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REDSHIFTS OF SOUTHERN RADIO SOURCES. III.

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ABSTRACT

We report further observations with the image-tube dissector scanner on the 4 m Anglo-Australian telescope of 35 objects associated with Parkes radio sources. Redshifts are given for 25 QSOs and two radio galaxies. Three QSOs which have only a weak ultraviolet excess or appear neutral in color have redshifts greater than 2.5. The neutral stellar object PKS 2126−15 has a redshift of 3.27.
Subject headings: galaxies: redshifts — quasars — radio sources: general

I. INTRODUCTION

We present further observations from a continuing program designed to provide comprehensive optical and radio data for southern QSOs selected from the Parkes 2700 MHz survey (see Wall, Wright, and Bolton 1976 and references therein). Previous observations in this program have been reported in Papers I (Peterson *et al.* 1976) and II (Wright *et al.* 1977). Our primary aim is to examine the properties of QSOs found in high-frequency radio surveys for comparison with the properties of QSOs found from surveys at lower frequencies.

Two identification procedures are being used to establish the optical counterparts of the radio sources. Where positions of moderate accuracy (∼10″) are available, the identification is based upon the presence of an object with an ultraviolet excess within the radio error box (see Peterson, Bolton, and Savage 1976 and references therein). For radio positions of high accuracy (≤2″) measured with the NRAO[1] three-element interferometer (Condon, Hicks, and Jauncey 1977), the identification is based on the coincidence of the radio and optical positions, without reference to color. Since the present sources are drawn from both of these categories, an assessment can be made of the effects of color selection on QSO properties.

II. THE OBSERVATIONS

The image-tube dissector scanner (Robinson and Wampler 1972) was used at the f/15 Cassegrain focus of the 4 m Anglo-Australian telescope (Wampler 1975) to obtain spectral scans covering the wavelength region 3500 Å to 8000 Å with a resolution of ∼10 Å, and the wavelength region 3500 Å to 7250 Å with a resolution of ∼5 Å. Scans of 44 objects were obtained in 1976 June and September.

The 27 objects for which redshifts have been determined are given in Table 1. The positions in Table 1 are accurate to about 6″ except for those sources with positions given to 0″.1, where the accuracy is about 1″. The magnitudes in Table 1 are derived from the integrated spectral scans and have a standard error of about 0.4 mag. Optical and radio variables are indicated in Table 1 by parentheses around the magnitudes or radio flux densities. The radio flux densities are the most recent Parkes measurements. The color of the object is obtained from a comparison between the red and blue Palomar Sky Survey prints and from the results of two-color, blue and ultraviolet, photographs.

Measurements of the strengths and widths of the emission lines used to determine the redshifts are given in Table 2. Values given in parentheses are of relatively low accuracy. The line-to-continuum ratio is the excess height of the line above the continuum divided by the height of the continuum and is therefore negative for absorption features. The line width ($\Delta\lambda_{1/2}$) is the full width at half-maximum intensity.

In addition to the objects in Tables 1 and 2 for which redshifts were obtained, the following objects were found to have "continuous" spectra in that no features with a line-to-continuum ratio of greater than 0.2 were seen: PKS 0035+121, 0048−090, 0110−342, 0301−342, 1034−293, 1301−192, 2233−148, and 2254+074.

The bright stellar objects near the radio positions of the following sources were found to have normal stellar spectra: PKS 0016−77, 0017−411, 0020−521, 0542−

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384, 1328−05, 1330−328, 1756−686, 1953−425, and 2313−277.

In Paper II we stated that a broad, shallow absorption "trough" existed to the short-wavelength side of the Mg II emission line in the object PKS 0422−380. Similar features are present in several of the objects discussed in this *Letter*. The approximate extent (full width at the level of the continuum) of the trough in these objects is: PKS 0029−414, 500 Å; 0049−832, 300 Å; 0135−247, 250 Å; 0621−786, 500 Å; 1207−399, 250 Å; 2142−75, 400 Å; and 2329−384, 400 Å. No trough is present in 0101−76; for 1912−549, 1929−457, 2300−683, 2314−116, and 2352−342, the presence of a trough is uncertain. The *equivalent* width of the feature is generally similar to that of the adjacent Mg II emission line. We believe that this trough, when present, lends support to the identification of the adjoining emission feature as Mg II λ2798 in cases where no other lines can be identified in the spectrum.

III. NOTES ON INDIVIDUAL OBJECTS

0029−414.—A strong, narrow absorption line lies to the short-wavelength side of the Mg II emission line at an observed wavelength of 4978 Å. This is similar to the objects 2142−75 (this *Letter*, below) and 0454+039 (Paper II).

