

IDENTIFICATION OF RADIO SOURCES BETWEEN DECLINATIONS $+27^{\circ}$ AND -30°

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Summary

Seventy-four identifications have been made from inspection of the 48 in. Sky Survey prints in positions of 150 sources measured with the 210 ft telescope. Thirty-seven of the identified sources are galaxies and 37 possible quasi-stellar objects. In 26 cases previously suggested identifications are confirmed. Finding charts are given for the remainder.

INTRODUCTION

Shimmings (1968; present issue pp. 65-79) has recently measured positions of 150 sources between declinations $+27^{\circ}$ and -33° . These positions have an average accuracy of $15''$ arc in both coordinates. We have searched the 48 in. Palomar Sky Survey prints in these positions for identifications.

The selection list for the position measurements comprised all sources in the Parkes catalogue for declinations $+20^{\circ}$ to $+27^{\circ}$ (Shimmings and Day 1968) with flux densities at 2650 MHz ≥ 0.8 flux units and all sources north of -33° in the more southerly zones of the Parkes catalogue with flux densities at 2650 MHz ≥ 0.8 flux units that had not been previously measured by Shimmings, Clarke, and Ekers (1966). In addition, some sources with spectral indices flatter than -0.5 and flux densities between 0.5 and 0.8 flux units were included.

The result of the search for identifications is as follows:

- 15 of the fields were heavily obscured,
- 1 contained a known supernova remnant,
- 60 contained only stars of normal colour,
- 37 contained blue stars that could be quasi-stellar objects,
- 37 contained galaxies.

North of declination $+20^{\circ}$ many of the sources are in the 3C or revised 3C catalogues, and identifications for 18 have been previously given by Wyndham and others. For the sake of completeness these identifications are repeated with references to both the original identification and to finding charts. South of $+20^{\circ}$ eight of the identifications have been previously suggested from this observatory on the basis of the Parkes catalogue positions. Here again the confirmations are listed and references given to finding charts. Finding charts for 49 new identifications are given in the present paper.

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TABLE 1
LIST OF IDENTIFICATIONS

(1) Parkes Cat. No.	(2) Position (1950.0) R.A. Dec. h m s °	(3) Flux Density at 1410 MHz	(4) Spectral Index	(5) Type	(6) Magni- tude	(7) Galactic Coordinates μ δ	(8) Ref. to Identifi- cation*	(9) Ref. to Finding Chart*	(10) Remarks†	(11) Other Cat. Nos.
0005-06	00 05 56.0	-06 15.5	1.3	-0.8	g	19	95	-67		4C -6.1
0011+20	00 11 18.5	20 29.0	0.8	-1.0	QSO?	18	111	-41		4C 21.2
0013-00	00 13 37.5	-00 32.0	0.8	-0.5	QSO?	19.5	104	-62		
0036+03	00 36 43.8	03 03.4	1.6	-0.7	E2	14.3	117	-59		4C 8.5
0038+08	00 38 17.0	08 37.5	1.5	-0.9	E3	17	119	-54		
0048-09	00 48 09.0	-09 45.4	1.1	+0.3	g	18.5	122	-72		
0053+26	00 53 09.1	26 08.4	1.8	-1.2	E	17.5	124	-36		3C 28
0115+02	01 15 42.8	02 42.5	1.5	-0.7	QSO?	17.5	136	-59		4C 2.4
0119+11	01 18 59.5	11 34.2	1.2	-0.6	g	19.5	135	-50		
0127+23	01 27 15.0	23 22.9	3.0	-0.7	QSO	19	134	-38		3C 43
0133+20	01 33 39.8	20 42.2	3.5	-1.0	QSO	17.6	137	-41		3C 47
0204+06	02 04 28.0	06 44.8	1.4	-0.6	QSO?	16	154	-51		4C 6.9
0207+09	02 07 07.5	09 35.8	1.2	-0.7	N	17	153	-48		4C 9.8
0312+10	03 12 37.9	10 01.7	1.5	-0.7	g	19.5	171	-39		4C 10.10
0312-03	03 12 52.0	-03 27.8	1.3	-0.9	QSO?	18.5	185	-48		4C -3.11
0408+07	04 08 32.2	07 00.3	1.6	-0.6	QSO?	18	185	-31		4C 7.14
0422+00	04 22 12.2	00 29.2	1.4	-0.5	QSO	17	194	-35		
0453+22	04 53 42.4	22 44.7	3.4	-0.8	g	19	176	-15		3C 132
0512+24	05 12 59.3	24 55.2	3.0	C	D	17	180	-8		3C 136.1
0628+25	06 28 18.7	25 02.8	1.2	-0.7	E	18	188	7		3C 162
0642+21	06 42 25.0	21 25.1	2.7	-0.8	g	19	193	8		3C 166
0649+22	06 49 45.5	22 36.4	1.0	-0.9	g	19	193	10		4C 22.18
0710+11	07 10 16.0	11 51.4	2.7	-1.0	QSO	17.5	205	10		3C 175
0721+16	07 21 59.2	16 07.7	1.5	-0.9	D	17.5	202	14		4C 15.21
0802+24	08 02 35.5	24 18.5	5.0	-0.6	D	15	198	26		3C 192
0805-07	08 05 49.1	-07 42.4	1.2	-0.4	QSO?	19.5	229	13		
0812+13	08 11 57.0	13 07.4	1.7	-0.8	E	18	210	24		4C 13.37
0827+07	08 27 23.0	07 55.7	1.3	-0.9	QSO?	20	217	25		4C 7.25
0829+18	08 29 25.0	18 42.4	1.1	-0.4	N	18	206	30	Possible jet in p.a. 180°	

