OPTICAL OBJECTS IN THE FIELDS OF SOUTHERN RADIO SOURCES

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Summary

Positions of stars and galaxies in the fields of 18 radio sources south of declination $-35°$ have been determined with an accuracy of $0''\cdot5$ arc. The study has yielded 11 identifications with galaxies brighter than $V = 17^m$.

I. Introduction

The recent increase in positional accuracy of radio sources greatly facilitates optical identification of the objects responsible for the radio radiation. At Mount Stromlo Observatory a program was commenced in 1962 to photograph the fields of southern radio sources. Excluded from the program were previously well-known or suggested identifications (cf. Bolton, Gardner, and Mackey 1964), and it was expected that most identifications would be with galaxies appreciably fainter than $V = 12\cdot5^m$. About 50 regions have been photographed so far. The present paper is a first report, presenting the results for the 18 fields which at first inspection seemed most likely to yield identifications, that is, to belong to classes I or II (cf. Bolton, Gardner, and Mackey 1964, p. 363).

II. Observations and Reductions

It is to be expected that many of the optical objects connected with the extragalactic radio sources will be very faint. Survey plates should therefore reach as faint a magnitude as possible and at the same time permit separation of non-stellar and stellar objects with the highest possible degree of certainty. The primary material for the present investigation consists thus of plates taken in visual light at the Newtonian focus of the Mount Stromlo 74 in. telescope; the scale is $22''\cdot7$ arc per mm. Eastman Kodak 103a-D plates were used behind a 2 mm Chance OY 4 filter, and the exposure times were in most cases 75 min. For good seeing the limiting magnitude is expected to be fainter than $V = 21^m$.

The field of a 74 in. plate is too restricted, even when the largest possible plate size is used (about $50'$ by $50'$) to permit a sufficient number of reference stars with known positions to occur in it. Moreover, any catalogue star that happens to fall in the field will be badly overexposed on a plate exposed for faint objects. Therefore, it was found necessary to perform the determinations of the positions in two steps. Short exposures, 2–5 min, were made on Eastman Kodak 103a-D plates behind a 2 mm Schott GG 14 filter with the 20/26 in. Schmidt telescope of

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Uppsala Southern Station. These plates cover about 3°·7 by 3°·7, and the scale is 2′ arc per mm. From the relevant catalogue (cf. Appendix), 6 to 12 reference stars were identified on each Schmidt plate; these were generally within 1° from the estimated source position and symmetrically distributed around it. With these standard stars, positions were established for 6 to 12 faint stars within the field of the 74 in. plate around the object or objects of interest. These secondary standard stars were then used to determine positions of the extended objects visible on the 74 in. plate. It should be noted that all extended objects and the secondary standards were near the centre of the field and not affected by coma to any significant degree.

TABLE 1

DATA FOR THE RADIO SOURCES

Source No.	Position (1950)		Conversion Factor	Flux at 21 cm (f.u.)	Spectrum			Polarization at 21 cm
	R.A. h m s	Dec. ° ′			75→ 350	21→ 75	11→ 21	
0003−56	00 03 27·8	−56 45·3	8·222	2·0	0·7	0·9	0·9	
0007−44	00 07 58*	−44 40·0*	10·668	1·7	1·0	1·1	1·0	
0023−33	00 23 03·6	−33 20·1*	12·532	1·7	0·8	1·0	1·2	
0043−42	00 43 56·2	−42 24·0	11·076	9·1	0·6	0·7	1·0	8·8%
0114−47	01 14 13·6	−47 37·4	10·108	2·1	0·8			
0125−41	01 25 01·5	−41 28·2	11·240	1·4			1·1	
0131−36 A	01 31 18·2	−36 44·7	12·020	7·1	0·8	0·7		
B	01 31 57·2							
0251−67	02 51 11*	−67 30·4*	5·744	1·2	1·1	1·3		
0410−75	04 10 03·3	−75 15·3*	3·818	13·5	0·5	0·8	1·0	<1%
0427−53	04 27 54·5	−53 56·1	8·830	5·6	0·8	0·8	1·1	<1·5%
1655−77	16 55 10·0	−77 37·5	3·218	2·5				
1954−55	19 54 20·0	−55 17·7	8·540	7·0	0·8	0·6	0·9	<1·5%
2006−56	20 06 25·3	−56 39·9	8·250	1·9	1·2			
2014−55	20 14 05·7	−55 49·2	8·426	1·8	0·9	0·8		
2041−60	20 41 20·3	−60 29·9	7·384	2·8	1·1	1·1	1·8	
2152−69	21 53 02·1	−69 55·9	5·148	32	0·8	0·7	0·9	2–3%
2204−54	22 04 27·0	−54 01·0	8·811	2·4		0·2	0·4	
2356−61	23 56 26·7	−61 11·8	7·226	23·7	1·0	0·8	1·3	5%

* Positions taken from the Parkes catalogue.

