Mon. Not. R. astr. Soc. (1982) **199**, 81–91

Spectroscopy of the QSO pair PKS 0254–334

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Received 1981 July 7; in original form 1981 May 12

Summary. The radio QSO PKS 0254 – 334/R with $z_{\rm em} = 1.9130$ is located 60 arcsec from the radio-quiet QSO 0254 – 334/2 with $z_{\rm em} = 1.8640$. Spectroscopy with a resolution of ~ 2 Å has identified nine absorption-line systems in 0254 – 334/2 – four definite, four probable and one possible. The Lα absorption line is extraordinarily weak relative to the heavy-element lines in three of these systems, implying that hydrogen is almost absent or nearly totally ionized. Absorption by Mg II at a common redshift of about 0.213 is possibly present in both members of the QSO pair although their separation is unusually large. This absorption may be caused by two separate galaxies in a cluster or by a single cloud of gas covering both QSOs.

1 Introduction

The pair consists of a 17th magnitude flat-spectrum radio QSO, PKS 0254 – 334/R, with emission redshift $z_{\rm em} = 1.9130$ and a 16.5 magnitude radio-quiet QSO, 0254 – 334/2, with $z_{\rm em} = 1.8640$ located 60 arcsec to the east and south. A finding chart has been provided by Peterson & Bolton (1973), the redshifts have been published by Peterson *et al.* (1976) and accurate coordinates have been listed by Wright, Peterson & Jauncey (1979), which will be referred to as Paper 1.

This last paper also described low-resolution (~ 7 Å) spectroscopic observations of 0254 – 334/2. The emission lines of N V, Si IV + O IV], C IV and C III] were present and the first three were accompanied by strong P Cygni absorption lines. Some of these showed evidence for multiple components at $z_{\rm abs} = 1.847$, 1.832, 1.813 and possibly at 1.802. However, there was no clear evidence for Lα emission or absorption. Lα emission is missing in other QSOs, such as PKS 1157 + 014 (Wright *et al.* 1979) and PKS 0528 – 250 (Morton *et al.* 1980) but we were unaware of any objects with such strong N V, Si IV and C IV absorption when none is apparent at Lα.

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The higher resolution observations described in the present paper were made primarily to investigate the apparent absence of Lα absorption. We found the Lα absorption in about eight separate lines, weaker than the strongest N v and C iv P Cygni absorptions, but strong enough to depress the Lα emission that is probably also present. At the same time we were able to make a more detailed study of all the other absorption lines in both objects.

This paper continues our intermediate-resolution studies of selected QSOs from the Parkes radio surveys. In this series absorption line data have already been reported for PKS 1157+014 by Wright *et al.* (1979), for 0528−250 by Morton *et al.* (1980), and for 0805+046 (4C05.34) by Chen *et al.* (1981).

2 Observations

The new data were obtained on the nights of 1978 November 28 and 1978 December 5 UT using the image photon counting system (IPCS) at the $f/8$ Cassegrain focus of the 3.9 m Anglo-Australian telescope. A long slit of the RGO spectrograph was placed at position angles of 93° or 273° in line with the pair of QSOs. The two-dimensional facility of the IPCS allowed us to take data from both objects at the same time together with a pair of sky windows adjacent to each QSO. The width of the slit corresponded to 2 arcsec on the sky which was close to the image diameter on both nights.

The gratings had rulings of 1200 line mm^{-1} giving dispersions of 33 Å mm^{-1} in first order and effective blazes near 3700 Å the first night and 4600 Å the second night. This system provided an effective spectral resolution of about 2 Å. The effect of IPCS sensitivity irregularities was minimized by using a continuum, flat-field calibration source and the sky background was removed from the data for each QSO by subtracting the means of the appropriate sky windows.

The wavelength range was approximately 3180–4174 Å the first night and 3750–4770 Å the second night. The two sets of data were added together in the overlap region and suitable multiplication factors were applied on each side to produce a reasonably smooth continuum. Therefore the ordinate in Figs 1 and 2 does not represent actual counts per channel and the continuum distribution is not reliable over widths much greater that those of the broadest spectral features. A much better representation of the continuum distribution for 0254−334/2 can be found in fig. 2 of Paper I.

3 The emission lines

The improved resolution of these spectra has permitted us to redetermine the emission-line redshifts as listed in Table 1. The observed wavelengths have been converted to vacuum for

Table 1. Emission lines in the two QSOs.

Ion	λ_{lab}^{vac} (Å)	λ_{obs}^{air} + corr to vac		z_{em}	
		/2	/R	/2	/R
H I	1215.67		3539.5 + 1.0		1.9124
N V	1240.14	2549: + 1.0	3605: + 1.0	1.8626:	1.908:
O IV	1402.46	4016 + 1.1		1.8643	
C IV	1549.05	4435 + 1.2	4511.8 + 1.3	1.8638	1.9135
C III]	1908.73	5460* + 1:5		1.8613:	
Adopted mean				1.8640	1.9130

* From Paper I.

comparison with the laboratory values. Following Wills & Netzer (1979) and Wills (1980) we have assumed that the Si IV + O IV] blend is due primarily to O IV] with an effective wavelength of 1402.46 Å.