0906+01	09 06 35.5	01 33.9	1.4	-0.3	QSO?	17.5	229	31				
0949+24	09 49 09.5	24 36.6	1.9	-0.7	db	18	206	50				3C 229
1004+13	10 04 44.0	13 03.5	1.3	-0.8	QSO?	16	225	49				4C 13.41
1022+20	10 22 34.5	20 25.6	0.9	-0.8	QSO?	18.5	217	56				3C 242
1055+20	10 55 37.0	20 07.8	2.2	C	QSO?	18.5	222	63				4C 20.24
1103-24	11 03 45.7	-24 28.5	1.3	-0.9	D	17.5	274	32	8			11-27
1118+23	11 18 04.0	23 44.2	1.2	-1.0	D	17.5	218	69	4			3C 256
1131-17	11 31 52.5	-17 11.2	1.5	-0.8	QSO?	19	278	42				11-17
1137+12	11 37 53.0	12 19.7	1.6	-0.8	E3	16.5	252	68	2			4C 12.42
1222+21	12 22 22.7	21 39.4	1.5	-0.6	QSO	18	255	82				4C 21.35
1226-21	12 26 08.5	-21 09.8	1.3	-0.8	db	20	296	41				12-47
1254-30	12 54 37.0	-30 05.6	1.3	-1.0	db	16	304	33				12-38
1328+25	13 28 16.0	25 24.6	7.0	-0.5	QSO	17.5	23	81	9			3C 287
1328-25	13 28 22.0	-25 44.4	1.5	-0.9	QSO?	20	314	36				
1329-25	13 29 45.0	-25 44.5	1.3	-0.7	D	19.5	315	36				
1347+21	13 47 15.5	21 25.2	1.1	C	QSO?	16	12	75				4C 21.40
1404-01	14 04 14.5	-01 39.9	1.2	-0.8	QSO?	19.5	337	55				4C -1.31
1410-06	14 10 57.0	-06 15.3	1.1	-0.7	E	19	336	50				
1423+24	14 23 35.2	24 17.2	1.5	-0.9	QSO?	18	30	69				4C 24.31
1449-13	14 49 51.5	-12 59.0	1.3	-0.8	E	18	343	40				14-19
1502+26	15 02 47.5	26 12.5	7.1	-1.0	db	14	39	60	10			3C 310
1505+01	15 05 56.0	01 13.4	1.3	C	QSO?	17.5	0	48				4C 01.41
1511+26	15 11 30.8	26 18.6	4.0	-0.8	db	16	39	58	10			3C 315
1514+00	15 14 05.0	00 26.0	2.5	-0.6	E3	16.5	1	46				4C 0.56

