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Ionization state of the absorption systems in the BL Lac object 0215+015 and properties of low-excitation absorbers*

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Summary. Spectra of the BL Lac object 0215+015 have been obtained with the ESO 3.6-m telescope at a resolution of 18 and 29 km s^{-1} from 5650 to 6850 Å. Absorption lines of Mg I, Mg II, Mn II and Fe II are detected in the system at z=1.345 known from previous observations. These lines break up into four components spread over 180 km s^{-1} with observed equivalent widths of isolated features ranging from 35 to 2800 mÅ. Accurate estimates of the velocity structure and column densities of the singly ionized and neutral elements mentioned above are derived for the multiple system at z=1.345 using a line-profile fitting procedure. No Mg II or Fe II absorption was found in the six other metal-rich systems known by their Lyα and C IV or Si III absorptions even though weak C II absorption has been reported for two of them.

In the Lyα–C IV range we find that the following are good indicators for the presence of Mg II and Fe II absorptions (i) strong absorption lines from O I and Si II, and if only Si II is detected the Si II $\lambda\lambda$1304, 1526 lines must be present, (ii) equivalent width ratios W_r(C II λ1334)/W_r(C IV λ1548) and W_r(Si II λ1260)/W_r(Si III λ1206) of order unity or larger. We have estimated the occurrence of Mg II absorption in homogeneous surveys at high redshift. We find a density per unit redshift for Mg II systems of dN/dz=0.29 at $\langle z\rangle$=1.7, which is five times smaller than that derived for C IV systems. The comparison of our results with those obtained at lower redshift, $\langle z\rangle$=0.5, suggests an absence of cosmological evolution for the Mg II systems.

1 Introduction

Sharp metal-rich absorption systems in the spectra of quasars and BL Lac objects are generally believed to be of intervening origin (e.g. Weymann, Carswell & Smith 1981) but their association with normal galaxies is not firmly established. In particular, most high-redshift absorption

*Based on observations made at the European Southern Observatory.

systems are of much higher excitation than high-latitude gas in our Galaxy and haloes or extended discs around nearby galaxies (Wolfe 1983; Bergeron & Boissé 1984). This could be reconciled with the intervening galaxy assumption if the ionization state of the absorbing clouds are evolving with redshift or if there are two phases among the metal-rich absorption systems.

The rest equivalent width (W_r) distribution of C IV and Mg II doublets show different behaviour at both the low and large W_r end (Bergeron & Boissé 1984). At the low W_r end the density per unit redshift and unit W_r is steeply increasing for C IV systems while it is flattening for Mg II systems, and at the large W_r end there is an excess of Mg II systems.

Searching for Mg II or Fe II absorptions from systems with detected C IV doublets, Boissé & Bergeron (1985) found that in the systems with W_r(C IV λ1548)$\geq$1 Å the low-excitation lines are present and usually stronger than C IV λ1548. In the weaker system, with W_r(C IV λ1548)<1 Å, the Mg II and Fe II lines are most often not detected, with W_r(Mg II λ2796)/W_r(C IV λ1548)<0.3–0.5. This suggests that indeed two phases are present among the metal-rich absorbers, but this may reflect an opacity effect rather than an ionization state difference.

To find the ionization degree in the C IV absorption systems and to check whether the absence of weak Mg II doublets can be really interpreted as a turn-over in the W_r distribution of the low-excitation lines and not as an observational bias, one needs to measure very weak Mg II absorption lines. To this purpose we started a very high-resolution survey of Mg II and Fe II lines from known C IV systems, using the very efficient new ESO echelle spectrograph.

In this paper we present observations in the red for the BL Lac object 0215+015. This already extensively observed object is very well suited for our ionization state study since it has an unusually large number of absorption systems. Among the seven systems detected (Pettini *et al.* 1983; Blades *et al.* 1985) one, at z=1.345, is very strong and of low excitation with neutral elements present; the C IV doublet is as weak as W_r(C IV λ1548)=0.44 Å while W_r(Mg II λ2796)~W_r(Fe II λ2382)~1.9 Å. A double structure is detected in the C IV doublet and the Si II λ1526 line (Blades *et al.* 1982) and one of these components at z=1.345 may break up into two as suggested by observations at a resolution of 27 km s^{-1} of the Fe II λ2600 blend (Hunstead *et al.* 1983). The Mg II and Fe II wavelength regions from the six other systems were not observed but for two systems the C II λ1334 absorption was detected. These two systems at z=1.549 and 1.649 are also known to show multiple discrete components but C II is not present in all the subsystems (Blades *et al.* 1982).

Our observations, made at a resolution of 18 km s^{-1} (see Table 1), are presented in Section 2.

Table 1. Journal of the observations.