In 0254 – 334/2 the peaks of Si IV + O IV] and C IV appear to be separated from their associated absorption lines and give consistent redshifts. The N V emission profile may be affected by the adjacent absorption and the C III] measurement is from a lower resolution spectrum, so that neither of these lines was used in the final estimate of $z_{\rm em} = 1.8640 \pm 0.0003$. This value is slightly larger than the 1.857 derived in Paper I, owing to an improved value for the mean rest wavelength of O IV], a better estimate of the observed peak of C IV, and the conversion of the observed wavelengths to vacuum values. The expected position for Lα emission is 3481 Å (air). Fig. 1 shows that there are peaks near 3459 and 3493 Å.

We conclude that Lα emission is probably present but attenuated by several absorption lines.

The redshift of PKS 0254 – 334/R was found to be 1.9130 ± 0.0006 from Lα and C IV, close to the low resolution estimate of 1.915 by Peterson *et al.* (1976). The N V feature is broad without a definite peak.

4 The absorption lines

Tables 2 and 3 contain the observed wavelengths and equivalent widths of the principal absorption lines in the two QSOs derived from the spectra shown in Figs 1 and 2. Both air and vacuum wavelengths are quoted, all corrected for the Earth's orbital motion. The typical standard error is ± 0.25 Å for the narrowest, strong features but larger for the broader and weaker lines. The laboratory wavelengths and *f*-values are from the compilation of Morton (1978).

4.1 0254 – 334/2

As already implied by the preliminary analysis in Paper I, this object has several redshifts systems with relatively few lines each. Consequently a comprehensive search programme for absorption systems, like the programme used by Morton *et al.* (1980), was not as effective as simply correlating C IV or Si IV doublets with Lα. We have identified eight such systems and one Mg II doublet. Only seven of the 39 lines remain completely unidentified and six more have an unidentified component. The systems found are listed in Table 4 and are discussed below in order of increasing redshift. In the discussion the wavelengths are the observed values in air, to facilitate reference to Figs 1 and 2, whereas the redshifts are based on vacuum values.

4.1.1 System A: z = 0.2125 – probable, low ionization

This system depends entirely on the identification of the pair of lines at 3390.1 and 3397.6 Å with the Mg II λλ 2796.35, 2803.53 doublet. These lines cannot be believably identified in any other system and their wavelength and strength ratios suggest the Mg II identification is likely. However, allowance has to be made for a slight, longward broadening of the 3390 Å line. This may be caused by noise or by the longward component of the N V doublet in system B (see below). The Mg I λ 2852.97 line is predicted at 3458.2 Å but the form of the spectrum would make it difficult to see a weak line near this wavelength.

