

VLA OBSERVATIONS OF 91 QUASARS AT $0.35 < z < 1$ ROB PRICE,^{1,2} ANN C. GOWER,¹ J. B. HUTCHINGS,³ S. TALON,³ D. DUNCAN,³ AND G. ROSS¹*Received 1992 September 23; accepted 1992 November 9*

ABSTRACT

We present NRAO-VLA⁴ snapshot observations of 91 radio quasars with $0.35 < z < 1$ chosen to sample the redshift-luminosity plane as widely as possible, to enable the study of the radio evolution of quasars. Their evolution has been discussed by Hutchings, Price, & Gower and Neff & Hutchings. The observations were made at 6 and 20 cm in the A-array and have $\sim 0''.4$ and $1''.2$ resolution, respectively. The primary purpose of this paper is to present the radio images and image parameters of a morphologically unbiased and uniformly reduced sample of quasars. We include only a brief discussion of the sample selection, observations, and data reductions. This is the second sample in a series of papers presenting the VLA observations of quasars.

Subject headings: quasars: general — radio continuum: galaxies — surveys

1. INTRODUCTION

The VLA provides high-resolution and high-sensitivity radio images that are required to undertake detailed morphological studies of quasars. Such studies provide information about the formation and evolution of the radio structure of quasars and can also be used as cosmological probes of the environment in which quasars form and evolve. Previous high-resolution radio imaging surveys of (or including) quasars have been presented by Neff (1982), Machalski & Maslowski (1982), Hintzen, Ulvestad, & Owen (1983, hereafter HUO), Barthel (1984), Gower & Hutchings (1984), Owen & Puschell (1984), van Breugel, Miley & Heckman (1984), Swarup, Sinha, & Hildrup (1984), Rogora, Padriella, & Ruiter (1986), Barthel et al. (1988), and Spence et al. (1989).

This paper is the second in a series of papers that present radio images of quasars to study the luminosity and redshift dependence of the radio morphology in a largely unbiased sample. The first paper (Gower & Hutchings 1984) included images of 40 quasars with $z < 0.35$ at 6 and 20 cm in the A-array of the VLA. The analysis of the first two surveys (quasars with $z < 1$) is presented in Hutchings, Price, & Gower (1988, hereafter HPG). Papers by Neff, Hutchings, & Gower (1989), and Neff & Hutchings (1991) extend the redshift distribution out to $z < 2$ and beyond $z = 2$, with samples of 72 and 58 quasars, respectively, observed at 6 cm in the A-array. In this paper we present A-array observations of a sample of 91 quasars at 6 and 20 cm with $0.35 < z < 1.0$. Measurements obtained from the images contained in this paper are presented in Table 1 of HPG. They include redshifts, core, and lobe luminosities at 6 and 20 cm, core spectral index, linear core-lobe distances, lobe-core-lobe bending angles, the fraction of the

flux in the core component, source morphology, and core variability.

The main purpose of this paper is to present the radio images of those quasars discussed in HPG with $0.35 < z < 1.0$. The sample selection, observations, and reductions are briefly outlined in § 2. Section 3 presents the images of quasars that contain extended radio structure in Figure 1, and Table 1 contains the image parameters for all the quasars in the sample. This is followed by comments on individual sources in § 4.

2. SAMPLE SELECTION, OBSERVATION, AND REDUCTION

The sample was chosen entirely on the basis of redshift and 2.7 GHz luminosity as listed or interpolated in the Dixon (1970) catalog, based on single-dish data, with the aim of covering as wide a range of these parameters as possible, within the constraints of a 24-hr observing run scheduled on the VLA. The distribution of source types and core luminosities are thus unselected, and should be representative within our selection parameter space. Fairly uniform coverage of the total luminosity-redshift plane, at 6 and 20 cm, can be seen in Figure 1 of HPG.

The observations were made in the A-configuration of the VLA on 1985, January 4, generally at both 6 and 20 cm (central frequencies 4.8801 and 1.4899 GHz, respectively). Observations of the sample quasars were single ~ 5 minute snapshots, interspersed with calibration sources, and the flux density scale was calibrated using 3C 286. The 40 sources in our sample which were previously observed by HUO at 20 cm were observed only at 6 cm. Unpublished self-calibrated revisions of the HUO images were kindly provided by J. Ulvestad (1987, private communication). The quasars for which we used HUO or Ulvestad revised images are indicated in column (11) of Table 1.

The data were edited and calibrated using the NRAO software on the DEC 10 computer by D. Wunker, and imaged at the VLA and DRAO using AIPS. After initial mapping and CLEANing, greater dynamic range was obtained, where possible, using self-calibration. The theoretical noise level was ~ 0.27 and ~ 0.18 mJy beam⁻¹ at 20 and 6 cm, respectively. For the weaker sources the observed rms noise levels were con-

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sistent with these values, while for brighter sources (peak flux ≥ 200 mJy) the dynamic range limit ($\sim 1000:1$) increased the rms noise level. The resolution of the final images is $\sim 1''.2$ at 20 cm and $\sim 0''.4$ at 6 cm (for u - v tapered 6 cm images the resolution is $\sim 0''.9$). The quasars show a wide variety of structures, and care has to be taken in interpreting these images, since some flux may be missing from the large-scale structure. The smallest spacing of the VLA in the A-configuration is ~ 1 km, and the largest scale structure fully determined in these observations is $\sim 35''$ at 20 cm and $\sim 10''$ at 6 cm.

3. IMAGES AND IMAGE PARAMETERS

Figure 1 presents contour maps of those quasars that contained extended radio structure at either 20 or 6 cm. The 20 and 6 cm images are presented side by side and display complementary views of the radio structure that are very useful in analysis. The 20 cm images are more sensitive to the large-scale structure because of the larger beam and the steep spectral index of the extended emission. The higher resolution 6 cm images allow for better identification of the core component and provide accurate positional measurements of the core and lobe components.

Table 1 summarizes the image parameters of the 91 quasars in our sample. The first line for each quasar corresponds to the 6 cm image and the second line to the 20 cm image. A total of 106 images are presented in Figure 1. Forty other images are presented in HUO and/or Ulvestad (1987, private communication) at 20 cm. Twenty-seven images showed unresolved (point-source) structure or marginally resolved structure (PS and PS⁺, respectively, in col. [9]) and are not included in Figure 1. Seven sources had observational problems at one wavelength (0222-008, 0336-019, 0738+313, 0821+447, and 1012+488 at 6 cm; 0810+327, 1819+408 at 20 cm), and one source (1352-203) was not detected at 6 cm. For source position, beam size and position angle, and rms noise level of the HUO images see Table I of HUO. We only include an estimate of the percentage of missing flux from the HUO images in our Table 1.

The columns of Table 1 are described here:

Column (1): The IAU source name.

Column (2): Common radio name.

Columns (3)–(4): The right ascension and declination of the radio core. Core positions were generally measured using the 6 cm image, which are of higher resolution and contain less extended emission. If 6 cm data were unavailable or of poor quality, the 20 cm image was used, and the positions are then listed on the second line. The positions were generally obtained by performing a two-dimensional Gaussian fit to the radio core. In the cases where this was not possible the radio core peak position was used. The radio cores are usually easy to identify on the images in Figure 1 (most obvious on the 6 cm images), otherwise we add a note clarifying the core position in § 4.1. The positional accuracy is $\lesssim 0''.5$.

Column (5)–(6): The FWHM major and minor axes of the CLEAN beam in arcsec and the position angle of the major axis measured counterclockwise from North in degrees. Large 6 cm beams correspond to images that have been tapered, which is designated in column (10). HUO presents details of

the beam sizes and position angles for the 40 images of theirs that we used.

Column (7): The rms noise level of the image background in mJy. The theoretical rms noise levels for our observations are ~ 0.18 at 6 cm and ~ 0.27 at 20 cm. See HUO for the rms noise level for their images.

Column (8): The dynamic range of an image is defined as the ratio of the image peak to the rms noise level. They are generally between 300:1 and 1000:1.

Column (9): The fraction of missing flux in an image is determined by comparing the total flux in our VLA images to the total radio flux estimated from the measurements in the Dixon (1970) catalog. These values provide useful estimates of the flux missing from our images due to the poor sampling of the large-scale structure by the VLA in the A-array. Blanks in this column indicate that we were unable to determine the total radio flux from the Dixon catalog, which for some quasars is caused by the unknown variability of the radio core component. We include estimates of missing flux from HUO images since their Table 1 included total VLA fluxes.

Column (10): This column includes notes for sources that have undergone special processing.

TAP—image has been u - v tapered to improve the sensitivity to large-scale structure.

R, D—map center has been shifted in right ascension, R, and/or declination, D, to center the source. The numbers give the size of the shift in arcsec. The shifts generally indicate a discrepancy between the radio core position and the quasar position listed in Hewitt & Burbidge (1980). If the shift is appreciable, the image should be treated with caution since “bandwidth smearing” causes the image to be elongated in a radial direction relative to the original map center chosen for the observations.

PS—source was unresolved (point source) at the given wavelength. These images are not presented in Fig. 1.

PS⁺—the radio structure is resolved, but the image is only marginally larger than the beam and therefore not presented in Figure 1.

Column (11): The numbers correspond to references for which we were able to find 6 or 20 cm VLA A-array images in the literature. We have used the NASA/IPAC Extragalactic Database (Helou et al. 1991) to locate the images, which is complete back to ~ 1983 from the main astronomical journals. For numbers 1 and 3 (HUO and Ulvestad) it is important to note that we did not observe these quasars, so the reader is referred to HUO for 20 cm images. For the other references Figure 1 still contains our image to maintain a uniformly observed and reduced set of radio images. The references are presented as a possible guide to more sensitive radio images of selected quasars.

4. COMMENTS ON INDIVIDUAL SOURCES

Two confusing issues that may occur when using the radio images in this paper or the derived parameters in HPG are (1) identifying the quasar core and (2) comparing our 6 cm image with the 20 cm image shown in HUO. In this section we clarify which radio component aligns with the optical QSO for the confusing cases and describe the sources for which our 6 cm image differs dramatically from the 20 cm HUO image.

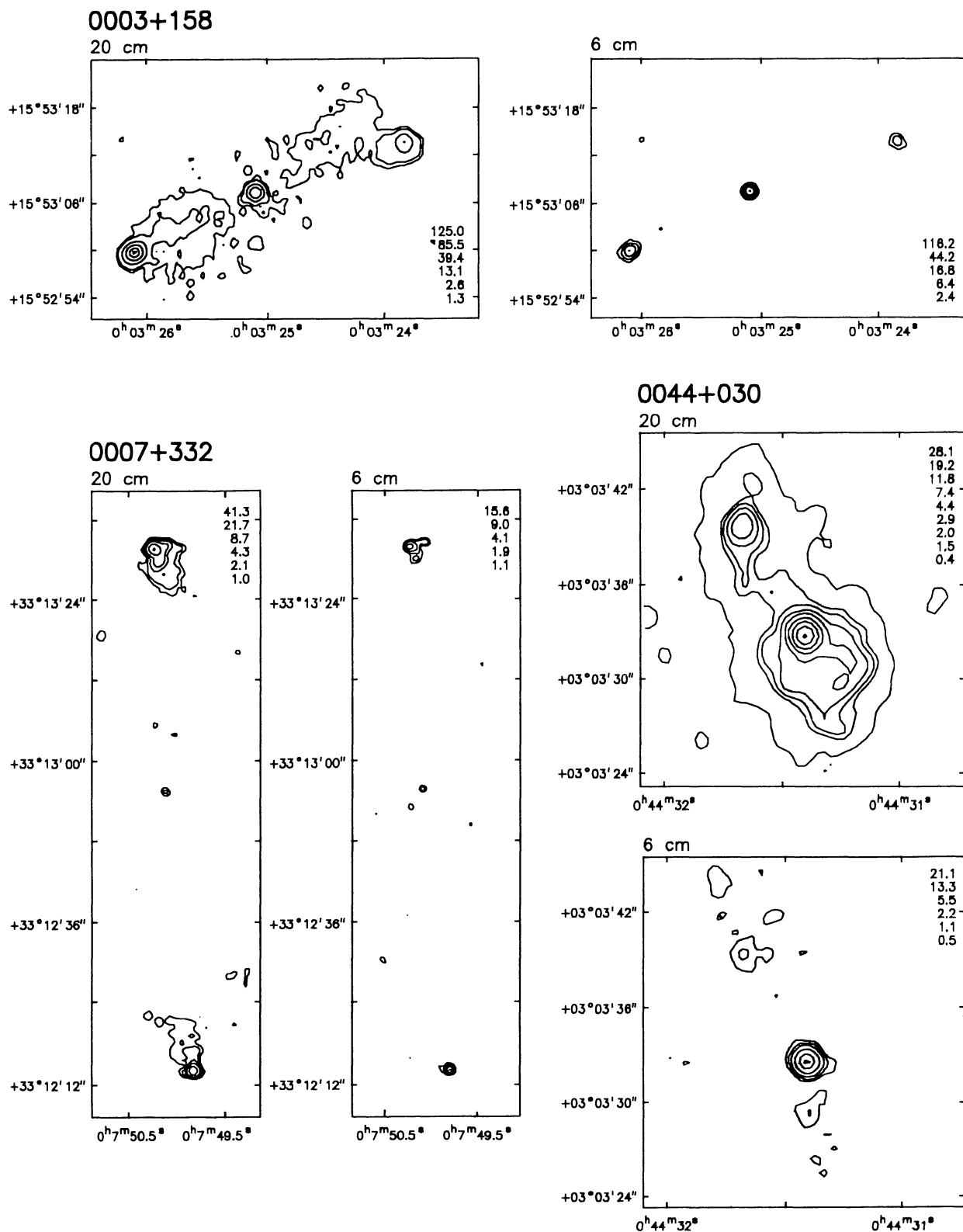


FIG. 1.—Radio contours of the extended structure of 91 quasars at 6 and 20 cm are presented. The quasars were observed with the VLA in its largest configuration (the A-array) to produce images with $\sim 0''.4$ and $\sim 1''.2$ at 6 and 20 cm, respectively. The contour levels are in mJy beam^{-1} as indicated on each map. The borders on the images contain all the structure observed in these A-array observations, but may not contain all the large-scale flux. The percentage of missing flux has been estimated for all 91 quasars, along with other map parameters in Table 1. Quasar positions are not indicated on the images, but are easily identified as the bright, central, compact sources (most obvious in the 6 cm images). For sources where the identification of the core is not obvious, clarification has been noted in § 4.1. For all quasars in our sample the core positions given in columns (3) and (4) of Table 1 provide greater accuracy than can be measured directly from the images.

