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Further spectroscopic observations of 25 quasi-stellar objects (*)

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Summary. — Twenty-five quasars reported either variable or with P Cygni profiles, and for the majority of which the redshift is high ($Z_e \gtrsim 2$), were observed spectrographically at the Cassegrain focus of the ESO 3.6 m telescope. For most of them the emission and absorption redshifts are confirmed : in a few cases new lines are detected, as well as new absorption redshift(s).

Key words : Spectroscopy — quasars — redshifts.

1. **Introduction.** — Spectroscopic observations of a large number of quasars reveal absorption lines whose redshift is generally smaller than that measured for the emission lines. This observational fact leads to the question of the origin of the absorptions. Strong arguments in favour of the *intrinsic hypothesis* are given by the observations of P Cygni profiles in a few high redshift QSOs : for these objects the resonance lines of e.g. C IV and Si IV exhibit profiles which may be interpreted in terms of mass-outflow from the central quasars. In a previous paper (Surdej and Swings, 1981) we presented for the quasars PHL 5200 and RS 23 the observational data, the results of theoretical calculations explaining the P Cygni profiles of the C IV and Si IV doublets, and the determination of some basic physical and geometrical parameters characterizing the quasar plus envelope system.

In the present paper, we report on spectroscopic observations of known QSOs that could bear some similarities to PHL 5200 and RS 23. They were selected on the basis of optical variability and/or the presence of P Cygni profiles in their spectrum, and for most of them on the fact that they have a large emission redshift (see e.g. the catalogue of Burbidge *et al.*, 1977).

2. **Observations.** — The widened (300 μ) spectrograms on which the present study is based were obtained at the Cassegrain focus of the ESO 3.6 m telescope (La Silla, Chile), by using a Boller and Chivens spectrograph equipped with a Carnegie tube followed by baked IIIaJ plates ; during the two observing runs, in December 1977 and July 1978, the dispersions were respectively 186 and 168 Å mm^{-1} corresponding to equivalent spectral resolutions of ≃ 7.5 and ≃ 6.8 Å. Because of the important noise of the photocathode appearing on the spectra through a strong and non-uniform background, only a qualitative description of the spectra is given, except for the redshift determination. Figure 1 illustrates the type of data on which this investigation is based.

The redshifts derived from our plates, 1950 coordinates, dates of observations of the 25 quasars, and the exposure times of the spectra are listed in table I.

The quasar and comparison spectra were scanned on a Grant measuring machine, and the reduction was performed with the *image handling and processing* system of ESO Geneva. Table II lists for each quasar, ordered according to decreasing redshift, the measured emission line wavelengths (r.m.s. accuracy ≤ 0.7 Å) corrected for the earth's heliocentric motion ; wavelengths based on the redshift are also listed (second line) in the rest frame of the object. The mean error reported with each redshift of table II is derived on the basis of an equal weight given to all the emission lines definitely present in the QSO's spectrum. Vertical bars give the actual limits in wavelength of the plates ; underlined values indicate newly discovered lines or new values for the redshifts which differ, within the error measurements, from previous published data ; I.D. indicates that a line is definitely present although ill-defined, and thus not taken into account in the determination of Z_e ; N.S. refers to a blend between the corresponding emission line and a night sky line ; finally an asterisk is given to lines whose centre is displaced toward the red because of the obvious presence of a blueshifted absorption component. For convenience table II is split in two sections corresponding to two sets of redshifts : $1.9 < Z_e < 3.1$, and $0.5 < Z_e < 1.5$.

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3. **Notes on individual objects** [1]. — Only those objects for which new or interesting observational data are obtained in the present investigation are considered below.

Q 0805 + 046. — All absorption lines having a strength ≥ 3 in the scale of Lynds (1971) appear on our spectrum ; all absorption lines due to Ly α (as suggested by Lynds) in the various redshift systems have been measured. In addition many absorptions appear shortward of Ly α, but it is difficult to assess whether they are due to the quasar or to the background of the spectrogram.

Q 0049-393. — Two well defined absorptions in the blue wing of Ly α have the following wavelengths : 4574.7 and 4620.7.