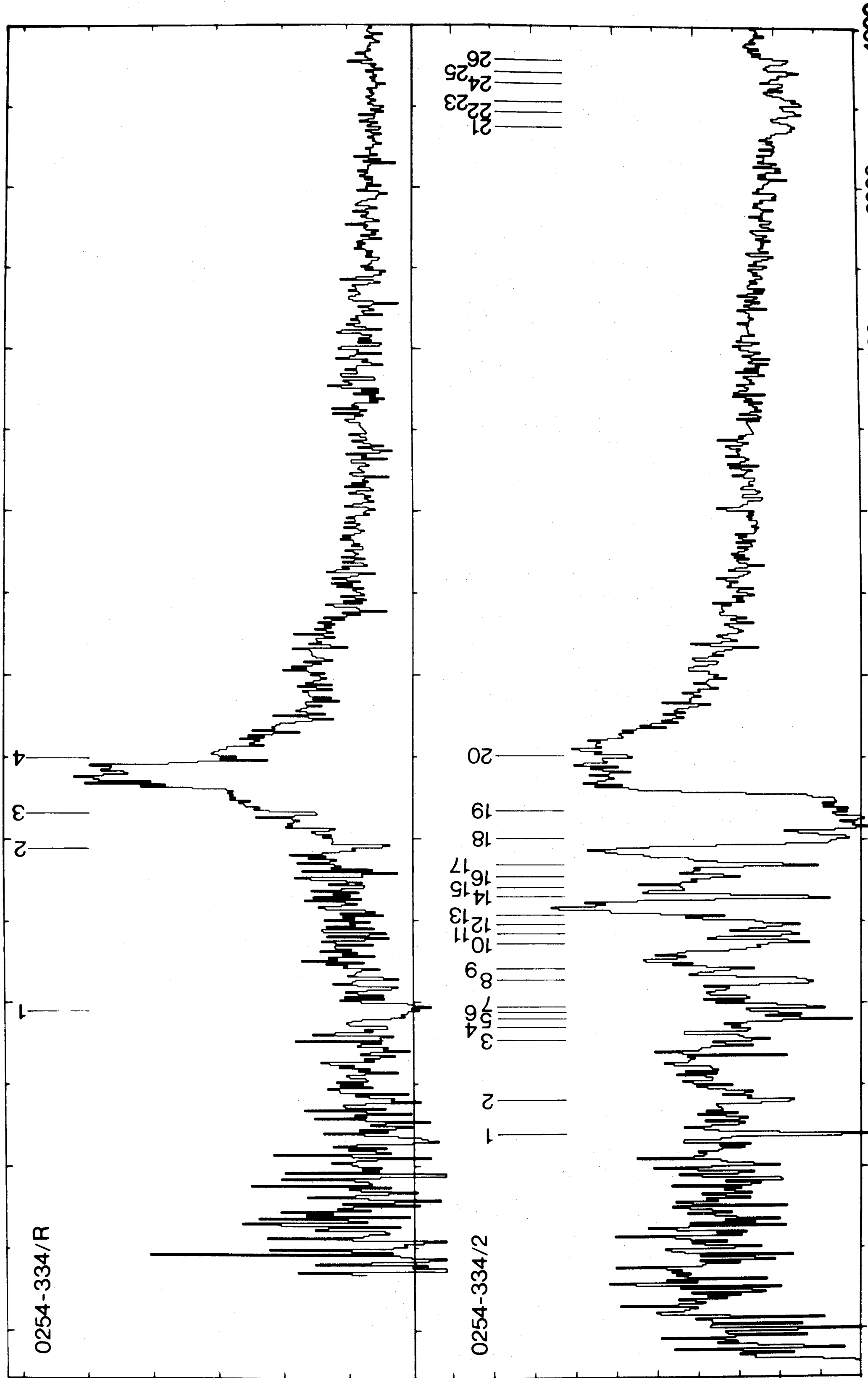

Figure 1. Relative fluxes f_λ from 3200 to 4000 Å for the radio QSO 0254 − 334/R (upper) and the radio-quiet QSO 0254 − 334/2 (lower). The absorption lines are labelled with the numbers from Table 2.

