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The remarkable absorption-line systems in the quasar Tololo 1037-27

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Summary. We present the first medium-resolution spectroscopic observations of the quasar Tololo 1037−27 (z_{em}=2.18). We find 49 absorption lines between 3500 and 6000 Å, and identify seven absorption-line redshifts. Remarkably, six of the absorption systems are in the small redshift range z_{abs}=1.971 to z_{abs}=2.138.

The two most prominent absorption systems, z_{abs}=2.138 and z_{abs}=2.082 are of high ionization and the full width at half maximum at rest and after correction for the instrumental response of their Lyα and C IV lines is in the range 600–1100 km s^{-1}, i.e. larger than the width of lines which would be produced by absorbing material in a single galaxy. These properties, along with the high density of absorption-line systems, suggest that the Lyα and C IV lines are the superposition of several unresolved lines arising from absorption by individual galaxies in two groups or clusters of galaxies, possibly members of the same supercluster. The gas in these clusters could be influenced by the proximity of this or other quasars, which might explain the high degree of ionization of the absorbing gas. Alternatively, and perhaps less likely, the two absorption systems are intrinsic to the quasar and represent two outflows of gas.

The four other absorption line systems at z_{abs}=2.128, 2.070, 2.028 and 1.971 respectively, show lower degrees of ionization, and velocity profiles which are consistent with them originating in intervening galaxies or clusters of galaxies.

The significantly lower redshift system at z_{abs}=1.077 is a low-ionization intervening galaxy system.

Three rather strong absorption lines, including one at a wavelength just above that of Lyα in emission, remain unidentified.

1 Introduction

Broad absorption lines are observed in the optical spectra of a small fraction (0.03–0.10) of quasars and provide direct evidence for acceleration of thermal gas by the quasars (Weymann, Carswell & Smith 1981). The absorbing gas is usually highly ionized with the strongest lines being C IV λ1549 and N V λ1240. Even in the few known cases where there is also broad Mg II λ2800 in absorption the C IV line is very strong.

Absorption-line systems intrinsic to quasars nevertheless display a large variety in widths and structures of the profiles. High-wavelength resolution observations have revealed that some absorption features are in fact groups of narrow lines, while in other cases the profiles have been found to be smooth. It is difficult to know how narrow the 'broad absorption lines' intrinsic to quasars can be because for values of the full width at half maximum (FWHM) less than $\sim 1500\,\mathrm{km\,s^{-1}}$, they can be confused with absorption features produced by a galaxy cluster whose densest region is crossed by the line-of-sight. Moreover, if the cluster is sufficiently close to the quasar the ionizing flux of the quasar is capable of increasing the degree of ionization of the gas in the cluster beyond that found in normal haloes.

Here, we present the first spectroscopic observations and analysis of the absorption-line systems in the quasar Tololo 1037−27. This quasar was discovered in an objective prism survey by Bohuski & Weedman (1979) who gave $z_{\mathrm{em}}=2.23$ and $m_{\mathrm{B}}=17.4$. Our observations show that this quasar has a rich and remarkable absorption spectrum. Six absorption-line systems are found between $z_{\mathrm{abs}}=1.971$ and $z_{\mathrm{abs}}=2.138$. The two strongest of these systems are highly ionized and have Lyα and C IV linewidth between 600 and $1100\,\mathrm{km\,s^{-1}}$ wide. These lines could be the superposition of the absorption lines produced in the haloes of galaxies in two separate clusters, where the absorbing material is ionized by the quasar. Alternatively these absorption systems could be intrinsic to the quasars and represent two outflows of gas.

2 Spectroscopic observations

The quasar was first observed for 1 hr on four different nights in 1983 March, using the Boller and Chivens spectrograph of the ESO 3.6-m telescope equipped with an IDS detector. The grating was set at a different angle each night in order that a given wavelength fell on a different location of the IDS phosphor. The wavelength range so covered was 4100–6000 Å. The grating and slit combination gave an effective wavelength resolution of 7 Å.*

These observations were complemented in 1985 May by observing Tololo 1037−27 with the ESA Photon Counting Detector (ESA PCD, di Serego Alighieri, Perryman & Macchetto 1985) and the Boller and Chivens spectrograph at the 2.2-m telescope at La Silla. We obtained spectra totalling 7800 s of integration. These observations spanned the 3420–4500 Å range with an effective resolution of 3.8 Å.

