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Redshifts of 10 quasar candidates in the field of the rich absorption line quasar Q0122−380*

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Abstract. We have obtained low resolution (∼20 Å FWHM) slit spectra of 10 quasar candidates located within one degree of the $z = 2.181$ quasar Q0122−380 with the objective of searching for signs of large scale structure matching the intervening rich absorption complexes seen over the redshift range $1.81 \lesssim z \lesssim 1.97$ toward this object. Of the 8 confirmed quasars, 4 turn out to have redshifts $z < 1.8$, placing them well in front of the redshift range of interest. Two of the three confirmed quasars at redshift $z > 1.8$ show no obvious absorption matching that of Q0122−380 at our spectral resolution and signal-to-noise ratio. The third object at a redshift of $z = 1.868$ displays strong $z_{\rm abs} \sim z_{\rm em}$ absorption systems at $z \simeq 1.84$ and $z \simeq 1.86$ and a possibly BAL-like trough at $z \simeq 1.76$. If not intrinsic in nature, the former two systems could potentially be related to the absorption seen in Q0122−380, albeit over a distance of $50\farcm2$ ($D_\perp \simeq 13\,h^{-1}$ Mpc at $z \simeq 1.9$).

Key words: galaxies: distances and redshifts – galaxies: quasars: absorption lines – galaxies: quasars: individual: Q0122-380 – cosmology: observations – cosmology: early Universe – cosmology: large-scale structure of Universe

1. Introduction

The existence of large scale structure at high redshift ($z \gtrsim 1$) provides an important constraint on theories for the formation of structure and evolution of the Universe. One approach to probing for such structure is through the study of intervening metal line absorption systems in quasar spectra. Such systems are believed to trace galaxies through their extended gaseous halos.

Statistical analysis of the redshift distribution of available samples of quasar absorption systems suggest that large scale clustering on comoving scales up to ∼100 Mpc may have been in place already at z∼2–3 (e.g. Quashnock et al. 1996).

The complementary technique of probing for large scale structure in the plane of the sky by searching for correlated absorption in adjacent lines of sight is hampered by the relatively low density of high redshift quasars bright enough for detailed absorption line work. Nonetheless, several potential high redshift 'absorption superclusters' spanning tens of Mpc on the sky have been identified in this manner. These include the $z \simeq 1.65$ absorption systems seen toward PKS 0273−233 (Foltz et al. 1993); the two pairs of damped Lyα systems seen at $z \simeq 2.38$ and $z \simeq 2.85$ toward Q2138−4427 and Q2139−4434 (Francis & Hewitt 1993; Francis et al. 1996); the apparent structures at $z \simeq 2.3$ and $z \simeq 2.5$ detected in a dense quasar field near the south Galactic pole by Williger et al. (1996); and the well-studied case of the strong absorption spanning $1.8 \lesssim z \lesssim 2.2$ in the field of the quasar pair Tol 1037−2703/1038−2712 (Jakobsen et al. 1986; Dinshaw & Impey 1996; Lespine & Petitjean 1997; and references therein).

With the aim of searching for further such cases of intervening high-redshift superclusters Romani et al. (1991) searched the quasar catalogs for suitable background objects near quasars known to display rich metal line absorption systems. One of the most promising fields identified by Romani et al. is that of the $z = 2.181$ quasar Q0122−380, an object whose absorption spectrum contains at least seven C IV systems between $1.81 \lesssim z \lesssim 1.98$ (Carswell et al. 1982) and happens to lie within a field in which Savage et al. (1984) have carried out a deep objective prism quasar search. Q0122−380 is therefore surrounded by 11 quasar candidates of brightness $V \simeq$19–20 within a 1° radius, corresponding to comoving distances $D_\perp \lesssim 44\,h^{-1}$ Mpc at $z \simeq 1.95$.

In this paper we present exploratory slit spectra and redshifts of these quasar candidates. As it turns out, several of the objects of interest are either not confirmed as quasars, or lie at significantly lower redshift than indicated by their preliminary catalog entries, thereby rendering the field toward Q0122−380 rather less promising for the purpose of searching for high redshift superclusters than originally thought.