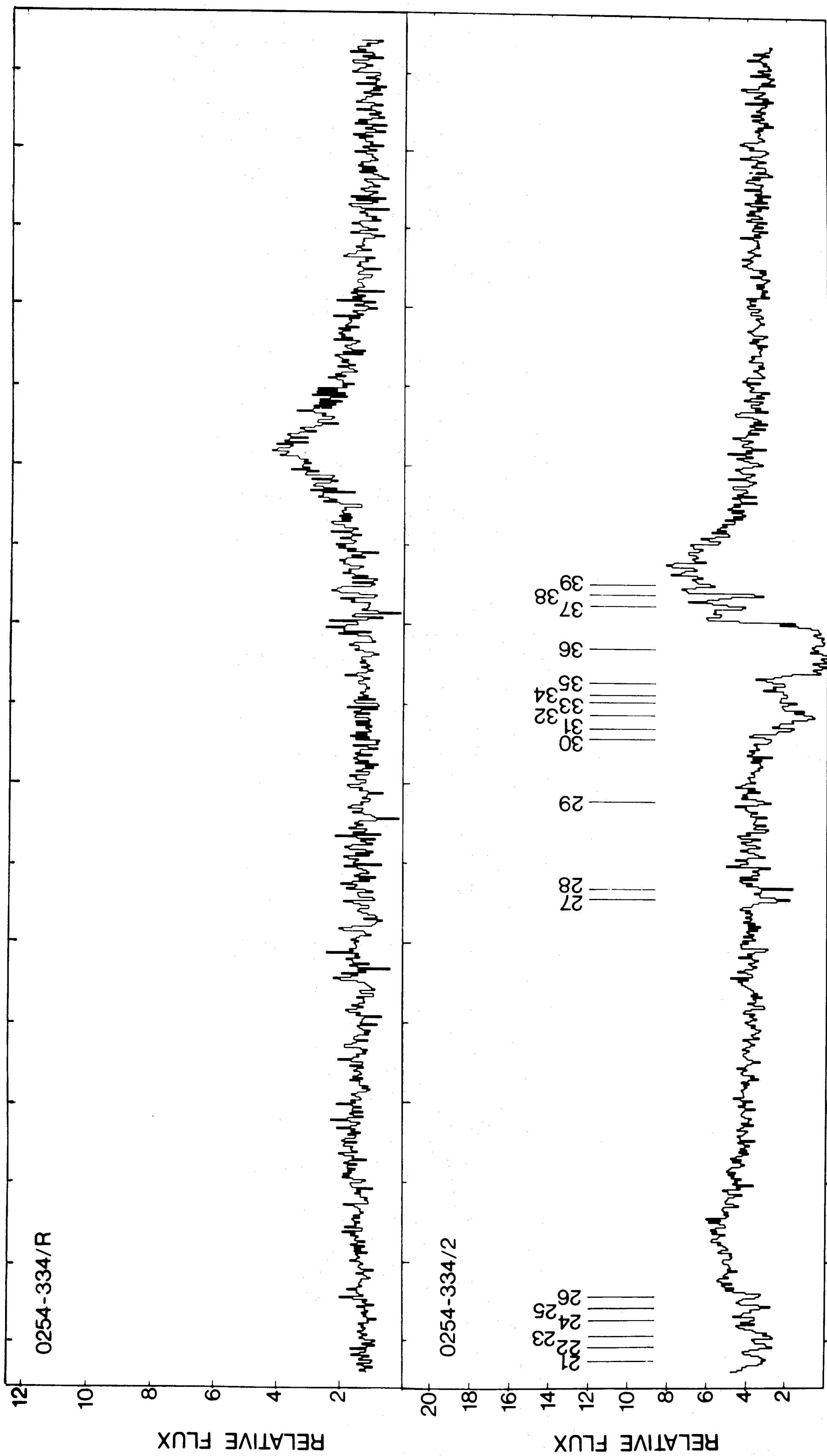

Figure 2. Relative fluxes f_λ from 3930 to 4770 Å for the radio QSO 0254 – 334/R (upper) and the radio-quiet QSO 0254 – 334/2 (lower). The absorption lines are labelled with the numbers from Table 2.

Table 2. Absorption lines in 0254 – 334/2.

No.	λ_{obs}^{air}	λ_{obs}^{vac}	W_λ	Ion	λ_{lab}^{vac}	f	z	$\Delta\lambda$ obs-calc	Notes
1	3319.8	3320.8	2.5	HI	1215.67	0.416	B	-0.5	Used for z
2	3340.7	3341.7	2.1						
3	3378.2	3379.1	1.11						
4	3384.8	3385.8	0.76	NV	1238.81	0.152	B?	+1.25	
5	3390.1	3391.0	2.7	MgII	2796.35	0.592	A	+0.4	Used for z
6	3393.5	3394.5	1.94	NV	1242.80	0.0757	B?	-0.95	Incl. unident. blend
7	3397.6	3398.6	2.1	MgII	2803.53	0.295	A	-0.7	Used for z
8	3413.3	3414.3	3.0	HI	1215.67	0.416	C	+0.8	Used for z
9	3420.6	3421.6	1.35	HI	1215.67	0.416	D	-0.5	Used for z
10	3435.6	3436.6	4.7	HI	1215.67	0.416	E	+0.5	Incl. unident. blend
	3437.5	3438.5							Min. of asym. line
11	3441.8	3442.8	3.5	HI	1215.67	0.416	F	-0.2	Used for z
12	3448.5	3449.5	6.4	HI	1215.67	0.416	G	+0.2	Used for z, main feature
13	3453.8	3453.9							Satellite minimum
14	3464.5	3465.4	3.3	HI	1215.67	0.416	H	-0.35	Used for z
15	3470.6	3471.6	1.94	HI	1215.67	0.416	I	0	Used for z
16	3476.0	3477.0	3.4						Incl. unident. blend
	3477.8	3478.8		NV	1238.81	0.152	C	+0.35	Min. of asym. line
17	3484.3	3485.3	6.0	NV	1242.80	0.0757	C	-4.4	Incl. unident. blend
				NV	1238.81	0.152	D	-1.95	
18	3500.4	3501.4	8.6	NV	1242.80	0.0757	D	+2.9	
				NV	1238.81	0.152	E	-0.1	Used for z
19	3517	3518	22.3	NV	1242.80	0.0757	E,F,G		Broad absorption
				NV	1238.81	0.152	F,G,H?		
20	3550.2	3551.2	0.30						
21	3937.5	3938.6	2.4	SiIV	1393.76	0.528	E	-0.9	Incl. unident. blend
22	3946.6	3947.7	2.0	SiIV	1393.76	0.528	F	+0.3	Used for z
23	3953.5	3954.6	2.3	SiIV	1393.76	0.528	G	-0.05	Used for z
24	3964.0	3965.1	0.61	SiIV	1402.77	0.262	E	+0.2	Used for z
25	3971.8	3972.9	1.09	SiIV	1402.77	0.262	F	0	Used for z
26	3979.2	3980.3	0.89	SiIV	1402.77	0.262	G	+0.1	Used for z
27	4229.1	4230.3	1.97	CIV	1548.19	0.194	B	+0.5	Used for z
28	4235.7	4236.9	1.17	CIV	1550.76	0.097	B	+0.1	Used for z
29	4290.6	4291.8	0.59						
30	4329.3	4330.5	1.07						
31	4336.1	4337.3	2.2						
32	4344.2	4345.4	7.0	CIV	1548.19	0.194	C	-1.8	Incl. unident. blend
33	4352.2	4353.4	2.3	CIV	1550.76	0.097	C	-1.0	Used for z
34	4357.7	4359.0	2.8	CIV	1548.19	0.194	D	+0.85	Used for z
35	4364.2	4365.4	2.2	CIV	1550.76	0.097	D	0	Used for z
36	4386.1	4387.3	30.0	CIV	1548.19	0.194	E,F,G		Broad absorption
				CIV	1550.76	0.097	E,F,G		
37	4412.9	4414.2	0.84	CIV	1548.19	0.194	H	+0.5	Used for z
38	4420.1	4421.3	1.38	CIV	1550.76	0.097	H	+0.2	
				CIV	1548.19	0.194	I	+0.1	
39	4427.1	4428.4	0.57	CIV	1550.76	0.097	I	-0.1	Used for z