The signal-to-noise of the combined spectrum is mediocre at the edges and has a minimum in the interval 4000–4400 Å. There, the upper limit to the equivalent width of undetected absorption lines is ~3–4 Å, while it is ~1 Å for $\lambda > 4400$ Å. Between 4000 and 3600 Å the 'Lyman forest' is the main source of uncertainty in determining equivalent widths, wavelengths, and linewidths. Below 3600 Å the signal-to-noise is small ($\lesssim 3$) and the measurements particularly uncertain.

3 Results and discussion

3.1 THE EMISSION LINES

The peaks of the strongest emission features Lyman α, C IV λ1549 and Si IV λ1393, 1403 blended with O IV] λ1406 give $z_{\mathrm{em}}=2.18\pm0.05$. The other strong emission features are the blend Si III]

*These first observations of Tololo 1037−27 were conducted in the course of a study of the C IV λ1549 and C III λ1909 line profiles, in a list of about 20 quasars which we had selected for their redshift and their apparent magnitude (Ulrich & Collin-Souffrin, in preparation). A few of the selected quasars turn out to be inadequate for a study of the line profiles because of their prominent absorption lines. Tololo 1037−27 is one of them.

λ1892+C III]λ1909 and a feature at ~2080±10 Å. The latter has been noted previously (Phillips & Hawley 1978; Arp 1984). It is unidentified and could be an Fe II multiplet.

3.2 THE ABSORPTION LINES

The measured characteristics of the absorption lines are given in Table 1 with our suggested identifications.

The lines were measured interactively. The central wavelength of a line was determined from the first moment of the profile (over the range set manually by the cursor). However, in many instances where lines are asymmetrical and/or obvious blends, this central wavelength can differ by several angstroms from the wavelength of the minimum. In such cases, the minimum wavelength is also given in the notes to Table 1. For normal isolated lines the full width at half maximum is taken to be 2.3 σ, σ being the second moment of the profile (which strictly applies only to Gaussian lines). Errors were estimated for the equivalent widths taking into account the propagation of the counting statistics as well as an estimated uncertainty, typically 20 per cent, in locating the continuum level. Evidently, in an object with such strong and numerous absorption features, a systematic error in locating the continuum level may also have occurred. Additional errors affect the measured equivalent widths of blended lines (e.g. lines 6, 7 and 10, 11) or lines for which the level of the local continuum is particularly uncertain (e.g. lines 11, 23, 26). In Table 1, we classify the lines into three categories: According to the estimated *internal* error attached to them, 'a' designates those for which the equivalent widths are known with an error equal to or less than ±50 per cent. 'b' designates the lines for which the error on the equivalent width is between ±50 and ±100 per cent. Marginal detections and other dubious lines are indicated by 'c'.

In Figs 1 & 2, the three best 1-hr IDS spectra were combined to give the spectrum in the range 4200–7000 Å. Below 4200 Å the spectrum displayed comes from five exposures of 1200 s, each taken in very good seeing conditions, with the ESA PCD. For display the ESA PCD data have been smoothed with a Gaussian of 10 Å FWHM, while the measurements given in Tables 1 and 2, have been made on unsmoothed data.

3.3 THE CHARACTERISTICS OF THE SEVEN ABSORPTION-LINE SYSTEMS

We have identified seven absorption-line systems (Table 2). Three lines which we consider certain remain unidentified. Two of them, at 3773 and 3862 Å respectively, are at wavelengths shorter than the Lyα emission peak at ~3870 Å. The third one at 3902 Å is longward of Lyα emission.

The properties of the four strongest high-redshift systems are given in Table 3(a, b). Equivalent widths of lines in the galactic disc and halo, and in well-studied narrow-line systems in quasars are also given for comparison. It is a peculiarity of these four redshift systems that there are multiple coincidences between the redshifted wavelengths of several of their lines. For three out of four redshift systems the N V λ1240 line falls at the location of the Lyα line in another system. Similarly in three out of four systems the Si II λ1260.4 is blended with the Lyα line (two cases) and N V λ1240 line (one case) of other redshift systems. This peculiarity hampers the analysis of the physical conditions of this gas, especially when using data of medium-wavelength resolution.

The systems at z=2.128 and z=2.070 are based on the identification with Lyα of the lines at 3802 and 3733 Å respectively and on the identification with C IV λ1549 of the weak absorption lines sitting in the blue wing of the two strong C IV λ1549 absorptions at 4857 and 4770 Å respectively. They are considered probable.

The absorption line system at z=1.077 displays seven low-ionization lines normally found in the absorption spectrum of intervening galaxies.

Table 1. Absorption-line measurements.