The plates were measured in a Hilger two-coordinate measuring machine. All reductions were performed using an IBM 1620 electronic computer. Standard coordinates were calculated from the usual flat-field equations (e.g. Smart 1936) for 74 in. plates. On Schmidt plates, equations derived by Dixon (1962) for Schmidt coordinates were used. The relationship between standard coordinates and measured coordinates was assumed to be linear and was obtained by the method of least squares.

Care was taken to avoid systematic errors in the measurements, particularly in establishing the secondary standards on the Schmidt plates. Each Schmidt plate

was measured independently by two observers; each measured it twice, rotating it through 180° for the second measurement. The difference between the results of two observers never exceeded 0″·6 arc. For the 74 in. plates the corresponding difference between the results of two observers was never more than 0″·3 arc.

Considering the errors in the measurements and in the catalogue values, we find that the standard error of the coordinate systems established on the 74 in. plates may be conservatively estimated as less than 0″·5 arc in each coordinate.

III. Results

Table 1 gives, for each of the fields studied, the number of the radio source in the Parkes catalogue (Bolton, Gardner, and Mackey 1964; Price and Milne 1965), the position of the radio source (epoch 1950), the conversion factor from seconds of time to seconds of arc at that declination ($= 15 \cos \theta$), the flux density at 21 cm in units of 10^{-26} W m^{-2}(c/s)$^{-1}$, the spectral indices for various ranges, and the percentage polarization at 21 cm. In general, the positions quoted* are those determined by A. J. Shimmins, Margaret E. Clarke, and R. D. Ekers in a program of accurate position measurements with the 210 ft telescope of the Australian National Radio Astronomy Observatory. For a few objects, such data were not available and the positions have been taken from the Parkes catalogue. These are marked with an asterisk.

Table 2 gives for each field the position of the radio source and the positions of a number of stars and galaxies in the region. The positions are referred to a convenient field centre, which is given at the head of each section. The radio source is identified by its number in the Parkes catalogue. Stars are denoted by letters, galaxies by numbers. Coordinates are given as differences from the field centre and are quoted in seconds of time and seconds of arc respectively. The field centre is exact; for convenience it is chosen at whole seconds of time and whole minutes of arc. The position of the radio source is not known as accurately as the positions of the optical objects, but it is quoted in the same format for ease of comparison. All positions are in equinox 1950·0 and epoch 1963.

Charts of the fields are given in Figure 1. The standard stars of Table 2 are marked as dots and identified by letters, and the galaxies are marked as circles and identified by numbers. The numbering is in order of increasing right ascension. In addition, a number of faint stars and galaxies have been plotted in order to facilitate the identification of the field. For the more extended objects the size of the circle indicates approximately the size of the galaxy. The position of the radio source is marked with a cross, the lengths of the arms being equal to the maximum errors in the radio position.

Table 3 contains further information on objects near the radio source positions. Data regarding the radio dimensions of the sources are also shown, since these are vital to the criterion of a suggested optical identification. The contents of parts (*a*) and (*b*) of the table are further explained below.

* Communicated in advance of publication by R. D. Ekers.

TABLE 2

POSITIONS OF RADIO SOURCES, REFERENCE STARS, AND GALAXIES RELATIVE TO THE FIELD CENTRES
(1950·0 COORDINATES)

Field centre	$00^h03^m20^s$	$-56°46'00''$		$00^h08^m00^s$	$-44°40'00''$	
Radio source	0003−56	$+07^s·80$	$+42''·0$	0007−44	$-02^s·00$	$\pm00''·0$
Reference stars	a	−34·10	+392·9	a	−46·47	+238·9
	b	−25·64	−221·9	b	−45·07	−271·2
	c	−22·80	−67·1	c	−38·08	−467·0
	d	+08·53	+02·0	d	−17·42	+112·4
	e	+08·82	+393·0	e	+08·24	−152·4
	f	+19·40	−165·0	f	+21·88	−215·0
	g	+27·97	+225·4	g	+27·10	+232·7
	h	+40·32	−193·6	h	+29·53	−481·6
Galaxies	1	+06·64	+129·4	1	−13·34	−303·2
	2	+11·68	+184·3	2	−06·67	+104·4
	3	+18·67	−99·6	3	+04·76	+159·8
Field centre	$00^h23^m00^s$	$-33°20'00''$		$00^h43^m50^s$	$-42°24'00''$	
Radio source	0023−33	$+03^s·60$	$-06''·0$	0043−42	$+06^s·20$	$\pm00''·0$
Reference stars	a	−24·70	+56·7	a	−40·82	−194·1
	b	−24·46	+220·6	b	−28·38	+281·0
	c	−11·69	−118·4	c	−18·95	−154·3
	d	−08·73	+387·4	d	−05·41	+93·8
	e	+20·39	+172·4	e	+07·66	−251·8
	f	+22·46	−44·4	f	+17·44	−356·5
	g	+23·22	+295·0	g	+23·77	+258·7
	h	+33·00	−346·8	h	+28·98	−281·8
Galaxies	1	+02·25	+37·8	1	−07·66	+68·4
	2	+03·07	+93·2	2	−01·43	−12·7
	3	+04·98	+285·6	3	+05·98	−13·6
	4	+13·99	+105·8	4	+12·90	−53·0
	5	+16·64	−108·2			
Field centre	$01^h14^m00^s$	$-47°38'00''$		$01^h25^m00^s$	$-41°28'00''$	
Radio source	0114−47	$+13^s·60$	$+36''·0$	0125−41	$+01^s·50$	$-12''·0$
Reference stars	a	−10·69	+244·0	a	−13·06	+37·4
	b	−10·20	−48·8	b	+02·24	+362·8
	c	−01·91	+79·8	c	+27·46	+461·8
	d	+01·69	−227·3	d	+43·70	+112·3
	e	+10·75	+395·2	e	+46·66	−285·1
	f	+23·80	−252·4			
	g	+24·28	+364·2			
	h	+41·44	−32·6			
Galaxies	1	+14·87	−29·3	1	+02·12	+119·5
				2	+23·18	+416·8
				3	+28·22	+143·2