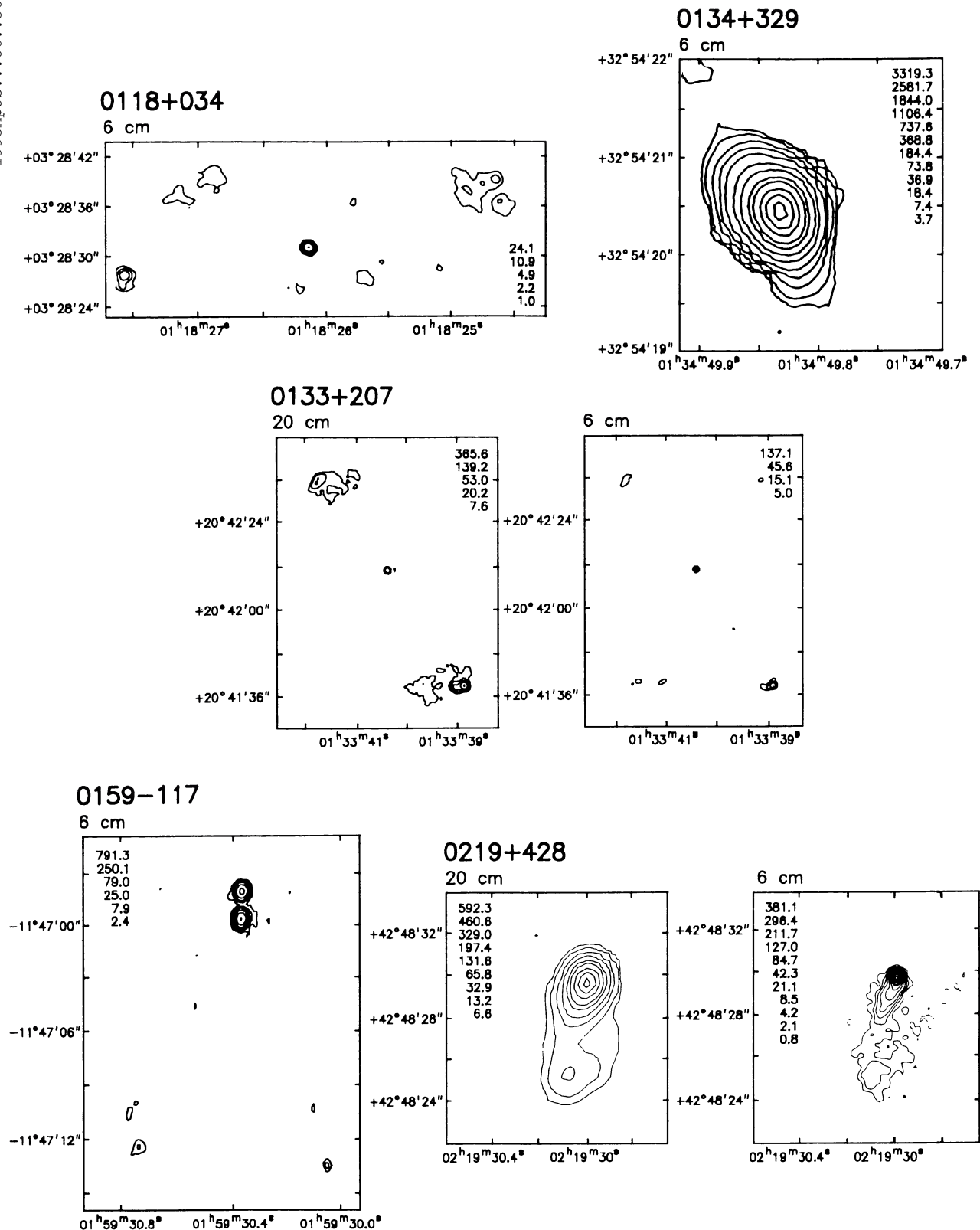
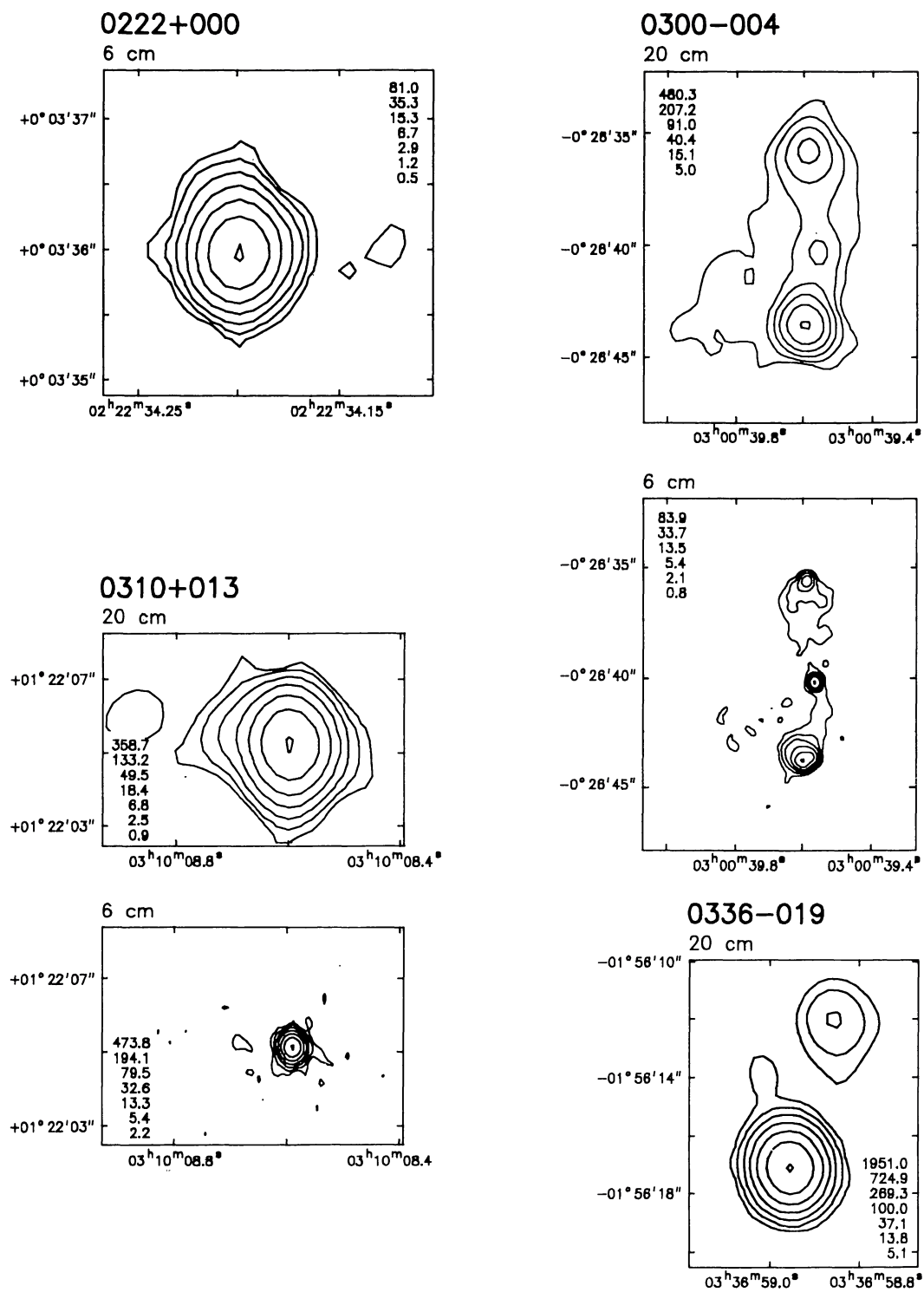
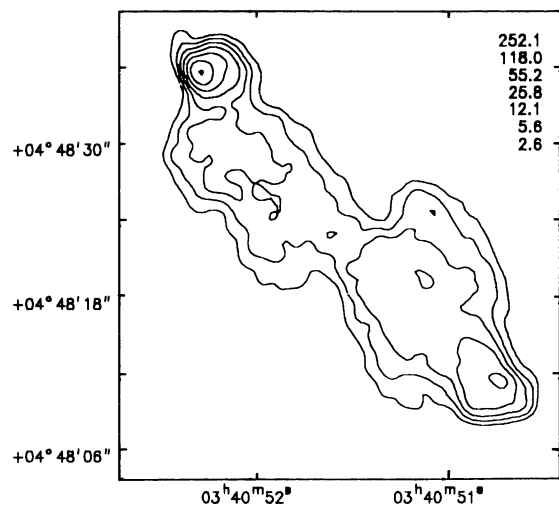