	λ (Å)		W_λ(obs) (Å)	FWHM(obs)* (Å)	Suggested Identifications		Redshift	System
1	3479.8	c	6.9	-				
2	3518.4	c	23.1	-				
3	3538.1	c	-	-				
4	3556.2	c	4.6	-				
5	3569.3	c	2.9	-				
6	3585.8	a	4.0	-	SiIII	λ1206.5	1.97207	6
7	3609.8	a	8.7	11	Lyα	λ1215.7	1.9711	6
					SiII	λ1193.3	2.028	5
8	3623.0	c	1.8	-				
9	3650.5	a	5.5	6.5	SiIII	λ1206.5	2.0257	5
10	3678.2	a	10.7	10	Lyα	λ1215.7	2.0256	5
11	3706.2	c	1.7	-				
12	3718.5	a	3.4	4	SiIII	λ1206.5	2.0820	3
13	3733.9	b	3.5	7	Lyα	λ1215.7	2.0714	4
14	3744.1	b	7.0	9.2	Lyα	λ1215.7	2.0798	3
15	3773.1	a	7.1	8				
16	3788.2	a	4.5	5	SiIII	λ1206.5	2.1398	1
17	3803.0	a	4.0	3.8	Lyα	λ1215.7	2.1282	2
18	3815.0	b	14.3	11.5	Lyα	λ1215.7	2.1381	1
					NV	λ1240.1	2.0764	3
					SiII	λ1260.4	2.0268	5
19	3862.2	b	2.9	4				
20	3884.4	a	3.4	>6	NV	λ1240.1	2.1323	1
					SiII	λ1260.4	2.0819	3
21	3902.4	a	1.8	8				
22	3937.9	c	1.4	-				
23	3956.6	a	4.2	5	SiII	λ1260.4	2.13916	1
24	4076.1	c	2.8	-				
25	4149.0	c	<4.5	-	SiIV	λ1393.8	1.9767	6
26	4167.0	c	<4.5	-	SiIV	λ1402.8	1.9705	6
27	4187.4	b	3.0	4.5	CII	λ1334.5	2.1378	1
28	4217.8	c	<4.5	-	SiIV	λ1393.8	2.0261	5
29	4248.8	c	<4.5	-	SiIV	λ1402.8	2.0288	5
30	4296.1	b	6.0	8.4	SiIV	λ1393.8	2.0823	3
31	4324.0	b	6.0	10	SiIV	λ1402.8	2.0824	3
32	4374.1	c	<5	-	SiIV	λ1393.8	2.1382	1
33	4400.8	c	-	-	SiIV	λ1402.8	2.1371	1
34	4603.9	a	2.8	10	CIV	λ1549.2	1.9718	6
35	4691.9	a	4.0	12	CIV	λ1549.2	2.0286	5
36	4756.0	c	-	-	CIV	λ1549.2	2.0700	4
37	4770.8	a	17.5	21	CIV	λ1549.2	2.0795	3
38	4791.0	c	-	-	SiII	λ1526.7	2.1381	1
39	4844.0	c	-	-	CIV	λ1549.2	2.1268	2
40	4857.9	b	13.3	19	CIV	λ1549.2	2.1357	1
41	4930.8	b	-	-	FeII	λ2373.7	1.0773	7
42	4946.7	a	1.4	7	FeII	λ2382.8	1.0760	7
43	5246.9	a	2.1	7	AlII	λ1670.8	2.1403	1
44	5370.5	c	-	-	FeII	λ2585.9	1.0768	7
45	5397.9	a	2.1	7	FeII	λ2599.4	1.0766	7
46	5804.9	a	2.3	7	MgII	λ2795.5	1.0765	7
47	5819.5	a	2.2	7	MgII	λ2802.7	1.0764	7
					AlIII	λ1854.7	2.1377	1
48	5846.0	b	1.0	-	AlIII	λ1862.8	2.1383	1
49	5921.3	a	1.2	7	MgI	λ2852.1	1.0761	7

(a) Error on W_λ(obs) is less than ±50%.

(b) Error on W_λ(obs) is between ±50% and ±100%.

(c) Lines are uncertain, possibly spurious.

(*) Not corrected for instrumental resolution which is ~3.8 Å for λ < 4200 Å (ESA PCD) and ~7 Å for λ >4200 Å (IDS).