No.	date	central wavelength(Å)	spectral coverage(Å)	exposure time(min)	seeing (arcsec)	resolution* FWHM (Å)
1[b]	aug 22, 84	6345	1040	90	2.5	0.60
2	aug 23, 84	6172	1056	120	3.1	0.37

* Resolution at central wavelength measured by fitting Gaussian profiles to the lines of the Thorium comparison lamp, reduced in the same way as the object frame.

b Obtained with the CCD read out binned in the direction of the dispersion.

With such a high resolution the multiple structure of the $z=1.345$ system can be studied in greater details than previously reported, and column densities of Mg II and Fe II can be evaluated for each subcomponent. For the multiple systems at $z=1.549$ and 1.649 the C IV discrete components are at least 30 km s^{-1} apart and we could search for Mg II or Fe II absorption associated with each cloud. In Section 3 we review the arguments in favour of a bimodal state of ionization for the metal-rich absorbers. A comparison between the density per unit redshift of low- and high-redshift Mg II systems is given in Section 4 and conclusions are presented in Section 5.

2 Observations

2.1 OBSERVATIONS AND DATA REDUCTION

The observations were carried out in 1984 August with the ESO echelle spectrograph (CASPEC) at the $f/8$ Cassegrain focus of the 3.6-m telescope at La Silla, Chile. The spectrograph has been described by D'Odorico & Tanne (1984). We used the 31.6 lines mm^{-1} echelle grating and the standard 300 lines mm^{-1} cross disperser. This combination gives a linear dispersion of 6.4 Å mm^{-1} at λ6200. The accuracy of the wavelength calibration in the normal mode (see below) is 2 km s^{-1} as estimated from both the rms of the fit to Thorium lines and the measured wavelengths of the [O I] and Na I night sky lines. The ESO CCD #3 was used as detector: it has an efficiency of 80 per cent at λ6200 and a read out noise of 45 electrons rms per pixel. In the red spectral region about 16 orders are recorded on the CCD in a single exposure, providing a full spectral coverage over 1050 Å. Fringing effects due to interference within the CCD are small, with an amplitude which never exceeds 10 per cent at $\lambda<6000$ Å.

The journal of the observations is given in Table 1. The slit width and length were 2.0 and 5.8 arcsec respectively for both exposures. For each exposure on the object a flat-field image and a wavelength comparison thorium spectrum were also recorded. On the first night the CCD was read out binned in the direction of the dispersion with an effective pixel size $60\times30\,\mu$m^2 to decrease the read out noise relative to the signal. A standard star, Feige 110, was also observed in the same configuration. As the BL Lac object was in a high state we observed it again, together with the standard star LTT 1020, selecting this time the normal mode (pixel size $30\times30\,\mu$m^2).

The data were reduced with the echelle reduction package implemented within MIDAS, the image processing system developed at ESO for the VAX 11/785 computer. The various steps of the data reduction have been described by D'Odorico, Pettini & Ponz (1985). For these observations we used the standard stars to obtain the response curve of the spectrograph and hence an absolute scale for the fluxes, and an accurate correction for the blaze function of the echelle orders. Once a set of parameters (extraction slit, bin size ...) has been chosen, the reduction proceeds automatically with only two emission lines to be interactively identified in the two-dimensional frame of the calibration lamp. The final results have been rebinned at 0.12 Å in the case of high resolution and at 0.30 Å for the low resolution. We have used mainly the former data for the discussion presented below, but we have also measured the detected lines in the binned spectrum for consistency and to help searching, and possibly correcting, for contamination by cosmic rays. We searched for weaker lines in both spectra and did not find any line in the high-resolution data which was not also present in the lower resoution one; in fact, a weak Mn II blend is possibly detected in the binned spectrum and not seen in the higher resolution data.

The signal-to-noise ratio measured from the extracted spectra in pixels is about 30 and 45 for the high- and low-resolution modes respectively. The weakest unresolved absorption line present in the high-resolution spectrum (see Table 2) has an equivalent width $W_{\rm obs}\sim40$ mÅ which is about a 4σ level. Below we will use a conservative detection limit of 50 mÅ for unresolved lines.

Table 2. Absorption lines.