Q 0207-398. — Many absorption features are present ; one of the systems has an accurately derivable $Z_a = 2.479 \pm 0.001$ on the basis of Ly α, Si IV and C IV. This result is in a good agreement with that reported by Whelan *et al.* (1979), $Z_a = 2.4787$.

Q 0046-315. — There are three well-defined absorption components in the violet wing of Ly α at 4305.9, 4346.0 and 4429.9 Å.

Q 0453-423. — 1) Two well defined and one probable (cf. Carswell *et al.*, 1977) absorptions appear respectively at 4420.1, 4406.8 and 4394.2 Å in the violet wing of Ly α.

2) In addition we confirm the two absorption redshift systems $Z_a = 1.1492$ and $Z_a = 2.2754$ suggested by Carswell *et al.* (1977). For the former we find $Z_a = 1.150 \pm 0.001$ on the basis of six lines due to Fe II (3), Mg II (2) and Mg I (1) ; for the latter we derive $Z_a = 2.275 \pm 0.001$ from Ly α, Si IV λ 1394, C IV λ 1548 and C IV λ 1550. A high-resolution study of the absorption spectrum of Q 0453-423 by Sargent *et al.* (1979) has revealed the presence of five absorption-line systems among which the two that we confirm here. They actually found that the redshift system $Z_a = 1.150$ is double, with a splitting of 280 km s^{-1}.

Q 2112-407. — Unidentified absorptions are clearly present at 3802.1, 3824.3 and 4055.1 Å and one is probable at 4258.3 Å.

Q 2116-358. — 1) Absorptions are present in the violet wing of Ly α (on 3 spectra), at 3998.2, 4014.4 and 4032.1 Å. There are clear, although ill-defined, broad unresolved P Cygni absorptions near the Si IV and C IV emission lines.

2) Two unidentified absorptions appear also at 4178 and 4203 Å.

Q 1246-057. — As a preliminary remark, and warning, one should point out the fact that all the lines in the spectrum of Q 1246-057 are very broad, and therefore not measurable with high accuracy.

1) All the absorptions we observe (at 3850.4, 3874.0, 3903.6, 4101.2, and 4598.1 Å) were resolved by Boksenberg *et al.* (1978) usually into multiple components.

2) It is possible to determine the maximum and mean velocities in the P Cygni absorption component of the Si IV and C IV line profiles. For both resonance doublets, we find v_e (max) = − 19 000 km s^{-1}, and v_e (mean) = − 16 604 km s^{-1}, in perfect agreement with the values derived by the authors (Surdej and Swings, 1981) from image dissector scanner data.

Q 1448-232. — The redshift value derived from our observations is different (outside the error bars) from that published previously (2.208 ; Savage *et al.*, 1976).

Well defined absorption components appear at 3848.3, (3860.3) and 3876.7 Å in the blue wing of Ly α ; another absorption (unidentified) is present at 4002.3 Å.

Q 0642-349. — The redshift obtained here is slightly different (at the limit of the error bars) from that given in Wright *et al.* (1977).

1) Ly α and C IV show a clear absorption feature in their blue wing (P Cygni structure) at $Z_a = 2.143 \pm 0.001$.

2) The faint emission feature attributable to SiIV/O IV] similarly shows a complex of absorption lines in its blue wing.

3) It is not unlikely that the absorption features in the violet wing of Ly α seen at 3797.6 and at 3771.4 Å be real. There exist indeed some ill-defined absorption features in the blue wing of C IV, with approximately the same shifts.

Data of higher quality are badly needed on this object.

Q 2055-440. — Two pronounced absorption features are visible in the blue wing of Ly α, at (3586.2) and 3670.2 Å.

Q 2225-055 (PHL 5200). — 1) As indicated by the asterisks in table II, we have considered for the resonance doublets the longer wavelength of the doublet when deriving the value of the redshift (see Surdej and Swings, 1981).

2) Two absorption features appear at 3726.1 and 3886.5 Å. Lynds (1967) had suggested to identify the latter to a fairly weak O I line ($Z_a = 1.980$), but Burbidge (1968) clearly rejected that possibility. Both identifications thus remain open.