0312−77.—The Balmer lines have a common asymmetrical profile. Weak emission lines at observed wavelengths of 4601 Å, 5530 Å, and 5580 Å could not be identified.

0329−255.—The permitted emission lines are extremely broad. Many absorption features are also present that cannot be identified at the emission-line redshift.

1254−333.—The Balmer lines have a common asymmetrical profile. Hδ is probably also present at an observed wavelength of 4860 Å.

1912−549.—Mg II λ2798 is probably present at an observed wavelength of about 3930 Å.

TABLE 1

RADIO SOURCES WITH REDSHIFTS

Parkes source number	Optical position R.A. (1950) h m s	Optical position Dec. (1950) ° ' "	Optical Ident.	Optical Mag.	Mean redshift $\bar{z}$	Radio flux density 2700 MHz (Jy)*	Radio flux density 5000 MHz (Jy)	Colour	Finding chart reference†
0029-414	00 29 01.3	-41 24 39	Q	17.0	0.896	0.23	0.22	UVX	F
0047-832	00 47 10.8	-83 13 10	Q	16.9	1.112	0.28	-	UVX	A
0100-270	01 00 31.79	-27 02 46.8	Q	17.5	1.597	0.26	0.24	BSO	J
0101-76	01 00 55.27	-76 02 56.1	Q	17.9	0.659	0.46	0.55	UVX	I
0102-80	01 01 58.5	-80 12 10	G	16.9	0.057	(0.46)	0.29	-	A
0135-247	01 35 17.16	-24 46 09.4	Q	16.9	0.831	1.30	(1.5)	BSO	C
0202-76	02 02 00.19	-76 34 28.8	Q	(17.6)	0.389	1.37	0.80	UVX	A
0252-549	02 52 00.29	-54 54 01.8	Q	(18)	0.537	(0.76)	(0.80)	UVX	I
0312-77	03 12 55.7	-77 03 01	Q	15.9	0.223	0.60	-	UVX	A
0329-255	03 29 00.48	-25 34 53.2	Q	17.1	2.685	0.41	0.39	Weak UVX	I
0621-786	06 21 29.7	-78 41 33	Q	17.5	0.942	0.16	-	UVX	A
1151-34	11 51 49.32	-34 48 47.9	Q	17.5	0.258	4.12	2.71	UVX	L
1207-399	12 06 59.59	-39 59 30.6	Q	16.1	0.966	0.59	(0.50)	UVX	F
1254-333	12 54 36.0	-33 18 30	Q	18.6	0.190	0.72	0.34	UVX	I
1912-549	19 12 35.2	-55 00 09	Q	16.6	0.398	0.19	0.12	UVX	K,M
1929-457	19 29 07.91	-45 43 05.3	Q	18.5	0.652	0.76	0.68	UVX	L
2058-425	20 58 42.27	-42 31 05.0	Q	17.6	0.221	0.98	0.70	UVX	F
2126-15	21 26 26.69	-15 51 51.5	Q	17.3	3.27	1.17	1.24	Neutral	D
2142-75	21 42 12.73	-75 50 04	Q	17.0	1.139	(1.38)	(1.28)	UVX	K
2144-362	21 44 29.9	-36 15 51	Q	(17.8)	2.081	0.24	0.31	UVX	G
2200-238	22 00 07.75	-23 49 42.1	Q	18.5	2.118	(0.40)	(0.46)	BSO	C
2212-299	22 12 25.14	-29 59 20.7	Q	17.5	2.703	0.54	0.44	No UVX	J
2300-683	23 00 28.5	-68 23 56	Q	16.4	0.512	0.43	0.34	-	M
2300-18	23 00 23.47	-18 57 34.9	G	18.1	0.127	0.92	0.89	UVX	B
2314-116	23 14 46.06	-11 38 48.7	Q	17.5	0.549	0.22	0.18	BSO	J
2329-384	23 29 18.9	-38 28 22	Q	16.2	1.202	(0.80)	(0.67)	UVX	L
2352-342	23 52 50.5	-34 14 20	Q	16.4	0.702	0.36	0.39	UVX	H

*1 Jy = 10^{-26} W m^{-2} Hz^{-1}

†References are: A, Anguita and Pedreros (1977); B, Bolton and Ekers (1966); C, Bolton, Shimmins, and Wall (1975); D, Condon et al. (1977); E, Ekers (1970); F, Peterson and Bolton (1972); G, Peterson and Bolton (1973); H, Peterson, Bolton, and Shimmins (1973); I, Peterson, Bolton, and Savage (1976); J, Savage and Wall (1976); K, Savage, Bolton, and Wright (1977); L, Shimmins et al. (1971); M, Wall and Cannon (1973).

