PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC
102: 1235–1240, November 1990

PUBLICATIONS OF THE
ASTRONOMICAL SOCIETY OF THE PACIFIC

Vol. 102 November 1990 No. 657

SPECTROSCOPY OF RADIO SOURCES FROM THE PARKES 2700 MHz SURVEY

D. J. THOMPSON, S. DJORGOVSKI,*†‡ AND R. DE CARVALHO‡§

Palomar Observatory, California Institute of Technology, Pasadena, California 91125

Received 1990 June 28, revised 1990 July 30

ABSTRACT

We present the results of long-slit CCD spectroscopy on 37 objects from the Parkes 2700 MHz survey, with data for an additional two companion objects. Eight of the objects are quasars, six more are AGNs, and five more are radio galaxies. Seventeen of the objects observed are stars and, thus, probable misidentifications. Three objects show featureless spectra and are identified as possible BL Lac objects. Spectra are presented for a total of 20 objects.

Key words: galaxies: redshifts–quasars–redshifts–spectroscopy

1. Introduction and Observations

The Parkes (PKS) 2700 MHz survey is a complete survey for objects with a limiting flux density of approximately $S_{2700} \geq 0.25$ Jy (Bolton *et al.* 1975; Bolton, Savage, and Wright 1979; and references therein). We have undertaken a follow-up slit spectroscopy program at medium resolution (3 Å–6 Å) of the objects in the PKS survey, using no systematic selection criteria, as a marginal weather backup project. In general, objects were selected on the basis of optical brightness or possibly interesting morphology on the published finding charts. Our goal is to classify the objects, obtain accurate redshifts, and identify objects worth pursuing in more detail.

The observations were done on UT 1988 April 8–10, UT 1988 June 8–9, UT 1988 September 12, and UT 1989 November 27 with the Modular Spectrograph on the 100-inch (2.5-m) telescope at Las Campanas; on UT 1988 July 14–16 with the 4-meter telescope at Cerro Tololo; and on UT 1988 January 10 and UT 1988 March 11 with the Double Spectrograph (Oke and Gunn 1982) at the Cassegrain focus of the Palomar Observatory Hale 200-inch (5-m) telescope. The weather was generally nonphotometric, with variable transparency due to cirrus. The seeing ranged from 1.5 to 3 arc seconds (FWHM). The slit widths and gratings varied but were chosen to give 3 to 6 angstrom resolution and covering approximate ranges of 4300 to 7300 angstroms. Exposure times ranged from 400 to 2000 seconds.

Wavelength calibration was accomplished with helium, neon, argon, and hollow cathode (Fe-Ar) lamps, giving an rms error in the dispersion solutions of ≤ 1 Å. Wavelength shifts due to instrument flexure were compensated for by taking frequent spectra of the helium arc lamps throughout the night or by extracting a sky spectrum adjacent to each object. Dome flat fields and spectroscopic flux standards from Oke and Gunn (1983), Stone (1977), Stone and Baldwin (1983), and Baldwin and Stone (1984) were used to correct for instrument response and to give an approximate flux calibration. Due to the variable transparency, the zero-point uncertainties of the flux calibration are estimated to be on the order of 0.5–1.0 magnitude. The data were reduced using standard procedures.

Thirty-seven PKS objects were observed, of which eight are quasars and six are Seyferts or active galaxies. An additional five objects are radio galaxies, only one of which shows weak emission lines. Three objects could not be identified due to the absence of any identifiable spectral features, two of which were previously noted as having featureless continuum spectra (0118−272 and 0823−223). We find some evidence for variability in 0118−272 and 1424+240, supporting the interpretation that these objects are BL Lacertae. In Table 1 we list the emission-line data derived from the spectra of the quasars

*Alfred P. Sloan Foundation fellow.

†Visiting Astronomer, Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatories, operated by AURA, Inc., under cooperative agreement with the National Science Foundation.

‡Visiting Investigator, Las Campanas Observatory, Carnegie Institution of Washington.

