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Interferometer phase calibration sources – I. The region $35° \leq \delta \leq 75°$

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SUMMARY

We present a catalogue of 800 compact radio sources in the declination range $35° \leq \delta \leq 75°$ whose positions have been measured to an rms accuracy of ~ 12 milliarcsec with the VLA. They are primarily intended for use as phase reference sources for the Jodrell Bank MERLIN but they will also be suitable phase calibrators for the VLA and the VLBI networks.

1 INTRODUCTION

Radio interferometers measure Fourier components of the source brightness distribution. Both the amplitude and the phase of a Fourier component give information about the source structure at a particular spatial frequency, but the phase also contains information about the position of the source. Unfortunately the observed phase is corrupted by unpredictable variations in the delay through the receiving equipment and by path length fluctuations in the atmosphere, both troposphere and ionosphere. The tropospheric phase fluctuations tend to be decorrelated above ~ 10 km but the ionospheric fluctuations are correlated beyond 1000 km and get worse with decreasing frequency. (For an introduction to these problems see Thompson, Moran & Swenson 1986.) Interferometers with baselines longer than a few kilometres are in general not phase stable, and useful images cannot be made simply by Fourier inverting the amplitude and phase data; equally the full astrometric potential of the array cannot be exploited. For the purpose of imaging sources the phase errors can be corrected by the process of 'self-calibration' (Schwab 1980; Cornwell & Wilkinson 1981) but in so doing the positional information in the observed phase is lost. Self-calibration can also only be used for sources which can be detected in a coherent integration time. Long-baseline arrays, such as MERLIN and the VLBI networks, are therefore constrained by the short coherent integration times (typically a few minutes in the frequency range 1.4 to 8.4 GHz) to observe relatively strong sources only. This seriously restricts the range of astronomical phenomena which they can study.

The other way to correct for the unpredictable phase variations is by 'external calibration' or 'phase referencing'. One observes a source with known position and structure, hence whose 'astronomical' phase is known, which lies sufficiently close to the target source that the atmospheric propagation delays to both sources are closely similar, i.e. they lie within the same isoplanatic patch. Hence there is spatial correlation between the phase variations in the 'target' and 'reference' source data. The observations of the two sources should also be made as closely as possible in time to ensure temporal correlation between the phase variations. Although a point source is ideal, the reference source can be imaged using self-calibration and the phase contributions due to its structure readily eliminated from the phase-referenced data. Phase referencing offers two great advantages over self-calibration: not only can weaker target sources be imaged, as the effective coherence time is increased from minutes to hours, but the position of the target source can be measured accurately relative to the reference source – this will be of increasing importance in the *HIPPARCOS* and *HST* era.

Phase referencing is a long-established technique, currently most widely exploited at the VLA. The VLA baselines are relatively short (compared with those of MERLIN and VLBI) and phase referencing is relatively easy in the frequency range 1.4 to 8.4 GHz. Spatial correlation is satisfactory for target-reference source distances of $\sim 10°$ and temporal correlation can be achieved with observations of the reference source every ~ 30 min. We wish to extend the phase-referencing technique to MERLIN, whose maximum baselines are about six times those of the VLA in its largest 'A' configuration. Especially at frequencies near 1.4 GHz the isoplanatic patch is smaller and the phase variations are more rapid than is typical with the VLA. One therefore needs to have a much denser grid of reference sources and to calibrate the phase more frequently. In this paper we describe a set of VLA observations which have enabled us to produce a suitable grid of reference sources in region $35° \leq \delta \leq 75°$. They will be useful for phase calibration with the VLA and the VLBI networks as well as MERLIN.

2 PHASE-REFERENCING REQUIREMENTS FOR MERLIN

Experience with MERLIN operating at 1.7 GHz indicates that, in the majority of circumstances, successful phase-referencing observations are possible if there is a suitable reference source within ~ 3° of the target and the cycle time between reference and target is ≤ 7 min. The small cycle time imposes a restriction on the strength of the reference source: for a good measurement of phase the signal-to-noise ratio must be of order 10 or more in a coherence integration time. Sources with correlated flux densities of > 50 mJy are sufficiently strong for MERLIN purposes. Other requirements for phase calibrators are that their structures should be simple, so that if necessary the structure phase can easily be recovered, and that their positions should be known to a fraction of the minimum lobe-spacing (0.07 arcsec at 5 GHz; 0.17 arcsec at 1.7 GHz). This positional requirement enables MERLIN images to be located on the sky to better than a beam diameter and also leads to very little smearing of the image of the target source (Morabito 1984). (Approximately, for reference source and target source separated by n radian, a smearing of $n\Delta\theta$ takes place where $\Delta\theta$ is the reference source position error.) One can, therefore, summarize the desirable characteristics of a phase-reference source for MERLIN as follows.

(1) It should lie within ~ 3° of the target source.
(2) It should produce ≥ 50 mJy correlated flux density on all baselines at all times and be a point or point-dominated source.
(3) Its position should be known to ≤ 0.02 arcsec.

Existing catalogues of calibrators are the VLA list (Perley 1990), containing 700 sources spread over the declination range −40° to +90°, and the VLBI catalogue (Ma *et al.* 1990) which has 182 sources with positions accurate to ~ 1 milliarcsec spread over the declination range $\delta \geq -30°$. The surface density of sources in these catalogues is not adequate for our purpose and we have therefore embarked on the production of our own catalogue.