TABLE 2 (*Continued*)

Field centre	$01^h31^m40^s$	$-36°45'00''$		$02^h51^m00^s$	$-67°29'00''$	
Radio source	0131−36 A	$-21^s.80$	$+18''.0$	0251−67	$+11^s.00$	$+84''.0$
	B	$+17.20$				
Reference stars	a	−26·30	+310·2	a	−26·10	−141·1
	b	−05·42	−150·7	b	−18·24	+125·8
	c	−00·30	+341·6	c	−03·90	+21·3
	d	+08·59	−172·0	d	+00·23	+202·1
	e	+24·84	+443·4	e	+06·41	−124·3
	f	+33·68	+262·2	f	+29·29	−66·5
	g	+36·17	−152·0	g	+49·98	+282·8
				h	+57·74	+175·6
				i	+69·72	−146·0
Galaxies	1	+03·63	+04·4	1	+27·83	−02·8
	2	+05·72	−117·3	2	+31·50	+25·7
	3	+07·62	+40·9	3	+32·91	+18·6
	4	+08·02	+99·3	4	+35·78	+11·4
				5	+36·26	−13·6
				6	+37·19	+05·6
				7	+45·91	+06·6
				1–6	+33·58	+07·5
Field centre	$04^h10^m10^s$	$-75°15'00''$		$04^h27^m50^s$	$-53°56'00''$	
Radio source	0410−75	$-06^s.70$	$-18''.0$	0427−53	$+04^s.50$	$-06''.0$
Reference stars	a	−60·82	−55·1	a	−28·84	+84·8
	b	−40·56	+67·0	b	−10·92	−165·2
	c	−18·74	−00·1	c	−04·71	+232·4
	d	−12·55	−172·1	d	+21·42	−330·2
	e	−04·88	+126·8	e	+44·72	−223·4
	f	−00·40	+24·7	f	+62·20	−76·9
	g	+28·69	+210·8			
	h	+73·55	+83·5			
	i	+78·91	−190·8			
Galaxies	1	−33·47	−42·3	1	−11·41	+146·6
	2	−23·05	−98·0	2	−06·79	−113·8
	3	−19·39	−04·1	3	−03·56	+114·9
	4	−17·44	−125·8	4	+07·60	−05·4
	5	−11·90	+54·2	5	+08·82	−09·4
	6	−01·25	−144·5	6	+11·94	−202·9
	7	+03·14	+69·4	7	+20·00	+33·2
				8	+20·60	−125·6
				9	+27·70	−05·6
Field centre	$16^h55^m10^s$	$-77°37'00''$		$19^h54^m20^s$	$-55°18'00''$	
Radio source	1655−77	$\pm00^s.00$	$-30''.0$	1954−55	$\pm00^s.00$	$+18''.0$
Reference stars	a	−48·87	+116·1	a	−24·08	−27·4
	b	−17·01	−122·5	b	−10·48	+241·2
	c	+34·76	−22·8	c	−06·40	−05·9
	d	+39·30	−401·2	d	−02·37	+111·2
	e	+66·29	+205·1	e	−01·26	+18·6
	f	+88·44	−46·5	f	+02·25	−255·6
	g	+104·54	+137·5	g	+08·98	−66·6
	h	+118·04	−198·5	h	+17·74	+123·8
				i	+35·64	+104·2
Galaxies	1	+02·49	−33·0	1	−22·54	−81·2
				2	−16·27	+182·3
				3	+11·15	+40·0

TABLE 2 (*Continued*)