§Permanent address: Observatorio Nacional-SPNq, Rua Gal. Bruce 586, São Cristóvão, Rio de Janeiro, Brazil.

and strong emission-line galaxies, while in Table 2 we list the same information for the absorption-line radio galaxies and "featureless spectrum" objects in this sample. None of these objects were found in the IRAS PSC. Seventeen PKS objects were found to be stars and are thus probable misidentifications of the radio sources. These are listed in Table 3. Figure 1 shows the spectra of all the nonstellar Parkes objects, not including the possible BL Lacs.

2. Comments on Selected Objects

PKS 0035−392: A $16^{m}.5$ quasar at $z = 0.596$ with a companion stellar object ~ 4 arc sec away in P.A. = 155°. We find that the companion is an M-type star. The spectrum of the quasar is remarkably similar to that of 3C 48 published by Phillips (1977). This quasar was previously identified by Peterson, Jauncey, and Wright (1976), who derived a redshift of 0.592. The excess *J*, *H*, and *K* flux found by Glass (1981) is most likely due to the M star.

PKS 0118−272: This possible BL Lac object was observed previously by Peterson *et al.* (1976), who noted the featureless continuum at ~ $16^{m}.5$. We find a continuum magnitude of $AB_{\nu} = 14^{m}.5$ at $\lambda = 6000$ Å, which may indicate some variability, though the spectrum was obtained under nonphotometric conditions.

PKS 0823−223: A 16^{m} possible BL Lac object. Wright, Ables, and Allen (1983) noted the featureless continuum of this object, but our spectrum shows two absorption lines, one apparently due to Na D λ5893, which is probably interstellar in origin, and the other at λ5349 which remains unidentified. We find no evidence for variability.

PKS 0858−279: Although the optical counterpart to this source, previously proposed by Bolton *et al.* (1975), is a $14^{m}.5$ galactic star, there is a 17^{m} quasar 3 arc sec north at P.A. = 0°, which we identify as the radio source. There is only one emission line in the spectrum; if it is Mg II λ2798, then we find $z = 1.14$.

PKS 0858−771: An 18^{m} Seyfert I at $z = 0.4900$. This object was previously identified by Wilkes (1986), who found $z = 0.489$.

PKS 0903−573: Although the optical counterpart proposed by White *et al.* (1987) is a 17^{m} star, there is a 19^{m} Seyfert I at $z = 0.695$ that is 4 arc sec west at P.A. = 265°, which we identify as the radio source.

PKS 1340+05: A $17^{m}.8$ BLRG at $z = 0.136$ as identified by Grandi (1983), which we confirm.

PKS 1342−314: The object identified in Shimmins and Bolton (1974) is a galaxy at $z = 0.143$. Since it shows no evidence of emission lines, and is in a crowded field, this may be a misidentification of the radio source.

PKS 1424+240: Listed at $16^{m}.5$ in Condon, Hicks, and Jauncey (1977), we find no obvious emission lines and several unidentified nonstellar absorption lines with a continuum magnitude of 15^{m}. We interpret this to be a possible BL Lac with intervening metallic absorber(s).

PKS 1437−153: We find the optical counterpart identified in Bolton *et al.* (1975) to be a $17^{m}.5$ star. Condon *et al.* (1977) changed the ID to a 19^{m} object approximately 13 arc sec northeast at P.A. ≃ 40° based on interferometer measurements. Véron-Cetty and Véron (1989) list this object in their Table 3 at $z = 0.254$, but the reference quoted there is incorrect.

PKS 1444−301: A galaxy at $cz = 4660$ km s^{-1} which does not show any emission lines. It is by far the brightest object in the Parkes error circle and, thus, is probably a correct identification of the radio source.

PKS 1601−00: Also known as 4C−00.63. We find this 17^{m} radio galaxy to be at $z = 0.0825$.

PKS 1602−002: Also known as PKS 1602−001 and PKS 1602−00. Identified as a 17^{m} quasar at $z = 1.625$ by Wills and Lynds (1978) and $AB_{1550} = 18^{m}.1$ at $z = 1.633$ by Wampler *et al.* (1984), we find a redshift of 1.64.

PKS 2153−219: A 17^{m} LINER at $z = 0.098$ possibly with high internal obscuration; the Hβ and [O III] λ5007 lines are completely absent.