3) Structure is seen within the Si IV line profile, i.e. a small emission is detected at 4130.9 Å which corresponds to a Doppler velocity shift v = − 3770 km s^{-1} in the rest frame of the quasar. Calculations of line profiles formed in outward-decelerating envelopes (see Surdej and Swings, 1981) compare well with these observations.

Q 2044-168. — 1) Blueshifted absorption components (one probable, one certain) are present for Ly α at (3521.9 Å → Z_a = 1.897) and 3547.9 Å → Z_a = 1.918 and for C IV at (4489.0 Å → Z_a = 1.897) and 4521.4 Å → Z_a = 1.918. These two systems correspond respectively to velocity shifts v_e = − 4093 and − 1929 km s^{-1} in the rest frame of the quasar.

[1] Notes on the 25 QSOs as well as a non-exhaustive bibliography that was searched through in each case, concerning identifications, redshifts, variability, etc., can be obtained upon request from the authors.

2) A possible absorption component appears in the red wing of Ly α at 3609.6 Å ($Z_a = 1.969$) and of C IV at 4599.2 Å ($Z_a = 1.968$), but these should be checked on higher quality spectra.

3) A blueshifted absorption definitely appears in the blue wing of C III] at about 5597.6 Å, but the redshift determination ($Z_a \simeq 1.93$) is not accurate due to the contamination by the λ 5577 night sky line.

Q 2134 + 004. — 1) The C IV emission is unusually broad.

2) Two absorption features are clearly present in the blue wing of Ly α at 3470.2 and 3493.8 Å (cf. Burbidge, 1970).

Q 0736-063. — 1) We confirm the two absorption redshift systems proposed by Carswell *et al.* (1976) $Z_a(1) = 1.9123$ and $Z_a(2) = 1.9299$. On the basis of the identifications of Ly α and the C IV doublet we indeed find $Z_a(1) = 1.912 \pm 0.001$ and $Z_a(2) = 1.930 \pm 0.001$. It is to be stressed that $Z_a(1)$ and $Z_a(2)$ are greater than Z_e in this quasar.

2) Unidentified absorptions seem to exist at 5208.3 and 5229.7 Å.

Q 0232-042 (PHL 1377). — As given in Kinman and Burbidge (1967) an absorption is found at 3756.7 Å, i.e. in the violet wing of C IV. It it is due to C IV, then Z_a is 1.425. A blueshifted C III] absorption cannot be seen, probably due to the fact that the C III] emission is faint and very wide on our spectrogram.

Q 0402-362. — Two well-defined absorptions appear at 5023.1 and 5037.8 Å : if attributed to the Mg II doublet $\lambda\lambda$ 2795.528, 2802.704, one finds an absorption redshift $Z_a = 0.797$. Higher quality data are needed in order to study the absorption line spectrum of this quasar.

Q 0837-121. — The emission line identifications for this low redshift quasar are given below ; the underlined data are new, i.e. not reported by either Baldwin (1975) or Kinman and Burbidge (1967) :

Mg II λ 2799 ; He II λ 3203 (?) ; [Ne V] λ 3346 ; [Ne V] λ 3426 ; [O II] λ 3727 ; [Ne III] λ 3868 ; [Ne III] λ 3967 ; H_δ ; H_γ ; [O III] λ 4363 ; H_β ; [O III] λ 4959 ; [O III] λ 5007.

The redshift was determined on the basis of 12 individual lines to be $Z_e = 0.1983 \pm 0.0009$.