Field centre	$20^h06^m30^s$	$-56°38'00''$		$20^h14^m10^s$	$-55°49'00''$	
Radio source	2006−56	$-04^s.70$	$-114''.0$	2014−55	$-04^s.30$	$-12''.0$
Reference stars	a	−16.64	−35.3	a	−23.06	−20.7
	b	−07.16	+74.7	b	−21.27	+34.6
	c	−01.98	+99.2	c	−14.34	−298.2
	d	+05.66	−77.6	d	−09.71	−137.6
	e	+08.17	−219.1	e	+06.52	−80.9
	f	+15.04	+59.0	f	+07.56	+196.5
	g	+20.09	+188.1	g	+28.23	+108.5
	h	+36.09	−171.3			
	i	+38.92	−73.8			
	j	+47.95	+03.8			
Galaxies	1	−10.33	−62.6	1	−03.88	+08.0
	2	−08.04	+69.4	2	−02.96	−43.5
	3	+16.97	−170.9	3	−02.68	−40.7
	4	+22.16	−28.2	4	−02.68	−50.8
	5	+24.83	−48.6			
Field centre	$20^h41^m20^s$	$-60°31'00''$		$21^h53^m00^s$	$-69°56'00''$	
Radio source	2041−60	$+00^s.30$	$+66''.0$	2152−69	$+02^s.10$	$+06''.0$
Reference stars	a	−35.31	−51.7	a	−35.04	−44.0
	b	−27.09	−270.7	b	−33.94	+107.1
	c	−25.41	+134.8	c	−29.66	−339.6
	d	+00.24	+204.2	d	+01.28	+293.2
	e	+12.17	+198.1	e	+28.49	−223.8
	f	+13.70	−106.9	f	+47.14	+72.2
	g	+14.58	+23.8	g	+63.96	+208.5
	h	+34.44	+59.7			
Galaxies	1	−07.25	+39.1	1	−02.20	+19.8
Field centre	$22^h04^m30^s$	$-54°01'00''$		$23^h56^m30^s$	$-61°12'00''$	
Radio source	2204−54	$-03^s.00$	$\pm 00''.0$	2356−61	$-03^s.30$	$+12''.0$
Reference stars	a	−57.76	+210.8	a	−52.84	−12.8
	b	−25.85	−304.4	b	−46.80	+264.5
	c	−16.49	+112.1	c	−21.49	−205.6
	d	+01.81	+274.9	d	+19.74	−152.0
	e	+05.39	−50.2	e	+20.55	+147.8
	f	+30.59	+96.2	f	+24.69	+04.0
	g	+31.46	−310.4	g	+24.92	+373.0
Galaxies	1	−00.90	−21.9	1	−22.46	+72.7
	2	+02.10	−76.8	2	−00.63	+19.4
	3	+02.38	−110.6	3	+06.06	−108.1

Column 1.—Radio source number.

Columns 2 and 3.—Radio dimensions from the Parkes catalogue and from the determinations of Shimmins, Clarke, and Ekers.

Column 4.—Number of galaxy or star, as in Table 2.

Columns 5 and 6.—Differences between the positions of the optical object and radio source in right ascension and declination, both given in seconds of arc. Asterisks indicate differences relative to the Parkes catalogue (cf. Table 1).

Column 7.—Hubble type of the galaxy. The classification was made independently by both authors with good agreement.

Column 8.—Visual magnitude V obtained by eye estimates and based on an adopted limiting magnitude for each plate according to exposure time and quality of the stellar images. It is hoped that V is within $\pm 1^{m}$.

Column 9.—Angular size D_t, in seconds of arc. For some galaxies the dimensions of the core (C) and the halo (H) are given. The measured diameter D_0 has been corrected for atmospheric and instrumental dispersion by means of the relation

$$D_t = (D_0^2 - d^2)^{\frac{1}{2}},$$

where d is the diameter of a nearby stellar image having about the same density as the image of the galaxy.

Column 10.—Position angle of the major axis of the galaxy.

Columns 11 and 12.—Number of members counted and estimated angular diameter of group when the galaxy appears to be a member of a cluster or group.

Further information about the objects in the fields is found in Table 3(*c*).

IV. Identifications

Radio positions in the Parkes catalogue are quoted as having maximum errors of $0'{\cdot}6$ arc for declinations north of $-40°$, increasing to $1'{\cdot}0$ arc at $-60°$ declination. Towards the south celestial pole the calibration of the source positions is still doubtful and the errors may become greater. The positions determined in the program of accurate position measurements of Shimmins, Clarke, and Ekers have maximum errors of $0'{\cdot}4$ arc.

As a criterion for satisfactory identification, we require that the positions of the optical object and the radio source differ by less than the dimensions of the radio source plus the above errors. When the radio source is double, we require the optical object to lie between the components and not further from the line joining the centres than the dimensions of one component plus the maximum error.