PKS 2358−161: An 18^{m} quasar at $z = 2.044$. This object was previously identified by Wright *et al.* (1983).

3. Concluding Remarks

The Parkes survey has long been a popular hunting ground for radio-selected quasars. These spectroscopic identifications have mainly concentrated on the brigher flat-spectrum objects, a majority of which turn out to be AGN. As the classification of the Parkes objects continues to fainter levels, more misidentifications can be expected. We find that fully 46% of the objects in our sample are probable misidentifications. Still, almost 40% of the objects in this work turned out to be active.

We are indebted to the staffs of Las Campanas Observatory, especially Oscar Duahalde, Angel Guerra, Fernando Peralta, and Alberta Zuniga; Cerro Tololo Inter-American Observatory, especially M. Hernandez, M. Navarete, H. Tirado, and R. Venegas; and Palomar Observatory, especially J. Carrasco, J. Henning, and D. Tennant for their help during the observations. This work was supported in part by a Kingsley Foundation Fellowship (D.J.T.) and the Alfred P. Sloan Foundation and the California Institute of Technology (S.G.D.).

REFERENCES

Baldwin, J., and Stone, R. P. S. 1984, *M.N.R.A.S.*, **206**, 242.
Bolton, J. G., Savage, A., and Wright, A. E. 1979, *Aust. J. Phys. Astrophys. Suppl.*, No. 46, 1.
Bolton, J. G., Shimmins, A. J., Wall, J. V., and Butler, P. W. 1975, *Aust. J. Phys. Astrophys. Suppl.*, No. 34, 1.
Condon, J. J., Hicks, P. D., and Jauncey, D. L. 1977, *A.J.*, **82**, 692.
Glass, I. S. 1981, *M.N.R.A.S.*, **194**, 795.
Grandi, S. A. 1983, *M.N.R.A.S.*, **204**, 691.
Hewitt, A., and Burbidge, G. 1987, *Ap. J. Suppl.*, **63**, 1.
Oke, J. B., and Gunn, J. E. 1982, *Pub. A.S.P.*, **94**, 586.
———. 1983, *Ap. J.*, **266**, 713.

Table 1

Quasars and Active Galaxies

Source	Line	rest	obs	z	ID, average z
PKS035-392	Mg II	2798	4468	0.5969	QSO/N galaxy
	[Ne V]	3426	5465	0.5953	z = 0.596 +/- 0.001
	[O II]	3727	5950	0.5965	
	[Ne III]	3869	6175	0.5960	
	[Ne III]	3968	6332	0.5959	
	H-delta	4102	6540	0.5946	
	H-gamma	4341	6929	0.5965	
PKS0452-515	Mg II	2798	6035	1.157	QSO
					z = 1.157 +/- 0.005
PKS0858-279	Mg II	2798	5988	1.140	QSO
					z = 1.14 +/- 0.01
PKS0858-771	[Ne V]	3426	5103	0.4895	Seyfert I
	[O II]	3727	5557	0.4911	z = 0.4900 +/- 0.0005
	[Ne III]	3869	5764	0.4898	
	[Ne III]	3968	5914	0.4905	
	H-delta	4102	6110	0.4895	
	H-gamma	4341	6468	0.4902	
	[O III]	4363	6502	0.4901	
	He II	4686	6978	0.4891	
PKS0903-573	Mg II	2798	4751	0.698	Seyfert I
	[O II]	3727	6306	0.692	z = 0.695 +/- 0/003
PKS1329-049	C IV	1549	4792	2.209	QSO
	C III]	1909	5912	2.097	z = 2.15 +/- 0.03
PKS1340+05	[O III]	5007	5694	0.137	Seyfert II
	[O I]	6300	7158	0.136	z = 0.136 +/- 0.001
	Ha	6563	7457	0.136	
	[N II]	6583	7477	0.136	
PKS1510-08	H-epsilon	3970	5398	0.360	Seyfert I
	H-delta	4102	5588	0.362	z = 0.360 +/- 0.002
	H-gamma	4341	5907	0.361	
	H-beta	4861	6611	0.360	
	[O III]	5007	6793	0.357	
PKS1602-002	C III]	1909	5018	1.629	QSO
	Mg II	2798	7398	1.644	z = 1.64 +/- 0.01
PKS1619-680	Mg II	2798	6601	1.359	QSO
					z = 1.36 +/- 0.01
PKS1814-63	[O III]	5007	5331	0.065	Seyfert II
	Ha	6563	6993	0.066	z = 0.065 +/- 0.001
	[N II]	6583	7005	0.064	
	[S II]blend	6716	7152	0.065	
PKS2153-219	Ha	6563	7206	0.098	LINER
	[S II]blend	6716	7377	0.098	z = 0.098 +/- 0.001
PKS2348-252	Mg II?	2798	6698	1.394	QSO
					z = 1.39 +/- 0.01
PKS2358-161	C IV	1549	4714	2.042	QSO
	C III]	1909	5815	2.046	z = 2.044 +/- 0.002