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References

BALDWIN, J. A. : 1975, *Astrophys. J.* **201,** 26.
BOKSENBERG, A., CARSWELL, R. F., SMITH, M. G. and WHELAN, J. A. J. : 1978, *Mon. Not. Roy. Astron. Soc.* **184,** 773.
BURBIDGE, E. M. : 1968, *Astrophys. J. Lett.* **152,** L111.
BURBIDGE, E. M. : 1970, *Astrophys. J. Lett.* **160,** L33.
BURBIDGE, G. R., CROWNE, A. H. and SMITH, H. E. : 1977, *Astrophys. J. Suppl. Ser.* **33,** 113.
CARSWELL, R. F., COLEMAN, G., STRITTMATTER, P. A. and WILLIAMS, R. E. : 1976, *Astron. Astrophys.* **53,** 275.
CARSWELL, R. F., SMITH, M. G. and WHELAN, J. A. J. : 1977, *Astrophys. J.* **216,** 351.
KINMAN, T. D. and BURBIDGE, E. M. : 1967, *Astrophys. J. Lett.* **148,** L59.
LYNDS, C. R. : 1967, *Astrophys. J.* **147,** 396.
LYNDS, C. R. : 1971, *Astrophys. J. Lett.* **164,** L73.
SARGENT, W. L. W., YOUNG, P. J., BOKSENBERG, A., CARSWELL, R. F. and WHELAN, J. A. J. : 1979, *Astrophys. J.* **230,** 49.
SAVAGE, A., BROWNE, I. W. A. and BOLTON, J. G. : 1976, *Mon. Not. Roy. Astron. Soc.* **177,** 77 p.
SURDEJ, J. and SWINGS, J. P. : 1981, *Astron. Astrophys.* **96,** 242.
WHELAN, J. A. J., SMITH, M. G. and CARSWELL, R. F. : 1979, *Mon. Not. Roy. Astron. Soc.* **189,** 363.
WRIGHT, A. E., JAUNCEY, D. L., PETERSON, B. A. and CONDON, J. H. : 1977, *Astrophys. J. Lett.* **211,** L115.

TABLE I. — *Journal of observations.*

Object	z_e	R.A. (1950)	Decl. (1950)	Date (U.T.)	Exposure time	Other catalogue numbers
0046-315	2.721	$00^h46^m58^s$	-31°32′48″	1978 Jul. 12	84^m	PKS
0049-393	2.845	00 49 31	-39 22 42	1978 Jul. 11	67	
0130-403	3.014	01 30 50	-40 21 54	1977 Dec. 16	60	
0207-398	2.807	02 07 24	-39 53 50	1978 Jul. 12	59	
0232-042	1.440	02 32 37	-04 15 10	1977 Dec. 14	121	PKS, PHL 1377
				1977 Dec. 16	27	4C-04.06, OD-055
0402-362	1.416	04 02 02	-36 13 16	1977 Dec. 17	40	PKS
0448-392	1.290	04 48 01	-39 16 20	1977 Dec. 17	63	PKS
0453-423	2.659	04 53 48	-42 21 00	1977 Dec. 16	93	
0537-441	0.893	05 37 21	-44 06 40	1977 Dec. 16	30	PKS
0642-349	2.158	06 42 37	-34 56 36	1977 Dec. 19	93	PKS
0736-063	1.906	07 36 30	-06 20 03	1977 Dec. 16	87	PKS, OI-061
0805+046	2.875	08 05 20	+04 41 24	1977 Dec. 14	60	4C05.34, OI008
0837-121	0.198	08 37 28	-12 03 54	1977 Dec. 14	29	PKS, NRAO 299, 3C206, OI-162
1246-057	2.225	12 46 39	-05 42 59	1978 Jul. 10	47	
1448-232	2.215	14 48 09	-23 17 10	1978 Jul. 10	30	PKS
2040-374	2.278	20 40 06	-37 25 00	1978 Jul. 9	140	
				1978 Jul. 11	30	
2044-168	1.937	20 44 31	-16 50 08	1978 Jul. 11	60	PKS, OW-174
2055-440	2.053	20 55 42	-44 01 00	1978 Jul. 10	90	
				1978 Jul. 11	26	
2112-407	2.546	21 12 11	-40 43 18	1978 Jul. 11	90	
2115-305	0.979	21 15 11	-30 31 49	1978 Jul. 12	45	PKS, OX-325, MSH21-34
2116-358	2.336	21 16 24	-35 49 00	1978 Jul. 9	30	
				1978 Jul. 10	10	
				1978 Jul. 10	43	
2128-123	0.499	21 28 53	-12 20 21	1978 Jul. 12	28	PKS
2134+004	1.936	21 34 05	+00 28 26	1978 Jul. 11	67	PKS, PHL 61, OX057, DA553
2153-204	1.310	21 53 48	-20 26 30	1978 Jul. 12	62	PKS
2225-055	1.979	22 25 51	-05 34 00	1978 Jul. 10	105	PHL 5200, 4C-05.93