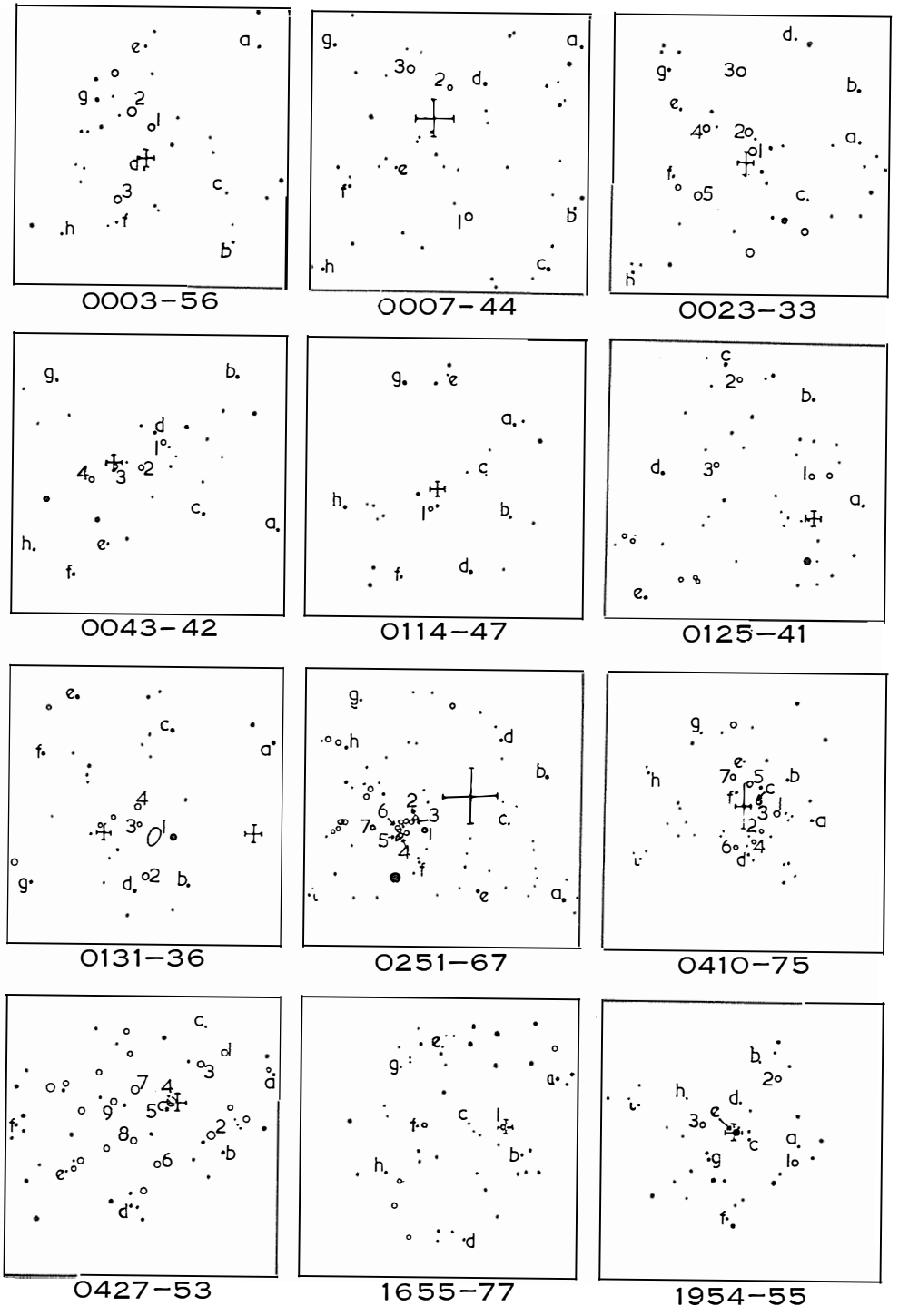
0003−56
0007−44
0023−33
0043−42
0114−47
0125−41
0131−36
0251−67
0410−75
0427−53
1655−77
1954−55

Fig. 1

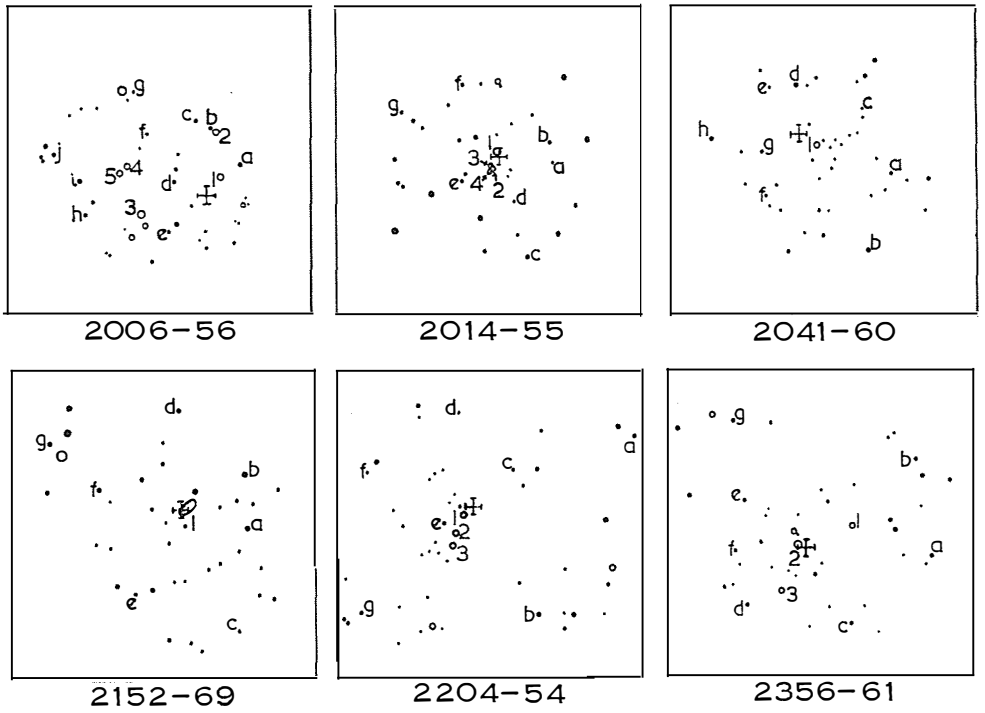

Fig. 1 (*Continued*)