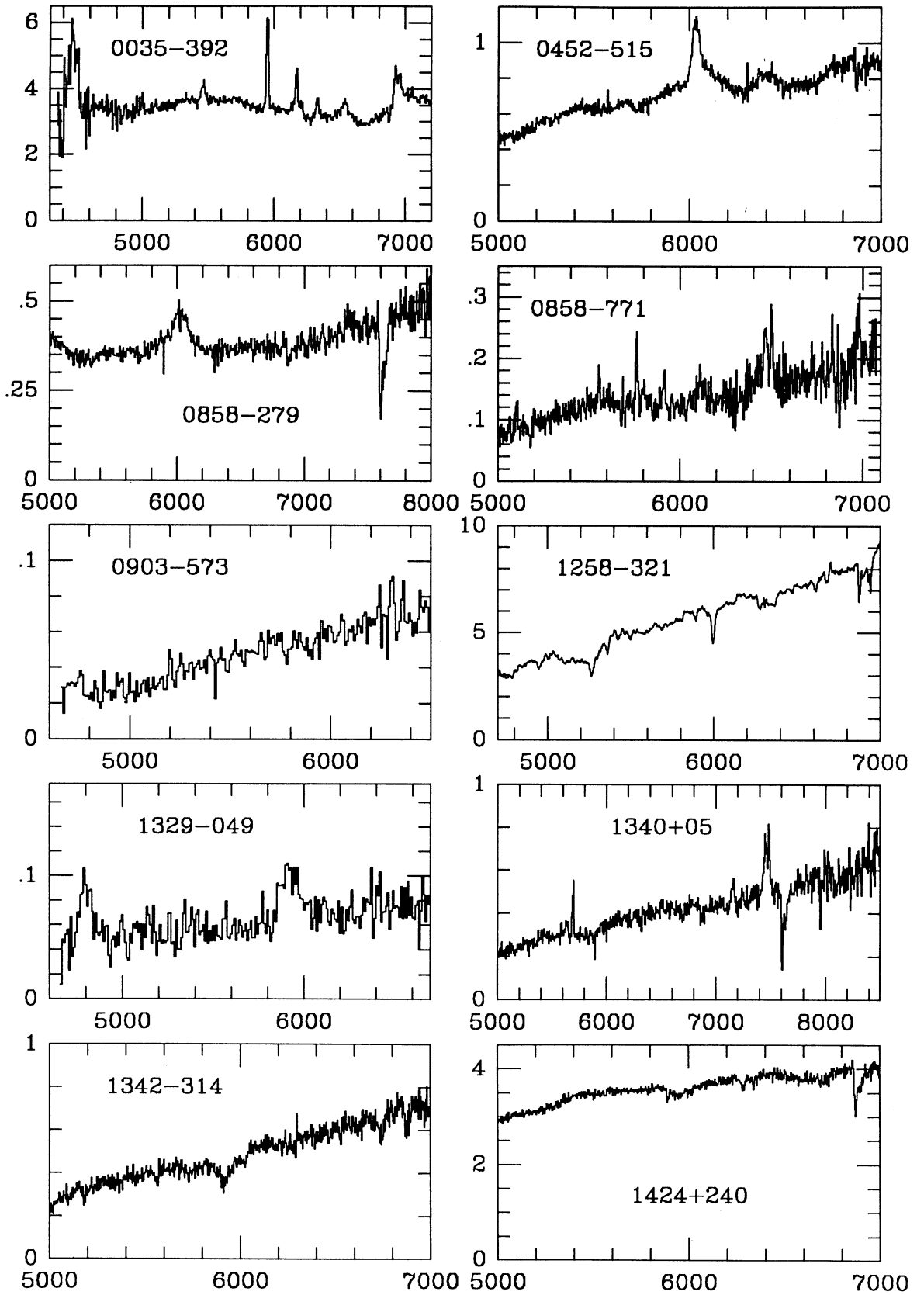

FIG. 1a–Spectra of the AGN, active galaxies, and radio galaxies in this sample. The flux calibration zero point may be uncertain by as much as 0.5–1.0 magnitude. Spectra are plotted as F_ν (mJy) versus λ(Å). See the text for details on selected objects.