TABLE IIa. — *Line identifications and associated redshifts.*

Q	z_e	O VI 1034.8	Ly α 1215.7	N V 1240.8	O I 1304.4	Si IV/O IV] 1401.6	C IV 1549.5	He II 1640.4	C III] 1908.7
0130-403	3.014 ±0.015	4153.1 1034.6	4898.1 1220.2	4963.3 1236.4		I.D.			
0805+046	2.875 ±0.001	4009.9 1034.8	4711.1 1215.8	4806.7 1240.5		I.D.	6004.6 1549.6	N.S.	
0049-393	2.845 ±0.004	3975.5 1034.0	4681.1 1217.6	4766.7 1239.8	5014.9 1304.4	I.D.?	I.D.+ N.S.	N.S.?	
0207-398	2.807 ±0.006	3946.1 1036.5	4632.9 1216.9	4717.7 1239.2	4974.1 1306.5	5323.7 1398.3	5895.6 1548.5		
0046-315	2.721 ±0.001		4523.7 1215.7	4617.6 1241.0	4852.8 1304.2	I.D.	I.D.		
0453-423	2.659 ±0.003	I.D.	4448.5 1215.9	4536.5 1240.0		5133.7* 1403.2*	5664.9 1548.4		
2112-407	2.546 ±0.002	I.D.	4307.1 1214.6	4400.3 1240.9	4625.5 1304.4	4957.2 1398.0	5496.6 1550.1	I.D.?	
2116-358	2.336 ±0.003		4058.1 1216.5	4139.3 1240.8		4669.4 1399.7	5172.4 1550.5		
2040-374	2.278 ±0.001		3985.3 1215.9	4067.6 1241.0		I.D.	5078.8 1549.5		6253.9 1908.0
1246-057	2.225 ±0.011		3941.2 1222.2	3986.0 1236.1		4514.0 1399.8	5002.1 1551.2		6146.2 1906.0
1448-232	2.215 ±0.002		3908.7 1215.8	3986.7 1240.1		I.D.	4983.6 1550.2		I.D.
0642-349	2.158 ±0.001		3839.4 1215.8	3917.9 1240.6		I.D.	4893.4 1549.5	I.D.	I.D.?
2055-440	2.053 ±0.002		3712.3 1216.0	3784.3 1239.6		I.D.	4731.9 1550.0	5006.3 1639.9	5830.3 1909.8
2225-055	1.979 ±0.002		3623.3 1216.3	3703.3* 1243.2*		4174.8* 1401.4*	4621.7* 1551.5*		5679.6 1906.6
2044-168	1.937 ±0.001		3570.7 1215.7	3643.1 1240.3		I.D.	4553.4 1550.3	4815.8 1639.6	5608.2 1909.4
2134+004	1.936 ±0.002		3572.6 1216.7	3643.8 1240.9	3828.2 1303.7	I.D.	4550.1 1549.6	4813.3 1639.2	5606.5 1909.3
0736-063	1.906 ±0.013		3551.7 1222.2	3595.8 1237.3		I.D.	4491.4 1545.5	I.D.	N.S.?

TABLE IIb.

Q	z_e	C IV 1549.5	C III] 1908.7	Mg II 2799.1
0232-042	1.440 ±0.001	3779.5 1549.0	4658.3 1909.2	
0402-362	1.416 ±0.001	3743.3 1549.4	4611.3 1908.7	
2153-204	1.310 ±0.002	3579.0 1549.4	4406.6 1907.6	6470.4 2801.0
0448-392	1.290 ±0.001	3549.4 1549.6	4371.5 1908.5	
2115-305	0.979 ±0.001		3778.7 1909.4	5537.8 2798.3
0537-441	0.893 ± ?		I.D.?	5299.4 2799.1
2128-123	0.499 ± ?			4195.8 2799.1
0837-121	0.198 ±0.001	See "Notes on individual objects"		

