Redshift of southern radio galaxies^{*}

R. Scarpa^{1, **}, R. Falomo² and J.E. Pesce³

¹ Dipartimento di Astronomia Università di Padova, Via Osservatorio 5, 35122 Padova, Italy
E-mail: riccardo@astrpd.pd.astro.it

² Osservatorio Astronomico di Padova, Via Osservatorio 5, 35122 Padova, Italy
E-mail: falomo@astrpd.pd.astro.it

³ Space Telescope Science Institute 3700 San Martin Drive, Baltimore, MD 21218, U.S.A.
E-mail: pesce@stsci.edu

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Abstract. — We report optical spectroscopy and redshift determination for 22 radio galaxies, extracted from the Ekers et al. (1989) compilation. Selected sources, which have both Fanaroff & Riley type I and II radio morphology and are classified as elliptical or S0, have a typical early-type spectrum with strong absorption lines as generally observed in non-radio elliptical galaxies. Only in two cases, 0344–345 and 1521–300, moderately strong emission lines are observed.

Key words: galaxies: distances and redshift

1. Introduction

We are currently studying a large sample of radio galaxies in the southern hemisphere, both of Fanaroff & Riley class I and II (FR) (Fanaroff & Riley 1974). The sample is drawn from the lists of Wall & Peacock (1985) and Ekers et al. (1989) selecting objects with optical counterpart classified as elliptical or S0, in the distance range $0.01 < z < 0.12$, in order to study their optical morphological and photometrical properties (Fasano et al. 1996) and the Megaparsec-scale environments (Pesce et al. 1996). The results from these studies will also be used to compare the radio galaxy optical properties with those of the BL Lacertae host galaxies. This is useful for testing the hypothesis that BL Lacs are radio galaxies with a relativistic jet closely aligned toward the observer line of sight (see e.g. Urry & Padovani 1995 and references therein).

Because complete redshift information was not available for the Ekers et al. subsample (for the Wall & Peacock list see Tadhunter et al. 1993), we undertook optical spectroscopic observations to obtain the missing values.

Table 1. Redshift of radio galaxies

Object	α (1950)	δ (1950)	m_V	redshift
0005 – 199	00 05 43	–19 56 30	16.8	0.1216 ± 0.0005
0013 – 316	00 13 45	–31 40 09	16.8	0.1071 ± 0.0008
0155 – 212	01 55 32	–21 16 52	17.8	0.1597 ± 0.0004
0229 – 208	02 29 18	–20 53 35	16.0	0.0895 ± 0.0006
0247 – 207	02 47 17	–20 42 56	15.4	0.0864 ± 0.0007
0257 – 398	02 57 32	–39 52 30	15.3	0.0661 ± 0.0004
0312 – 343	03 12 33	–34 18 46	15.6	0.0669 ± 0.0004
0344 – 345	03 44 35	–34 32 02	16.3	0.0535 ± 0.0004
0452 – 190	04 52 06	–19 00 17	14.8	0.0389 ± 0.0002
0533 – 377	05 33 40	–37 45 04	16.7	0.0964 ± 0.0008
0712 – 349	07 12 07	–34 56 12	15.9	0.0446 ± 0.0003
0940 – 304	09 40 12	–30 30 27	14.5	0.0385 ± 0.0003
1002 – 320	10 02 26	–32 02 07	17.4	0.0887 ± 0.0008
1043 – 290	10 43 48	–29 05 21	15.4	0.0598 ± 0.0003
1257 – 253	12 57 07	–25 23 29	16.0	0.0648 ± 0.0006
1354 – 251	13 54 27	–25 08 46	15.4	0.0379 ± 0.0002
1521 – 300	15 21 29	–30 01 46	15.3	0.0196 ± 0.0004
1929 – 397	19 29 59	–39 47 06	15.5	0.0744 ± 0.0004
2209 – 255	22 09 32	–25 33 19	15.9	0.0626 ± 0.0003
2333 – 327	23 33 30	–32 46 34	15.6	0.0518 ± 0.0002
2350 – 375	23 50 39	–37 30 35	16.5	0.1151 ± 0.0008
2353 – 184	23 53 21	–18 26 26	16.0	0.0727 ± 0.0004

Send offprint requests to: R. Scarpa

^{*}Based on observations collected at the European Southern Observatory, La Silla, Chile

^{**}Present address: Space Telescope Science Institute 3700 San Martin Drive, Baltimore, MD 21218, U.S.A.