3 THE INITIAL SOURCE LIST

To generate a denser grid of potential phase-calibration sources we started with the assumption that sources with flat radio spectra have structures dominated by milliarcsec cores. With this in mind we selected a sample of flat-spectrum sources in the declination range $0° \leq \delta \leq 75°$ using the Green Bank surveys conducted at 1.4 and 5 GHz by Condon & Broderick (1985, 1986) and Condon, Broderick & Seielstad (1989). From tape copies of the surveys, generously provided by Dr Condon in advance of publication, we produced a list of sources with positions and flux densities at both frequencies using the software package DAOPHOT implemented in STARLINK. For each source we calculated the two-point spectral index from 1.4 to 5 GHz and selected all those objects with spectral indices larger than $\alpha = -0.5$ (α defined as $S_\nu \propto \nu^\alpha$), i.e. with flatter spectra. To obtain the required surface density of sources we set a flux density limit of 200 mJy at 5 GHz. The positions we obtain at 5 GHz from the Green Bank survey are accurate to about 30 arcsec rms.

Our ultimate aim is to derive a catalogue of phase calibrators over most of the sky visible to MERLIN, i.e. north of $\delta = -30°$. This is an ambitious programme. As a first step, we decided to observe sources in the region $35° \leq \delta \leq 75°$ and only later to observe the other areas of the sky. We are limited by confusion from galactic emission as to how close to the plane we can reliably select flat-spectrum sources from the Green Bank surveys; for this reason we excluded the region $|b| < 2.5°$ from consideration. Our initial list contained 902 sources satisfying the following criteria:

(1) $S_{5\,\mathrm{GHz}} \geq 200$ mJy;
(2) $\alpha \geq -0.5$;
(3) $|b| \geq 2.5°$; and
(4) $35° \leq \delta \leq 75°$.

We plotted the distribution of these sources in the sky and noted that there were undesirably large holes (~ 5°) in some areas. To fill in these holes we selected a further 33 sources with $S_{5\,\mathrm{GHz}} \geq 150$ mJy.

4 OBSERVATIONS AND DATA REDUCTION

4.1 The observing strategy

The VLA is the natural instrument to use to measure accurate positions for a large number of sources in a relatively short time. Single 'snapshot' observations also yield useful structural information which enables us to reject some sources as unsuitable calibrators. This is particularly valuable as our separation into sources with flat and steep radio spectra using just the 1.4- and 5-GHz flux densities is not very reliable. We expected (and found) a significant contamination of resolved steep-spectrum objects in our initial sample.

The observations were carried out in three sessions between 1990 February 19 and 23. This is the optimum time of year for good phase stability with the VLA (Sramek 1990). During our observations, 23 telescopes were available. The total observing time was 60.5 hr.

We selected 8.4 GHz as our observing frequency, as here the VLA is at its most sensitive. The 'A' configuration was chosen both to give the resolution (typically 200 milliarcsec) which is similar to that of MERLIN at 1.7 GHz, and because the longer baselines should result in a higher astrometric accuracy. Because the initial positions for our candidate reference sources derived from the Green Bank surveys were only accurate to ~ 30 arcsec rms, we restricted the observing bandwidth to 25 MHz in order to avoid excessive bandwidth smearing of sources with large initial position errors. The flux density scale was calibrated by observing 1328+307 (3C286). Another calibrator, either 0316+413 (3C84) or 1611+343, was observed in five different hour angles to determine the instrumental polarization.

In order to achieve high positional accuracy for the new grid of sources, we decided to calibrate the phases using only sources whose positions have been measured to milliarcsec accuracy by VLBI. The main catalogue is that of Ma *et al.* (1990) while a list of additional sources (unpublished) was kindly provided by Dr J. Russell. These positions form a reference frame with an internal accuracy of ~ 1 milliarcsec and have been derived from extensive series of VLBI observations over many years. There are about 80 of these primary calibration sources in the declination range $30° \leq \delta \leq 80°$, and they are adequately spaced for phase-reference observations with the VLA; it is seldom necessary to drive more than 12° from any target to reach a calibrator. The list of primary calibrators used in our observations is given in Table 1 and their positions in Table 2 described

Table 1. List of calibrators used in the VLA survey. Positions are given in Table 2.

0016+731	0716+714	1030+415	1642+690	2200+420
0026+346	0749+540	1031+567	1732+389	2253+417
0133+476	0804+499	1039+811	1738+476	2352+495
0159+723	0812+367	1144+402	1739+522	
0202+319	0814+425	1150+812	1749+701	
0224+671	0820+560	1216+487	1807+698	
0300+470	0828+493	1357+769	1823+568	
0316+413	0833+585	1418+546	1842+681	
0333+321	0836+710	1435+638	1954+513	
0355+508	0859+470	1448+762	2005+403	
0552+398	0917+624	1504+377	2017+745	
0609+607	0917+449	1611+343	2021+614	
0642+449	0923+392	1633+382	2030+547	
0707+476	0954+658	1637+574	2037+511	
0711+356	1020+400	1641+399	2051+745	

later. We used J2000.0 coordinates throughout the observations and analyses.

All sources, including calibrators, were scheduled in 2-min scans or snapshots. Only one snapshot per source was taken; allowing for telescope drive time this gives about 1 to 1.5 min of integration time on each source. To minimize the phase errors arising from temporal changes in the atmospheric phase paths, we observed the same calibration source before and after pairs of target sources, thus the time between repeat observations of the calibrator was about 6 min. All the observations were made within ± 2 hr of meridian transit.