Notes

line 7 – Line is asymmetrical with the red side steeper. Minimum of the line profile is at 3612.0 Å which if identified with Lyα λ1215.7 gives z=1.9711. Possible contributor is Si II λ1193.3 in redshift system z=2.028 at 3613 Å.

line 9 – The minimum of the line is at 3650.0 Å. There is a weaker component at 3655 Å which, if identified with Si III λ 1206.5 gives z=2.0294, a value which is in fairly good agreement with the values obtained from the other lines in this redshift system. The main contributor to line 9, then, appears to be an unidentified line at 3650 Å, possibly

Lyα at z=2.0032; no other line, however, is detected at the same redshift. The FWHM is an estimate for the 3650 Å line only. The equivalent width given in the table is for the blend of which Si III λ1206.5 at z=2.029 contributes about one third.

line 10 – Asymmetrical line with extended blue wing. Minimum is at 3681 Å which, if identified with Lyα 1215.7 gives z=2.0279. Possible contributors to this line are Si II λ1193.3 in the system z=2.082 at 3678 Å, and N V λ1240.1 in the system at z=1.971 at 3684 Å; the latter is expected to be very weak.

lines 13, 14 – The two lines at λ_{obs}=3733.9 and λ_{obs}=3744.1 are not completely resolved. The narrower line at 3733.9, if Lyα λ1215.7, gives z=2.0714. At this redshift C IV λ1549 falls at 4758.2 Å in rather good wavelength agreement with the weak feature at 4756 Å in the blue wing of the strong line at centred λ =4774 Å.

Si II λ1260.4 at z=1.9714 falls at 3745 Å and is a likely contributor. N V λ1240 at z=2.028 falls at 3755 Å, in poor agreement with the observed wavelength, and is expected to be very weak in view of the weakness of C IV λ1549.2 in the z=2.028 system. Additional contributor at 3744.5 Å is Si II λ1193.3 at z=2.138.

line 15 – Strong unidentified line. Identification with Lyα would give z=2.104. The C IV λ1549 line at this redshift would fall at 4808 Å where no line is detected. The system, however, could be of very high-ionization or have a low-metal content.

line 17 – The narrowest line observed. If Lyα this line gives z=2.128. At this redshift C IV λ1549 is at 4846 Å in rather good wavelength agreement with the weak feature at 4844 Å in the blue wing of the strong line centred at 4861 Å.

line 18 – This line carves into the blue wing of the quasar Lyα emission line. The line N V λ1240.1 at z=2.082 falls at 3822 Å and is very probably the feature seen on the red side of line 17. The line Si II λ1260.4 at z=2.028 falls at 3816.5 Å.

line 19 – Strong unidentified line.

line 20 – This line falls near peak of Lyα emission. It could be much stronger and wider than quoted. Blended with a weaker contributor.

line 21 – Probable. Unidentified.

lines 25, 26 – Uncertain. Wavelengths fit Si IV $\lambda\lambda$1393, 1402 at z=1.971.

lines 28, 29 – Uncertain. Wavelengths fit Si IV $\lambda\lambda$1393, 1402 at z=2.028.

lines 32, 33 – Uncertain. Wavelengths fit Si IV $\lambda\lambda$1393, 1402 at z=2.138.

line 36 – Probable; see note line 13.

line 38 – Very probable. Line is located in steep red edge of the strong absorption line 37 at 4770.8 Å.

line 39 – Probable; see note line 17.

line 43 – Certain line but redshift is in slight disagreement with the value, 2.1375, given by the other lines of the system.