2. Observations

Table 1 lists the coordinates, magnitudes and preliminary redshifts z^* of all objects listed in the Hewitt & Burbidge (1993) catalog and located within a circle of 1° radius centered on Q0122−380. These 11 objects along with Q0122−380 itself were observed with the ESO 3.6 m telescope and ESO Faint

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* Based on optical spectroscopy obtained at the European Southern Observatory, La Silla, Chile

Table 1. Objects observed in the field of Q0122−380

Object	α(J2000)			δ(J2000)			m_V	$z^{*\dagger}$	z_{em}	$\theta^{\ddagger}$
Q0122−380	01^h	24^m	$17^s.52$	−37°	44′	27″.0	16.5	2.181	2.189±0.006	
Q0117−379	01	19	56.47	−37	38	39. 3	20.0	1.48	1.484±0.007	52.0
Q0117−380	01	19	45.65	−37	48	27. 1	18.9	2.02	2.020±0.007	53.9
Q0118−377	01	20	43.15	−37	28	38. 5	19.0	0.34	1.728±0.007	45.3
Q0120−3781	01	22	35.50	−37	32	56. 9	19.5	2.15	2.124±0.007	23.2
Q0120−3785	01	22	45.05	−37	35	31. 6	19.5	2.17	1.516±0.004	20.3
Q0121−373	01	24	15.06	−37	05	13. 9	19.4	1.49	1.055±0.009	39.2
Q0124−373	01	26	15.52	−37	07	46. 1	19.8	0.88	0.920±0.010	43.5
Q0125−376	01	28	05.78	−37	22	37. 6	19.0	1.84	1.868±0.008	50.2
0121−379[a]	01	23	25.89	−37	42	23. 6	19.7	2.21	· · ·	10.4
0123−372[a]	01	25	27.10	−36	58	06. 1	20.3	2.13	· · ·	48.4
0117−378[b]	01	19	56.82	−37	37	28. 4	20.0	2.25	· · ·	· · ·

† Preliminary redshift listed in Hewitt & Burbidge (1993)
‡ Angular distance from Q0122−380 in arcmin.
a Object is a star, not a quasar.
b No object was found at the catalog coordinates.

Object Camera and Spectrograph (EFOSC1) on 1995 September 28. EFOSC1 was equipped with a thinned back-side illuminated TEK CCD with 512×512, 27 μm pixels. We used a 230 Å mm^{-1} (B300) grism in combination with a 2″ wide slit to obtain spectra covering the wavelength range 3750–6950 Å at ∼20 Å (FWHM) resolution. The spatial resolution is 0.61″ pixel^{-1}.

The seeing conditions on both nights were poor. Nevertheless, the high throughput of EFOSC1 ensured good signal-to-noise (S/N) spectra of objects as faint as $m_V = 20$ (S/N≥8 in the continuum near 5500 Å). For most objects we took a single 1200 s exposure. For 0117−379, being the faintest target at $m_V = 20.0$, we exposed for 1800 s. Prior to each spectroscopic observation, EFOSC1 was used in direct (filterless) imaging mode for target verification and automated slit acquisition. One quasar candidate, 0117−378, was not found at or near its catalog coordinates.

The data were reduced within the IRAF environment, following standard techniques. The spectra were put on a relative flux scale based on the standard stars LDS 235/EG 63 and LTT 2415 (Baldwin & Stone 1984; Stone & Baldwin 1983). The absolute calibration is ill determined, due to variations in seeing and atmospheric extinction over the night.

The resulting spectra of the 8 confirmed quasars are shown in Fig. 1 along with the relevant emission line identifications. The measured redshifts given in Table 1 were determined by averaging the redshifts measured for individual emission lines (e.g. Lyα, N V λ1240, C II λ1335, Si IV/O IV] λ1400, C IV λ1549, He II λ1640, Al III λ1857, C III] λ1909, and Mg II λ2799). For the wavelength of an emission line we adopted the average of the wavelengths of the peak (maximum signal) and of the center of a gaussian fit to the line, both determined after subtraction of the quasar continuum.

Two of the quasar candidates, 0121−379 and 0123−372, turn out to be Galactic stars. Their spectra are shown in Fig. 2. Unfortunately, of the observed quasar candidates 0121−379 would have been the quasar closest to Q0122−380, at an angular separation of $10'.4$.

3. Discussion

Romani et al. (1991) originally drew attention to the rich absorption line quasar Q0122−380 on the basis that it was surrounded by a number of quasar candidates closer than 1°. Of the 11 objects listed in Table 1, seven had preliminary redshifts $z > 1.8$, placing them near or behind the absorption seen between $1.81 \lesssim z \lesssim 1.98$ toward Q0122−380.

Of these seven high redshift candidates, only three (Q0117−380, Q0120−3781 and 0125−376) are confirmed as $z > 1.8$ quasars. Of the remainder, one (0117−378) could not be located, two (0121−379 and 0123−372) are identified as stars, and another (Q0120−3785) turns out to be at a lower redshift of $z = 1.52$. The four quasar candidates with lower preliminary redshifts $z < 1.8$ are all confirmed as such.