In order to establish the reliability and accuracy of the positions obtained we made a series of test and repeat measurements, as follows.

(1) We made observations of sources with known VLBI positions treating them identically to other targets.

(2) We observed a group of sources around 16 hr RA on two separate days to test the internal consistency of our results on typical target sources.

(3) We re-observed a 2-hr section of our first day's observations made during a snow storm which degraded the phase stability of the array. Observations of the affected sources were repeated on the last day when the weather was calm and clear, and the results from the two days enable us to compare our astrometric accuracy in two extremes of observing conditions.

(4) We observed one primary calibrator with different position offsets from the phase centre to determine the positional errors which arise due to bandwidth smearing.

4.2 The data reduction

The data were calibrated and reduced entirely within the NRAO AIPS software package. We used the antenna positions supplied by the VLA staff and made no additional corrections to the phases before applying the standard calibration procedures. The polarization calibration was then performed using the standard AIPS procedure. To analyse the data from such a large number of sources we employed an automatic procedure. First we located the target source, whose initial position is known only to ~ 30 arcsec, by making a large map (field of view 82 arcsec) from the externally calibrated data. We obtained the source position from this map by fitting a quadratic to the brightest component in the field using the AIPS program MAXFIT. In order to determine the source structure as well as possible, we then self-calibrated

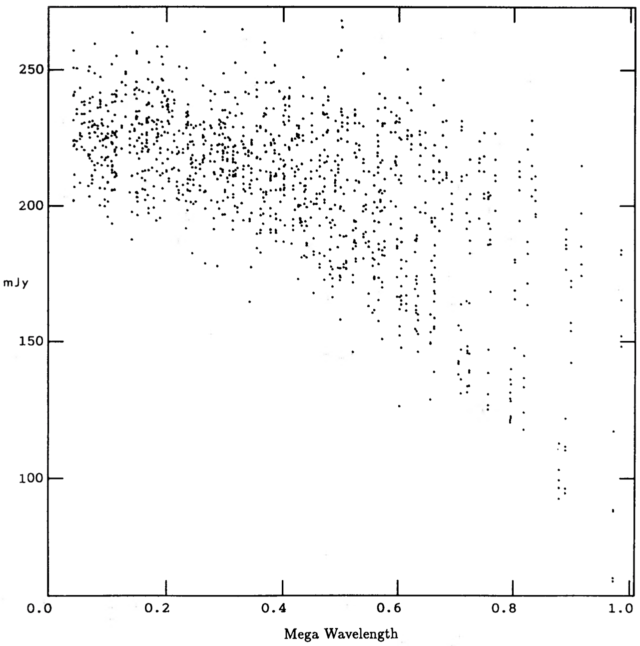

Figure 1. The observed visibility plotted against baseline length showing the effect of bandwidth smearing for a source offset by 55 arcsec from the phase centre.

the data: we made a second, smaller, map (field of view 20.5 arcsec) after shifting the map centre to the brightest peak of the source and performed two iterations of self-calibration, correcting only the phase. We then measured flux densities and rms noise levels from the final CLEAN map. We stress that our quoted positions in Table 2 were obtained from the data before self-calibration.

This automatic procedure did not always produce the desired results, usually when the position used for pointing the VLA was >40 arcsec in RA or Dec. from the true position, in which case the source fell outside the area of the first large map; the brightest peak in this map was then a sidelobe. To pick up such cases and to look for any other problems, e.g. confusion from a nearby source, we carried out careful checks on the data from each source, as described below.

(1) We checked that the observed visibilities were consistent with the peak and total flux densities in the map and with the structure of the source.

(2) We looked particularly carefully at sources for which the plot of visibility against baseline length resembled that shown in Fig. 1. In this example the initially assumed position of the source was 55 arcsec from the true position. The decrease in mean visibility and the splitting seen at large *uv* distances arises from delay decorrelation on those baselines whose position angles are not orthogonal to the position angle of the 'offset vector' from the true position. Note, however, that similar splitting in visibilities can arise from genuine structure (e.g. core–jet) if the source is close to the phase centre. All such cases had, therefore, to be investigated individually. If we suspected that a problem existed we applied a taper to the data and made a larger map (field of view 123 arcsec) to check if we had missed the real source in our first map.

5 RESULTS AND DISCUSSION

The positions and the flux densities of the new phase calibration sources found from our observations are given in Table 2. The columns are organized as follows.

Col. 1. Source name derived from B1950, coordinates.
Col. 2. Source name derived from J2000, coordinates.
Col. 3. Right ascension (hr, min, s) in J2000.
Col. 4. Declination (deg, min, s) in J2000.
Col. 5. Total flux density in mJy at 8.4 GHz.
Col. 6. Structure code. P: primary calibrators with >95 per cent of their flux density contained in an unresolved component, S: secondary calibrators up to 20 per cent resolved on the longest baselines but with point-dominated structure, D: double source.
Col. 7. Comments about the structure. EXT: extension, SEC: secondary component, PA: position angle in degrees with separation in arcsec, VLBI: positions from the VLBI catalogue of Ma *et al.* (1990), MAP: map presented in this paper (see Fig. 2).

All the sources in Table 2 are suitable for phase calibration with MERLIN and the VLA, though the secondary (S) sources are slightly resolved in the sense that the visibility amplitude on the longest baseline (~ 1 Mλ) may be up to 20

Table 2. List of phase calibrators.