Table 3. Absorption lines in PKS 0254 – 334/R.

No.	λ_{obs}^{air}	λ_{obs}^{vac}	W_λ	Ion	λ_{lab}^{vac}	Notes
1	3394.9	3395.9	10.0	Mg II	2799.9	λ weighted equally; components blended
					2799.5	λ weighted by W_λ in /2
2	3494.7	3495.7	3.6			
3	3515.4	3516.4	0.88			
4	3549.0	3550.0	0.68			
5	4173.1	4174.3	3.0			

4.1.2 System B: z = 1.7321 – definite, high ionization

This system depends on the two lines at 4229.1 and 4235.7 Å being identified as the C IV λλ 1548.19, 1550.76 doublet and the line at 3319.8 Å as Lα λ 1215.67. There is no evidence for Si IV λλ 1393.76, 1402.77 nor for any of the lower excitation Si II, C II or O I species. N V λλ 1238.81, 1242.80 may be present and the longward component may account for broadening of the shortward Mg II component in system A.

Table 4. Absorption redshift systems and velocities ΔV relative to emission lines.

	z_{abs}	ΔV (km s^{-1})	Ions	Status
0254 – 334/2	z_{em} = 1.8640			
A	0.2125	–	Mg II	Probable
B	1.7321	–14 120	H I, C IV, N V?	Definite
C	1.8079	–5 930	H I, C IV, N V?	Possible
D	1.8150	–5 170	H I, C IV, N V?	Probable
E	1.8265	–3 950	H I, Si IV, C IV, N V	Definite
F	1.8322	–3 350	H I, Si IV, C IV, N V	Definite
G	1.8374	–2 800	H I, Si IV, C IV, N V	Definite
H	1.8509	–1 370	H I, C IV, N V?	Probable
I	1.8557	–870	H I, C IV	Probable
0254 – 334/R	z_{em} = 1.9130			
A	0.2129	–	Mg II	Possible

4.1.3 System C: z = 1.8079 – possible, high ionization

This is an uncertain system. The redshift is based on identifying a strong line at 3413.3 Å as Lα and two weaker lines at 3477.8 and 4352.2 Å as the shortward and longward components of the N V and C IV doublets respectively. The longward component of the N V doublet is lost in the longward wing of a strong line at 3484.3 Å and the shortward component of the C IV doublet in a strong line at 4344.2 Å. If these identifications are correct, the weakness of the Lα line relative to the N V and C IV lines suggests that this is a high ionization system.

4.1.4 System D: z = 1.8150 – probable, high ionization

This system results from identifying a pair of weak lines at 4357.7 and 4364.2 Å with the C IV doublet and a weak line near 3420.6 Å as Lα. There is no evidence for low excitation lines such as Si II 1190.42 or C II 1334.53.

The next three systems will be discussed together since they are all similar. They are:

4.1.5 System E: z = 1.8265 – definite, very high ionization
System F: z = 1.8322 – definite, very high ionization
System G: z = 1.8374 – definite, very high ionization

The redshifts of all three systems are defined by identifying the medium-strength group of lines near 3960 Å with Si IV $\lambda\lambda$ 1393.76, 1402.77 doublets. The extremely strong and broad absorption features near 3510 and 4385 Å can then be explained as saturated N V and C IV absorption in these same systems. Weak lines at 3435.6, 3441.8 and 3448.5 Å can be identified as Lα in systems E, F and G respectively. There is no evidence for low excitation lines such as Si II or C II in any system. Unless there is an exceptional underabundance of hydrogen, the extreme weakness of the Lα lines compared with N V and C IV implies very high ionization for these three systems.