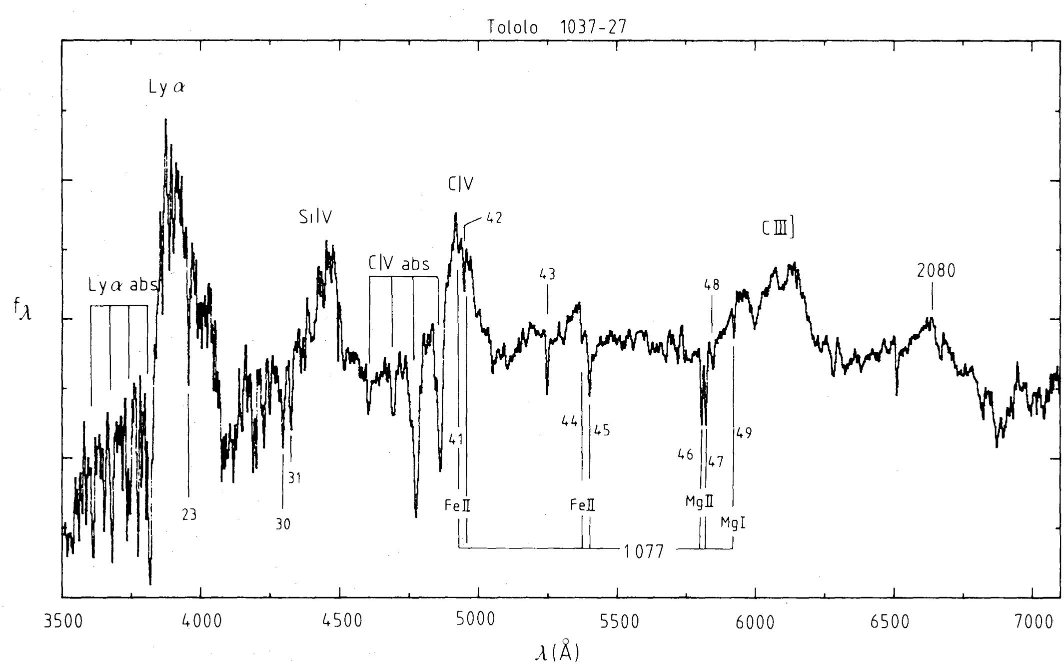

Figure 1. The spectrum of Tololo 1037−27 with the identifications of the strongest lines.

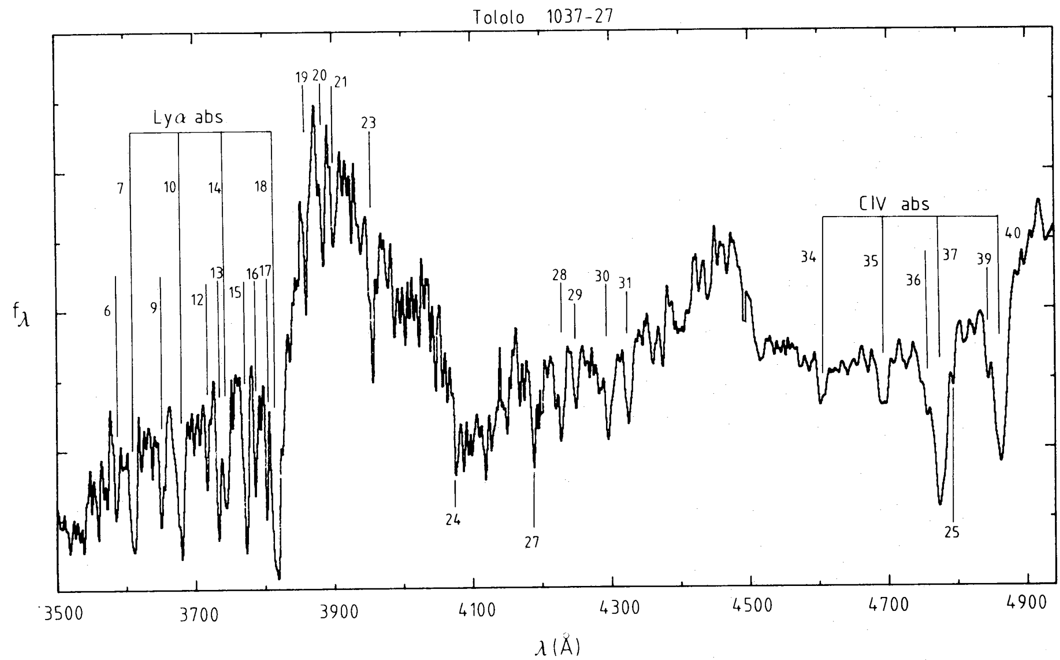

Figure 2. Enlarged section of the spectrum of Tololo 1037−27.

Table 2. Redshift systems in Tololo 1037−27.

System No.	z^1	Remarks	$V_{\mathrm{ejection}}{}^2$
	2.18	Emission redshift	0
1	2.138	Strong absorption line system of mixed ionization.	4000
2	2.128	Lyα and C IV λ1549 only. Probable.	4950
3	2.082	Strong absorption line system of high ionization.	9400
4	2.070	Lyα and C IV λ1549 only. Probable.	10600
5	2.028	W(Lyα)/W(C IV λ1549)~3	14700
6	1.971	W(Lyα)/W(C IV λ1549)~3	20400
7	1.077	Low ionization only. Intervening galaxy absorption spectrum.	–

[1]Error on emission redshift: ±0.05, on absorption redshifts: ±0.001.
[2]Using $V/c=(r^2-1)/(r^2+1)$ where $r=(1+z_{\mathrm{em}})/(1+z_{\mathrm{abs}})$.

z=2.138. This is the richest system. It shows a mixture of high- and low-ionization species. From the values given in Table 1 the ratios of the equivalent widths of the C IV and Lyα lines, and of the C IV and N V lines are 0.93 and 4.2 respectively. One source of uncertainty about these values is the fact that the three lines occur in the Lyα and C IV emission lines of the quasar, the profiles of which are themselves uncertain. The possibility that components of the Lyα forest are blended with the Lyα absorption line at $z=2.138$ is another source of uncertainty. Finally the Si II λ1260 at $z_{\mathrm{abs}}=2.028$ and the N V λ1240.1 at $z=2.082$ could both contribute ~1.2 Å to the rest equivalent width of Lyα. As a result the ratio of equivalent widths C IV/Lyα in the system $z_{\mathrm{abs}}=2.138$ could be as high as 2.