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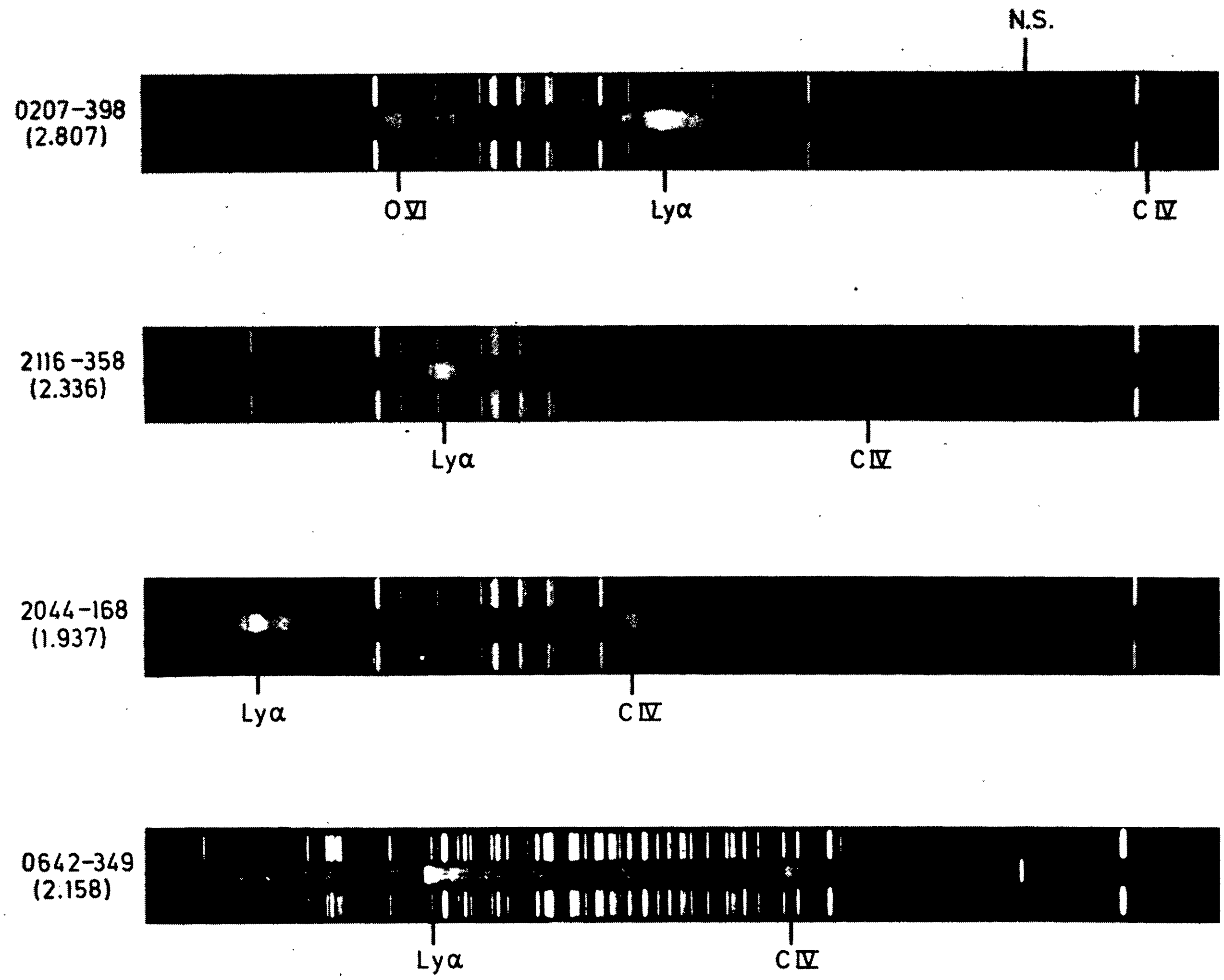

FIGURE 1. — Emission and absorption components in the spectra of the four quasars Q 0207-398, Q 2116-358, Q 2044-168 (168 Å mm^{-1}), and Q 0642-349 (186 Å mm^{-1}).