FIG. 1—Continued

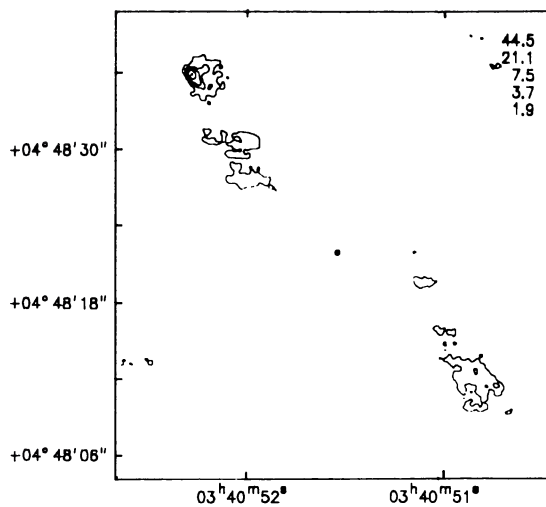
FIG. 1—*Continued*

0340+048

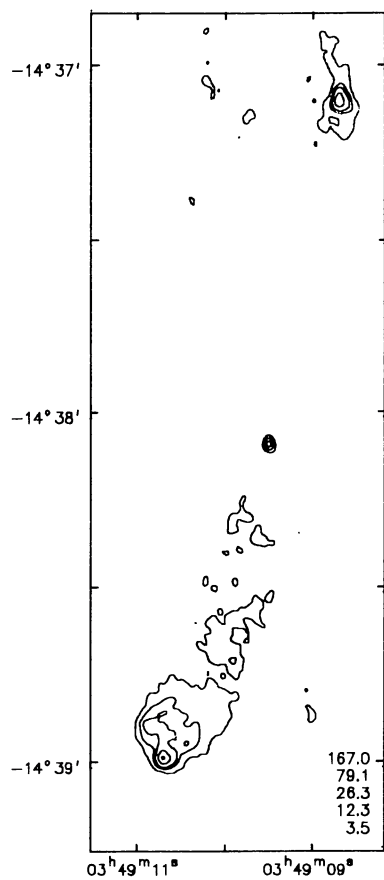
20 cm



6 cm

**0349-146**

20 cm



6 cm

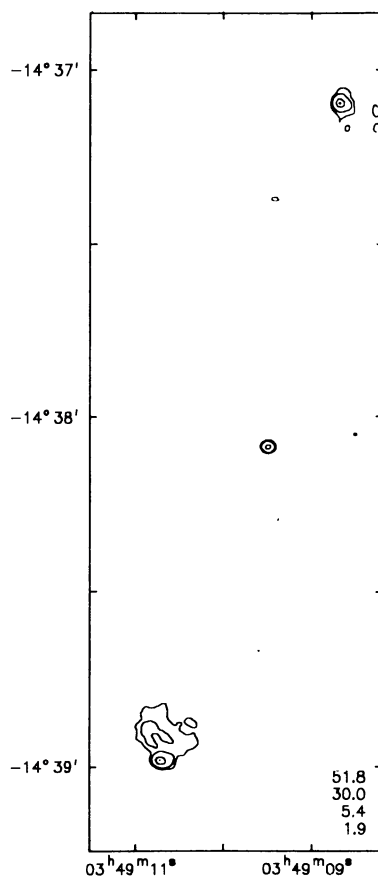


FIG. 1—Continued

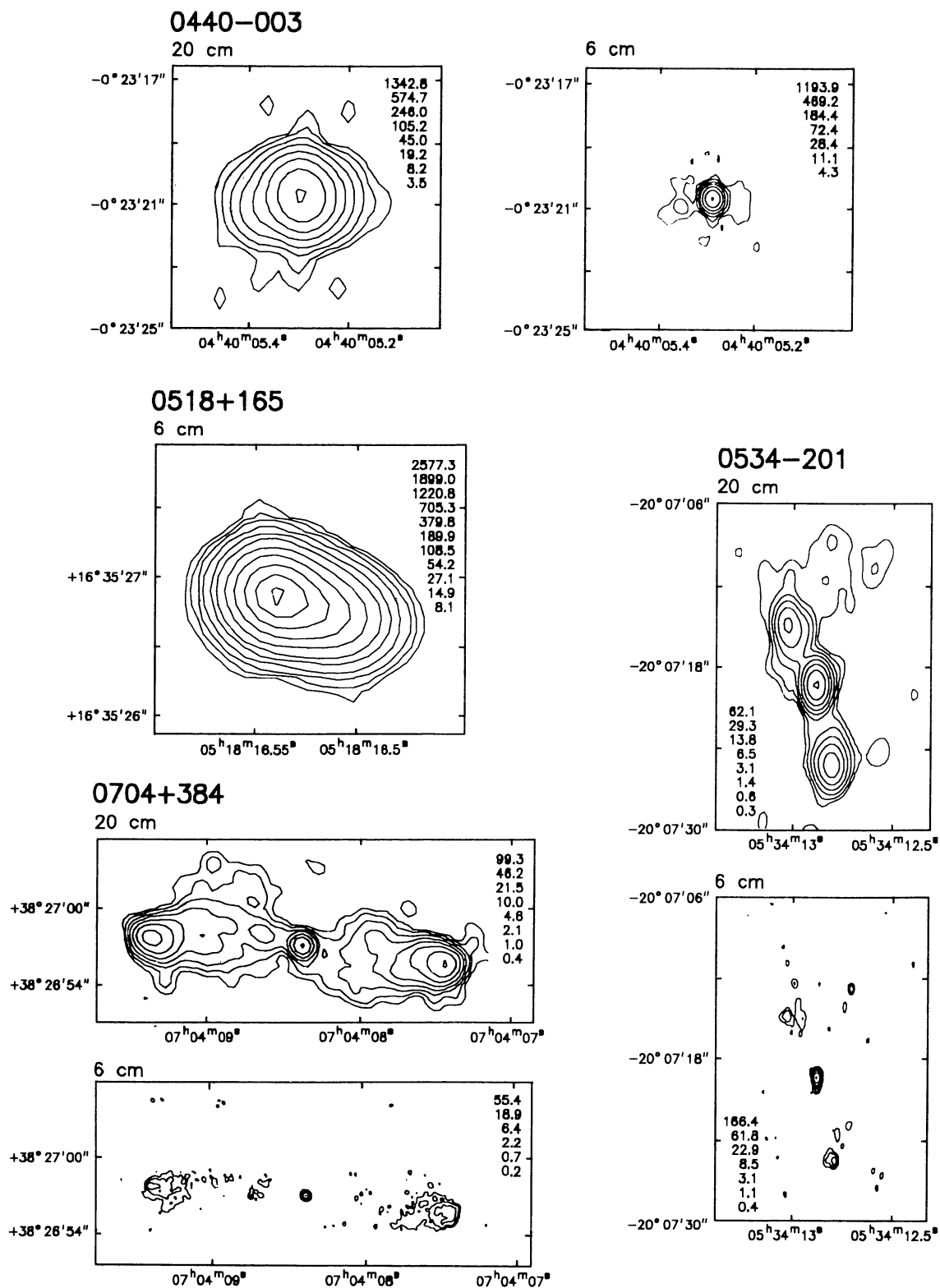
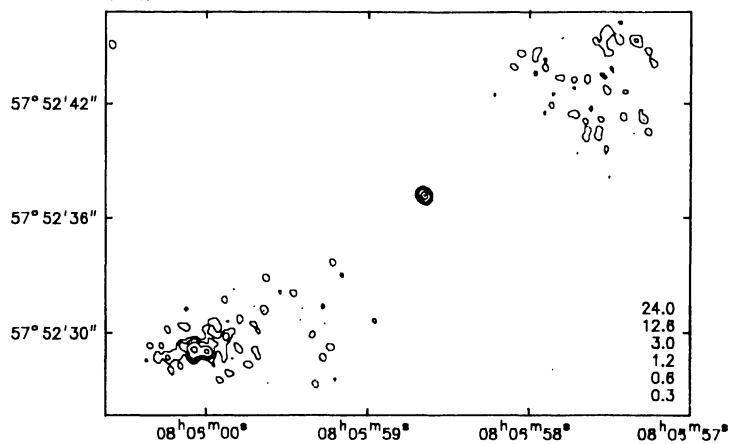


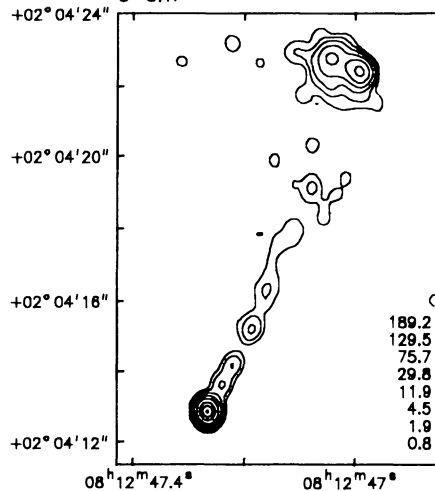
FIG. 1—Continued

0805+579

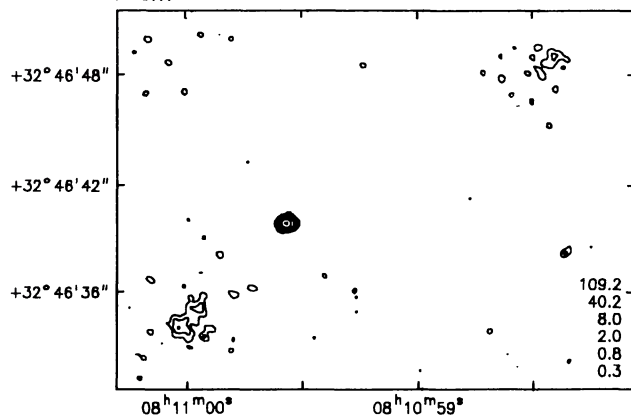
6 cm

**0812+020**

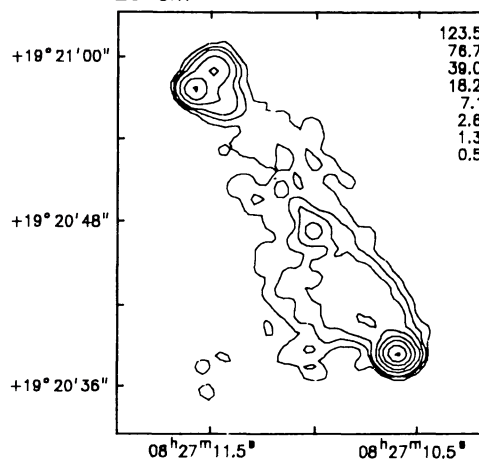
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**0810+327**