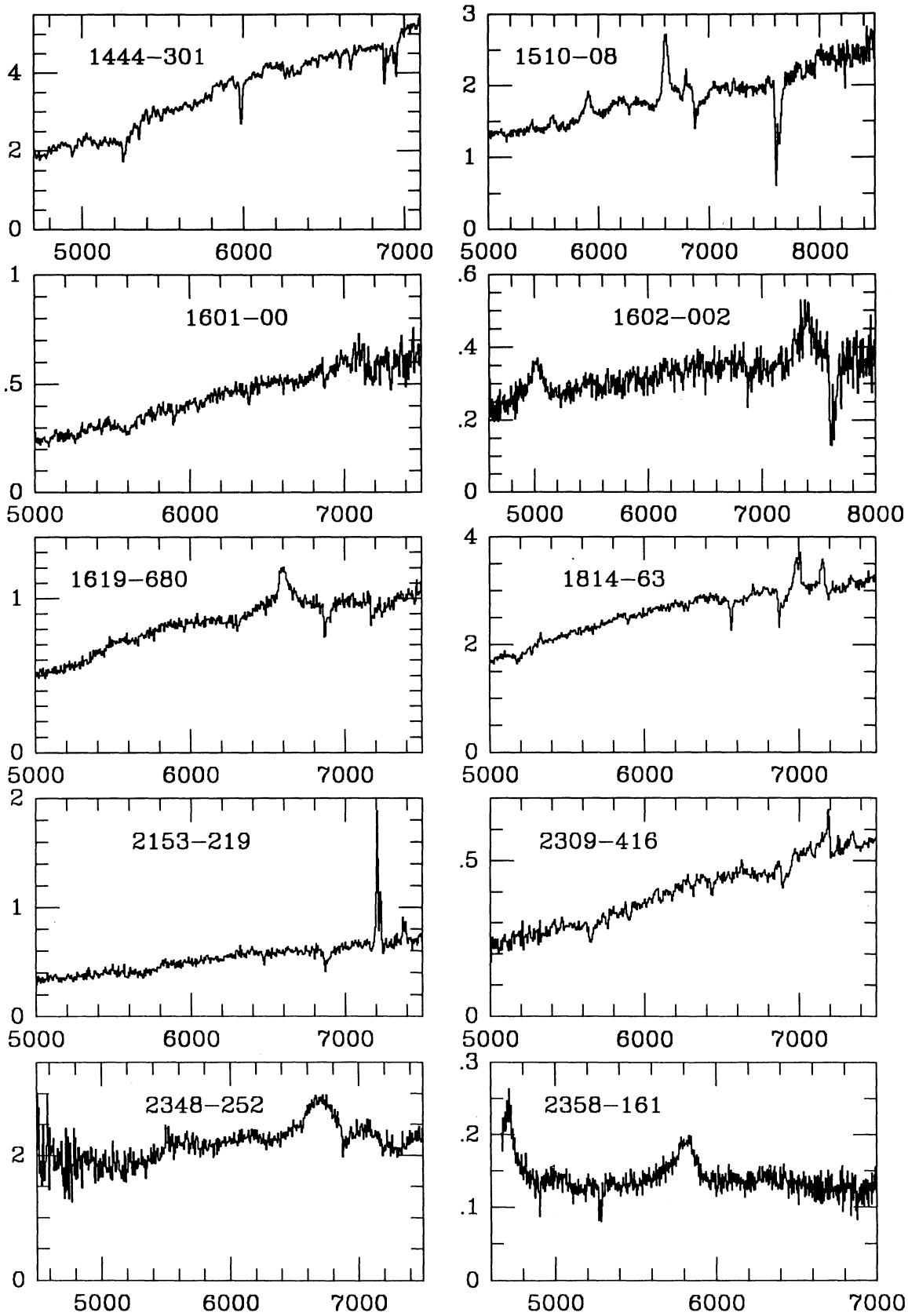

FIG. 1b—Spectra of the AGN, active galaxies, and radio galaxies in this sample. The flux calibration zero point may be uncertain by as much as 0.5–1.0 magnitude. Spectra are plotted as F_ν (mJy) versus λ(Å). See the text for details on selected objects.

Table 2

Radio Galaxies and Possible BL Lac Objects

Source	Line	rest	obs	z	ID, average z
PKS0118-272	none				Possible BL Lac
PKS0823-223	? abs.		5349		Possible BL Lac
	Na D abs.	5893	5896	-----	
PKS1258-321	Na-D abs.	5893	5996	0.0175	Galaxy
					cz=5300 +/- 200 km/s
PKS1342-314	G band	4300	4915	0.143	Galaxy
	Mg I abs.	5175	5915	0.143	z = 0.143 +/- 0.002
	Na D abs.	5893	5914	0.144	
PKS1424+240	? abs.		5950		Possible BL Lac
	? abs.		6285		
PKS1444-301	Na D abs.	5893	5985	0.016	Galaxy
					cz = 4660 +/- 200 km/s
PKS1601-00	Mg I abs.	5178	5604	0.0822	Galaxy, weak Ha em?
	Na D abs.	5893	6381	0.0827	z = 0.0825 +/- 0.0005
PKS2309-416	Mg I abs.	5178	5652	0.092	RG with weak lines
	Na D abs.	5893	6432	0.091	z = 0.093 +/- 0.002
	Ha	6563	7186	0.095	
	[S II]bleand	6716	7343	0.093	