Line number	λ* (Å)	W_{obs} (Å)	Identification	z
1	5889.96#	0.090	NaI 5889.95#	0.000002
2	5895.96#	0.052	NaI 5895.92#	0.000007
3	6042.00	0.069	MnII 2576.88 /3	1.34470
4	6042.98	0.035	MnII 2576.88 /4	1.34508
5	6062.46	} 0.41	FeII 2586.64 /1	1.34376
6	6063.20		FeII 2586.64 /2	1.34405
7	6064.96	} 1.23	FeII 2586.64 /3	1.34473
8	6066.06		FeII 2586.64 /4	1.34515
9	6094.17	} 0.98	FeII 2600.18 /1	1.34375
10	6094.98		FeII 2600.18 /2	1.34406
11	6096.67	} 2.20	FeII 2600.18 /3	1.34471
12	6097.74		FeII 2600.18 /4	1.34512
13	6553.95	} 1.69	MgII 2796.35 /1	1.34375
14	6554.83		MgII 2796.35 /2	1.34407
15	6556.54	} 2.84	MgII 2796.35 /3	1.34468
16	6557.80		MgII 2796.35/ 4	1.34513
17	6570.74	} 1.20	MgII 2803.53 /1	1.34374
18	6571.64		MgII 2803.53 /2	1.34406
19	6573.27	} 2.65	MgII 2803.53 /3	1.34464
20	6574.40		MgII 2803.53 /4	1.34504
21	6686.61	} 0.31	MgI 2852.97 /1	1.34374
22	6687.59		MgI 2852.97 /2	1.34408
23	6689.56	} 0.43	MgI 2852.97 /3	1.34477
24	6690.72		MgI 2852.97 /4	1.34518

* Wavelengths are vacuum, heliocentric values except for NaI (# : air, heliocentric values).

As mentioned above 0215+015 was very bright at the time of the observations. This BL Lac object is strongly variable and its magnitude ranges from $R\sim14$ down to $B>18.5$ (Blades *et al.* 1985). On 1984 August 23 we derived a magnitude per unit frequency at $\lambda 6000$ of 13.8 from the comparison with the standard star spectrum taken in the same configuration.

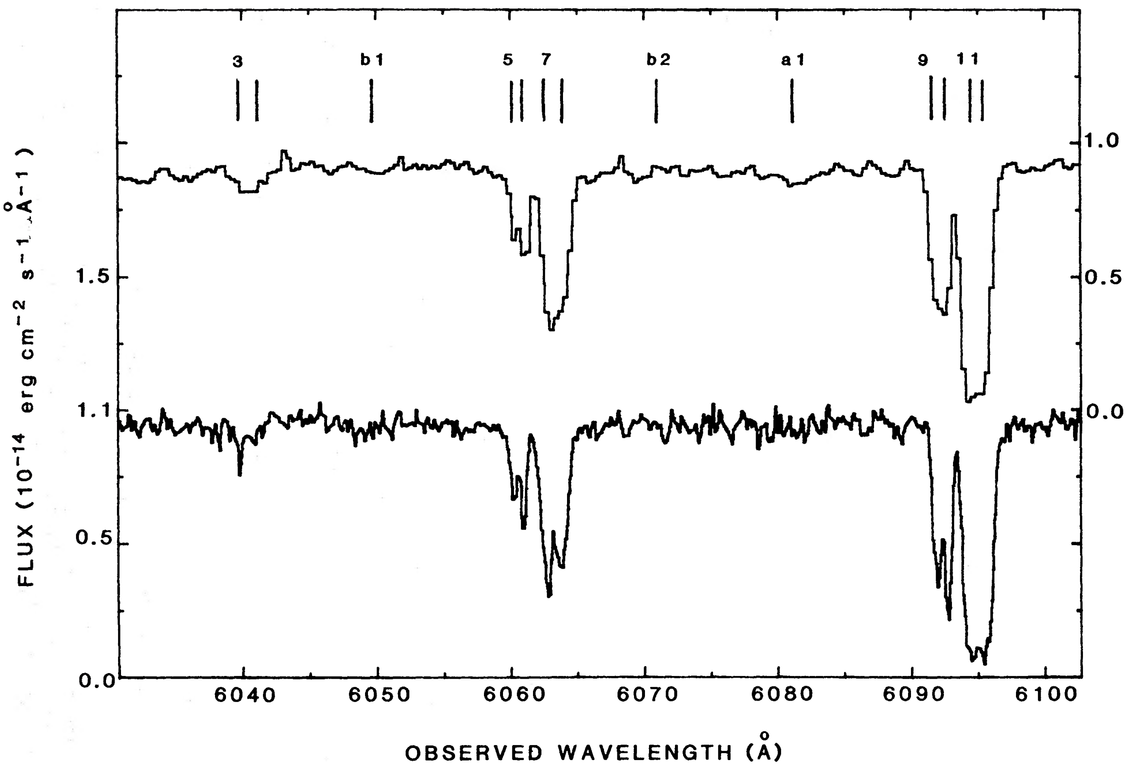

Figure 1. Portions of the two spectra of the BL Lac object 0215+015 (bottom – normal model; top – binned mode) showing the region of the strong Fe II λλ2586, 2600 doublet and the weak Mn II λ2586 line in the redshift system $z=1.345$. The very weak Mn II λ2593 line (labelled a1) from the same absorption system is present in the binned mode spectrum only at a 4σ level. The expected position of the Fe II λλ2374, 2382 lines in the redshift system $z=1.549$ are also indicated (labelled b1, b2). The spectral resolution is 18 and 29 km s^{-1} for the normal and binned mode respectively. The vertical intensity scale for the normal mode is displayed in the lower left, that for the binned mode on the upper right.