1 Source name B1950.	2 J2000.	3 R.A. h m s	4 Dec. ° ' "	5 Flux Density (mJy)	6 Code	7 Comments on structure
0001+478	0003+481	00 03 46.04126	48 07 4.1337	75	P	
0001+459	0004+462	00 04 16.12934	46 15 17.9680	220	P	
0002+541	0005+544	00 05 4.36292	54 28 24.9382	391	P	
0003+380	0005+383	00 05 57.17550	38 20 15.1685	1157	P	
0005+568	0007+571	00 07 48.47107	57 06 10.4542	127	P	
0005+683	0008+686	00 08 33.47570	68 37 22.0485	93	S	WEAK EXT PA 40
0006+397	0009+400	00 09 4.17497	40 01 46.7245	247	S	EXT PA -25
0008+704	0011+707	00 11 31.90189	70 45 31.6545	661	P	
0010+463	0013+466	00 13 16.48961	46 36 8.6816	258	P	
0010+405	0013+408	00 13 31.13114	40 51 37.1480	550	S	WEAK SEC PA -25, 1"
0015+529	0017+532	00 17 51.75964	53 12 19.1255	644	P	
0016+731	0019+734	00 19 45.78710	73 27 30.0190	1364	P	VLBI
0018+428	0020+430	00 20 49.97982	43 04 38.3286	125	P	
0018+715	0021+718	00 21 2.81860	71 50 20.7863	224	P	
0018+729	0021+732	00 21 27.37784	73 12 41.9283	196	P	
0019+451	0022+454	00 22 6.61110	45 25 33.8458	298	P	
0020+446	0023+449	00 23 35.44097	44 56 35.7686	232	P	
0021+464	0024+467	00 24 21.53870	46 44 6.2355	194	S	WEAK EXT PA 165
0022+390	0025+393	00 25 26.15705	39 19 35.4466	456	P	
0024+596	0027+599	00 27 3.29104	59 58 52.9831	194	P	
0027+703	0030+706	00 30 14.41644	70 37 40.0416	430	P	WEAK EXT PA -120
0027+587	0030+590	00 30 43.45536	59 04 19.7303	132	P	
0035+413	0038+416	00 38 24.84498	41 37 6.0046	985	P	
0035+503	0038+505	00 38 28.41356	50 35 25.8225	232	S	TRIPLE PA -80,8"
0037+487	0039+490	00 39 46.99948	49 00 33.1804	262	P	
0039+568	0042+571	00 42 19.45224	57 08 36.5829	830	P	
0042+456	0045+459	00 45 0.03509	45 55 15.2693	95	S	WEAK EXT PA 165
0044+387	0046+390	00 46 47.57892	39 00 47.1485	215	P	
0044+566	0047+569	00 47 0.43138	56 57 42.3925	467	P	
0046+511	0049+514	00 49 37.99007	51 28 13.7002	218	P	
0048+447	0051+449	00 51 36.47640	44 59 35.9736	245	P	
0049+437	0052+440	00 52 27.82855	44 02 54.5142	206	P	
0051+706	0054+708	00 54 17.68844	70 53 56.6246	288	P	
0051+679	0054+681	00 54 17.62372	68 11 11.1752	272	P	
0057+678	0100+681	01 00 51.66449	68 08 20.5466	856	P	
0058+498	0101+500	01 01 16.99876	50 04 44.9914	127	P	
0059+581	0102+584	01 02 45.76299	58 24 11.1392	1399	P	
0102+511	0105+514	01 05 29.55877	51 25 46.5763	112	P	
0102+480	0105+483	01 05 49.92953	48 19 3.1829	741	P	
0106+678	0110+680	01 10 12.86977	68 05 41.2197	524	S	
0108+388	0111+391	01 11 37.31921	39 06 28.0852	830	P	
0108+433	0111+435	01 11 37.61514	43 35 31.4633	84	S	
0109+351	0112+353	01 12 12.94503	35 22 19.2954	402	S	WEAK EXT
0110+495	0113+498	01 13 27.00695	49 48 24.0572	499	S	WEAK EXT PA 55
0121+560	0124+563	01 24 25.82647	56 18 51.9134	352	P	
0122+470	0125+473	01 25 7.70700	47 18 3.0889	138	P	
0122+705	0126+707	01 26 7.84546	70 46 52.3797	121	P	
0123+731	0127+733	01 27 4.71690	73 23 12.6755	153	P	
0125+487	0128+490	01 28 8.06468	49 01 5.9766	363	P	
0129+560	0132+563	01 32 20.45034	56 20 40.3721	406	P	
0129+431	0132+434	01 32 44.12727	43 25 32.6667	235	P	
0131+691	0134+694	01 34 40.76180	69 25 10.8960	193	P	
0133+476	0136+478	01 36 58.59530	47 51 29.1020	1699	P	VLBI
0137+467	0140+469	01 40 43.07341	46 58 28.4970	140	P	
0140+412	0143+414	01 43 3.18361	41 29 20.4367	247	P	
0140+490	0143+492	01 43 46.87905	49 15 41.5860	113	P	
0141+579	0145+581	01 45 14.29933	58 10 49.7830	143	P	
0144+584	0147+586	01 47 46.54378	58 40 44.9748	136	S	
0144+487	0147+489	01 47 37.77592	48 59 37.5052	161	S	MAP
0145+386	0148+389	01 48 24.37679	38 54 5.2227	343	P	