Table 3

Sources Misidentified with Galactic stars

Name	Name
PKS0658-656	PKS1451-19
PKS0759+183	PKS1540-337
PKS0853+03	PKS1750+093
PKS0858-279	PKS1814-51
PKS0903-573	PKS1942+038
PKS1326+06	PKS2259-37
PKS1328-05	PKS2311-587
PKS1342-00	PKS2359-259
PKS1437-153	

Peterson, B. A., Jauncey, D. L., and Wright, A. E. 1976, *Ap. J. (Letters)*, **207**, L5.

Phillips, M. M. 1977, *Ap. J.*, **215**, 746.

Shimmins, A. J., and Bolton, J. G. 1974, *Aust. J. Phys. Astrophys. Suppl.*, No. 32, 1.

Stone, R. P. S. 1977, *Ap. J.*, **218**, 767.

Stone, R., and Baldwin, J. 1983, *M.N.R.A.S.*, **204**, 347.

Véron-Cetty, M. P., and Véron, P. 1989, *ESO Scientific Report*, No. 7.

Wampler, E. J., Gaskell, C. M., Burke, W. L., and Baldwin, J. A. 1984, *Ap. J.*, **276**, 403.

White, G. L., Batty, M. J., Bunton, J. D., Brown, D. R., and Corben, J. B. 1987, *M.N.R.A.S.*, **227**, 705.

Wilkes, B. J. 1986, *M.N.R.A.S.*, **218**, 331.

Wills, D., and Lynds, R. 1978, *Ap. J. Suppl.*, **36**, 317.

Wright, A. E., Ables, J. G., and Allen, D. A. 1983, *M.N.R.A.S.*, **205**, 793.