2.2 REDSHIFTED ABSORPTION LINES

All the absorption lines detected are listed in Table 2. The strong absorption lines of Mg I, Mg II and Fe II from the $z=1.345$ system exhibit multiple structure. Weak Mn II lines shown in Fig. 1 from the two strongest subcomponents are present. The Fe II λ2586 line, the least saturated of the stronger absorptions, clearly shows four components spread over 180 km s^{-1} as can be seen in Fig. 1. The two redder components merge together in the saturated Mg II lines (Fig. 2), in which a weaker fifth component might be present at the red end. The weak Mg I lines are shown in Fig. 3. The Mg II and Fe II lines extend over a velocity range at least as large as that observed for C IV (Blades *et al.* 1982) which implies that no subcomponent of high excitation is present in the $z=1.345$ system.

The absorbing cloud parameters for the $z=1.345$ system are derived from the absorption line profiles using a line synthesis analysis program developed by D. Pelat (Pelat & Alloin 1980). All parameters were left independent except for the Mg II doublet for which the velocity dispersion was set identical for the two lines of each subcomponent. The difference in the redshifts found for the two lines of a doublet for a given cloud gives an estimate of the uncertainty in the redshift. The quality of the fit for the Fe II lines can be seen in Fig. 4. The resulting velocity dispersion, relative velocity of the components and the ionic column densities are given in Table 3. The oscillator strengths f are from Morton (1978) except for Fe II (Nussbaumer, Pettini & Storey 1981). It is already evident from the line profiles that the relative stength of components 1 and 2 is reversed

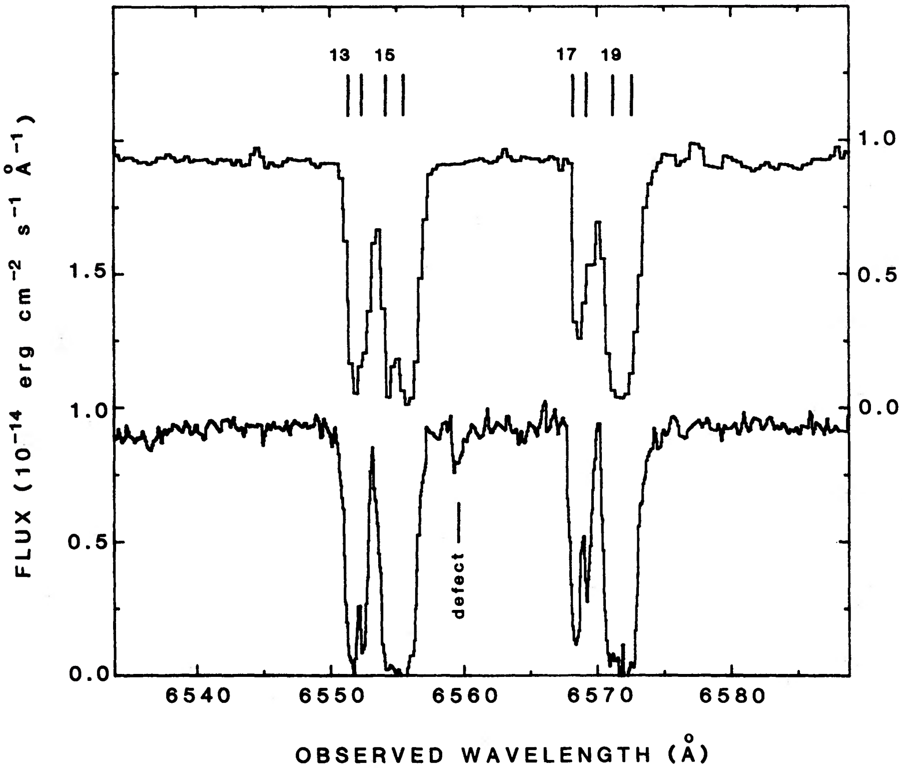

Figure 2. Same as Fig. 1 for the region of the Mg II $\lambda\lambda$2796, 2803 doublet in the redshift system z=1.345.

