.13 ± 0.32	13.05 ± 0.42	3.19 ± 2.50	11.44 ± 0.26	6.20 ± 2.54
3	-21.9	12.69 ± 0.12	4.06 ± 2.14	···	···	···	···
4	-10.3	12.75 ± 0.06	4.24 ± 1.00	12.90 ± 1.67	1.26 ± 3.63	···	···
5	3.2	12.80 ± 0.17	2.30 ± 0.69	···	···	···	···
6	19.0	13.13 ± 0.04	8.47 ± 1.20	13.08 ± 1.30	1.61 ± 1.58	10.71 ± 0.83	2.79 ± 7.60
7	36.7	12.97 ± 0.06	4.86 ± 0.57	13.16 ± 1.70	1.66 ± 3.26	···	···

Table 3.76: Q1421 + 331: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.843247$		Mg II		Fe II		Mg I	
1	-0.4	13.10 ± 0.10	3.15 ± 0.23	13.47 ± 0.07	2.34 ± 0.18	11.28 ± 0.07	1.86 ± 1.10
$z_{\rm abs} = 0.902871$		Mg II		Fe II		Mg I	
1	-103.6	11.96 ± 0.14	7.57 ± 1.65	11.61 ± 0.18	2.55 ± 3.35	···	···
2	-87.8	12.77 ± 0.08	9.23 ± 1.71	11.93 ± 0.17	6.77 ± 3.75	···	···
3	-77.0	12.52 ± 0.11	3.56 ± 0.84	11.75 ± 0.22	4.90 ± 3.37	···	···
4	-59.7	12.65 ± 0.01	10.3 ± 0.45	12.13 ± 0.07	5.48 ± 1.36	···	···
5	-17.6	12.79 ± 0.04	3.37 ± 0.32	12.86 ± 0.10	2.76 ± 0.07	···	···
6	-8.2	12.93 ± 0.08	3.46 ± 0.85	12.48 ± 0.05	3.89 ± 0.79	···	···
7	7.6	13.29 ± 0.06	10.2 ± 2.03	12.77 ± 0.05	7.74 ± 1.35	10.74 ± 0.33	4.60 ± 4.43
8	23.4	14.44 ± 0.85	4.03 ± 0.94	13.60 ± 0.02	4.99 ± 0.18	11.58 ± 0.06	7.47 ± 1.23
9	65.2	11.62 ± 0.06	2.45 ± 1.24	11.26 ± 0.47	2.13 ± 8.65	···	···
10	83.1	12.99 ± 0.03	4.41 ± 0.17	12.27 ± 0.07	5.49 ± 1.27	···	···
$z_{\rm abs} = 1.172609$		Mg II		Fe II		Mg I	
1	-43.4	12.46 ± 0.03	4.08 ± 0.42	12.20 ± 0.06	1.91 ± 1.08	10.85 ± 0.38	6.83 ± 5.38
2	-36.2	11.94 ± 0.10	4.88 ± 1.57	11.58 ± 0.16	2.93 ± 0.63	···	···
3	-17.9	12.57 ± 0.03	6.71 ± 0.63	12.32 ± 0.04	6.36 ± 0.99	···	···
4	0.6	13.11 ± 0.02	7.23 ± 0.36	12.75 ± 0.02	6.32 ± 0.45	11.53 ± 0.07	10.59 ± 2.62
5	20.2	12.06 ± 0.06	4.09 ± 1.03	···	···	···	···
6	28.9	11.96 ± 0.22	2.26 ± 1.76	···	···	10.72 ± 0.60	4.54 ± 10.5
7	35.8	12.75 ± 0.07	2.95 ± 0.49	12.32 ± 0.09	4.86 ± 1.08	10.81 ± 0.32	3.08 ± 4.09

Table 3.77: Q1548 + 093: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.770646$		Mg II		Fe II		Mg I	
1	-4.1	13.34 ± 0.01	12.83 ± 0.38	13.11 ± 0.06	25.9 ± 3.90	12.27 ± 0.07	14.2 ± 2.78