Table 2. Line identifications¹

Object	ID	λ (Å)	e.w. (Å)	notes	Object	ID	λ (Å)	e.w. (Å)	notes
0005 – 199	CaII H 3933	4411.3	8.3 ± 0.2		0940 – 304	CaII H 3933	4084	6 ± 2.5	
	CaII K 3968	4449.7	9.3 ± 0.2			CaII K 3968	4120	6 ± 2.5	
	G-band 4304	4824	12.2 ± 2.2			G-band 4304	4472.7	...	
	MgI 5175	5806.5	5.0 ± 1.0			MgI 5175	5373.1	4.6 ± 1.0	
0013 – 316	Na D 5892	6611.6	5.5 ± 0.8		1002 – 320	Ca+Fe 5269	5470.7	1.6 ± 0.5	
	CaII H 3933	4360.1	2.3 ± 1.0			Na D 5892	6120.4	5.0 ± 0.5	
	CaII K 3968	4391.0	2.8 ± 1.0			CaII K	4284.5	...	
	G-band 4304	4761.8	6.6 ± 1.5			CaII H	4315.8	...	
	MgI 5175	5727.7	5.1 ± 0.8			MgI 5175	5634.9	9.4 ± 1.0	
0155 – 212	Na D 5892	6523.6	7.0 ± 0.8		1043 – 290	Na D 5892	6416.3	5.1 ± 0.8	
	CaI H 3933	4562	...			CaII H	4166.1	11.7 ± 1.8	
	G-band 4304	4988	1.3 ± 0.5			CaII K	4206.8	10.3 ± 1.5	
	MgI 5175	6005	6.2 ± 1.0			G-band 4304	4560.8	7.0 ± 1.0	
	Ca+Fe 5269	6264	2.5 ± 0.4			MgI 5175	5484.8	4.5 ± 0.5	
0229 – 208	NaD 5892	6837	6.8 ± 1.0		1257 – 253	Ca+Fe 5269	5585.8	1.4 ± 0.4	
	CaII H 3933	4288.1	8.1 ± 1.0			NaD 5892	6245.5	7.5 ± 1.1	
	CaII K 3968	4323.5	8.2 ± 1.0			CaII H 3933	4192.5	11 ± 2.5	
	G-band 4304	4684.9	4.0 ± 0.5			G-band 4304	4584.7	8.5 ± 1.4	
	MgI 5175	5638.1	5.3 ± 0.6			MgI 5175	5508.9	9.3 ± 1.0	
0247 – 207	Na D 5892	6421.7	5.9 ± 0.8		1354 – 251	Ca+Fe 5269	5605.7	...	
	CaII H 3933	4275.2	...			NaD 5892	6274.1	5.7 ± 0.6	
	CaII K 3968	4311.5	...			Ca II H	4082.0	...	
	G-band 4304	4670	...			MgI 5175	5370.9	13.0 ± 2.0	
	MgI 5175	5622.1	8.4 ± 0.5			Ca+Fe 5269	5468.6	2.1 ± 1.1	
0257 – 398	Ca+Fe 5269	5723.8	1.6 ± 0.2		1521 – 300	Na D 5892	6116.4	3.6 ± 0.7	
	Na D 5892	6404.9	6.2 ± 0.4			MgI 5175	5276.9	13.5 ± 2.5	
	G-band 4304	4591.9	9.5 ± 1.5			Ca+Fe 5269	5369.1	2.2 ± 0.9	
	MgI 5175	5516.0	6.1 ± 0.6			NaD 5892	6010.4	3.3 ± 0.7	
	Ca+Fe 5269	5615.7	...			[OII] 6300	6423.5	1.9 ± 0.8	E
0312 – 343	NaD 5892	6281.4	5.9 ± 0.5		1929 – 397	H α	6692.9	15.0 ± 1.2	E
	CaII H 3933	4193.1	11 ± 2			[SII] 6716	6848.9	1.5 ± 0.3	E
	CaII K 3968	4235.3	10.7 ± 1.2			CaII 3933	4225.2	11 ± 3	
	G-band 4304	4592.4	9.6 ± 1.1			CaII 3968	4264.6	9.6 ± 1.8	
	MgI 5175	5521.9	13.0 ± 2.0			G-band 4304	4623	7.8 ± 1.7	
0344 – 345	Ca+Fe 5269	5621.9	1.8 ± 0.3		2209 – 255	MgI 5175	5558.6	15.0 ± 2.5	
	NaD 5892	6288.5	7.5 ± 0.9			Na D 5892	6334.3	8.6 ± 0.7	
	[OIII] 5007	5273.4	5.3 ± 1.2	E		CaII H 3933	4178.0	13 ± 0.5	
	MgI 5175	5449.5	6.4 ± 0.4			CaII K 3968	4216.0	10 ± 0.5	
	Ca+Fe 5269	5551.0	1.9 ± 0.4			MgI 5175	5501.0	5.5 ± 0.5	
0452 – 190	NaD 5892	6212.1	7.1 ± 0.6		2333 – 327	Ca+Fe 5269	5597.2	2.1 ± 0.3	
	[OII] 6300	6637.7	2.7 ± 0.4			NaD 5892	6263.8	6.2 ± 0.5	
	H α	...	$> 15 \pm 1.2$	B,E		H β	5113	2.8 ± 0.8	
	[SII] 6716-32	...	6.4 ± 1.2	B,E		MgI 5175	5444.3	11.4 ± 1.5	
	MgI 5175	5375.6	4.2 ± 0.6			Ca+Fe 5270	5541.0	2.6 ± 0.6	
0533 – 377	Ca+Fe 5269	5475.2	...		2350 – 375	NaD 5892	6198.2	4.5 ± 0.5	
	NaD 5892	6121.0	4.2 ± 1.0			CaII H 3933	4390.3	13.8 ± 2.5	
	CaII K 3933	4316.5	...			CaII K 3968	4422.5	12.6 ± 2.5	
	CaII H 3968	4347.5	...			G-band 4304	4796.9	8.6 ± 1.3	
	G-band 4304	4717.7	6.4 ± 1.1			MgI 5175	5774.8	10.8 ± 1.0	
0712 – 349	H β	5336.8	2.4 ± 0.4		2353 – 184	Ca+Fe 5270	5872.3	2.1 ± 0.8	
	MgI 5175	5670.7	5.0 ± 0.5			NaD 5892	6573.4	3.6 ± 0.6	
	Ca+Fe 5269	5775.0	1.6 ± 0.4			CaII 3933	4220.9	...	
	NaD 5892	6458.5	5.9 ± 0.8			CaII 3968	4254.1	...	
	CaII H 3933	4110.8	5 ± 2.5			H β	5213.9	2.5 ± 1.0	
	Ca+Fe 5269	5501.3	2.3 ± 0.7			MgI 5175	5552.2	19 ± 2.6	
	Na D 5892	6155.8	5.4 ± 0.5			Na D 5892	6319.7	6.9 ± 1.3	
	MgI 5175	5405.7	4.6 ± 0.7						