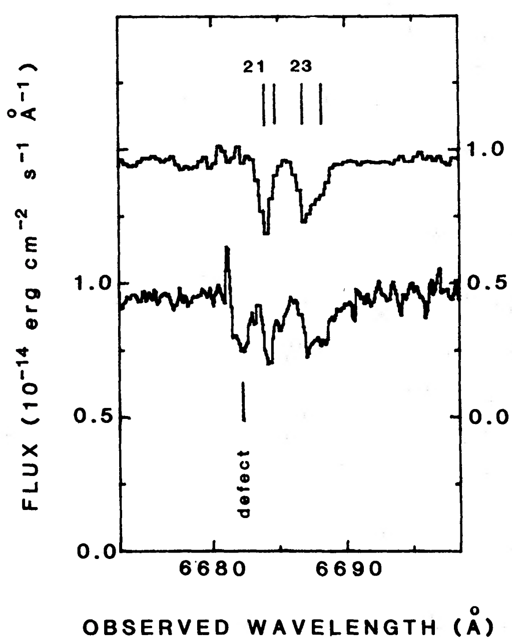

Figure 3. Same as in Fig. 1 for the region of the Mg I λ2853 line in the redshift system z=1.345.

between Mg II and Fe II. The relative differences found for components 3 and 4 in the Mg II and Fe II doublets appear to be real as also suggested by the different structure in the line profiles although these components are fairly saturated.

The striking result of our observations is the absence of a single Mg II or Fe II absorption from the six other systems. For the absorber of smaller redshift, z=1.254, both the Mg II and Fe II UV1

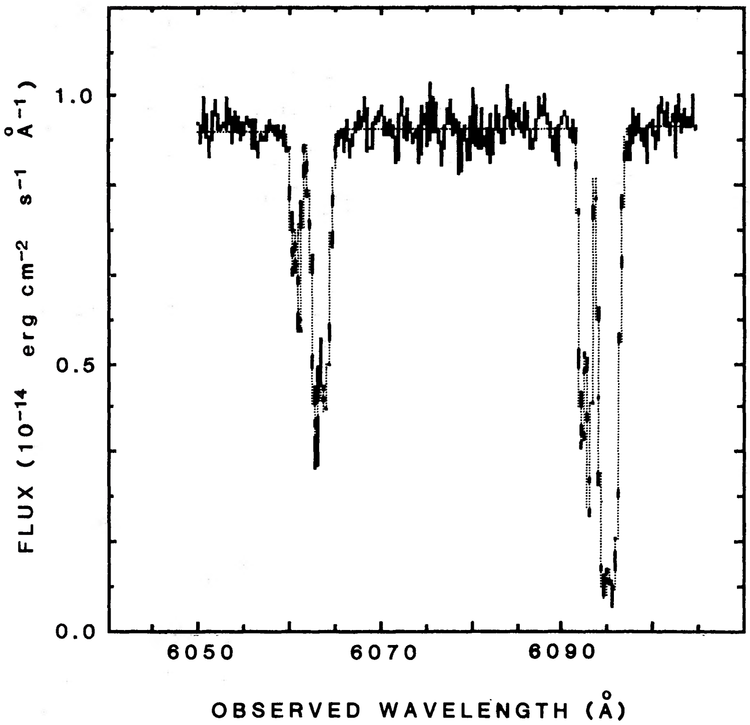

Figure 4. Comparison between observed (broken thick line) and computed (continuous thin line) absorption profiles for the Fe II $\lambda\lambda$ 2286, 2600 doublet in the $z=1.345$ system.

Table 3. Model fit parameters for the absorbing clouds at $z=1.345$.

Cloud number	b* km s^{-1}	Δv km s^{-1}	N cm^{-2}	b* km s^{-1}	Δv km s^{-1}	N cm^{-2}
ion		MgI			MgII	
1	17.1	-132	8.4 10^{11}	14.5	-121	5.3 10^{13}
2	15.0	-88	3.2 10^{11}	10.1	-76	1.9 10^{13}
3	21.5	0	6.3 10^{11}	17.8	0	4.5 10^{13}
4	37.6	52	10.0 10^{11}	30.7	54	19.0 10^{13}
ion		FeII			MnII	
1	17.1	-123	2.0 10^{13}			
2	9.4	-85	2.2 10^{13}			
3	26.5	0	8.4 10^{13}	7.8	0	2.1 10^{12}
4	25.2	53	6.4 10^{13}	10.2	49	1.0 10^{12}