Table 2 – *continued*

0148+546	0151+549	01 51 36.28759	54 54 37.6884	137	P	
0149+370	0152+372	01 52 12.22113	37 16 5.6763	268	P	
0149+710	0153+712	01 53 25.85172	71 15 6.4758	414	S	JET PA -90
0151+474	0154+477	01 54 56.29019	47 43 26.5392	690	P	
0153+744	0157+747	01 57 34.96658	74 42 43.2463	910	P	
0153+389	0156+392	01 56 31.40881	39 14 30.9289	175	P	
0159+723	0203+725	02 03 33.38570	72 32 53.6670	276	P	VLBI
0159+418	0202+420	02 02 43.65401	42 05 16.3423	406	P	
0200+539	0203+541	02 03 46.65936	54 11 57.6277	303	P	
0201+438	0204+440	02 04 54.78644	44 03 6.9206	250	P	
0201+365	0204+368	02 04 55.59586	36 49 18.0007	263	P	
0210+515	0214+517	02 14 17.93188	51 44 51.9674	168	P	
0212+735	0217+738	02 17 30.81724	73 49 32.6181	2261	P	
0213+444	0216+446	02 16 17.17074	44 37 43.4050	155	P	
0224+671	0228+673	02 28 50.05220	67 21 3.0238	1774	P	VLBI
0227+403	0230+405	02 30 45.70679	40 32 53.0870	578	P	
0233+359	0236+362	02 36 38.28272	36 12 40.2577	147	P	
0238+711	0243+713	02 43 30.89108	71 20 17.9026	166	S	WEAK EXT PA -85
0248+430	0251+432	02 51 34.53719	43 15 15.8327	1196	P	
0249+383	0253+385	02 53 8.88698	38 35 24.9867	454	S	WEAK EXT PA 50
0250+508	0253+510	02 53 57.60831	51 02 56.4950	286	P	
0251+393	0254+395	02 54 42.63160	39 31 34.7140	367	P	
0252+657	0257+659	02 57 1.34284	65 56 35.4204	243	P	
0254+434	0257+436	02 57 59.07693	43 38 37.6777	128	P	
0256+424	0259+426	02 59 38.38223	42 36 43.1192	320	S	
0258+533	0302+535	03 02 22.73541	53 31 46.5343	364	P	
0259+681	0304+683	03 04 22.00693	68 21 37.4632	742	S	WEAK EXT PA -130
0300+470	0303+472	03 03 35.24270	47 16 16.2750	2058	P	VLBI
0302+625	0306+627	03 06 42.66109	62 43 2.0222	270	P	
0303+697	0308+699	03 08 27.82758	69 55 58.9001	212	P	
0307+380	0310+382	03 10 49.88050	38 14 53.8452	453	P	
0309+411	0313+413	03 13 1.96146	41 20 1.1903	673	S	WEAK EXT PA -70
0310+372	0313+374	03 13 36.27074	37 25 24.1057	177	P	
0310+435	0314+437	03 14 8.05390	43 45 19.7705	129	P	
0314+696	0319+698	03 19 22.07340	69 49 25.6034	159	P	
0316+413	0319+415	03 19 48.16050	41 30 42.1030	33643	P	VLBI
0317+659	0322+661	03 22 27.23103	66 10 28.2979	275	P	
0318+438	0321+439	03 21 36.87080	43 59 22.4808	339	S	EXT PA 125
0321+467	0325+469	03 25 20.30426	46 55 6.6727	360	P	
0325+395	0328+396	03 28 50.31276	39 40 44.5585	240	S	MAP
0327+467	0330+469	03 30 32.62811	46 56 23.3210	161	S	WEAK EXT PA 10
0327+364	0330+366	03 30 34.76550	36 39 41.0339	219	P	
0328+677	0332+678	03 32 59.52412	67 53 3.8602	146	P	