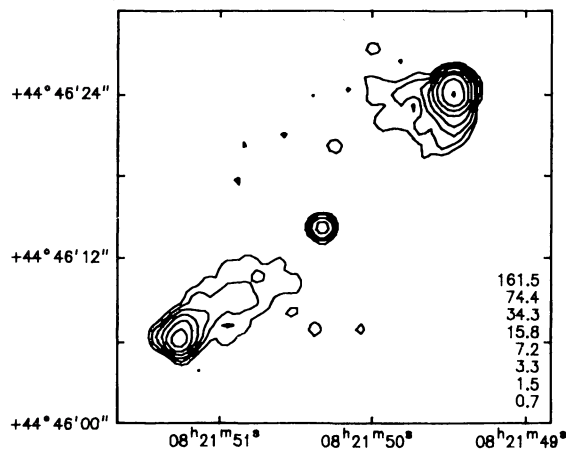
6 cm

**0827+193**

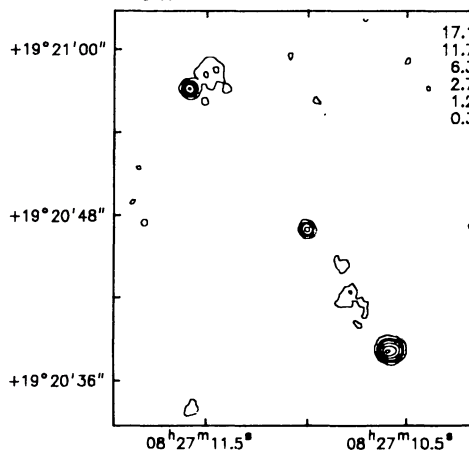
20 cm

**0821+447**

20 cm

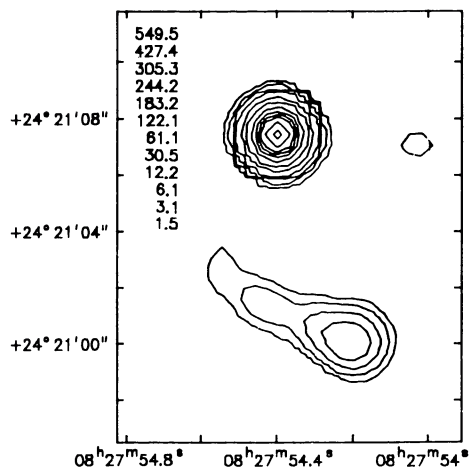


6 cm

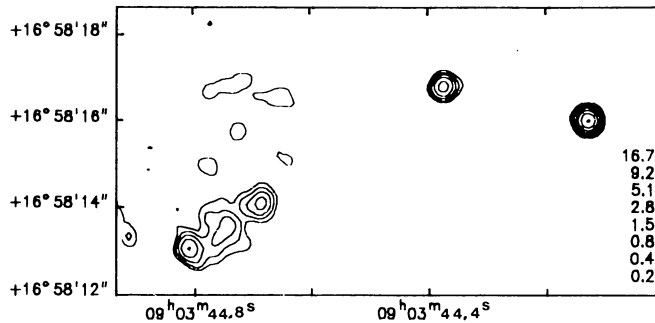
FIG. 1—*Continued*

0827+243

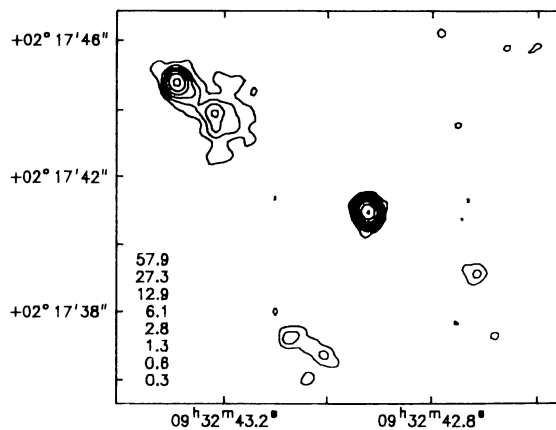
20 cm

**0903+169**

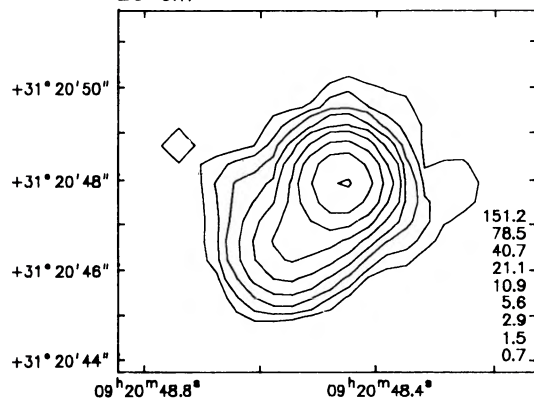
6 cm

**0932+023**

6 cm

**0920+313**

20 cm



6 cm

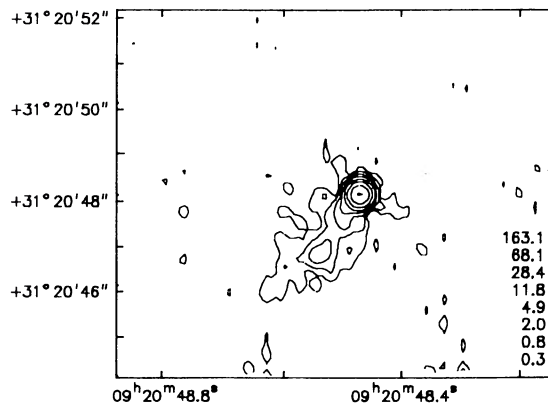


FIG. 1—Continued

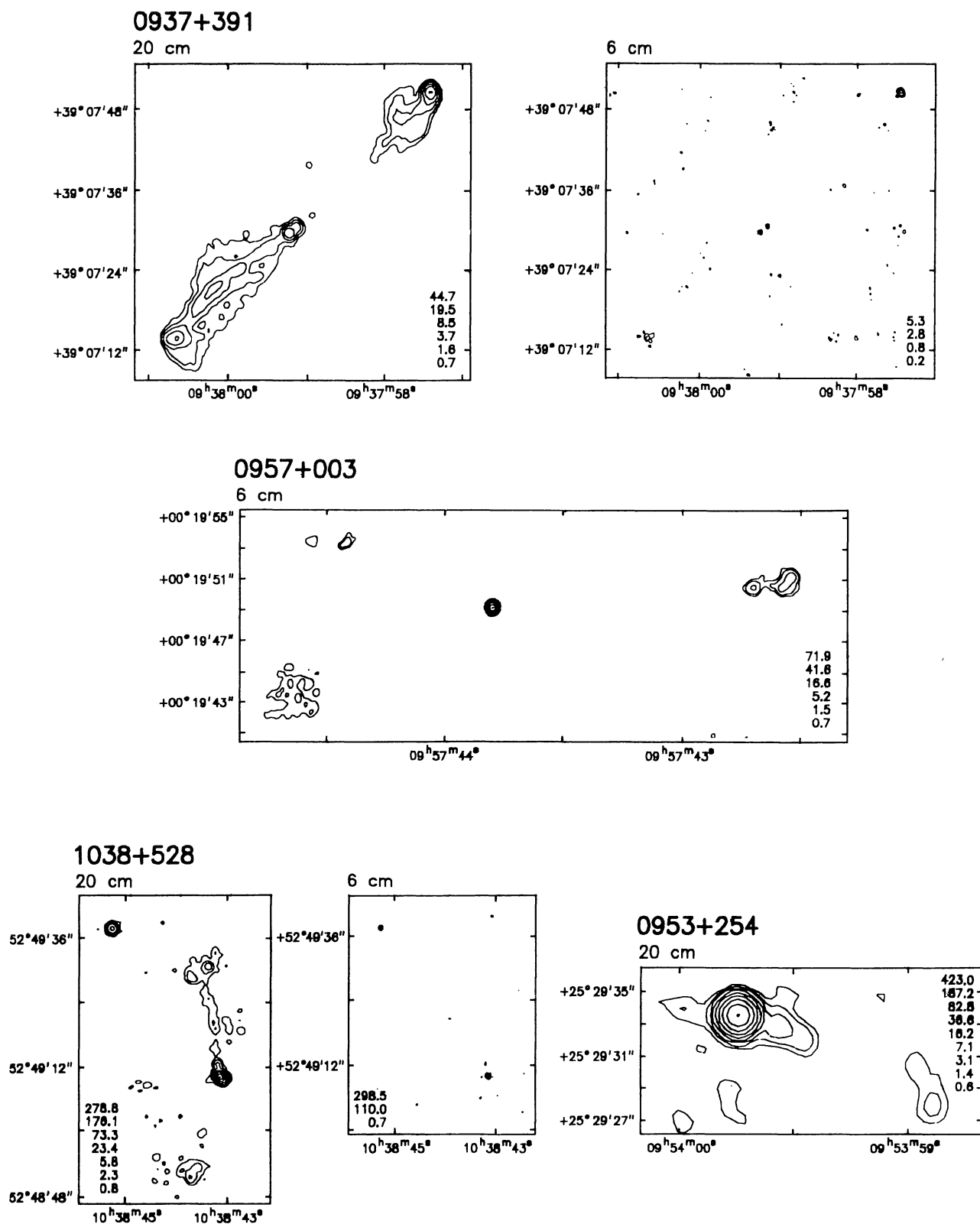
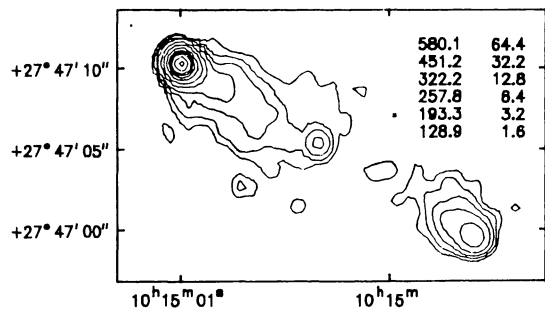