If the radio source is not extended, then the positions must differ by less than the above errors alone. These criteria are adopted in recognition of the fact that radio sources are frequently not centred on the associated optical object.

The first galaxy listed for each radio source given in Table 3(*a*) fulfils these criteria. In three cases (0023−33, 0043−42, 2006−56), a second galaxy, which just fails to fulfil the criteria, is also listed. In each of these cases the radio source is extended, and the possible involvement of an object at a greater distance cannot be entirely ignored. In the case of 2014−55, the area of the radio source encompasses one comparatively bright galaxy and a close triplet of objects, two of which are so faint that it is not possible to decide whether they are galaxies or stars. Any of these may be involved, but for the moment we suggest the brightest galaxy as the identification.

Fig. 1.—Finding charts for the fields of the radio sources. North is up and east is to the left. Each square represents an area 15 by 15 min arc, with the exception of the chart for 0251−67 where the crowding of objects necessitates a large scale; for the latter field the square is 10 by 10 min arc. Stars are plotted as dots, with the reference stars identified by letters. Galaxies are plotted as circles and identified by numbers. The radio source is marked by a cross, the lengths of the arms being equal to the maximum errors in the radio position.

TABLE 3

OPTICAL OBJECTS IN THE FIELDS OF RADIO SOURCES

(a) Galaxies with Good Positional Agreement

Radio Source No.	Radio Dimensions		Optical Object	Positional Differences (sec arc)		Hubble Type	V (mag)	D_t (sec arc)	P.A. Major Axis of Galaxy	Cluster	
	Parkes	SCE†		R.A.	Dec.					No. of Members	Size
0023−33	> 1′ NS		1	−16·9	+43·8*	EO	16	5		14	19′
			2	−06·6	+99·2*	EO	16	6			
0043−42	> 1′ NS		3	−02·4	−13·6	EO	16	8		4	6′
	> 40″ EW		2	−84·5	−12·7		18	5			
0114−47	> 40″ EW Ext. NS at 11 cm; may be double	~ 3′ NS	1	+12·8	−65·3	E?	16·5	4			
0131−36 A	> 45″ EW	Double in R.A.; ext. in Dec.	1	+305·7	−13·6	SO–Sa peculiar	13·0	C: 11×8	5°	9	32′
B				−163·1				H: 42×20	170°		
0427−53	> 40″ EW	Possibly ext. 2′ NS	4	+27·4	+00·6	EO	15	12		60	40′
			5	+38·1	−03·4	EO	14	8			
1655−77		< 1′·5 EW	1	+08·0	−03·0	EO	17	8		7:	15′
2006−56	> 35″ EW	7′ NS	1	−46·5	+51·4	SO	16	13×4	64°	13 or	10′
	> 1′ NS		2	−27·6	+183·4	E5	16	6×3	120°	30	30′
2014−55	> 1′ NS		1	+03·5	+20·0	EO	15·5	13			
			2	+03·2	−31·5	EO?	17·5	2:			
			3	+05·2	−28·7	EO?	16·5	3			
			4	+05·2	−38·8	EO?	16·5	5			
2152−69	25″ EW		1	−22·1	+13·8	E3	14	C: 18×12	133°	12	26′
								H: 40×20			
2204−54			1	+18·5	−21·9	SO	17	11×15	96°	9	17′
2356−61	40″ EW		2	+19·3	+7·4	E3	16	6×4	6°	10	21′

TABLE 3 (*Continued*)

(*b*) *Objects with Poor Positional Agreement*

Radio Source No.	Radio Dimensions		Optical Object	Positional Differences (sec arc)		Hubble Type	V (mag)	D_t (sec arc)	P.A. Major Axis of Galaxy	Cluster	
	Parkes	SCE†		R.A.	Dec.					No. of Members	Size
0003−56			d	+06·0	−40·0						
0007−44	~ 1′ NS		2	−49·8*	+104·4*	E?	17	3			
			3	+72·1*	+159·8*	E	16	9			
0125−41			1	+06·9	+131·5	E	18+	4			
0251−67	> 35″ EW Ext. in Dec. 20′ S		1–6	+126*	−77*		17–18	each ~ 2		10	1′·1
0410−75	< 20″ EW		5	−19·8	+72·2*	SO	15+	11×5	126°	9	7′
			1	−102·2	−24·3*	E4	16+	7×4	39°		
1954−55	> 1′ NS > 40″ EW		e	−10·7	+00·6		12				
2041−60	< 15″ EW		1	−55·7	−26·9	E	17+	7			

* Differences relative to Parkes catalogue positions. † Determinations of Shimmins, Clarke, and Ekers.