As is evident from Fig. 1, our low resolution spectra of two of the three confirmed $z > 1.8$ quasars (Q0120−3781 and Q0117−380) reveal no obvious C IV absorption features in the wavelength range 4350–4600 Å that could potentially be associated with the absorption spanning $1.81 \lesssim z \lesssim 1.97$ toward Q0122−380. However, the line detection limit of our spectra is only $W_\lambda \gtrsim 8$ Å at these wavelengths.

A more promising case is that of the final object, Q0125−376, whose redshift of $z = 1.868$ lies close to that of the absorption complex at $z \simeq 1.91$ in Q0122−380. Moreover, our spectrum of Q0125−376 (which has a better S/N ratio than those of Q0120−3781 and Q0117−380) shows three strong ($W_\lambda \gtrsim 9$ Å) absorption features at $\lambda \simeq 4395$ Å, $\lambda \simeq 4435$ Å and $\lambda \simeq 4275$ Å, respectively. The former two features are almost certainly due to C IV absorption from two $z_{abs} \sim z_{em}$ systems at $z \simeq 1.837$ and $z \simeq 1.864$, an interpretation that is further strengthened by plausible detections of matching Si IV lines at

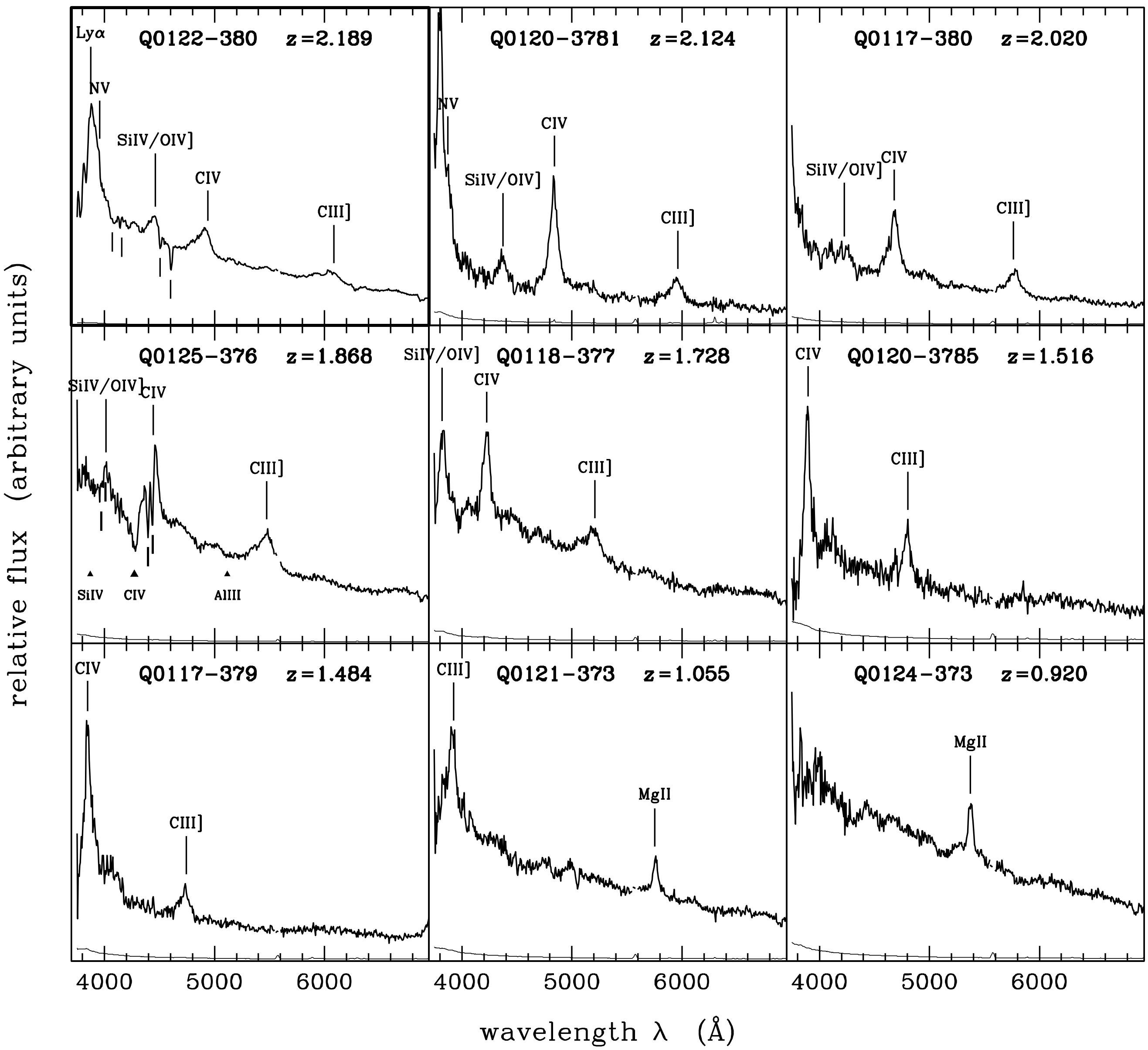

Fig. 1. Spectra of the eight confirmed quasars. For reference the spectrum of Q0122−380 is given in the top-left panel. The strongest emission features and the corresponding emission-line redshifts are indicated. The spectra span the range 3750–6950 Å and the resolution is ∼20 Å. The fluxes have been normalized to the flux in a 100 Å region centered on 5470 Å. Below each spectrum, the 1-sigma noise level is shown as a thin curve. The two C IV and Si IV absorption complexes seen near $z \simeq 1.91$ and $z \simeq 1.97$ toward Q0122−380 are marked in its spectrum. In the spectrum of Q0125−376 the $z_{\rm abs} \sim z_{\rm em}$ absorption systems at $z \simeq 1.84$ and $z \simeq 1.86$ are indicated by vertical bars, the BAL-like absorption troughs by small triangles.