Table 3.78: Q1622 + 235: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.656114$		Mg II		Fe II			
1	-78.4	12.32 ± 0.12	2.57 ± 1.14	$\cdots$	$\cdots$		
2	-25.6	13.66 ± 0.02	37.7 ± 1.87	13.57 ± 0.03	33.07 ± 2.77		
3	36.1	13.94 ± 0.05	25.0 ± 1.02	13.83 ± 0.01	20.87 ± 0.34		
$z_{\rm abs} = 0.797107$		Mg II					
1	-68.9	12.52 ± 0.05	7.96 ± 1.12				
2	-28.0	12.15 ± 0.09	4.58 ± 1.58				
3	4.5	12.81 ± 0.04	10.4 ± 0.94				
4	63.7	12.48 ± 0.06	5.35 ± 1.14				
$z_{\rm abs} = 0.891253$		Mg II		Fe II		Mg I	
1	-86.0	13.00 ± 0.02	12.6 ± 0.48	12.81 ± 0.06	8.56 ± 1.54	$\cdots$	$\cdots$
2	-44.5	13.01 ± 0.02	11.5 ± 0.71	12.17 ± 0.24	10.0 ± 5.76	$\cdots$	$\cdots$
3	-18.2	15.12 ± 1.78	5.65 ± 2.26	13.80 ± 0.03	13.2 ± 0.76	11.62 ± 0.06	12.9 ± 1.81
4	15.0	15.82 ± 0.60	5.12 ± 0.75	14.22 ± 0.03	17.5 ± 0.86	12.01 ± 0.02	11.8 ± 0.65
5	55.1	13.54 ± 0.01	20.3 ± 0.40	13.78 ± 0.05	7.05 ± 0.70	12.03 ± 0.02	6.44 ± 0.43
6	72.1	12.78 ± 0.53	1.68 ± 0.99	13.49 ± 0.04	6.33 ± 0.52	11.66 ± 0.04	10.1 ± 1.23

Table 3.79: Q1634 + 706: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.905554$		Mg II					
1	-0.1	12.47 ± 0.01	2.77 ± 0.10				
$z_{\rm abs} = 0.990240$		Mg II		Fe II		Mg I	
1	-21.9	13.11 ± 0.01	7.39 ± 0.15	12.77 ± 0.02	5.19 ± 0.27	11.35 ± 0.04	6.85 ± 0.74
2	-10.0	12.17 ± 0.11	2.15 ± 0.81	12.15 ± 0.09	4.33 ± 1.57	...	...
3	1.7	12.82 ± 0.16	6.46 ± 0.86	12.38 ± 0.13	4.20 ± 1.12	10.85 ± 0.48	7.65 ± 5.33
4	12.9	13.10 ± 0.09	16.7 ± 2.40	12.33 ± 0.22	12.5 ± 5.54	11.30 ± 0.30	17.59 ± 5.69
5	24.7	12.09 ± 0.20	5.03 ± 1.34	...	...	...	...

Table 3.80: Q2128 − 123: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.429735$		Mg II		Mg I		Ca II	
1	-39.8	12.38 ± 0.04	7.66 ± 0.91	$\cdots$	$\cdots$	$\cdots$	$\cdots$
2	-25.7	12.01 ± 0.08	3.48 ± 1.23	11.37 ± 0.14	9.03 ± 4.18	$\cdots$	$\cdots$
3	-0.6	15.24 ± 0.51	4.45 ± 0.46	12.12 ± 0.03	4.98 ± 0.48	11.85 ± 0.03	6.78 ± 0.68
4	12.2	13.49 ± 0.07	5.58 ± 0.47	11.70 ± 0.08	6.39 ± 1.52	11.24 ± 0.13	5.98 ± 2.36

Table 3.81: Q2145 + 064: VP Decomposition

No.	v [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]	$\log N \pm \sigma$ [cm^{-2}]	$b \pm \sigma$ [km s^{-1}]
$z_{\rm abs} = 0.790777$		Mg II		Fe II	
1	-109.5	12.55 ± 0.00	2.04 ± 0.01	$\cdots$	$\cdots$
2	-101.7	13.38 ± 0.06	2.42 ± 0.08	12.82 ± 0.02	3.86 ± 0.36
3	-3.4	12.56 ± 0.15	1.04 ± 0.17	$\cdots$	$\cdots$
4	3.6	12.57 ± 0.02	14.1 ± 0.58	$\cdots$	$\cdots$
5	63.3	12.76 ± 0.01	9.91 ± 0.32	12.39 ± 0.09	5.28 ± 1.65
6	86.6	12.18 ± 0.04	8.86 ± 1.00	11.86 ± 0.23	1.57 ± 3.23