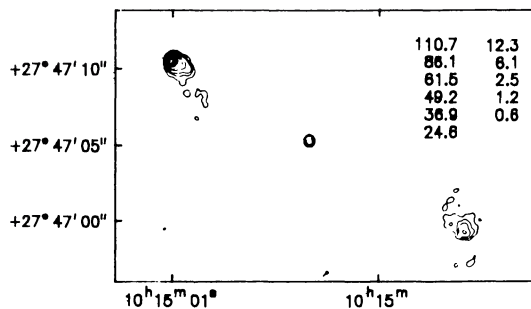
FIG. 1—Continued

1015+277

20 cm

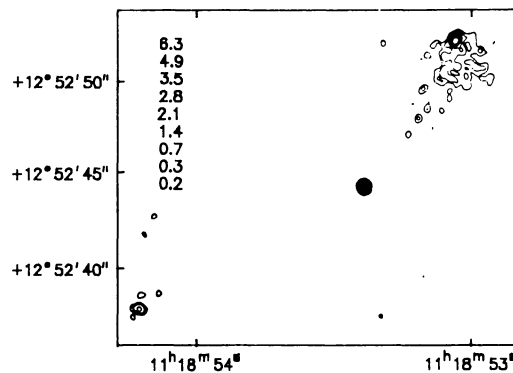


6 cm



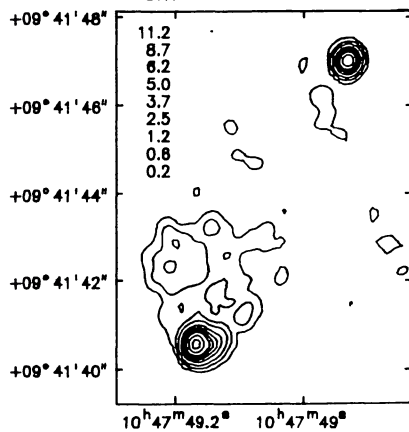
1118+128

6 cm



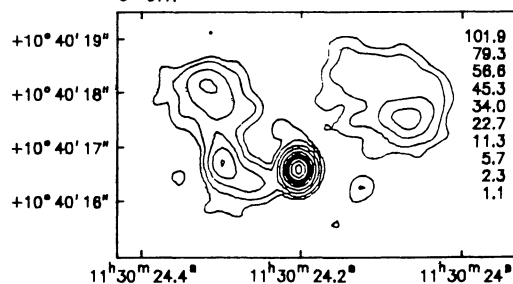
1047+096

6 cm



1130+106

6 cm



1146+111

6 cm

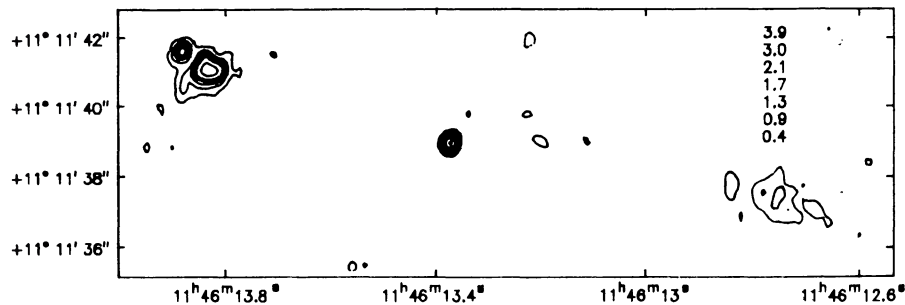


FIG. 1—Continued

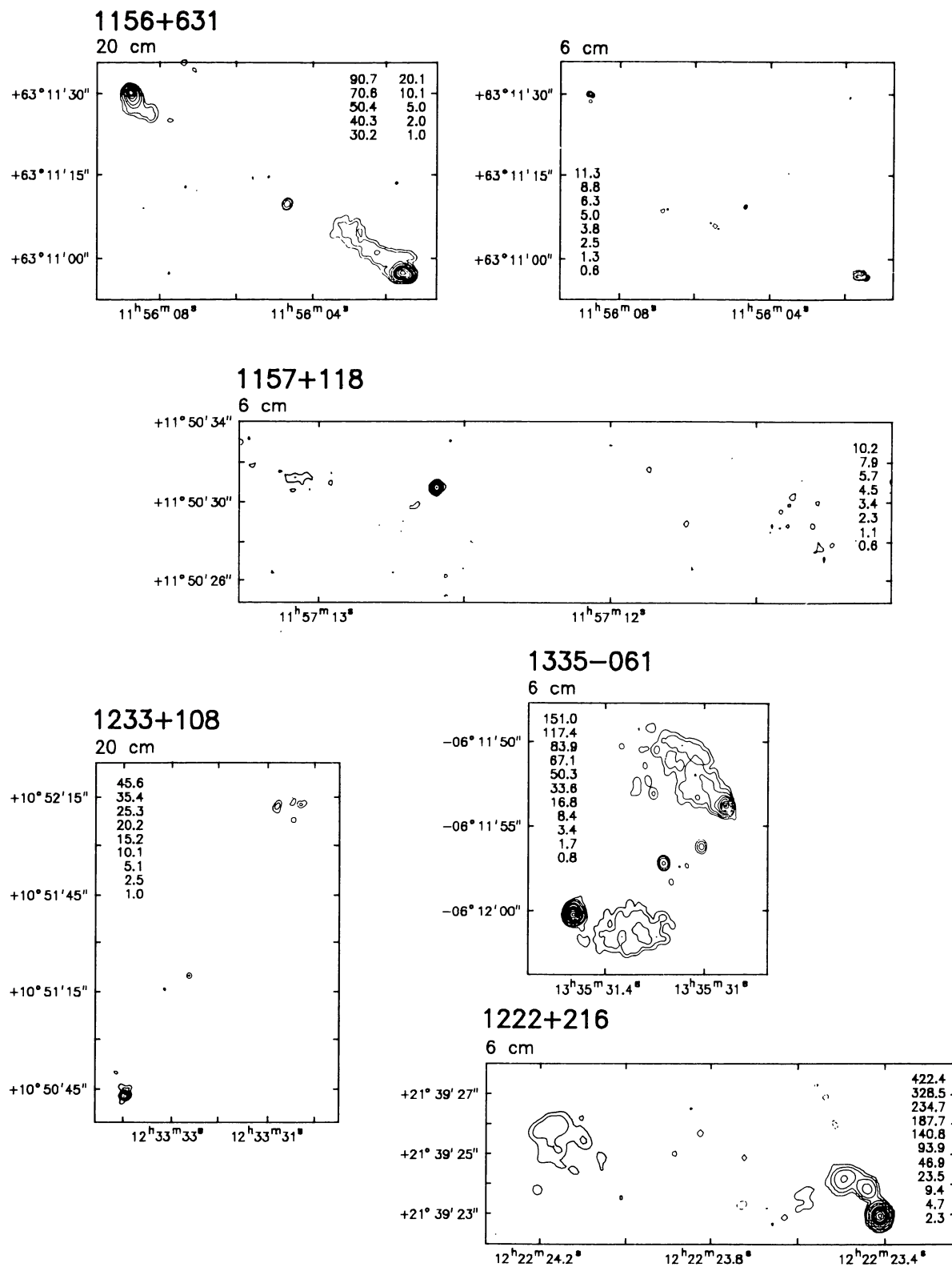


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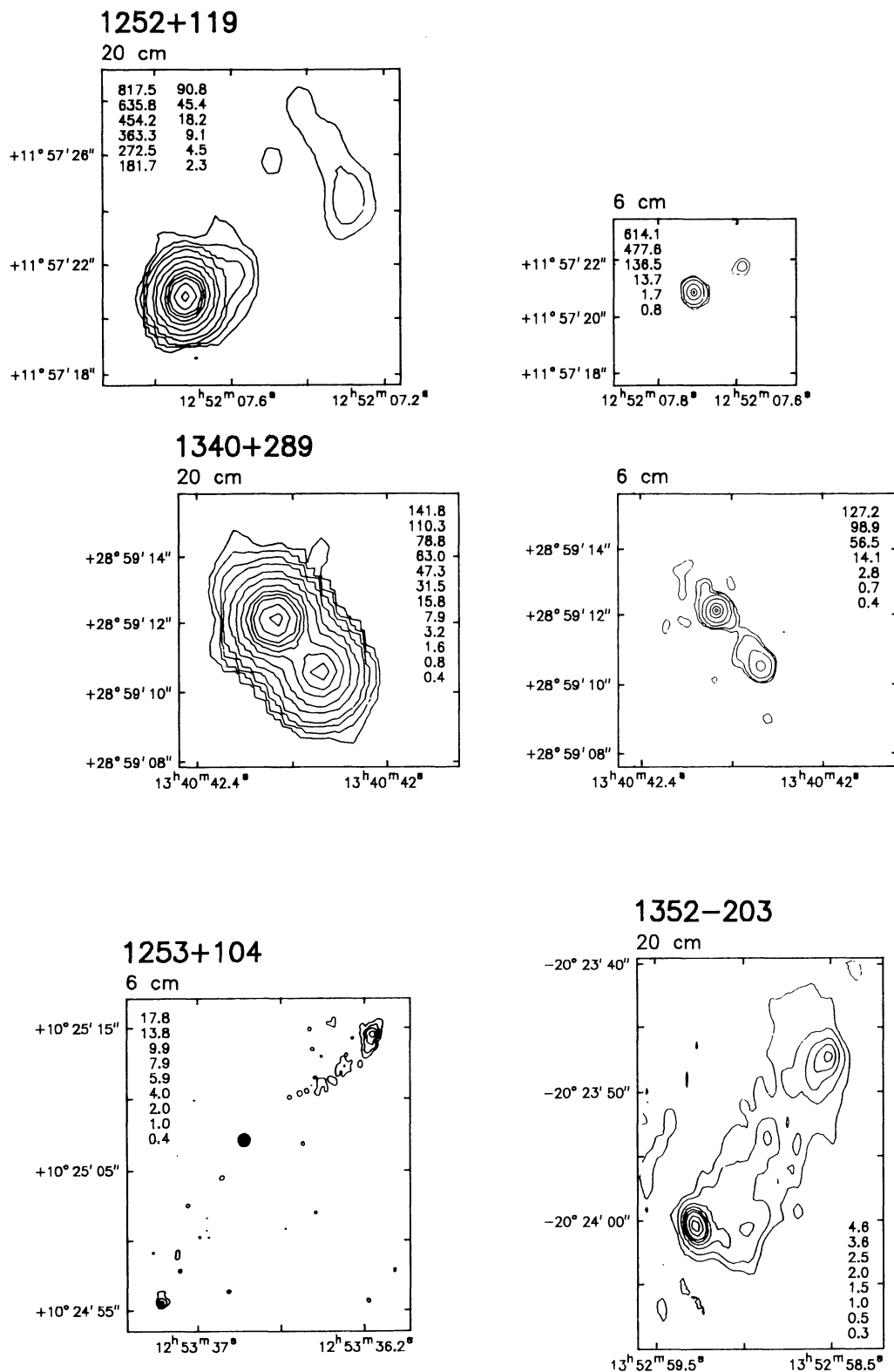
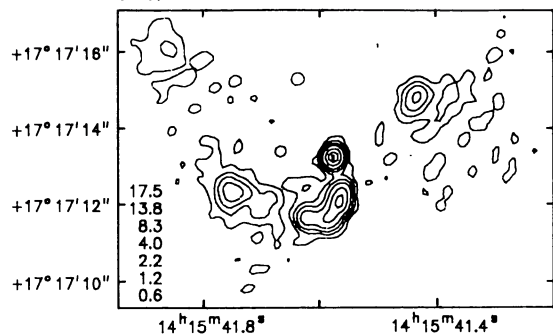


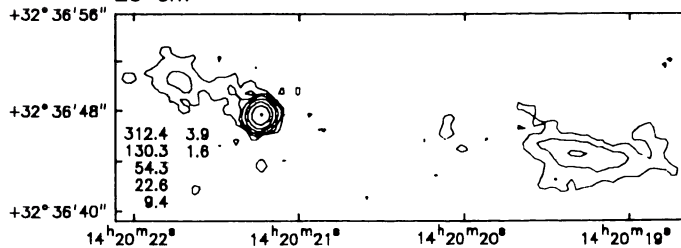
FIG. 1—Continued

1415+172

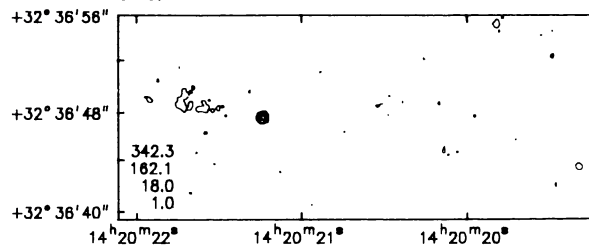
6 cm

**1420+326**

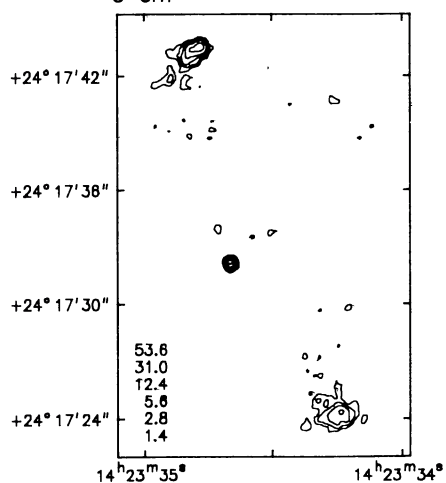
20 cm



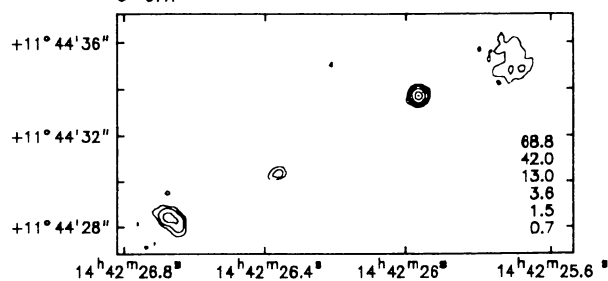
6 cm

**1423+242**

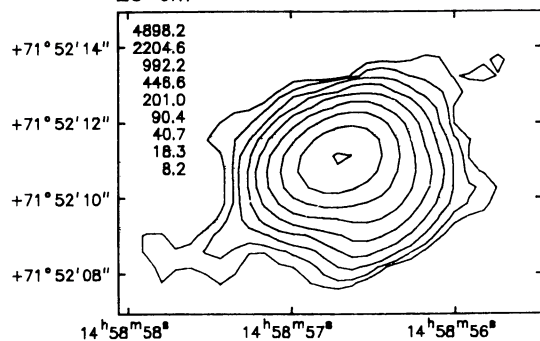
6 cm

**1442+117**

6 cm

**1458+718**

20 cm



6 cm

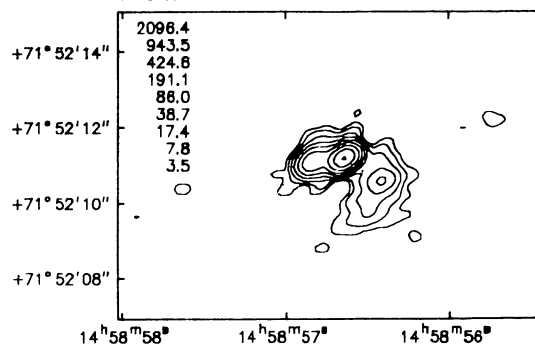


FIG. 1—Continued

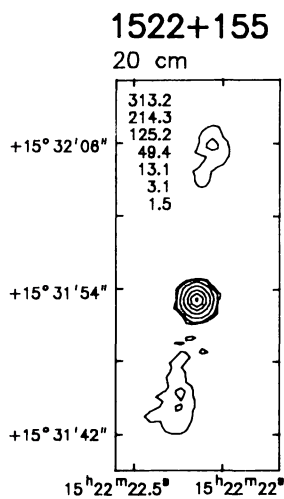
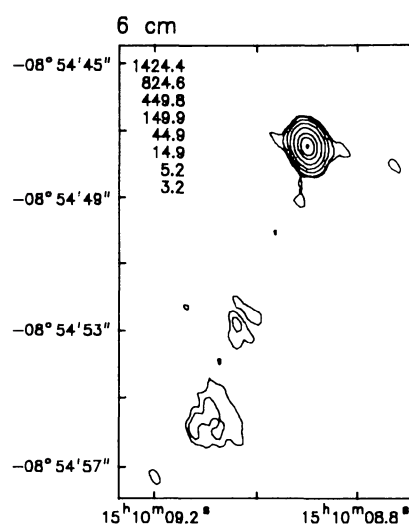
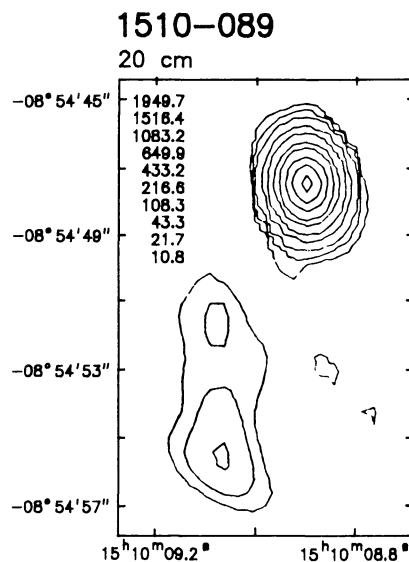
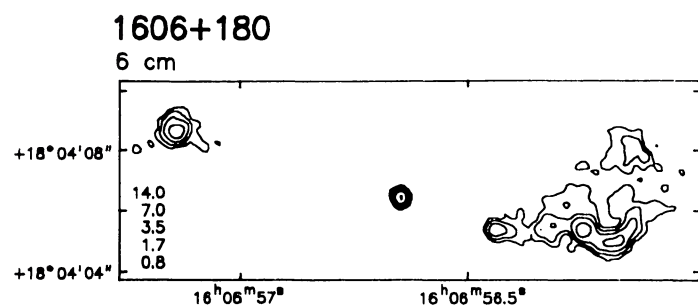
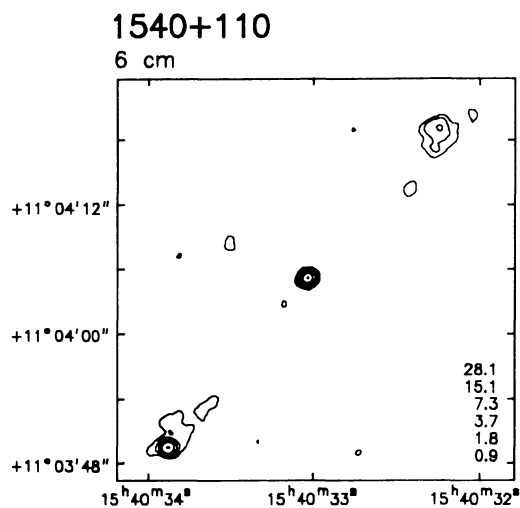
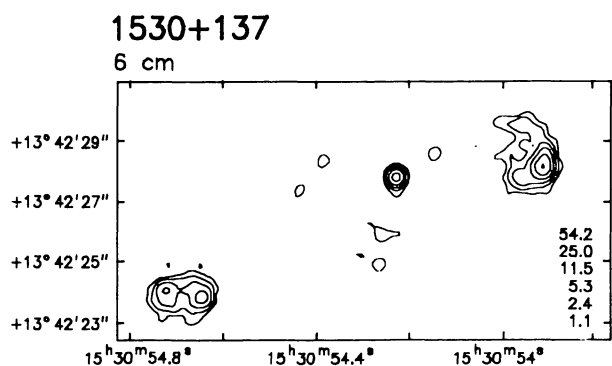
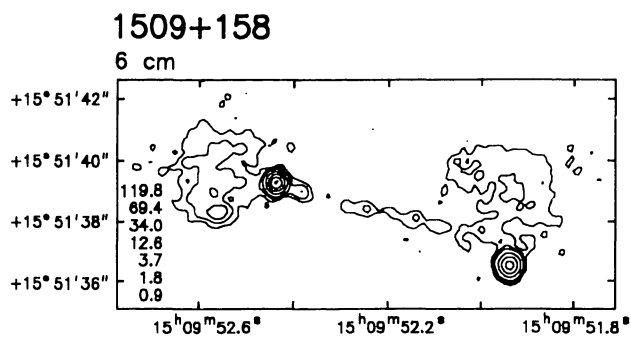
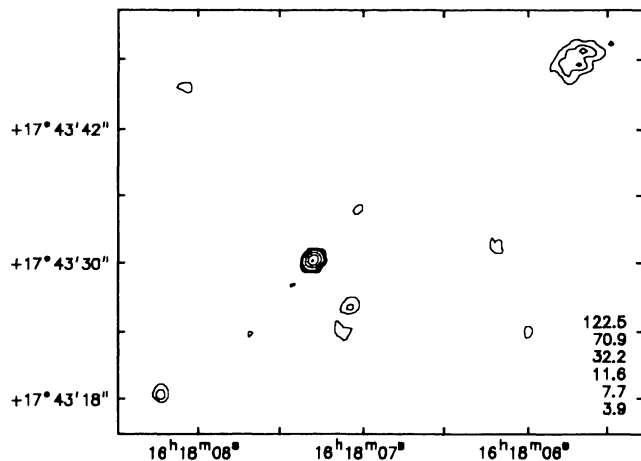