The observed FWHM of the C IV and Lyα lines are 19 and 12 Å respectively. After correction for the instrumental width (7 and 3.8 Å respectively) and for the splitting of the C IV doublet

($\delta\lambda$=2.57 Å) the FWHM at rest is found to be between 630 and 1150 km s^{-1} for C IV depending on the doublet ratio and 900 km s^{-1} for Lyα. These values of the FWHM are larger than the width of lines which would arise from one typical galaxy, but consistent with the widths expected if the absorption lines are formed by the superposition of discrete components arising from absorption by individual galaxies in a cluster. In this case the absorbing material would have a high-ionization state indicating significant absorption by halo material. A high value of CIV/Lyα (~1.25) has previously been found in the z_{abs}=2.1683 system in the quasar 0002−422 (Table 3(a), and Sargent, Young & Boksenberg 1979). Our data give some indication (which needs confirmation from high-resolution spectra) that the low-ionization lines in the system z_{abs}=2.138 are narrower than the high-ionization lines. This is not surprising as the different galaxies along the line-of-sight give rise to sets of absorption components with different line intensity ratios depending on the orientation of the intervening galaxies.

Alternatively the C IV and Lyα lines at z_{abs}=2.138 could be formed by an outflow of gas with $V_{ejection}$=4000 km s^{-1} and $\Delta V_{ej}/V_{ej} \lesssim 0.25$. In general the broad absorption-line systems in quasars show only lines of highly ionized elements (C^{+2}, N^{+4}) and Lyα, but, in a few cases lines of both high and low ionization are observed: in the low-redshift quasar PG 1700+518, the Mg II feature has recently been observed together with lines of C IV and Si IV (Wampler 1985; Pettini & Boksenberg 1985; Turnshek *et al.* 1985). In NGC 4151, the outflowing gas producing the blueshifted absorption lines is detected through numerous high- and low-ionization lines (Bromage *et al.* 1985). The presence of both high- and low-ionization lines in the z=2.138 system in Tololo 1037−27 could thus be analogous to these rather exceptional cases.

z=2.082. This system is similar to the previous one, the main difference being that it does not have lowly ionized lines. The ratio W(C IV)/W(Lyα) is ~2. It is better determined than for the z_{abs}=2.138 system because the local continuum can be better defined, but the uncertainty due to possible blends still exists. The blending with components of the Lyα forest would, like in the previous system, tend to push the ratio W(C IV)/W(Lyα) to higher values. The rest FWHM of the Lyα line is 2.7 Å or 660 km s^{-1}, and the rest FWHM of the C IV doublet is 6.8 Å, corresponding to 700–1100 km s^{-1} depending on the doublet ratio. One is thus faced with the same two alternatives as with the z_{abs}=2.138 system. Either the lines C IV and Lyα in the z_{abs}=2.082 system are formed by the superposition of lines arising from halo material in a cluster along the line-of-sight or the lines are formed by an outflow of gas. In the outflow hypothesis the ejection velocity is higher (V_{ej}=9000 km s^{-1}) while the dispersion of ejection velocity is the same (600–1100 km s^{-1}) giving $\Delta V_{ej}/V_{ej} \lesssim 0.1$.

z=2.128 and 2.070. These two systems are very close in redshifts to the two previous ones. If the two strong systems at z_{abs}=2.138 and z_{abs}=2.082 are due to intervening clusters then the systems at z_{abs}=2.128 and z_{abs}=2.070 represent individual galaxies in these clusters.

z=2.028 and *1.971*. In these systems the ratios of the equivalent widths of the Lyα and C IV lines is ~3, and the FWHM of the C IV lines is less than 800 km s^{-1}. This is consistent with each of these two systems being produced by absorption arising from one galaxy or group of galaxies.

z=1.077. This system defined by seven low-ionization lines which all have the instrumental profile is produced by the disc of an intervening galaxy.

Conclusions

The first medium-resolution observations of Tololo 1037−27 have led to the identifications of seven absorption-line redshift systems. Six absorption-line systems have redshifts between z_{abs}=1.971 and z_{abs}=2.138. The two strongest ones, z_{abs}=2.138 and z_{abs}=2.082, are rather similar in character: the ratio of equivalent widths W(C IV)/W(Lyα) is ~2 for the z_{abs}=2.082 system and between 1 and 2 for the z_{abs}=2.138 system. After correction for the instrumental resolution the

Table 3. (a) Properties of absorption-line systems.