* taking into account the instrumental broadening function

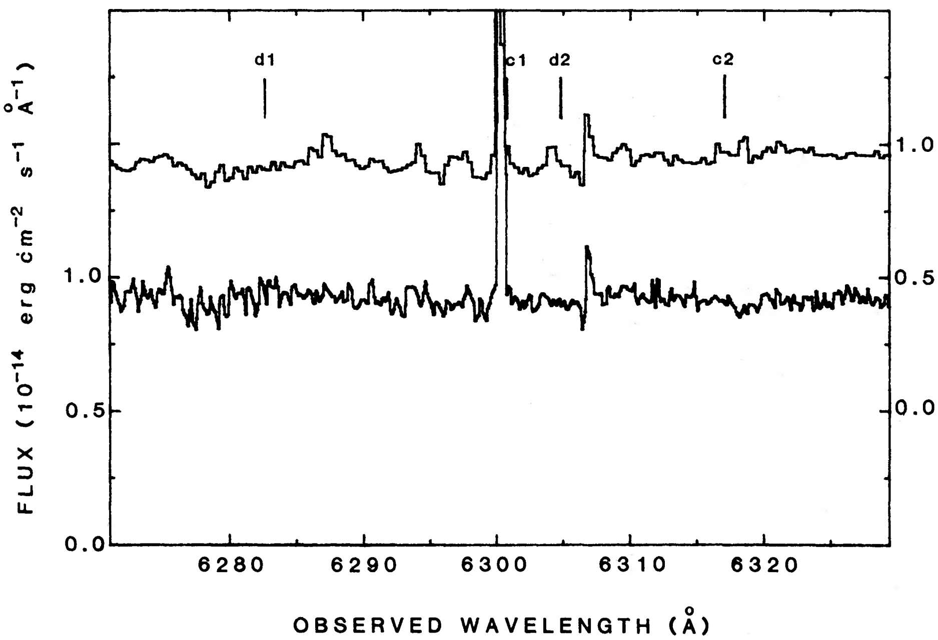

Figure 5. Region of the spectra, displayed as in Fig. 1, showing the expected positions of the Mg II λλ2796, 2803 doublet in the redshift system $z=1.254$ (labelled c1, c2) and of the Fe II λλ2374, 2382 lines in the redshift system $z=1.649$ (labelled d1, d2).

doublets fall in our observed wavelength range (although Mg II λ2796 is expected at about the wavelength of the sky line [O I] λ6300, which cannot be well subtracted in the data extraction due to the relatively poor seeing and the small slit length). For the remaining systems only Fe II lines are in our observed wavelength range, but the region of the strong Fe II λ2382 is studied for the six systems. The ratio $y \equiv W_r$(Fe II λ2382)/W_r(Mg II λ2796) equals 0.6 to 1 in absorption systems in which the Mg II doublet is detected (see e.g. Bergeron & Boissé 1984) and constraints roughly as strong can be derived from Fe II λ2382 as from Mg II λ2796. For the three stronger systems, the region in which these lines are expected are shown in Figs (1) and (5). For the Fe II λ2382 region of the $z=1.549$ system a very weak absorption feature is present in both spectra (Fig. 1) at about the same wavelength λ6069 with an observed equivalent width of 35 mÅ, smaller than our adopted detection limit of 50 mÅ, and with no corresponding feature at Fe II λ2344. We present in Table 4 our upper limits for the low-excitation lines together with the global measurements for the $z=1.345$ system and quote the measurements of Blades *et al.* (1985) for the absorption lines in the

Table 4. Absorption lines in the strong systems.

z	W_r(CII1334)	W_r(CIV1548)	W_r(FeII2382)	W_r(MgII2796)
1.254		0.42		<0.044*
1.345	1.27	0.44	1.92	1.93
1.549	0.10	0.89	<0.020	
1.649	0.28	0.90	<0.019	

* Derived from W_r(MgII2803) < 0.022 and using a doublet ratio of 2.0 (see text).

blue of λ5650. The upper limits on the strength of the low-excitation lines lead to a ratio W_r(Mg II λ2796)/W_r(C IV λ1548)<0.03–0.10 using $y=2/3$ and a Mg II doublet ratio of 2. This pushes down the constraint found by Boissé & Bergeron (1985) by one order of magnitude, strengthening the assumption of two phases among the metal-rich absorption systems.

Another intriguing result concerns the absence of Fe II absorption when C II is detected. In absorbers of low excitation, as the $z=1.345$ system (see also results for Q0551−366 and Q2206−199N in Boissé & Bergeron 1985), the equivalent width ratio $x \equiv W_r$(Fe II λ2382)/W_r(C II λ1334) is larger than unity. A lower limit on x can be derived assuming that both lines are optically thin and that the ionization degrees Fe II/Fe and C II/C are identical. The large abundance ratio C/Fe (the cosmic value equals 29) is partly compensated by a value of $\lambda^2 f$ for C II λ1334 of only 0.11 times that for Fe II λ2382 and one would expect an observed ratio $x \geq 0.3$. We find upper limits for x of 0.2 and 0.07 for the $z=1.549$ and 1.649 systems respectively. These low values of x suggest a difference in the degree of ionization of C and Fe or Mg.