4.1.6 System H: z = 1.8509 – probable, medium ionization

This system is defined by identifying a strong line at 3464.5 Å as Lα and a pair of lines at 4412.9 and 4420.1 Å as the C IV doublet. The disconcerting strength reversal of this pair is almost certainly due to a strong contribution from the shortward component of the C IV doublet in system I discussed below. Weak Si IV absorption may be present and also N V λ 1238.8, but the weaker N V component was not detected. The shortward component of the Si IV doublet is almost completely masked by the stronger Si IV line in system F.

4.1.7 *System I: z = 1.8557 – probable, high ionization*

This system relies on identifying the line at 4427.1 Å with the longward component of the C IV doublet and part of the strong line at 4420.1 Å with the shortward component. A line at 3470.6 Å is probably Lα in the same system but the form of the continuum makes its strength rather difficult to estimate. Weak Si IV absorption may be present with the shortward component of the doublet again lost in a strong line in system G. There is no reliable evidence for absorption by any low ionization species in this system.

4.2 PKS 0254 – 334/R

The spectrum of PKS 0254 – 334/R (Fig. 1) shows relatively few strong absorption lines – although in the region shortward of the Lα emission line where absorption is normally expected the signal-to-noise ratio is rather poor. The stronger lines that *are* seen are listed in Table 3.

We have not been able convincingly to identify any absorption systems unique to this object. Nor is there significant evidence for the existence of absorption lines common to the spectra of both QSOs, with the notable exception that the Mg II doublet feature seen in the spectrum of 0254 – 334/2 near 3395 Å may also be present in PKS 0254 – 334/R. We shall discuss this point further in the next section.

5 Discussion

The most interesting feature of the spectrum of 0254 – 334/2 is the unusual weakness of the Lα absorption compared to that of C IV and N V in systems E, F and G. In Table 5 we compare the rest equivalent widths with those in systems B and C (z = 1.9800, 1.9686) of PKS 1157 + 014 (Wright *et al.* 1979) and system A (z = 2.812) in PKS 0528 – 250 (Morton *et al.* 1980). Systems B and C of PKS 1157 + 014 have wide saturated absorption lines of Lα, N V and C IV similar to N V and C IV in systems E, F and G of 0254 – 334/2, and in contrast with PKS 0528 – 250 which has wide saturated Lα like 0254 – 334/2 but much weaker N V and C IV. The systems in 1157 + 014 and 0254 – 334/2 have high ionization such as might occur in a QSO wind or a galactic halo, whereas the one in 0528 – 250 has low ionization similar to an interstellar cloud.

In some cases, particularly Lα in 1157 + 014, a correction has been made in Table 5 for the estimated contributions of other systems. Furthermore unidentified blends allow us to quote only an upper limit for Lα in 0254 – 334/2. Nevertheless it is clear that while Lα is

Table 5. Equivalent widths of certain absorption lines.

Object	Systems	W_λ (Å) rest frame			
		Lα	N V	Si IV	C IV
0254 – 334/2	E, F, G	<5.	11.	3.3	11.
PKS 1157 + 014	B, C	15:	13.	6.6	13.
PKS 0528 – 250	A	18.5	0.4	1.5	2.4

the strongest absorption in both 1157+014 and 0528–250, this transition is weaker than either C IV or N V in 0254–334/2. Obviously the relative abundance of neutral hydrogen in 0254–334/2 must be abnormally low. It is difficult to proceed further and quantify the discussion, since we do not have reliable values for the Doppler velocity parameters in each system. However, consideration of the profiles of the Si IV lines in the three systems suggests that they are unsaturated and have velocity parameters of about 100 km s^{-1} in systems F and G and between 100 and 200 km s^{-1} in system E. In what follows, for simplicity we shall take $b = 150$ km s^{-1} in E, 100 km s^{-1} in F and 100 km s^{-1} in G.

The total equivalent width of the C IV absorption is about 30 Å in the observed frame. We shall assume that all six lines in the three absorption systems are saturated but not damped and contribute equally to this value, and thus obtain an approximate equivalent width for each member of the C IV doublet in each system of 5 Å. Similarly we find an equivalent width of 5 Å for N V.

In Table 6 we list values of the column densities in C^{3+} and N^{4+} and compare these to the column density of neutral hydrogen in each of the three redshift systems.

It can be seen that the abundance ratios of both C^{3+} and N^{4+} relative to H^0 are very high compared to the cosmic values (Allen 1973) of $C/H = 3 \times 10^{-4}$ and $N/H = 1 \times 10^{-4}$ by number. Furthermore, the ratios listed in Table 5 are only lower limits, since not all of the carbon and nitrogen can be in the C^{3+} and N^{4+} states.

Providing the *total* abundances of each element are reasonably normal, the most direct interpretation of these values is that the absorbing gas is very highly ionized, possibly with H^+/H^0 as high as 10^5. Turnshek *et al.* (1980) have reached similar conclusions for three other QSOs which also have broad, detached absorption features. These authors discuss the location of the absorbing material and mention that the cause of the high degree of ionization may be high-energy photons, high-energy particles or shock-heating.