Line	ζ Pup[1]	HD 36402[2]	0215+015[3]	0002-422[4]	Tololo 1037-27[5]		Remarks (Tololo 1037-27)
			z=1.345	z=2.1683	z=2.138		
	W(λ)	W(λ)	$W(\lambda)_{rest}$	$W(\lambda)_{rest}$	$W(\lambda)_{rest}$	$FWHM_{rest}$[6]	
SiII λλ1193.3,1190.4	0.398	0.750	<2.86	1.43			Former blended with Lyα at z=2.082. Latter blended with Lyα at 2.070
SiIII λ1206.5	0.278	0.450	1.45	0.94	1.4	400	
Lyα λ1215.7	-	-	5.63	1.8	4.6	900	blend with weaker lines
NV λλ1242.8,1238.8	0.005	<0.030			1.1	460	blend with weaker line
SiII λ1260.4	0.232	0.820	<1.79	0.63	1.3	380	
OI λ1302.2, SiII λ1304.4	0.367	0.580	2.9	1.09	<1.3		
CII λ1334.5	0.281	0.970	1.27	1.0	~0.9	320	
SiIV λ1393.8	0.068	0.240	0.2	0.91	<1.6		Line is present but uncertain.
SiIV λ1402.8	0.048	0.140	0.15	0.76	-		Line is present but uncertain.
SiII λ1526.7	0.233	0.320	0.72	0.48			
CIV λ1548.8,1550.8	0.239	0.520	0.72	2.25	4.1	630-1150	
AlII λ1670.8	0.218	0.480	0.78		0.7	400	line has instrumental width
AlIII λ1854.7	0.133	0.120	0.14		-		blend with MgII λ2802.7 at z=1.077
AlIII λ1862.8	0.081	0.100	0.13		0.3		

1) Morton, 1978
2) Savage and de Boer, 1981
3) Blades et al., 1984
4) Sargent, Young and Boksenberg, 1979
5) This paper

6) Not corrected for instrumental resolution which is ~300 km s^{-1} near Lyα and 400 km s^{-1} near CIV λ1549. The CIV doublet splitting corresponds to 496 km s^{-1}.

Table 3 (b). Properties of strong absorption line system.

Line	$W(\lambda)_{rest}$ (Å)	$FWHM_{rest}$[7] ($km\,s^{-1}$)	Remarks
z=2.082			
Si II λ1193.3	–	–	blended with Lyα at $z=2.028$
Si III λ1206.5	1.1	320	
Lyα λ1215.7	2.3	740	
N V λ1238.8, 1242.8	–		blend with Lyα at $z=2.138$
Si II λ1260.4	–		blend with N V λ1240 at $z=2.138$
Si IV λ1393.8	2.0	600	
Si IV λ 1402.8	2.0	700	
C IV λ 1548.8, 1550.8	5.0	600–1100	
Al III λ1670.8	<0.3		
z=2.028			
Si II λ1193.3	–	–	blended with Lyα at $z=1.971$
Si III λ1206.5	0.6	–	blended with unidentified line
Lyα λ1215.7	3.5	800	blend with weaker lines
N V λ1238.8, 1242.8			
Si II λ1260.4	–		blend with Lyα at $z=2.138$
Si IV λ1393.8	≤1.5		
Si IV λ1402.8	≤1.5		
C IV λ 1548.8, 1550.8	1.3	≤800	
Al II λ1670.8			
z=1.971			
Si II λ1193.3			
Si III λ1206.5	1.3	500	
Lyα λ1215.7	2.9	900	
N V λ1238.8, 1242.8			blended with Lyα at $z=2.028$
Si II λ1260.4			blended with Lyα at $z=2.082$
Si IV λ1393.8	<1.5		
Si IV λ1402.8	<1.5		
C IV λ1548.8, 1550.8	0.95	≤650	
Al II λ1670.8			

[7]Not corrected for instrumental resolution. See note 6 in Table 3(a).

rest FWHM of these lines is in the range 500–1100 $km\,s^{-1}$ which is close to the highest values found for the velocity dispersion in a cluster of galaxies. These properties suggest two possible origins for these systems: outflows of gas intrinsic to the quasar or, more likely, absorption by gas in two clusters of galaxies along the line-of-sight.

In the case of gas outflows, the dispersion of the ejection velocities is remarkably small. Two Seyfert galaxies, NGC 3516 (Ulrich & Boisson 1983) and NGC 4151 (Bromage *et al.* 1985) have outflows of gas producing absorption lines as narrow as in Tololo 1037−27 but V_{ej} is only ~1000 $km\,s^{-1}$ in these intrinsically faint active nuclei.