¹ E= emission line; B=line blended with other lines or with the atmospheric absorption bands.

2. Observations and results

Optical spectroscopy was obtained at the European Southern Observatory (ESO), La Silla, Chile, using the 1.5 m spectrographic telescope equipped with a Boller & Chivens spectrograph during three observing runs in July 1993, July 1994 and February 1995. The detector employed was a Ford Aerospace CCD with $15\ \mu\text{m}$ -pixels, which covers the range $3800\text{--}9000\ \text{\AA}$ at a resolution of $3.8\ \text{\AA}/\text{pixel}$. Standard data reduction procedures were adopted to obtain 1-dimensional wavelength calibrated extracted spectra.

Spectra have also been corrected for the wavelength dependent sensitivity of the instrument.

The achieved precision on wavelength calibration was better than $\sim 1\ \text{\AA}$. In all cases, a gaussian was fitted to the line profile to evaluate the line position.

In Table 1 we report for each source the measured redshift, as derived from line identifications of Table 2, together with the estimated uncertainty.

Table 3. Redshift of companions

Radio Gal.	$z_{\text{gal.}}$	$\Delta\alpha^1$	$\Delta\delta^1$	$z_{\text{comp.}}$
0229 – 208	0.0895	11	–10	0.090 ± 0.001
1929 – 397	0.0744	–20	14	0.076 ± 0.004
2031 – 359 ²	0.088	–9	24	0.0895 ± 0.0003
2333 – 327	0.0518	13	–101	0.0522 ± 0.0002

¹ Projected distance in arcsec.

² Coordinate of this source are (1950): 20 31 32, –35 59 27

Table 2 gives the measured wavelength and equivalent width of the stronger lines (Cols. 3 and 4), while Fig. 1 reports for each object the observed spectrum. All sources show a typical early-type spectrum, exhibiting the Ca II H, K, *G*-band, Mg I, absorption lines (Fig. 1). Only in two cases (0344–345 and 1521–300) emission lines are detected ($\text{H}\alpha$, [O III], [S II]). The spectrum of 0344–345 resembles that of a Seyfert 2.

Finally in Table 3 we give for 4 objects the redshift of a close companion galaxy, which in all cases was found to be at the same distance as the radio source. We report in Cols. 1 and 2 the name and z of the radio galaxy, in Cols. 3 and 4 the projected distance in arcsec of the companion, and in the last column the measured companion’s redshift.

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Fig. 1. Spectra of radio galaxies. Fluxes are in arbitrary units. Main features and atmospheric absorptions ($\oplus$) are marked

Fig. 2.

Fig. 3.