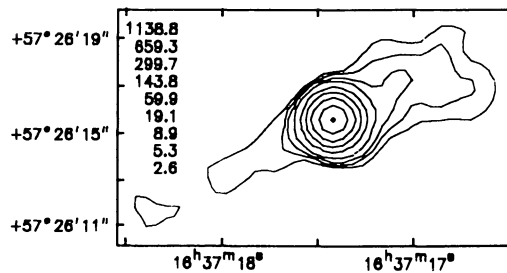
FIG. 1—Continued

1618+177

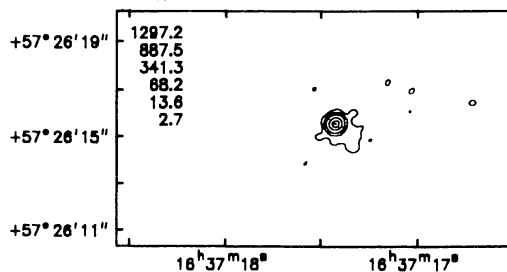
6 cm

**1637+574**

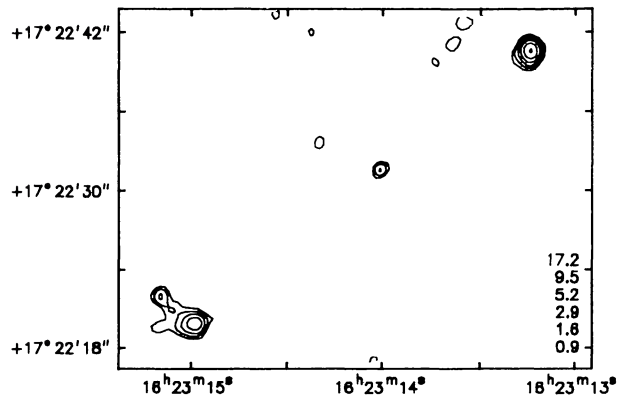
20 cm



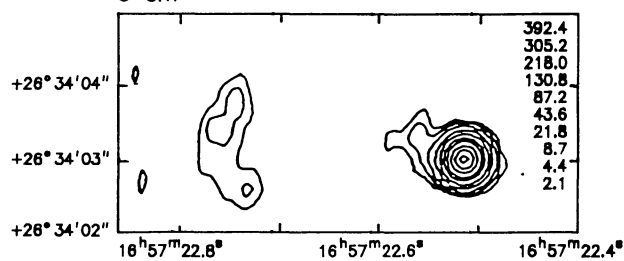
6 cm

**1623+173**

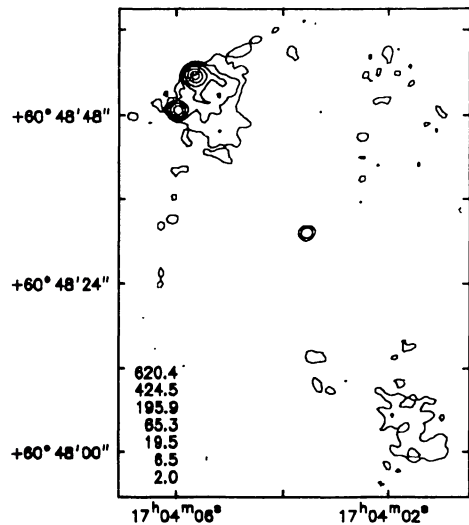
6 cm

**1657+265**

6 cm

**1704+608**

20 cm



6 cm

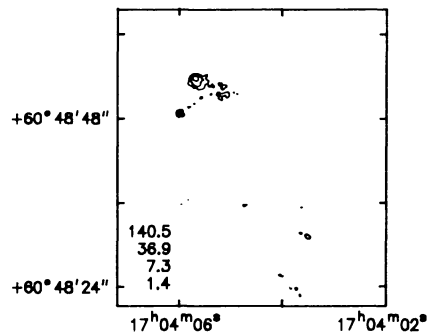


FIG. 1—Continued

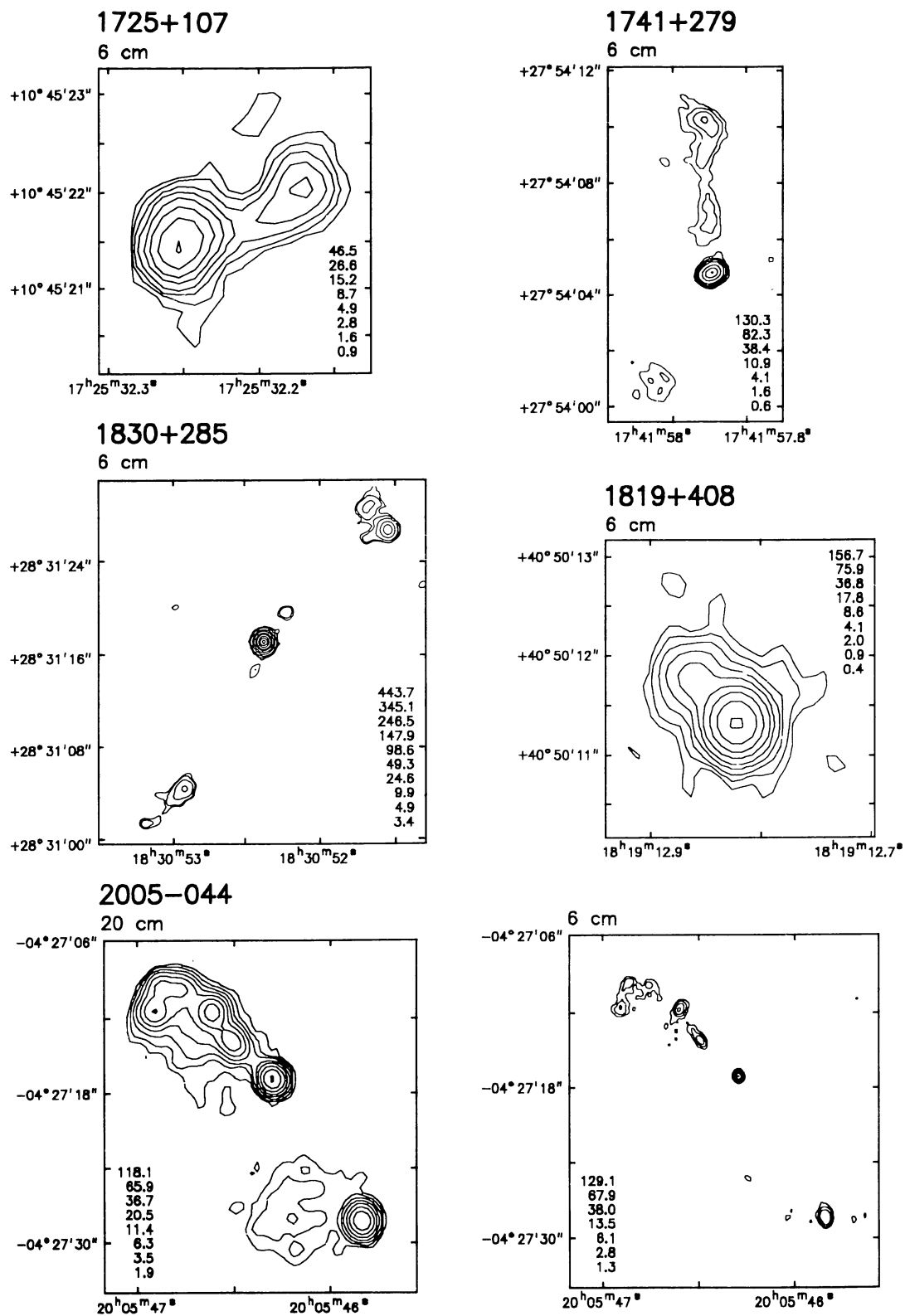


FIG. 1—Continued

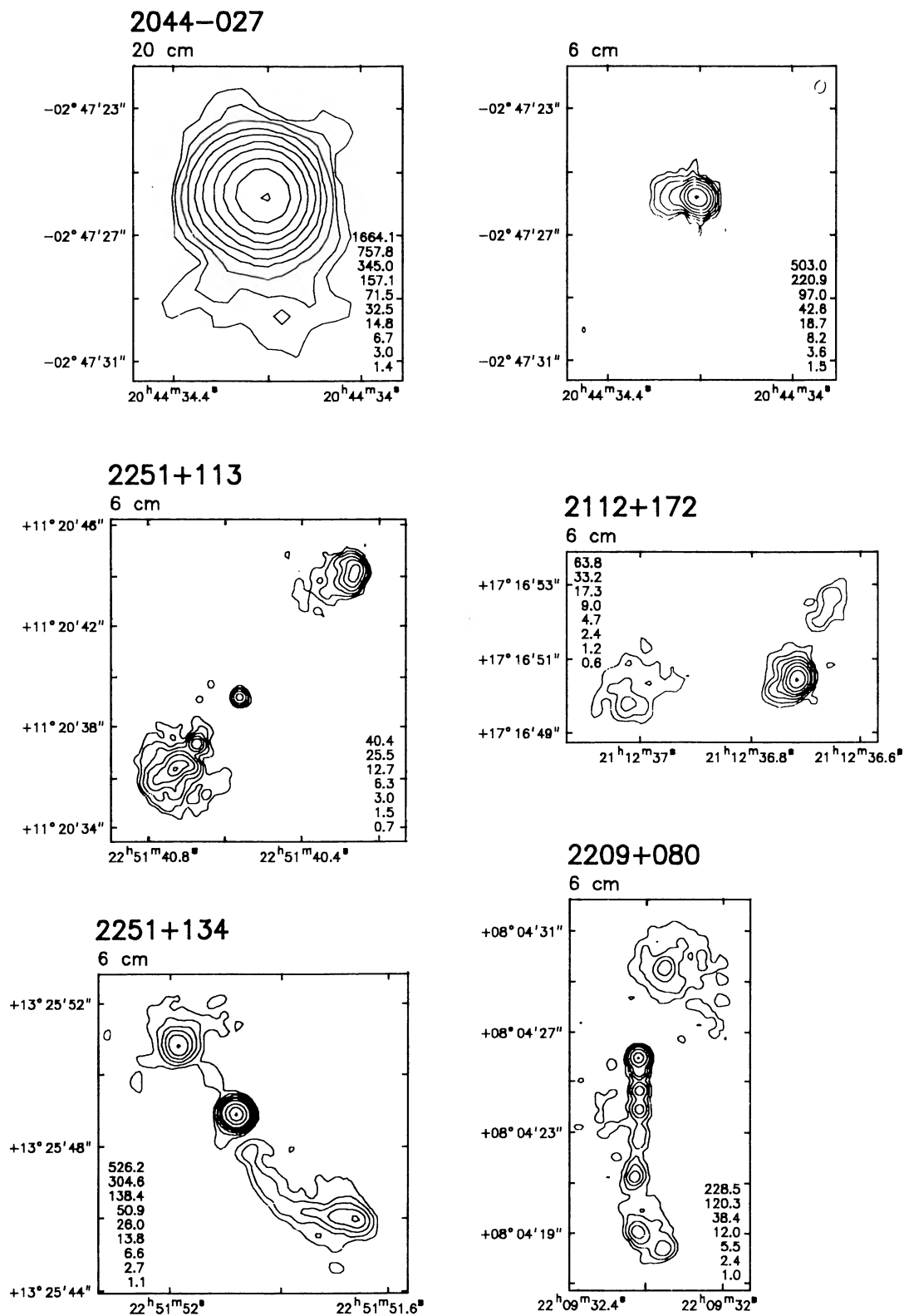


FIG. 1—Continued

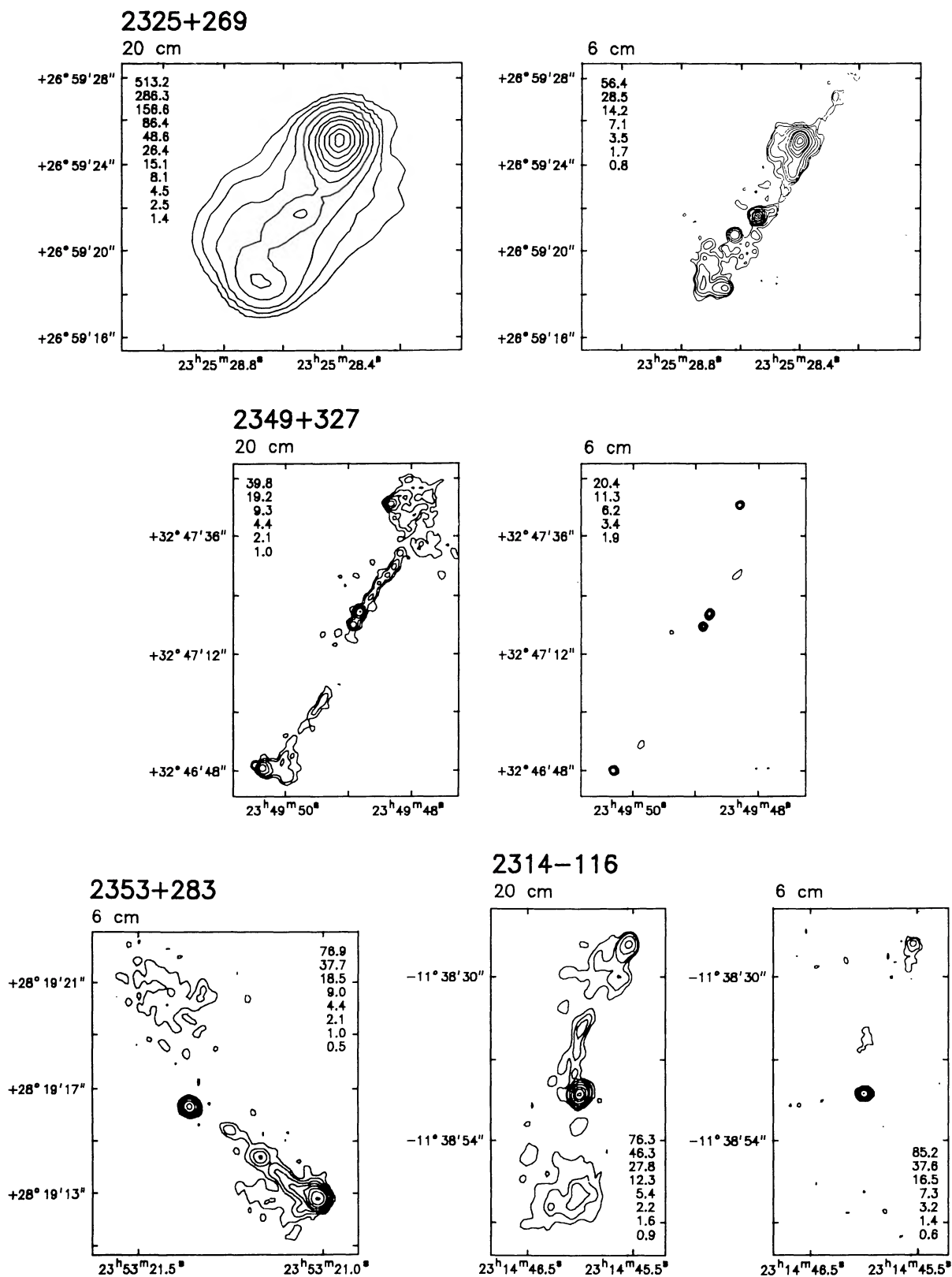


FIG. 1—Continued

TABLE 1
IMAGE PARAMETERS

(1) Source Name	(2) Radio Name	(3) α	(4) Core Position δ	(5) Beam Size ($''$)	(6) θ ($^{\circ}$)	(7) RMS (mJy)	(8) DR	(9) MF (%)	(10) Comments	(11) Map Reference
0003+158	4C15.01	00 03 25.08	+15 53 07.1	0.87 0.86	42	0.5	230	25	TAP	
0007+332	4C33.01	00 07 50.10	+33 12 55.7	1.23 1.19	34	0.5	290	35	TAP	
0044+030	PKS	00 44 31.41	+03 03 32.7	0.88 0.84	25	0.3	50	50	TAP	
				1.13 1.08	35	0.3	810	40		
0056-001	4C-00.06	00 56 31.76	-00 09 18.8	1.03 1.00	33	0.2	90		TAP	
				1.34 1.23	13	0.2	160			
				0.46 0.38	-1	0.6	2480	0	PS	
0114+074	4C07.04	01 14 49.51	+07 26 30.1	1.56 1.31	-3	1.9	1300	0	PS	
				0.95 0.92	54	2.4	140	0	R6,D13,PS	
0118+034	4C03.02	01 18 26.13	+03 28 30.8							1
				1.01 0.84	75	0.4	60	65	TAP	2
0133+207	3CR47	01 33 40.41	+20 42 10.4					25		3
				0.89 0.87	37	1.0	140	50	TAP	4
0134+329	3CR48	01 34 49.84	+32 54 20.4	1.21 1.17	36	1.8	210	40		4
				0.36 0.35	34	1.3	2770	0		5,6
0159-117	3C57	01 59 30.36	-11 46 59.7	1.17 1.15	39	12.9	1000	0	PS+	
				0.51 0.36	-2	0.6	1390	5		
0219+428	3C66A	02 19 29.99	+42 48 29.8					10		3
				0.38 0.34	6	0.4	1090	30		7
0222+000	PKS	02 22 34.20	+00 03 35.9	1.21 1.12	16	1.0	650	10		7
				0.44 0.37	3	0.2	470	0		
0222-008	4C-00.12			1.38 1.26	14	0.3	1000	0	PS+	
						0.2	71		R300	
0300-004	4C-00.14	03 00 39.56	-00 26 40.1					0		1,8
				0.45 0.37	9	0.3	20	10		
0310+013	OE+017	03 10 08.59	+01 22 05.2	1.43 1.19	8	1.0	490	0		
				0.40 0.35	9	0.7	700	0	D24	
0336-019	OE-063			1.34 1.21	11	0.4	380	0		
								0		
0340+048	3CR93	03 36 58.95	-01 56 16.9	1.38 1.16	12	1.5	1370	0		
		03 40 51.54	+04 48 21.7	0.38 0.35	22	0.1	670	30		
0349-146	3C95	03 49 09.46	-14 38 05.4	1.31 1.21	21	1.2	220	15		
				1.18 1.15	6	0.1	920	45	TAP	
0429+415	3CR119	04 29 07.90	+41 32 08.6	1.66 1.09	8	1.5	120	30		
				0.40 0.37	53	3.4	1060	0	PS+	
0440-003	OF-067	04 40 05.29	-00 23 20.74	1.37 1.35	46	8.3	980	0	PS	
				0.44 0.37	4	1.6	810	50		
0518+165	3C138			1.40 1.16	10	1.0	1420	35		
				0.39 0.36	24	2.2	1240	0		5,6,9
0534-201	MC1	05 18 16.53	+16 35 26.8	1.15 1.11	36	8.9	900	0	PS+	
		05 34 12.88	-20 07 19.2	0.63 0.33	-1	0.2	1090			
0704+384	4C38.20	07 04 08.37	+38 26 57.1	2.00 1.12	1	0.2	430			
				0.34 0.32	31	0.1	480	15		
0738+313	OI+363			1.13 1.05	31	0.2	440	5		
0805+579	4C57.15	07 38 00.18	+31 19 02.1	1.23 1.18	32	2.0	1010	0	PS	
		08 05 58.63	+57 52 37.0	0.36 0.31	23	0.1	280	40		1
0810+327	B2	08 10 59.56	+32 46 39.8					0		
				0.37 0.37	45	0.1	880	25	R32	
0812+020	4C02.23	08 12 47.27	+02 04 12.9	0.42 0.36	8	0.2	870	25		1
								5		10
0821+447	4C44.17									
		08 21 50.33	+44 46 14.2	1.01 0.97	39	0.2	740	0		
0827+193	4C19.30	08 27 11.00	+19 20 47.2	0.65 0.58	20	0.1	160		TAP	
				1.20 1.13	32	0.2	540			
0827+243	OJ+248	08 27 54.40	+24 21 07.7	0.38 0.34	15	0.2	4780	5		
				1.26 1.18	26	0.4	1490	25		