0329+654	0333+656	03 33 56.74161	65 36 56.1789	120	S	EXT PA 90
0334+390	0337+392	03 37 59.61354	39 14 31.0486	141	P	
0335+599	0339+601	03 39 9.39416	60 08 56.9597	179	P	
0336+473	0340+475	03 40 10.78970	47 32 27.3276	169	P	
0338+480	0342+481	03 42 10.35224	48 09 46.9481	169	P	
0339+651	0344+653	03 44 32.63950	65 18 10.3836	172	P	
0340+362	0343+363	03 43 28.95271	36 22 12.4404	620	P	
0345+460	0349+461	03 49 18.74250	46 09 59.6621	844	P	
0349+662	0354+663	03 54 3.70096	66 21 26.1119	175	P	
0350+465	0354+467	03 54 30.01294	46 43 18.7537	704	P	
0351+389	0355+391	03 55 16.59120	39 09 9.8242	124	S	WEAK EXT PA 45
0352+605	0356+607	03 56 25.19960	60 43 57.9716	265	P	
0354+599	0359+600	03 59 2.64130	60 05 22.0500	834	P	
0355+508	0359+509	03 59 29.74775	50 57 50.1610	2404	P	VLBI
0402+379	0405+380	04 05 49.26348	38 03 32.2371	653	S	JET PA 20
0402+682	0407+683	04 07 49.16668	68 21 31.6257	227	P	
0412+447	0415+448	04 15 56.52464	44 52 49.6764	295	P	
0414+548	0418+549	04 18 19.34051	54 57 15.3274	243	S	WEAK EXT PA 115
0415+572	0419+573	04 19 19.41291	57 22 59.9769	408	S	WEAK EXT PA -125
0415+398	0419+399	04 19 22.55018	39 55 28.9766	640	P	
0416+387	0420+388	04 20 13.58588	38 49 43.0439	133	P	
0418+437	0421+438	04 21 52.06187	43 53 4.2161	128	P	
0418+532	0422+534	04 22 44.40044	53 24 26.2395	561	P	
0420+417	0423+418	04 23 56.01039	41 50 2.7020	1153	P	
0421+683	0426+684	04 26 50.06535	68 25 52.9554	166	S	JET PA -120
0424+670	0429+671	04 29 6.02175	67 10 16.5605	221	S	WEAK EXT PA -80
0424+414	0427+415	04 27 46.04549	41 33 1.0910	647	P	
0429+415	0432+416	04 32 36.50436	41 38 28.4328	2625	S	
0436+426	0440+427	04 40 7.87198	42 44 40.2509	260	S	WEAK EXT PA -10
0442+389	0446+390	04 46 11.49337	39 00 17.1064	495	P	
0443+592	0448+593	04 48 20.48381	59 21 49.8062	114	P	
0444+634	0449+635	04 49 23.30971	63 32 9.4532	467	P	
0445+364	0448+364	04 48 35.16078	36 29 31.4209	263	P	
0454+550	0458+551	04 58 54.84169	55 08 42.0423	236	P	
0500+640	0505+641	05 05 40.93595	64 06 26.3155	115	P	
0503+466	0507+467	05 07 23.65796	46 45 42.3486	422	S	WEAK EXT PA 110
0505+354	0509+354	05 09 5.84508	35 28 17.2891	215	P	
0510+559	0514+560	05 14 18.69971	56 02 11.0580	309	S	MAP
0513+714	0519+715	05 19 28.88345	71 33 3.7403	100	P	
0513+455	0517+456	05 17 28.89939	45 37 4.8714	555	S	
0514+474	0518+475	05 18 12.08986	47 30 55.5360	403	P	
0518+705	0524+705	05 24 13.43335	70 34 52.9191	170	P	WEAK SEC PA -70