Or db galaxy

* References to original identifications or finding charts are: 1. Bolton and Ekers (1967); 2. Clarke, Bolton, and Shimmins (1966); 3. Mathews, quoted from Schmidt (1965); 4. Wyndham (1966); 5. Sandage, Véron, and Wyndham (1965); 6. Schmidt and Mathews (1964); 7. Longair (1965); 8. Bolton, Clarke, and Ekers (1965); 9. Sandage and Wyndham (1965); 10. Dewhurst (1959); 11. Wyndham (1965).

† Notes on individual sources:

12. Object is 0'.6 north preceding the original object suggested by Bolton and Ekers (1967).
13. The radio and optical positions differ by 0'.4. However, unpublished interferometry results by D. J. Cole and D. K. Milne indicate that the radio source is 2' arc in extent.
14. Identification is confirmed on a two-colour (blue and u.v.) 48 in. plate.
15. This source was originally identified by Clarke, Bolton, and Shimmins (1966) as a possible quasi-stellar object on the basis of an incorrect catalogue right ascension. This object was shown to have an ultraviolet excess by Bolton and Kinman (1966). The source is extended in right ascension at 11 cm. The position of the peak given by Shimmins agrees with the galaxy. However, a weak confusing source towards later right ascension may be the quasi-stellar object (shown by an arrow on the finding chart). The identification with the galaxy has been given by Caswell and Wills (1967).

TABLE 1 (*Continued*)

(1) Parkes Cat. No.	(2) Position (1950.0) R.A. h m s	(3) Dec. ° ' "	(4) Flux Density at 1410 MHz	(5) Spectral Index	(6) Type	(7) Magni- tude	(8) Galactic Coordinates l_{11} b_{11}	(9) Ref. to Identi- fication*	(10) Ref. to Finding Chart*	(11) Remarks†	(12) Other Cat. Nos.
1517+20	15 17 50.0	20 26.9	2.3	-0.8	g	19.5	30 55	11	11		3C 318
1545+21	15 45 30.5	21 01.4	2.3	-0.7	QSO	16	34 49	4	4		3C 323.1
1550+20	15 50 13.0	20 14.5	2.2	C	g	18.5	33 48	4	4		3C 326
1606+10	16 06 23.5	10 36.8	1.6	-0.4	QSO?	18.5	23 41	5	5		4C 16.45
1622+23	16 22 32.5	23 52.0	2.7	-0.8	QSO	17.5	41 42	5	5		3C 336
1622-31	16 22 43.5	-31 01.7	1.6	-0.7	QSO?	19.5	348 13			Highly reddened field	
1634+26	16 34 21.5	26 54.3	1.3	-0.8	QSO?	18	46 40				4C 26.49
1645+17	16 45 28.5	17 25.4	1.9	-0.3	QSO?	18.5	35 34				4C 17.71
1801+01	18 01 43.5	01 01.3	1.4	-1.0	QSO?	19	28 11				
1810+26	18 10 29.8	26 28.2	1.1	-1.0	D	19.5	53 20			16	4C 26.55
1834+19	18 34 29.0	19 41.0	1.8	-0.7	E	14	12 2				
1915-12	19 15 07.5	-12 09.4	1.5	-1.0	db	18	25 -11				19-15
2005-04	20 05 46.0	-04 27.3	1.0	-1.0	QSO?	18	38 -19				3C 407
2031+21	20 31 18.7	21 26.0	2.2	-0.6	D	18.5	64 -11				4C 24.50
2039-29	20 39 38.5	-29 06.8	1.3	-1.0	QSO?	19.5	16 -36			Galaxy 0.2 n.f.	
2121+24	21 21 30.0	24 51.3	12.4	-0.8	D	17	74 -18	10	11		3C 433
2201+04	22 01 43.5	04 25.9	1.0	-0.4	QSO?	16	65 -39			17	4C 04.77
2227-08	22 27 02.1	-08 48.3	1.1	C	QSO?	18	55 -52	1	1	Odd spectrum $S_{2650} = 2.0$ f.u.	
2319+07	23 20 02.5	07 55.8	1.1	-0.3	QSO?	17.5	88 -49				3C 465
2335+26	23 35 57.0	26 45.3	6.9	-0.8	D	12	103 -33	10			4C 04.81
2338+04	23 38 24.0	04 14.6	1.6	-0.9	QSO?	19.5	92 -54				