A second interesting feature is the possible occurrence of the Mg II doublet absorption in the spectra of both PKS 0254–334/R and 0254–334/2 at almost the same redshift. The two lines are blended together in R and resolved in 2.

The situation as regards the broad feature (1) in PKS 0254–334/R (Fig. 1) is, however, more uncertain: only the close wavelength agreement with the lines in 0254–334/2 and the weak evidence of the lack of significant C IV absorption near 4325 Å lead us to suggest that the feature may also be Mg II. Since, however, the confirmation of common absorption in two QSOs separated by 1 arcmin would have very important implications, we shall briefly discuss the possibility here.

In 0254–334/2 the lines (5 and 7 in Fig. 1) are seen at good signal-to-noise, have the correct wavelength separation (within measurement error) and have reasonable intensity

Table 6. Abundances in the three strong absorption systems in 0254 – 334/2.

		System E (b = 150 km s^{-1})	System F (b = 100 km s^{-1})	System G (b = 100 km s^{-1})
Lα	W_λ (obs) (Å)	<4.7	3.5	<6.4
	N_{H^0} (cm^{-2})	$<2 \times 10^{15}$	1×10^{15}	$<1 \times 10^{17}$
C IV	W_λ (obs) (Å)	5	5	5
	$N_{C^{3+}}$ (cm^{-2})	1×10^{15}	2×10^{15}	2×10^{15}
	$N_{C^{3+}}/N_{H^0}$	$>5 \times 10^{-1}$	2	$>2 \times 10^{-2}$
N V	W_λ (obs) (Å)	5	5	5
	$N_{N^{4+}}$ (cm^{-2})	3×10^{15}	1×10^{16}	1×10^{16}
	$N_{N^{4+}}/N_{H^0}$	>2	1×10^{1}	$>1 \times 10^{1}$

ratios for an Mg II doublet. Furthermore, there is a plausible explanation for the longward broadening of the 3390 Å line as due to the longward component of the N V doublet in system B. We cannot, however, completely exclude the possibility that the features are Lα lines forming part of the Lα 'forest' usually seen shortward of the Lα emission feature in other QSOs. But we believe this explanation is less likely because no C IV absorption is seen near 4325 Å even though the high or medium levels of ionization of all the other absorption systems in 0254 – 334/2 result in fairly strong C IV features relative to the Lα features. In summary, we conclude that the identification of the lines as an Mg II doublet is probable, but not certain.

Our best estimate for the redshift of the absorbing material is 0.2125 in 0254 – 334/2 and 0.2129 in 0254 – 334/R, with a standard error of about 0.0001 in each case. The relative velocity of the two doublets is $100 \pm 30\,\mathrm{km\,s^{-1}}$. The relative velocity error is somewhat less than that estimated formally from the redshift errors since systematic wavelength calibration errors can be ignored. Two possible explanations for the common absorption are that it arises in galaxies in a single cluster located along the line of sight to the QSOs or in a single cloud of gas which covers both objects.

Inspection of a UK Schmidt IIIaJ plate (SRC – J4602) shows that the QSO pair lies in a rich cluster of galaxies with magnitudes close to the plate limit (~ 22 mag) and angular sizes typically 4 arcsec (see Plate 1). The general appearance of the cluster is consistent with its having a redshift of about 0.2. It would obviously be of great interest to confirm this value. We cannot accurately estimate the probability that two galaxies would lie along the line of sight to the QSOs, since we gave special attention to the pair because it appeared to have common absorption. In addition, the absorption cross-section of the galaxies may be substantially greater than their apparent, luminous cross-section. The richness of the cluster, however, suggests that the probability is not low. On the other hand, we note that at the epoch of the Palomar survey the radio-loud QSO was invisible and, in fact, no other object was visible on its position (Peterson & Bolton 1973). Thus we can set a limit to the magnitude of any intervening galaxy of $\gtrsim 20$ mag.

If the absorption is caused by a common gas cloud, the diameter of the cloud must be at least 370 kpc, since the QSOs are separated by 60 arcsec, and the gas cloud must have a redshift of 0.213. (We have assumed a Hubble constant of $50\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$.) From the observed strengths of the Mg II lines we can obtain an estimate of the Mg^+ column density. However, we have no reliable velocity dispersion information and can thus only set a lower limit of $\gtrsim 4 \times 10^{13}\,\mathrm{cm^{-2}}$. Assuming normal abundances, the total hydrogen column density should therefore be $\gtrsim 1.5 \times 10^{18}\,\mathrm{cm^{-2}}$. Using this lower limit, the lower limit for the linear size given above and assuming approximate spherical symmetry, we derive a limit to the cloud mass of $\gtrsim 2 \times 10^9 M_\odot$.