0833+276	OJ+256	08 33 21.93	+27 39 19.3	0.37 0.33	18	0.2	1170		PS	
				1.16 1.11	32	0.4	440		PS	
0903+169	3CR215	09 03 44.13	+16 58 16.0	0.35 0.34	34	0.1	180	90		2
								40		1
0920+313	B2	09 20 48.47	+31 20 48.1	0.33 0.33	38	0.2	1010			
				1.14 1.10	31	0.4	420			
0932+023	4C02.27	09 32 42.93	+02 17 40.9	0.40 0.34	8	0.2	410	50		2
								0		1
0937+391	4C39.27	09 37 59.21	+39 07 29.6	0.37 0.31	13	0.1	70	75	R2,D7	
				1.21 1.06	23	0.2	240	15		
0953+254	OK+290	09 53 59.74	+25 29 33.6	0.37 0.36	29	0.3	1890		PS	
				1.19 1.17	41	0.3	1310	0		

TABLE 1—*Continued*

(1) Source Name	(2) Radio Name	(3) α	(4) Core Position δ	(5) Beam Size (")	(6) θ (°)	(7) RMS (mJy)	(8) DR	(9) MF (%)	(10) Comments	(11) Map Reference
0957+003	4C00.34	09 57 43.80	+00 19 49.2	0.44 0.37	2	0.1	560	0		2
1012+488	4C48.28							25		1
1015+227	3C240	10 15 00.34	+27 47 05.3	0.38 0.34	1	0.2	680	70		3
1022+194	4C19.34	10 22 00.15	+19 27 34.7	1.23 1.09 0.37 0.33	9 3	0.5 0.8	1220 670	0	PS+	
1038+528	OL+564	10 38 43.15	+52 49 10.0	0.35 0.31 1.15 1.01	29 31	0.1 0.3	2420 1050	10	R9,D13	3
1047+096	4C09.37	10 47 48.93	+09 41 47.1	0.41 0.38	1	0.1	130	25	R29,D6	
1104+167	4C16.30	11 04 36.64	+16 44 16.4	0.38 0.34	3	0.6	590	40	R11,D21,PS	3
1118+128	4C12.40	11 18 53.39	+12 52 44.3	0.39 0.33	7	0.1	120	30		3
1130+106	4C10.33	11 30 24.20	+10 40 16.6	0.41 0.35	3	0.2	630	40		1
1146+111	MC2	11 46 13.37	+11 11 38.9	0.42 0.35	1	0.2	30	0		1
1151+102	MC2	11 51 14.38	+10 12 36.3	0.40 0.33 1.36 1.22	5 4	0.4 0.4	650 380	0	PS PS	1
1156+631	4C63.15	11 56 04.65	+63 11 09.7	0.38 0.30 1.21 1.00	—22 —28	0.1 0.3	110 320	40 30		
1157+118	MC2	11 57 12.60	+11 50 30.7	0.38 0.33	4	0.2	60	50		1
1222+216	4C21.35	12 22 23.41	+21 39 23.0	0.38 0.34	9	0.5	920	0		1
1233+108	MC2	12 33 32.67	+10 51 19.7	0.39 0.33 1.28 1.16	5 14	0.1 0.2	100 300	15 0	R4,D2 R9,D19	
1252+119	ON+187	12 52 07.72	+11 57 20.8	0.41 0.34 1.44 1.17	5 —3	0.3 0.8	2350 1080	20 15		
1253+104	MC2	12 53 36.78	+10 25 07.1	0.40 0.34	9	0.1	140	50		1
1258+287	5C4.105	12 58 04.10	+28 46 18.7	0.37 0.32 1.26 1.10	10 7	0.5 0.3	380 550	0	PS PS	
1335—061	4C—06.35	13 35 31.17	—06 11 57.1	0.48 0.35	9	0.3	560	30		3
1340+289	B2	13 40 42.24	+28 59 12.1	0.37 0.33 1.25 1.10	1 2	0.1 0.1	1010 1440	20 5		
1352—203	MC									
1415+172	OQ+125	13 52 58.88 14 15 41.58	—20 23 53.5 +17 17 13.2	2.00 1.10 0.37 0.35	10 5	0.3 0.3	20 70	15 0		1
1420+326	OQ334	14 20 21.24	+32 36 47.4	0.36 0.33 1.24 1.12	—10 —15	0.4 0.9	1030 440		R7,D7	
1423+242	4C24.31	14 23 34.65	+24 17 32.2	0.37 0.34	—9	0.4	150	25		3
1442+117	MC2	14 42 25.97	+11 44 33.6	0.39 0.34	9	0.2	340	10		1
1458+718	3C309.1	14 58 56.64	+71 52 11.1	0.55 0.36 1.90 1.28	—62 —62	1.0 2.4	2300 2150	15 20		5,6,9
1509+158	4C15.45	15 09 52.43	+15 51 39.3	0.38 0.34	—3	0.3	390	35		11
1510—089	OR—017	15 10 08.90	—08 54 47.6	0.59 0.39 1.61 1.21	14 1	1.0 2.8	1580 750	25		1,11 12
1522+155	MC3	15 22 22.15	+15 31 53.2	0.41 0.40 1.33 1.16	—50 —3	0.3 0.6	1030 515	0	PS+	
1530+137	4C13.55	15 30 54.23	+13 42 27.8	0.39 0.34	—1	0.3	197	20	R5,D6	1
1540+110	MC2	15 40 33.03	+11 04 05.0	0.92 0.87	—34	0.3	90	10	TAP	1
1548+114	4C11.50	15 48 21.18	+11 29 47.5	0.39 0.35	5	0.3	1450	0	D3,PS	1
1606+180	4C18.47	16 06 56.65	+18 04 06.4	0.39 0.33	—2	0.3	50	40		1
1618+177	3CR334	16 18 07.29	+17 43 30.3	0.93 0.86	—38	1.1	110	55	TAP	1
1623+173		16 23 14.00	+17 22 31.5	0.94 0.93	—48	0.3	70	65	TAP,R4,D7	1