TABLE 2

DETAILS OF INDIVIDUAL SPECTRA

(1) Name	(2) Mean redshift $\bar{z}$	(3) Observed wavelength λ_{obs} (Å)	(4) Ident.	(5) Emitted wavelength λ_{em} (Å)	(6) $\lambda_{obs}/(1+\bar{z})$ (Å)	(7) z	(8) Line-to-continuum ratio	(9) $\Delta\lambda_{1/2}$ (Å)
0029-414	0.896	5310	Mg II	2798	2801	0.898	0.31	120
		6103	He II	3220	3219	0.895	0.13	120
		6491	[Ne V]	3426	3424	0.895	0.18	60
0047-832	1.112	(4040)	CIII]	1909	(1913)	(1.116)	(0.5)	-
		4923	CII]	2326	2331	1.117	0.17	80
		5908	Mg II	2798	2797	1.112	0.39	120
0100-270	1.597	4022	CIV	1549	2518	1.597	0.70	75
		4959	CIII]	1909	3105	1.598	(0.4)	(100)
0101-76	(0.659)	4643	Mg II	2798	2798	0.659	0.62	100
0102-80	0.057	4541A	G	4304	4297	0.055	-0.45	30
		5289	[OIII]	5007	5004	0.056	0.44	15
		5468A	Mg I	5175	5174	0.057	-0.29	30
		6232A	Na D	5892	5897	0.058	-0.29	20
		6948	Hα	6563	6574	0.059	0.68	45
0135-247	0.831	5124	Mg II	2798	2798	0.813	0.43	80
0202-76	0.389	(3890)	Mg II	2798	(2801)	(0.390)	(1.0)	(100)
		(6765)	Hβ	4861	(4870)	(0.392)	(0.4)	(100)
		6889	[OIII]	4959	4960	0.389	1.3	20
		6949	[OIII]	5007	5003	0.388	3.3	20
0252-549	0.537	4300	Mg II	2798	2798	0.537	1.5	100
		5251	[Ne V]	3426	3416	0.533	0.33	30
		(6340)	Hδ	4102	(4125)	(0.546)	(0.5)	-
		6684	Hγ	4340	4349	0.540	(1.0)	(50)
0312-77	0.223	4552	[OII]	3727	3722	0.221	0.2	<20
		4720	[Ne III]	3869	3859	0.220	(0.2)	<20
		5020	Hδ	4102	4105	0.224	(0.2)	(60)
		5315	Hγ + [OIII]	(4345)	4346	0.223	0.48	65
		5948	Hβ	4861	4863	0.224	1.26	65
		6063	[OIII]	4959	4957	0.223	0.75	<20
		6122	[OIII]	5007	5006	0.223	2.24	<20
0329-255	2.685	(3800)	Ly β + OVI	(1030)	(1031)	(2.682)	-	-
		(4520)	Ly α + NV	(1220)	(1227)	(2.705)	1.17	130
		4660	Si II	1260	1265	2.698	(0.2)	((70))
		5167	Si IV + OIV]	(1400)	1402	(2.691)		
		5696	CIV	1549	1546	2.677	0.62	130
		7020	CIII]	1909	1905	2.677	(0.6)	(55)
0621-786	0.942	5435	Mg II	2798	2798	0.942	0.52	65
1151-34	0.258	4687	[OII]	3727	3726	0.258	(0.6)	25
		4852	[Ne III]	3869	3857	0.254	(0.4)	30
		(6091)	Hβ	4861	(4842)	(0.253)	0.35	50
		6226	[OIII]	4959	4959	0.255	1.15	25
		6297	[OIII]	5007	5006	0.258	2.50	25
1207-399	0.966	5500	Mg II	2798	2798	0.966	0.40	100
		(5555)	[AIV]	2860	(2826)	(0.94)	-	-
1254-333	0.190	5187	Hγ	4340	4359	0.195	0.30	(60)
		5571	Hβ	4681	4682	0.187	0.82	(80)
		(5931)	[OIII]	4959	(4984)	(0.196)	(0.16)	(25)
		5957	[OIII]	5007	5006	0.190	0.28	(25)
		7817	Hα	6563	6569	0.191	4.23	(120)
1912-549	0.398	(3926)	Mg II	2798	(2808)	(0.40)	(0.4)	-
		6091	Hγ	4340	4357	0.403	0.32	40
		6781	Hβ	4861	4851	0.395	0.63	60
		6935	[OIII]	4959	4961	0.398	(0.6)	<20
		7001	[OIII]	5007	5008	0.398	0.94	<20
1929-457	0.652	4623	Mg II	2798	2798	0.652	0.7	(120)
		(4915)	[Ne V]	2974	(2975)	(0.653)	(0.4)	(50)
		6154	[OII]	3727	3725	0.651	0.5	(30)
2058-425	0.221	5937	Hβ	4861	4862	0.221	0.51	75
		6060	[OIII]	4959	4963	0.222	0.20	30
		6111	[OIII]	5007	5005	0.220	0.57	30