Table 2 – *continued*

0520+411	0523+412	05 23 55.78017	41 13 50.8117	242	P	
0529+483	0533+483	05 33 15.86584	48 22 52.8071	544	P	
0530+421	0533+421	05 33 56.48446	42 10 54.4201	263	S	EXT PA -90
0532+391	0535+391	05 35 55.11803	39 10 58.3971	154	P	
0532+506	0536+506	05 36 20.23181	50 38 26.2546	909	S	
0533+446	0537+446	05 37 30.06295	44 41 3.5332	155	P	
0535+677	0541+677	05 41 13.39852	67 45 23.2853	153	P	
0537+531	0541+532	05 41 16.17329	53 12 24.8379	747	P	
0537+392	0540+392	05 40 44.43773	39 16 12.2362	89	P	
0538+474	0541+474	05 41 49.24487	47 29 7.6028	675	S	MAP
0540+456	0544+456	05 44 1.16610	45 41 2.7795	129	P	
0540+529	0544+529	05 44 14.07480	52 58 6.5137	199	P	
0548+378	0552+379	05 52 17.93797	37 54 25.2821	492	S	WEAK EXT PA 125
0548+689	0554+689	05 54 0.80720	68 57 54.4506	150	P	
0549+431	0553+431	05 53 26.06364	43 09 5.2231	88	P	
0550+356	0554+356	05 54 9.52961	35 41 31.4069	176	P	
0552+398	0555+398	05 55 30.80600	39 48 49.1630	6984	P	VLBI
0554+580	0559+580	05 59 13.39407	58 04 3.4432	501	P	
0555+378	0559+378	05 59 0.45269	37 49 55.5171	224	P	
0559+422	0602+422	06 02 58.94381	42 12 9.9993	277	P	
0600+442	0604+442	06 04 35.62972	44 13 58.5460	439	P	
0601+578	0605+578	06 05 42.22752	57 53 16.3513	108	P	
0602+405	0605+405	06 05 50.85587	40 30 8.1025	776	S	WEAK EXT PA -135
0602+673	0607+673	06 07 52.67197	67 20 55.4166	588	P	
0603+476	0607+476	06 07 23.25420	47 39 46.9550	407	P	
0604+728	0610+728	06 10 48.86913	72 48 53.1885	391	P	
0607+624	0612+624	06 12 10.32594	62 25 34.0160	84	P	
0609+413	0612+413	06 12 51.18558	41 22 37.3979	234	P	
0609+607	0614+607	06 14 23.86660	60 46 21.7540	750	P	VLBI
0610+510	0614+510	06 14 49.15890	51 02 13.1236	164	P	
0611+483	0615+483	06 15 4.05295	48 19 4.7388	241	P	
0612+570	0617+570	06 17 16.92290	57 01 16.4162	311	P	
0613+368	0616+368	06 16 50.65955	36 51 48.6503	92	P	
0618+588	0623+588	06 23 21.77907	58 49 1.8688	240	P	
0620+385	0623+385	06 23 28.94031	38 30 49.8032	187	P	
0620+459	0623+459	06 23 56.51064	45 54 39.5061	161	P	
0620+389	0624+389	06 24 19.02193	38 56 48.7245	633	S	WEAK SEC PA 0
0621+446	0625+446	06 25 18.26517	44 40 1.6284	183	P	
0627+532	0631+531	06 31 34.68599	53 11 27.7537	312	P	
0629+362	0633+362	06 33 14.70324	36 12 7.0182	133	P	
0630+497	0633+497	06 33 52.20678	49 43 45.9385	150	P	
0630+367	0633+367	06 33 34.41199	36 42 49.7352	149	P	
0632+502	0636+501	06 36 11.01792	50 09 59.6320	248	P	
0632+435	0635+435	06 35 56.28129	43 33 12.9108	140	P	
0633+734	0639+734	06 39 21.96228	73 24 58.0503	772	S	WEAK SEC PA -35,3"
0633+596	0638+595	06 38 2.87300	59 33 22.2075	553	P	
0635+351	0639+351	06 39 9.58868	35 06 22.5427	162	S	EXT PA -100
0636+680	0642+679	06 42 4.25682	67 58 35.6258	436	P	
0638+528	0642+527	06 42 27.82149	52 47 59.2824	156	P	
0639+352	0642+351	06 42 58.14017	35 09 18.3876	191	P	
0641+393	0644+392	06 44 53.71000	39 14 47.5407	616	P	WEAK EXT ? PA 30
0642+449	0646+448	06 46 32.02630	44 51 16.5890	2184	P	VLBI
0643+548	0647+547	06 47 16.04637	54 46 12.7534	139	S	WEAK SEC PA -65,3.2"
0644+491	0648+491	06 48 47.11904	49 07 20.7357	153	P	
0646+600	0650+600	06 50 31.25557	60 01 44.5466	753	P	
0650+371	0653+370	06 53 58.28274	37 05 40.6112	972	P	
0650+453	0654+452	06 54 23.71370	45 14 23.5410	372	P	
0651+428	0654+427	06 54 43.52629	42 47 58.7276	149	P	
0651+410	0655+410	06 55 10.02429	41 00 10.1479	373	P	
0652+426	0656+426	06 56 10.66286	42 37 2.7512	134	S	JET PA 35
0652+577	0657+576	06 57 12.50268	57 41 56.7395	142	P	
0655+696	0701+696	07 01 6.61591	69 36 29.4136	253	P	
0700+470	0704+470	07 04 9.55875	47 00 56.0405	335	P	
0702+612	0707+611	07 07 0.61645	61 10 11.5875	235	P	WEAK EXT PA 70
0705+377	0709+376	07 09 9.22231	37 37 53.1716	182	P	
0707+476	0710+475	07 10 46.10520	47 32 11.1420	609	P	VLBI
0707+424	0710+423	07 10 44.32692	42 20 55.0451	208	P	
0708+742	0714+741	07 14 36.12361	74 08 10.1422	137	P	
0709+509	0713+508	07 13 12.89619	50 53 43.9049	111	P	
0710+439	0713+438	07 13 38.16418	43 49 17.1994	1192	P	
0711+356	0714+355	07 14 24.81800	35 34 39.7920	592	P	VLBI
0713+669	0718+668	07 18 5.63143	66 51 53.3316	97	P	
0714+457	0717+456	07 17 51.85314	45 38 3.2521	569	P	
0716+714	0721+713	07 21 53.44880	71 20 36.3630	581	P	VLBI
0716+477	0720+476	07 20 21.49866	47 37 44.1132	247	P	
0718+374	0722+373	07 22 1.25998	37 22 28.6279	234	P	
0723+488	0727+487	07 27 3.10169	48 44 10.1149	269	S	WEAK EXT PA 5
0724+571	0728+570	07 28 49.63210	57 01 24.3667	632	P	
0727+409	0730+408	07 30 51.34725	40 49 50.8263	377	P	
0729+562	0733+560	07 33 28.61493	56 05 41.7344	116	P	
0730+504	0733+503	07 33 52.52117	50 22 9.0511	730	P	
0731+479	0735+478	07 35 2.31207	47 50 8.4202	450	P	
0732+755	0739+754	07 39 13.19623	75 27 47.7019	122	P	
0733+597	0737+596	07 37 30.08713	59 41 3.1948	235	P	
0733+646	0737+645	07 37 58.97973	64 30 43.3543	242	P	