TABLE 1—*Continued*

(1) Source Name	(2) Radio Name	(3) α	(4) Core Position δ	(5) Beam Size ($''$)	(6) θ ($^\circ$)	(7) RMS (mJy)	(8) DR	(9) MF (%)	(10) Comments	(11) Map Reference
1637+574	OS+562	16 37 17.43	+57 26 15.7	0.37 0.35 1.23 1.22	−37 −44	0.7 0.7	2110 1710			13
1657+265	4C26.51	16 57 22.52	+26 34 03.0	0.36 0.34	7	0.4	1210	0		1
1704+608	3CR351			0.33 0.32 1.09 1.08	−42 44	0.5 1.0	320 1000	45 25	RI6,D15 TAP	
1725+107	MC2	17 04 03.53 17 25 32.25	+60 48 31.4 +10 45 21.4	0.37 0.35	23	0.4	190	0	R20,D21	
1741+279	4C27.38	17 41 57.90	+27 54 04.8	0.36 0.33	6	0.2	620	35 15		1 14
1819+408	4C40.37	18 19 12.82	+40 50 11.3	0.36 0.33	0	0.2	920	0		1
1830+285	4C28.45	18 30 52.38	+28 31 17.0	0.99 0.91	15	1.0	510	35 20	TAP	1
2005−044	3C407	20 05 46.29	−04 27 17.0	0.46 0.36 1.47 1.30	11 11	0.4 0.7	350 180	25 15		
2044−027	3C422	20 44 34.21	−02 47 25.8	0.48 0.37 1.43 1.25	−4 −2	0.5 0.7	1100 2500	5 0		
2112+172	4C17.86	21 12 36.72	+17 16 50.5	0.36 0.35	18	0.2	290	15 0		
2142+110	MC2	21 42 52.35	+11 01 36.3	0.40 0.38	−26	0.4	960	0 0	R4,D6,PS	3 3
2154+100	MC2	21 54 45.22	+10 00 05.9	0.38 0.37 1.28 1.22	33 28	1.7 0.4	200 590	0 40	PS PS	
2209+080	4C08.64	22 09 32.22	+08 04 26.0	0.38 0.38	36	0.4	670	20 0		1
2234+282	B2	22 34 01.73	+28 13 23.2	0.39 0.39 1.28 1.26	47 40	3.1 1.0	530 1080	0 0	PS PS	
2251+113	4C11.72	22 51 40.56	+11 20 39.2	0.38 0.36	25	0.2	200	20 0		1
2251+134	4C13.85	22 51 51.88	+13 25 48.9	0.38 0.37	20	0.4	1460	0 0	R17	1
2314−116	PKS	23 14 46.01	−11 38 47.2	0.90 0.87 1.65 1.23	81 −11	0.2 0.3	390 290	40 30	TAP	
2325+269	3C463	23 25 28.55	+26 59 21.6	0.35 0.33 1.19 1.16	24 35	0.3 0.4	190 1380	20 0		
2344+092	4C09.74	23 44 03.77	+09 14 05.4	0.47 0.44 1.28 1.27	59 30	2.0 3.3	720 500	0 0	PS PS	
2349+327	4C32.69	23 49 48.93	+32 47 18.1	0.97 0.87 1.16 1.11	19 37	0.4 0.4	50 110	55 25	TAP	
2353+283	4C28.59	23 53 21.36	+28 19 16.3	0.34 0.32	25	0.2	410	10 0	R6,D9	1

REFERENCES.—Hintzen et al. 1983; (2) Swarup et al. 1984; (3) Ulvestad 1987; (4) Fernini et al. 1991; (5) Pearson et al. 1985; (6) Spence et al. 1989; (7) Ulvestad et al. 1983; (8) Downes et al. 1986; (9) van Breugel et al. 1984; (10) Owen & Puschell 1984; (11) Saikia et al. 1990; (12) O'Dea et al. 1988; (13) Kollgard et al. 1990; (14) Saikia et al. 1989.

In most cases our 6 cm image does not contain the extended structure in the HUO 20 cm image. We also describe when the revised images produced by J. Ulvestad (1987, private communication) differ dramatically from those shown in HUO.

First, a few sources require comments that do not fit into either of these categories:

0222−008: The 20 cm image is not presented since the bandwidth smearing effects were severe, as the Hewitt & Burbidge (1980) position was $\sim 5'$ off in right ascension.

0336−019: The 6 cm image is not presented because of problems with the data, but we were able to obtain a 6 cm core flux.

1233+108: The 6 cm image was not presented since only an unresolved core and an unresolved hot spot in the southern lobe were detected.

1510−089: The 20 cm image of this variable source is from an earlier epoch than the 6 cm image (A. C. Gower & J. B. Hutchings 1992, private communication).

4.1. Radio Core Identification

0159−117: Based on the optical position, we assumed the southern of the two bright point sources to be the core. This

remains to be verified since the uncertainty in the optical position is probably comparable to the separation between the two radio components ($\sim 2''$).

0222−008: We did not detect a radio core in our 6 cm (bandwidth-smear) image and HUO do not give a position of the weak radio core in their 20 cm image.

0903+169: The radio core is the western point source in our image since it coincides with the optical position.

0937+391: We used the NW central component as the radio core, since it had a flatter spectral index than the SE central component.

1038+528: The point source to the northeast in both the 6 and 20 cm images is a background quasar with a redshift of 2.296 (Veron-Cetty & Veron 1985).

1335−061: The radio core is the bright, central component.

1352−203: No emission was detected at 6 cm, and the core position is estimated using the faint central bump that sits on the extended emission between the lobes in the 20 cm image.

1458+718: The radio core is at the peak of the 6 cm image.

1509+158: The radio core is the point source near the east lobe.

2349+327: We determined the core to be the southern of the two central sources based on its flat spectral index and spatial coincidence with the optical position.

4.2. HUO 20 cm Images

0114+074: The optical QSO coincides with the northern point source in HUO's image.

0159-117: Ulvestad's revised 20 cm image reveal a faint lobe south and east of the core, coincident with faint emission in our 6 cm image.

0903+169: Our 6 cm image covers only a small portion of the radio emission presented by HUO at 20 cm, which displays large north and south lobes.

0932+023: The HUO 20 cm image shows a large southwest lobe that is well outside the area displayed in our image.

1012+488: Very faint radio emission may be coincident with the optical quasar position in Ulvestad's revised 20 cm image. It is too weak to measure a radio core position.

1022+194: Ulvestad's image shows a core-halo type structure.

1047+096: Our 6 cm image does not display two unidentified point sources that are more than 300 kpc NW of the core. These sources were considered lobes by HUO, while we considered them unrelated to the quasar because of their compactness, flat spectral index, and distance from the core.

1104+167: We do not detect the large-scale structure seen in HUO, but suspect there is some low surface brightness emission since we have missed $\sim 40\%$ of the published total flux.

1222+216: The 20 cm HUO image displays a larger area which contains a faint southern lobe that we did not detect at 6 cm.

1725+107: A 20 cm image was not presented by HUO since the detected structure was only two unresolved sources. We identify the quasar with source "A" of HUO based on the Veron-Cetty & Veron (1985) optical position.

2112+172: The HUO structure more than $15''$ from the core is probably spurious, since it does not appear in the revised images of J. Ulvestad (1987, private communication).

2142+110: Ulvestad's revised 20 cm image shows a faint lobe $\sim 30''$ south of the core.

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REFERENCES

- Barthel, P. D. 1984, Ph.D. thesis, Leiden Univ.
 Barthel, P. D., Miley, G. K., Schilizzi, R. T., & Lonsdale, C. J. 1988, *A&AS*, 73, 515
 Dixon, R. S. 1970, *ApJS*, 20 (updated version [1985] available from author)
 Downes, A. J. B., Peacock, J. A., Savage, A., & Carrie, D. R. 1986, *MNRAS*, 218, 31
 Fernini, I., Leahy, J. P., Burns, J. O., & Basart, J. P. 1991, *ApJ*, 381, 63
 Gower, A. C., & Hutchings, J. B. 1984, *ApJ*, 89, 1658
 Helou, G., Madore, B. F., Schmitz, M., Bica, M. D., Wu, X., & Bennett, J. 1991, in *Databases & On-Line Data in Astronomy*, ed. M. A. Albrecht & D. Egret (Dordrecht; Kluwer), 89
 Hewitt, A., & Burbidge, G. 1980, *ApJS*, 43, 57
 Hintzen, P., Ulvestad, J., & Owen, F. 1983, *AJ*, 88, 709 (HUO)
 Hutchings, J. B., Price, R., & Gower, A. C. 1988, *ApJ*, 329, 122 (HPG)
 Kollgaard, R. I., Wardle, J. F. C., & Roberts, D. H. 1990, *AJ*, 100, 1057
 Machalski, J., & Maslowski, J. 1982, *AJ*, 87, 1132
 Neff, S. G. 1982, Ph.D. thesis, Univ. Virginia
 Neff, S. G., & Hutchings, J. B. 1991, *AJ*, 101, 434
 Neff, S. G., Hutchings, J. B., & Gower, A. C. 1989, *AJ*, 97, 1291
 O'Dea, C. P., Barvainis, R., & Challis, P. M. 1988, *AJ*, 96, 435
 Owen, F., & Puschell, J. J. 1984, *AJ*, 89, 932
 Pearson, T. J., Perley, R. A., & Readhead, A. C. S. 1985, *AJ*, 90, 738
 Rogora, A., Padriella, L., & de Ruiter, H. R. 1986, *A&AS*, 64, 557
 Saikia, D. J., Cornwell, T. J., & Muxlow, T. W. B. 1989, *J. Astrophys. Astron.*, 10, 203
 Saikia, D. J., Junor, W., Cornwell, T. J., Muxlow, T. W. B., & Shastri, P. 1990, *MNRAS*, 245, 408
 Spence, R. E., McDowell, J. C., Charlesworth, M., Fanti, C., Parma, P., & Peacock, J. A. 1989, *MNRAS*, 240, 657
 Swarup, G., Sinha, R. P., & Hildrup, K. 1984, *MNRAS*, 208, 813
 Ulvestad, J. S., Johnston, K. J., & Weiler, K. W. 1983, *ApJ*, 266, 18
 van Breugel, W., Miley, G., & Heckman, T. 1984, *AJ*, 89, 5
 Veron-Cetty, M. P., & Veron, P. 1985, ESO Scientific Report No. 4 (Garching; ESO)