shorter wavelengths. Based on a matching weaker feature seen at the anticipated position of Al III, we tentatively identify the third feature as the C IV trough of a weak and possibly detached BAL-like complex at $z \simeq 1.76$.

The two $z_{\rm abs} \sim z_{\rm em}$ systems seen in Q0125−376 could conceivably be associated with the absorption seen toward Q0122−380, falling squarely between the $z \simeq 1.91$ complex and the weaker $z \simeq 1.814$ system detected in that object by Carswell et al. (1982). In a standard cosmological model with $q_0 = 0.5$ the angular distance between Q0125−376 and Q0122−380 of $50\farcm2$ at $z = 1.9$, corresponds to a projected comoving separation of $D_\perp = 36\,h^{-1}\,$Mpc ($\rm H_0 = h\,100\,km\,s^{-1}\,Mpc^{-1}$), which is comparable to the extent of local superclusters of galaxies.

On the other hand, the presence of possibly BAL-like absorption at lower redshift would argue that the two $z_{\rm abs} \sim z_{\rm em}$ systems seen in Q0125−376 are intrinsic in nature.

While higher resolution observations would be required to further delineate these possibilities and properly map the absorption toward the three confirmed $z > 1.8$ quasars above, the exploratory observations presented here already make it clear that the field surrounding Q0122−380 is not as promising for

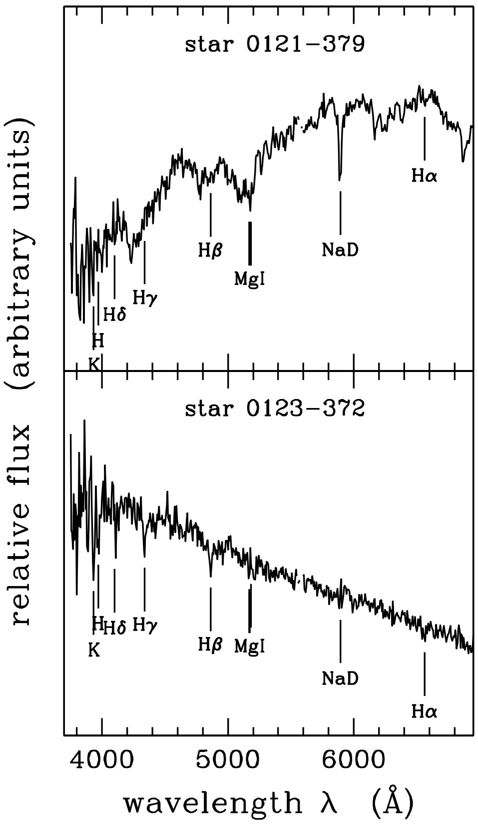

Fig. 2. Spectra of the two stars misclassified as quasars in Hewitt & Burbidge (1993). The stellar absorption features are indicated.

searching for large scale structure at high redshift as had initially been hoped.

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