2.3 GALACTIC ABSORPTION

The Na I doublet is detected at $z \sim 0$. The observed equivalent widths (Table 2) are underestimates of the true W as the absorptions are partially blended with the strong night sky Na I emission which could not be well subtracted in our extracted spectrum due to the short slit length and the poor seeing. In Table 2, however, we give the true values of the line position obtained by profile fitting analysis. These lines are unresolved, $b<7\,\mathrm{km\,s^{-1}}$, and of the same strength as the galactic Ca II doublet detected by Pettini *et al.* (1983). They are centred at $v_{\mathrm{LSR}}=-8.3\,\mathrm{km\,s^{-1}}$ whereas Pettini *et al.* (1983) obtained $v_{\mathrm{LSR}}=0\,\mathrm{km\,s^{-1}}$ for the galactic K and H lines. The Na I doublet is optically thin and the column density derived from the line profile fitting analysis is N(Na I)$=5.5\,10^{11}\,\mathrm{cm^{-2}}$.

3 Existence of a bimodal state of ionization

Two states of ionization appear to be present in the metal-rich absorbers as derived from the properties of the sample of 21 systems studied by Boissé & Bergeron (1985) and the four stronger systems in 0215+0.15 (see Table 4). Out of these 25 systems ($z \gtrsim 1.2$), observed in the C IV and Mg II or Fe II regions, nine show absorption from Mg II and/or Fe II. These low-excitation lines from Mg II or Fe II are either present and strong, or absent.

In the systems with W_r(C II λ1334)/W_r(C IV λ1548)$\gtrsim 1$, strong Mg II or Fe II lines are always detected with W_r(Mg II λ2796)/W_r(C IV λ1548)≥ 1. Other indicators of the presence of Mg II absorption are (i) a large equivalent width ratio W_r(Si II λ1260)/W_r(Si III λ1206)$\gtrsim 1$, (ii) the presence of O I or Si II ions with detectable Si III $\lambda\lambda$1304, 1526 lines. Eight additional low-excitation systems, studied in a wide spectral range, were considered to derive the above criteria [one in Q1225+317 (Grandi 1979), two in Q1331+170 (Carswell *et al.* 1975; Young, Sargent & Boksenberg 1982); two in PHL957 (Gilbert *et al.* 1976; Sargent *et al.* 1980), two in Q1756+237 (Turnshek, Weymann & Williams 1979) and one in the gravitational lens Q0957+561 A, B (Weymann *et al.* 1979; Young *et al.* 1981)]. Usually the absorption lines in these systems are strong with W_r(C II λ1334)$\sim W_r$(Mg II λ2796)$\gtrsim 1$ Å. Also the C II λ1335.7 fine-structure absorption line is rarely detected, implying densities $n<3\,\mathrm{cm^{-3}}$ for most systems (see e.g. Turnshek *et al.* 1979).

In the 16 systems with W_r(C II λ1334)/W_r(C IV λ1548)$\lesssim 0.3$, Mg II or Fe II lines are not detected with W_r(Mg II λ2796 or Fe II λ2382)/W_r(C IV λ1548)<0.4 (Boissé & Bergeron 1985) or even 0.1 (see Table 4). We intend to conduct additional observations in the red to confirm this.

Among the systems with no Mg II lines detected, there are a few cases with weak C II absorption. This is not likely to be a consequence of a low abundance ratio Mg/C, and most probably reflects a difference in the average ionization level of C and Mg (Bergeron & Stasinska 1986, in preparation). Indeed absorption line opacities are proportional to the element abundances and to $\lambda^2 f$, and the low cosmic abundance ratio Mg/C=1/18 is compensated by a large $\lambda^2 f$ ratio of 22 between the Mg II $\lambda 2796$ and C II $\lambda 1334$ lines.

4 Density per unit redshift of the low-excitation absorbers

Let us now estimate the fraction of low-excitation systems present in the QSOs observed by Young *et al.* (1982). They found a homogeneous unbiased sample of 26 C IV doublets in 30 QSOs. Among these 26 systems, four (in Q0237−233, Q0551−366, Q1225+317 and Q1337+170) are of low excitation with expected (using the criteria given in Section 3) and detected strong Mg II or Fe II lines (two systems mentioned in table 5 of Bergeron & Boissé 1984 and references therein, the other two observed by Boissé & Bergeron 1985). In the overall data of Young *et al.* (1982) there are three other low-excitation systems (not included in their unbiased C IV sample) with expected and observed Mg II or Fe II lines (see Weymann *et al.* 1979; Boissé & Bergeron 1985): in Q0237−233 the C IV doublet at $z=1.3645$ is in the Lyα forest of the QSO and in Q0957+561A, B and Q1101−264 W_r of the C IV lines is smaller than the lower limit used to define the unbiased C IV sample. Considering only the systems with C IV lines longward of the Lyα emission line, there are five low-excitation systems, all with detected Si II $\lambda 1526$ absorption and with W_r(Mg II $\lambda 2796$)>0.6 Å [or W_r(Fe II $\lambda 2382$)>0.4 Å]. The low-excitation systems represent one-fifth of the total number of unbiased C IV systems. Using $W_{r,\min}$(Mg II $\lambda 2796$)$=W_{,\mathrm{minr}}$(C II $\lambda 1548$)=0.3 Å gives only one additional system (in Q1101−264) with Si II $\lambda 1526$ not detected by Young *et al.* (1982) but present in the spectrum of Carswell *et al.* (1982). The density per unit redshift of low-excitation systems given by the homogeneous sample (five systems) is $dN/dz=0.29$ with $\langle z\rangle=1.7$.