* For explanation of numbering of references, see corresponding footnote on previous page.

† Notes on individual sources are:

16. Radio position is about 2' arc south of the optical centre. However, unpublished interferometry results by D. J. Cole and D. K. Milne suggest that the radio source may have an angular extent of 7'.

17. On the basis of the catalogue position the source was originally identified by Clarke, Bolton, and Shimmings (1966), as the galaxy 0.6 south preceding the blue object. Interferometry shows that the angular size of the source is $< 1'$. The 0.6 discrepancy is thus rather high. The accurate position by Shimmings is a good fit for the blue object suggested as a quasi-stellar object. However, the galaxy is not completely excluded.

IDENTIFICATION PROCEDURE

The regions of interest on the 48 in. Sky Survey print were examined with the aid of transparent overlays containing the error rectangle of the source position and the positions of 10 reference stars from the Yale catalogue. Positions of the suggested optical counterparts for the sources can be estimated with the aid of the overlay to $0'.2$ arc, or better, where the reference stars are close to the object. Their estimated positions are given in Table 1, columns 2 and 3. Except where noted, identifications were made only if the radio position and the estimated optical position for a source agreed to within $0'.25$ arc in both coordinates. The possibility of a chance coincidence with either a galaxy or a blue stellar object of magnitude 19.5 is about 1 in 10.

TABLE OF IDENTIFICATIONS

The identifications are listed in Table 1. Column 1 contains the Parkes catalogue number and column 13 the equivalent number in the 3C, 4C, or MSH catalogues. Columns 4 and 5 contain the flux density at 1410 MHz and the spectral index taken from the Parkes catalogue (C indicates a curved spectrum). Column 6 gives the type of object, as follows:

- E elliptical galaxy,
- D elliptical galaxy with diffuse outer envelope,
- S spiral galaxy,
- SO spherical system with a possible dust lane,
- db dumb-bell or double galaxy,
- N compact galaxy with starlike nucleus,
- QSO quasi-stellar object,
- QSO? possible quasi-stellar object.

Galaxies that are too faint to classify are denoted by g.

Estimates of the photographic magnitude for galaxies and visual magnitude for quasi-stellar objects are given in column 7. Columns 8 and 9 contain the new galactic coordinates of the object. References to prior identifications and to published finding charts are given in columns 10 and 11 and footnotes, and remarks or additional references to footnotes in column 12.

FINDING CHARTS

Finding charts for the identifications are given in Plates 1-6. These were prepared from the Sky Survey prints and the contrast has been increased slightly over that of the original prints. The finding charts for the galaxies were made from the "E" or red print and those for the quasi-stellar objects from the "O" or blue print, except for 0408+07, where the blue print contains flaws near the source. The scale is approximately $5 \text{ mm} = 1'$ arc, and north-east is at the top left-hand corner.

Note added in Proof

Dr. T. D. Kinman (personal communication) has kindly informed us that he has obtained confirmation of some of the suggested quasi-stellar objects through

two-colour photography. These are 0115+02, 0312-03, 1634+26, 1645+17, 1801+01, and 2005-04. He found no ultraviolet excess for 0204+06, 0408+07, and 2201+04.

Image tube spectra obtained by Dr. Leonard Searle and Bolton with the Mount Stromlo 74 in. telescope also indicate that 0204+06 is not a quasi-stellar object. Spectroscopic confirmation has been obtained for 0115+02 and 2319+07.

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