(*c*) *Notes*

Classification for a few objects listed in (*a*) and (*b*) above is on Morgan's system (Matthews, Morgan, and Schmidt 1964). Magnitudes and Hubble types are given for all galaxies that are numbered in Figure 1 but not listed in parts (*a*) or (*b*) of this table.

0023−33	Galaxies 1, 2, and 4 are about equally bright and dominate the cluster. No. 1 is possibly a D galaxy. No. 3 : SO, $V = 16$; no. 4 : SO, $V = 15{\cdot}5$; no. 5 : E, $V = 15$.
0043−42	The optical position of galaxy no. 3 is misquoted in the Parkes catalogue (Bolton, Gardner, and Mackey 1964). No. 1 : $V = 18$; no. 4 : EO, $V = 15{\cdot}5$.
0131−36	Galaxy no. 1 appears to have a dust lane running parallel to its major axis and slightly to the east of the core. It divides the line joining the centres of the two radio components in approximately the ratio 2 : 1. Note similarity to Centaurus A, NGC 5128. Westerlund has measured $V = 13{\cdot}0$, B−V = +0·93, and U−B = +0·18 for the whole galaxy, and $V = 15{\cdot}2$, B−V = +1·02, U−B = +0·57 for the core. Westerlund and N. Stokes have determined a red shift of 9008 km/sec from two plates (P.E. = ±30 km/sec) and noted a weak λ 3727 emission line. The field contains a large number of faint galaxies (similar to nos. 2 and 4) that have not been counted as cluster members. No. 2 : SO, $V = 15{\cdot}5$; no. 3 : EO, $V = 16{\cdot}5$; no. 4 : SO, $V = 16$.

TABLE 3 (*Continued*) (*c*) *Notes (cont.)*

0427−53	The two galaxies are separated 12″ arc in position angle 112°. The two objects appear to have a common halo. Dumb-bell type? Westerlund has observed the integrated quantities $V = 13{\cdot}2$, $B-V = +1{\cdot}15$, $U-B = +0{\cdot}82$. The optical position is misquoted in the Parkes catalogue (Bolton, Gardner, and Mackey 1964). No. 1 : E, $V = 15{\cdot}5$; no. 2 : SO, $V = 14{\cdot}5$; no. 3 : E, $V = 15$; no. 6 : SO, $V = 17$; no. 7 : SO, $V = 15$; no. 8 : E7, $V = 16$; no. 9 : S●, $V = 16{\cdot}5$.
1655−77	Galaxy no. 1 may be an outlying member of a group of 7 galaxies, diameter of group about 15′. The brightest galaxy in the group has $V = 15$.
2006−56	The two galaxies listed are average members of a fairly loose and ill-defined group. No. 3 : E, $V = 15$; no. 4 : SO, $V = 17$; no. 5 : E, $V = 16$.
2014−55	Objects nos. 2 and 3 are doubtful galaxies.
2152−69	Galaxy no. 1 is the brightest member of a loose group. It is possibly a D galaxy. Miss Smith has determined $V = 14{\cdot}7$, $B-V = +1{\cdot}08$, and $U-B = -0{\cdot}20$ for the core.
2204−54	Galaxy no. 1 may be a member of a doubtful cluster. Its brightest member is then galaxy no. 3 (SO, $V = 16$). No. 2 : E, $V = 18$.
2356−61	The region is rich in small dense groups of galaxies. The given object is the brightest member of one such group. It is possibly a D galaxy. No. 1 : E, $V = 17{\cdot}5$; no. 3 : E, $V = 17$.
0003−56	Galaxy no. 2 ($V = 16{\cdot}5$) is very asymmetrical around the core or has a fairly wide extension towards the south. Irr? No. 1 : E, $V = 17{\cdot}5$; no. 3 : E, $V = 17$.
0007−44	Object no. 2 is a doubtful galaxy. The star plotted inside the error rectangle has $V = 15$. No. 1 : E, $V = 17$.
0125−41	The star inside the error rectangle has $V = 16$. The source 0124−40 is close and could possibly be associated with this source, forming a double source. No. 2 : $V = 18$; no. 3 : SO, $V = 17+$.
0251−67	Possibly some extremely faint galaxies at eastern end of error cross. Nothing is observed optically that correlates with the southern radio extension. No. 7 : $V = 18+$.
0410−75	No. 2 : $V = 18$; no. 3 : E, $V = 17$; no. 4 : $V = 17{\cdot}5$; no. 6 : E, $V = 18$; no. 7 : $V = 17{\cdot}5$.
1954−55	The listed star is of spectral type GO according to spectrum taken by Miss Smith. Second brightest star in error rectangle has $V = 17$. No. 1 : E, $V = 17{\cdot}5$; no. 2 : E, $V = 17{\cdot}5$; no. 3 : E, $V = 16{\cdot}5$.
2041−60	Possibly extended, extremely weak object situated at SE. corner of error rectangle.