A more likely alternative is that these two absorption-line systems result from the superposition of discrete components arising from the haloes of galaxies in two different groups or clusters of galaxies possibly members of the same supercluster as the quasar. The high degree of ionization of the gas in these clusters could be due to the proximity of Tololo 1037−27 or other sources of ionizing photons.

The properties of the other four systems $z_{abs}=2.128$, 2.070, 2.028, and 1.971 respectively, are also consistent with the intervening galaxies or groups of galaxies. They and the low-ionization system at $z=1.077$ raise to seven the minimum number of galaxies along the line-of-sight.

Finally, regarding the density of C IV systems in Tololo 1037-27, we note that six systems satisfy the criteria used in the statistical anaysis of Young, Sargent & Boksenberg (1982), all having an apparent velocity relative to the quasar of $\beta = V/c < 0.07$ (Table 2). In this case, Tololo 1037−27 has a density of absorption-line systems very similar to the broad-absorption-line quasar Q1309−056 (Young *et al.* 1982), with a concentration of C IV systems towards smaller values of β, and a line density in that region much higher than the value found in non-troughed quasars. These properties were used by Young *et al.* to argue that ejection of material with velocities up to $\beta = 0.1$ is likely for Q1309−056.

High-resolution observations will show whether the absorbing gas is in several components or whether the lines have smooth profiles. The resolution of the lines into several components will be consistent with the components being caused by individual galaxies in a cluster, but will *not* prove it as many BAL quasars show broad absorption lines which break up, at high spectral resolution, into many narrow discrete components (e.g., Weymann & Foltz 1983). Finding that the absorption lines have smooth profiles would be consistent with gas outflows, but it is interesting to note that ionized gas spread throughout the cluster could also produce lines with smooth profiles. In this case the lines would statistically be symmetrical with respect to the cluster average velocity. Accurate determination of the line profiles with the potential of unveiling such asymmetries would enable one to investigate this possibility. Finally, better signal-to-noise spectra in the range 4000–4400 Å will provide measurements of or significant upper limits to a number of low-ionization lines, which are necessary to obtain a better determination of the state of the gas in the various absorption systems.

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References

Arp, H. C., 1984. *Astrophys. J.*, **283,** 59.
Blades, J. C., Hunstead, R. W., Murdock, H. S. & Pettini, M., 1984. Preprint.
Bohuski, T. J. & Weedman, D. W., 1979. *Astrophys. J.*, **231,** 653.
Bromage, G. E., *et al.*, 1985. *Mon. Not. R. astr. Soc.*, **215,** 1.
Morton, D. C., 1978. *Astrophys. J.*, **222,** 863.
Pettini, M. & Boksenberg, A., 1985. *Astrophys. J.*, **294,** L73.
Phillips, M. M. & Hawley, S. A., 1978. *Publs astr. Soc. Pacif.*, **90,** 650.
Sargent, W. L. W., Young, P. J. & Boksenberg, A., 1979. *Astrophys. J.*, **230,** 49.
Savage, B. D. & de Boer, K. S., 1981. *Astrophys. J.*, **243,** 460.
di Serego Alighieri, S., Perryman, M. A. C. & Macchetto, F., 1985. *Astrophys. J.*, **149,** 179.
Turnshek, D. A., *et al.*, 1985. *Astrophys. J.*, **294,** L1.
Ulrich, M. H. & Boisson, C., 1983. *Astrophys. J.*, **267,** 515.
Wampler, E. J., 1985. *Astrophys. J.*, **296,** 416.
Weymann, R. J., Carswell, R. F. & Smith, M. G., 1981. *Ann. Rev. Astr. Astrophys.*, **19,** 41.
Weymann, R. J. & Folz, C., 1983. In: *Proc. 24th Liège Inter. Ap. Colloq., Quasars and Gravitational Lenses*, p. 538, Université de Liège, Institut d'Astrophysique, Liege.
Young, P., Sargent, W. L. W. & Boksenberg, A., 1982. *Astrophys. J. Suppl.*, **48,** 455.

Note added in proof: The quasar Tololo 1038−27 located at 17.9 arcmin from Tololo 1037−27 has been found to have four absorption line redshift systems at z_{abs}=2.145, 2.08, 2.013 and 1.955, very close to the redshifts of four of the absorption systems in Tololo 1037−27 (P. Jakobson, M. A. C. Perryman, M. H. Ulrich, F. Macchetto and S. di Serego Alighieri, *Astrophys. J.,* in press).