Alternatively, we can derive a total mass limit from the relative velocity of the two absorption lines. Although the radial relative velocity is only poorly determined ($100 \pm 30\,\mathrm{km\,s^{-1}}$), we use the virial theorem to estimate a total mass of $\sim 1 \times 10^{12} M_\odot$ over the 370 kpc separation of the two objects. Our two mass estimates are therefore consistent. Clearly it would be worthwhile looking for the hydrogen radio emission near 1171 MHz from such a cloud, although high sensitivity and angular resolution will be required.

Acknowledgments

We would like to express our thanks to Nick Lomb and Chen Jian-Sheng for assistance with the reduction of the spectral data, and to Ann Savage of the UK Schmidt Telescope Unit for making available a copy plate of the field.

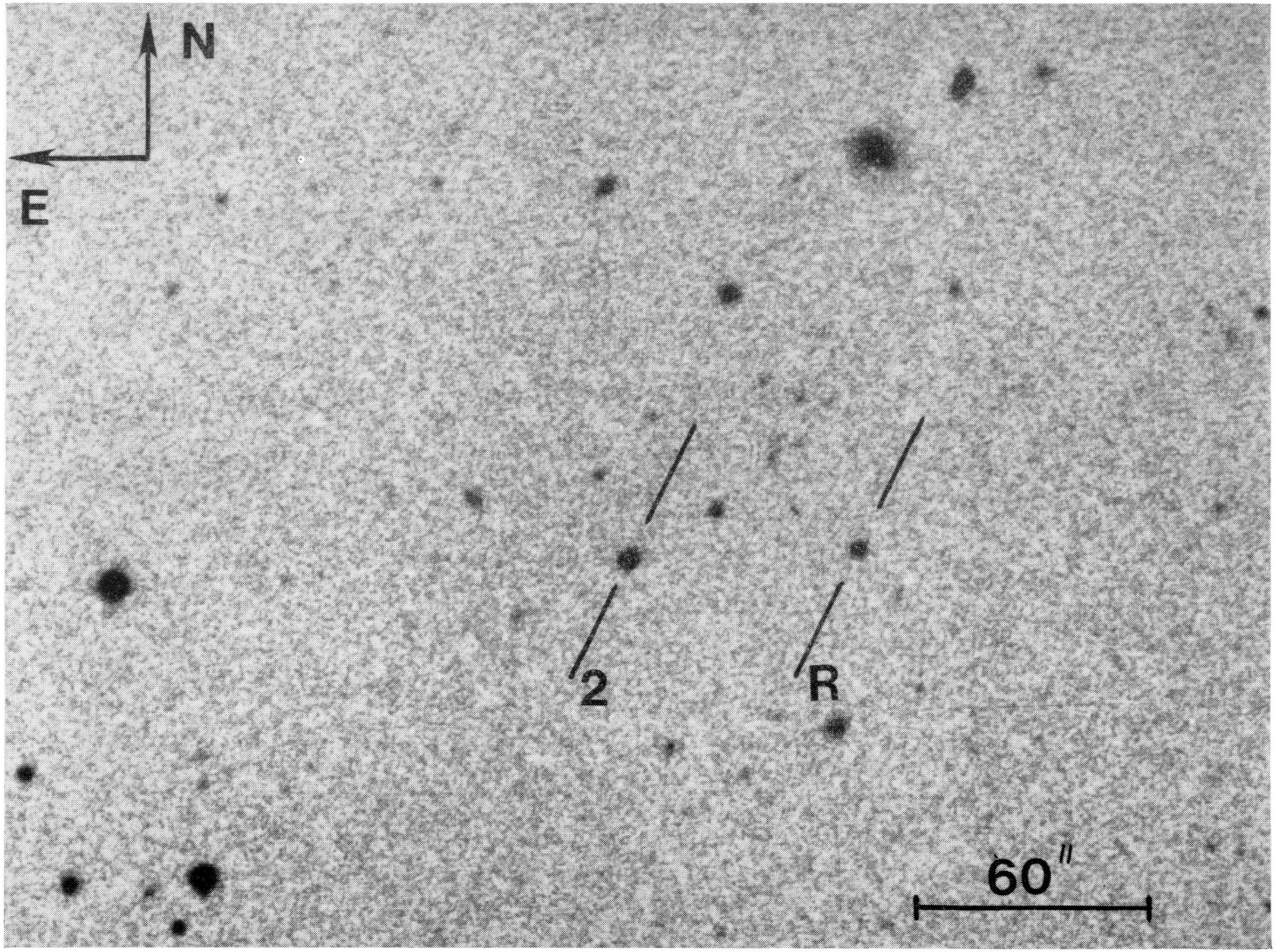

Plate 1. UK Schmidt IIIaJ plate J4602 (1978 October 24) showing the QSO pair PKS 0254–334 and a cluster of faint galaxies. The radio-loud QSO is labelled with an R and the radio-quiet one with a 2.

[*facing page* 90]

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