Since most of our suggested identifications are galaxies brighter than $V = 17^m$, falling inside error areas of about 2 sq min of arc, we may expect a chance coincidence in one case in 90 (cf. Dewhirst 1963).

Table 3(*b*) lists the fields where the agreement between the position of the radio source and nearby galaxies is less good. In a few cases, information is given about stars falling inside the error rectangles. For 1954—55, the bright star listed has already been ruled out as an identification as a consequence of spectrographic observations by one of us (L.F.S.).

Our identifications may be summed up as follows. For 11 sources, we find galaxies of types known to appear as radio sources inside the error rectangle. Of these, seven are of type E, one is a "double E", one is peculiar, and two are SO galaxies. In Table 3(*c*), we have indicated that in Morgan's system (Matthews, Morgan, and Schmidt 1964) three of our objects are possibly D galaxies and one a "dumb-bell" object. Only three galaxies are brighter than $V = 15^m$. Photographs of two of our identifications, 0131—36 and 0427—53, are shown in Plate 1. For seven sources we have listed stars and galaxies falling near the radio position. We feel that more observations, radio as well as optical, are needed before any conclusions about identifications of these sources can be drawn. A program is being undertaken to determine accurate magnitudes and colours in the U, B, V system as well as red shifts for the identified galaxies and for the possible identifications. At present, photoelectric observations of three objects are available, together with the red shift for one galaxy (0131—36), and these values are given in Table 3(*c*).

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VI. References

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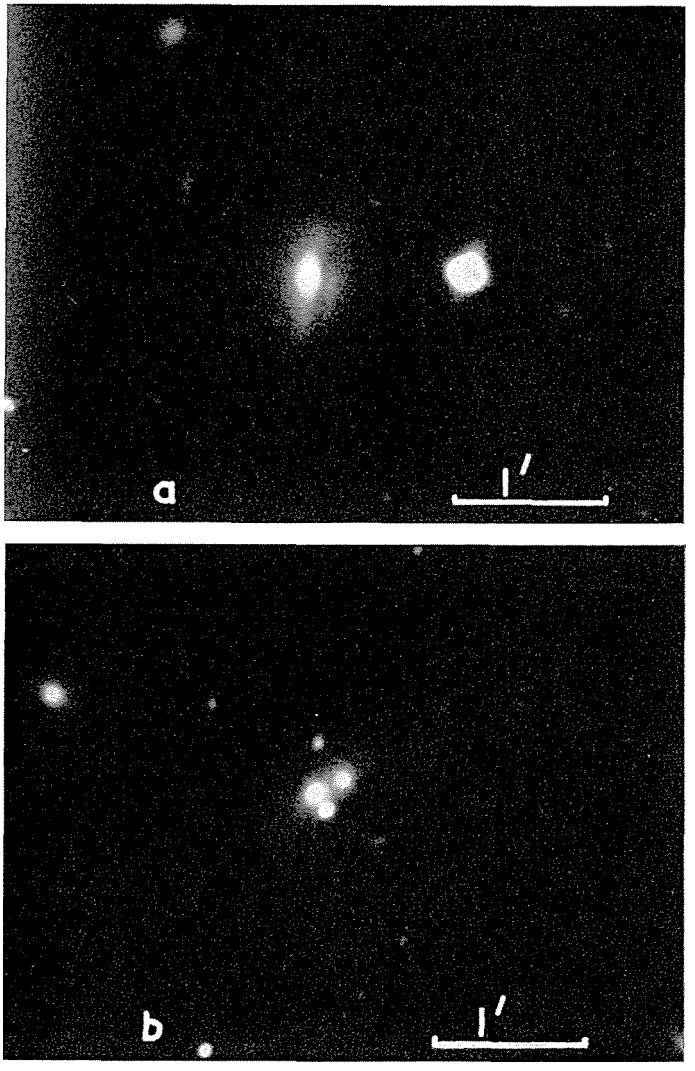
APPENDIX

CATALOGUES USED FOR REFERENCE STARS

Range in Declination	Catalogue
−35° to −40°	Annals of the Cape Observatory, Vol. 18, 1954
−40° to −52°	Cape Zone Catalogue of 20,843 stars, London, 1923 Proper motions of stars in the Cape Zone Catalogue, London, 1930 Catalogue of 20,554 faint stars in the Cape Zone, London, 1939
−52° to −56°	Annals of the Cape Observatory, Vol. 19, 1954
−56° to −64°	Annals of the Cape Observatory, Vol. 20, 1958
−65° to −82°	La Plata Publicaciones, Vol. IX, 1936 La Plata Publicaciones, Vol. X, No. 1, 1947

OPTICAL OBJECTS NEAR SOUTHERN RADIO SOURCES



Photographs of (*a*) 0131−36, (*b*) 0427−53. North is up and east is to the left. The prints are made from Eastman Kodak 103a-O plates exposed for 60 min through a Chance OY-10 filter at the Newtonian focus of the 74 in. telescope.