TABLE 2—*Continued*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2126-15	3.27	(4370)	Ly β	1026	(1023)	(3.26)	(0.5	(40)
		5198	Ly α	1216	1217	3.27	1.8	120
		5291	NV	1240	1239	3.27	0.7	90
		5940	Si IV	1396	1391	3.26	0.2	100
		6539	CIV	1549	1544	3.26	0.3	90
		(8180)	CIII]	1909	(1916)	(3.28)	(0.5)	100
2142-75	1.139	4085	CIII]	1909	1910	1.140	0.4	(60)
		5985	Mg II	2798	2798	1.139	0.33	50
2144-362	2.081	4772	CIV	1549	1549	2.081	1.3	120
		5890	CIII]	1909	1912	2.085	(0.3)	(120)
2200-238	2.118	3792	Ly α	1216	1216	2.118	(2.)	(60)
		4832	CIV	1549	1550	2.119	1.5	50
		(5127)	He II	1640	(1644)	(2.126)	0.3	(50)
		5948	CIII]	1909	1909	2.116	0.53	80
2212-299	2.703	(3817)	OVI	1034	(1031)	2.691	(1.)	(50)
		4503	Ly α	1216	1216	2.703	3.9	50
		4588	NV	1240	1239	2.700	0.81	65
		4838	Si II	1304	1307	2.710	0.3	65
		5185	Si IV + OIV]	(1400)	1400	(2.704)	0.3	80
		5735	CIV	1549	1549	2.702	1.1	70
		(6050)	He II	1640	(1639)	(2.689)	0.3	(40)
		7070	CIII]	1909	1909	2.704	0.4	(100)
2300-683	0.512	4227	Mg II	2798	2796	0.511	0.43	(100)
		6578	Hγ	4340	4351	0.516	0.3	(80)
		7350	Hβ	4861	4861	0.512	0.8	(70)
		(7589)	[OIII]	5007	(5019)	0.516	-	-
2300-18	0.127	(4360)	[Ne III]	3869	(3869)	(0.127)	-	-
		4899	Hγ	4340	4347	0.129	0.7	50
		5465	Hβ	4861	4849	0.124	0.5	80
		5592	[OIII]	4959	4962	0.128	2.1	<15
		5640	[OIII]	5007	5004	0.126	5.8	<15
2314-116	(0.549)	4333	Mg II	2798	2798	0.549	0.7	100
2329-384	1.202	(4213)	CIII]	1909	(1913)	(1.207)	0.3	(100)
		(5158)	CII]	2326	(2342)	(1.22)	0.1	(65)
		6158	Mg II	2798	2797	1.201	0.3	100
2352-342	0.702	4759	Mg II	2798	2796	0.701	0.60	140
		(6353)	[OII]	3727	(3733)	(0.705)	0.2	<30
		(6596)	[Ne III]	3869	(3875)	(0.705)	0.3	35

2126−15.—This object has an extremely rich absorption spectrum and will be discussed in greater detail in a separate paper (Jauncey *et al.* 1978).

2142−75.—Low dispersion spectra of this object with low signal-to-noise ratio (taken earlier by J. G. Bolton and Ann Savage and by us) showed one emission line at 5985 Å together with several absorption features on the short-wavelength side of the emission line. Such a combination of emission and absorption features is often seen in high-redshift QSOs where the emission is Lα. This suggested a possible identification of the 5985 Å line with Lα at a redshift of $\sim$4. However, our later high-dispersion spectra with high signal-to-noise ratio revealed a further emission line at 4085 Å. The two emission lines were then identified as C III] λ1909 and Mg II λ2798, both at a redshift of 1.14; the absorption features were identified with Mg II and Fe II at an absorption redshift of 0.958. The object is unusual in having deep absorption lines at a low emission redshift.

2144−362.—A strong absorption line with a half-width of about 30 Å lies at an observed wavelength of 5560 Å. This could possibly be Si II λ1807 at the emission redshift.

2200−238.—The profile of the C IV λ1549 line appears asymmetrical.

2352−342.—Three other emission features are probably present in this object at observed wavelengths of 4286 Å, 4473 Å, and 5008 Å. They can be identified, respectively, with [Mg VII] λ2512, [Mg VII] λ2632, and [Mg V] λ2931 at the emission redshift.

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