At lower redshift the Mg II absorption survey done by Tytler *et al.* (1986) gives for their M1 and composite samples [both with $W_{r,\min}$(Mg II $\lambda 2796$)=0.6 Å] $dN/dZ=0.18^{+0.40}_{-0.15}$ and $0.28^{+0.18}_{-0.12}$ respectively at $\langle z\rangle=0.5$. The value of dN/dz for Mg II systems at $\langle z\rangle=0.5$, derived from our estimate for low-excitation absorbers at $\langle z\rangle=1.7$, is in rough agreement with the observations of Tytler *et al.* (1986), if there is no cosmological evolution and if $q_0=0$ (predicted $dN/dZ=0.16$). This suggests that, if the high-excitation systems do not suffer a strong cosmological evolution, most of the low-redshift absorption systems have yet to be discovered by observation of their C IV doublet in the UV.

5 Conclusions

High-resolution observations in the red of the BL Lac object 0215+015 reveal only Mg II and/or Fe II absorption lines in one system ($z=1.345$) out of the seven known. For this system we find four Mg II components spanning 180 km s^{-1} and with individual velocity dispersions in the range $b=10$ to 31 km s^{-1}. Two components have saturated Mg II and Fe II lines and only high-resolution observations of lines of lesser opacity as Fe II $\lambda\lambda 1608$, 2374 will give the ultimate number of components. The relative abundance Fe II/Mn II equals 40 and 64 in clouds 3 and 4 respectively, a value lower than the cosmic abundance ratio Fe/Mn=160. The relative abundance Mg II/Fe II varies from 0.54 to 3.0 in the four clouds, most probably reflecting differences in the average ionization level of Mg and Fe.

An upper limit on the total H I column density of the four clouds is derived from Lyα absorption (damping limit), N(H I)<6.3 10^{19} cm^{-2} (Blades *et al.* 1985). A lower limit on N(H I) can be inferred from the O II or Mg II absorptions assuming cosmic abundances. From N(O I) the lower limit is underestimated since in regions of moderate opacity in the Lyman continuum, $\tau(\mathrm{Ly}) \sim 1-3$, H I could be present with H I/H>0.5, but O I is not dominant with O I/O<0.1 (see e.g. Bergeron & Souffrin 1971). Using the column density N(O I) given by Blades *et al.* (1985) we get $N(\mathrm{H\,I}) > 1.2\,10^{18}\,\mathrm{cm}^{-2}$. Assuming that Mg II exists only in the H I zone [$\tau(\mathrm{Ly}) > 1$] and taking our estimates of N(Mg II), we obtain as expected a larger value for the lower limit on N(H I) than with O I, $N(\mathrm{H\,I}) > 1.1\,10^{19}\,\mathrm{cm}^{-2}$. The range of N(H I) being 1.1 to $6.3\,10^{19}\,\mathrm{cm}^{-2}$, the H I zone cannot be of low temperature otherwise the 21-cm observations of Briggs & Wolfe (1983) should yield a positive detection. We infer from the observed Mg II column densities in the four $z=1.345$ clouds together with the lack of 21-cm absorption $T > 600$ K (>280 K if only the larger Mg II cloud is considered). This implies that the material of low excitation is in an H I transition region within a cloud of fairly high temperature and not in a cold cloud of neutral gas. This accounts for the large ionic ratio N(Mg II)/N(Mg I) which is in the range 64 to 194 in the four clouds.

For the two systems ($z=1.549$ and 1.649) in which a weak C II absorption is present, we have only obtained upper limits for the Fe II lines. The relative intensity of Mg II and Fe II lines is fairly constant when both ions are detected with $W_r(\mathrm{Fe\,II}\,\lambda 2382)/W_r(\mathrm{Mg\,II}\,\lambda 2796) \sim 0.6$ to 1.0 (see e.g. Bergeron & Boissé 1984). This ratio drops to 0.3 when both lines are optically thin, if Mg and Fe have the same degree of ionization and the abundance ratio Mg/Fe has the cosmic value. It would be of prime interest to observe 0215+015 in the spectral range $\lambda\lambda$ 7100–7450 to search for the Mg II doublet of the $z=1.549$ and 1.649 systems in order to study the differential ionization level of Mg and Fe in the intermediate cases of weak C II absorption.

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