Table 2 – *continued*

0735+674	0740+673	07 40 53.39840	67 19 8.2271	199	S	EXT PA 170
0738+491	0742+490	07 42 2.75080	49 00 15.6021	483	P	
0738+548	0742+547	07 42 39.79251	54 44 24.6626	138	P	
0739+398	0743+396	07 43 9.88664	39 41 30.7813	327	P	WEAK SEC PA -170,2"
0743+744	0749+743	07 49 22.45732	74 20 41.5949	394	P	
0745+579	0749+578	07 49 56.95355	57 50 15.3110	148	S	WEAK SEC PA 25,0.5"
0746+503	0750+502	07 50 8.34322	50 15 6.8053	197	P	
0746+483	0750+482	07 50 20.43759	48 14 53.5603	730	P	
0748+582	0752+581	07 52 9.67917	58 08 52.2564	285	P	
0749+540	0753+538	07 53 1.38500	53 52 59.6370	1162	P	VLBI
0749+718	0754+716	07 54 45.50108	71 40 56.7414	198	S	EXT -10, WEAK EXT 135
0749+376	0752+375	07 52 40.90801	37 30 24.3082	218	P	
0749+426	0753+425	07 53 3.33778	42 31 30.7631	280	P	
0750+535	0754+534	07 54 15.21766	53 24 56.4499	138	P	
0751+485	0754+483	07 54 45.67184	48 23 50.7467	187	P	
0752+639	0756+637	07 56 54.61130	63 47 59.0329	258	P	
0753+519	0756+518	07 56 59.54571	51 51 0.2370	113	P	
0753+373	0756+372	07 56 28.25133	37 14 55.6474	125	P	
0753+613	0757+611	07 57 44.69329	61 10 32.7642	123	P	
0758+594	0802+593	08 02 24.59315	59 21 34.8000	144	P	
0759+642	0803+640	08 03 52.15946	64 03 14.3636	202	P	
0802+733	0808+732	08 08 16.49176	73 15 11.9802	310	P	
0803+452	0806+450	08 06 33.47197	45 04 32.2740	423	P	
0803+514	0807+512	08 07 1.01457	51 17 38.6721	347	P	
0804+499	0808+498	08 08 39.66670	49 50 36.5280	853	P	VLBI
0805+410	0808+408	08 08 56.65180	40 52 44.8789	1161	P	
0805+538	0809+536	08 09 41.73240	53 41 25.0927	184	P	
0806+350	0809+349	08 09 38.88712	34 55 37.2563	147	S	WEAK EXT PA 145
0806+573	0811+572	08 11 0.60937	57 14 12.4939	348	P	WEAK SEC PA -120,2.3"
0807+417	0810+415	08 10 58.99286	41 34 2.8023	273	P	
0810+646	0814+645	08 14 39.19048	64 31 22.0286	213	P	
0812+367	0815+365	08 15 25.94520	36 35 15.1470	850	P	VLBI
0814+425	0818+423	08 18 16.00000	42 22 45.4120	1021	P	VLBI
0819+408	0822+406	08 22 57.55636	40 41 49.7665	274	P	
0820+560	0824+558	08 24 47.23660	55 52 42.6680	1629	P	VLBI
0821+621	0825+619	08 25 38.61209	61 57 28.5773	608	P	
0824+524	0827+522	08 27 53.69859	52 17 58.2869	188	P	
0824+355	0827+354	08 27 38.58906	35 25 5.0807	657	S	EXT PA 90
0828+493	0832+492	08 32 23.21710	49 13 21.0360	272	P	VLBI
0830+605	0834+603	08 34 17.54642	60 19 47.0680	339	P	
0830+425	0833+424	08 33 53.88502	42 24 1.8494	553	P	
0831+557	0834+555	08 34 54.90264	55 34 21.0855	3242	S	EXT PA -35
0833+416	0836+414	08 36 36.89322	41 25 54.7062	279	S	WEAK EXT PA -5
0833+585	0837+584	08 37 22.41000	58 25 1.8439	497	P	VLBI
0836+710	0841+708	08 41 24.36570	70 53 42.1720	1717	P	VLBI
0836+426	0839+424	08 39 56.56208	42 27 55.8229	206	S	EXT PA 40
0839+687	0843+685	08 43 49.10224	68 33 17.1577	260	P	
0839+458	0843+456	08 43 7.09556	45 37 42.8878	135	P	
0840+424	0843+422	08 43 31.63861	42 15 29.5066	348	S	
0841+387	0844+385	08 44 29.09764	38 30 55.6882	259	P	
0843+575	0847+573	08 47 28.06159	57 23 38.3355	242	P	
0844+463	0847+461	08 47 34.29950	46 09 27.9976	261	P	
0847+379	0850+377	08 50 24.73096	37 47 9.4732	252	P	
0848+686	0853+684	08 53 18.89863	68 28 19.0085	61	P	
0849+675	0853+673	08 53 34.32200	67 22 15.6652	127	P	
0850+625	0854+623	08 54 50.57576	62 18 50.1897	323	P	
0850+581	0854+579	08 54 41.99648	57 57 29.9234	918	P	
0851+580	0855+578	08 55 21.35749	57 51 44.0817	163	P	
0851+719	0856+717	08 56 54.86951	71 46 23.8943	118	P	
0859+433	0902+431	09 02 30.92062	43 10 14.1715	362	P	
0859+681	0903+679	09 03 53.15590	67 57 22.6827	635	P	
0859+470	0903+468	09 03 3.99040	46 51 4.1350	963	P	VLBI
0900+520	0903+518	09 03 58.57582	51 51 0.6583	273	P	
0902+490	0905+488	09 05 27.46476	48 50 49.9588	447	P	
0902+468	0906+466	09 06 15.53935	46 36 19.0197	212	P	
0903+669	0907+667	09 07 23.52399	66 44 46.9420	66	P	
0903+684	0907+682	09 07 52.94717	68 15 44.9183	210	P	
0905+420	0908+418	09 08 35.86228	41 50 46.2038	149	P	
0911+354	0914+352	09 14 39.42376	35 12 4.5869	226	S	WEAK SEC PA 40,0.6"
0913+391	0916+389	09 16 48.90469	38 54 28.1421	462	S	WEAK EXT PA 170
0913+657	0917+655	09 17 55.56633	65 30 15.1300	112	P	WEAK SEC PA 65,3.9"
0917+624	0921+622	09 21 36.23140	62 15 52.1790	1512	P	VLBI
0917+449	0920+446	09 20 58.45870	44 41 53.9840	1344	P	VLBI
0920+390	0923+388	09 23 14.45336	38 49 39.9040	369	P	
0920+416	0923+414	09 23 31.30517	41 25 27.4353	237	P	
0922+407	0926+404	09 26 0.42727	40 29 49.6727	272	P	
0923+392	0927+390	09 27 3.01420	39 02 20.8500	8012	P	VLBI
0924+732	0929+730	09 29 42.15651	73 04 4.5530	166	P	
0925+449	0928+447	09 28 24.13751	44 46 4.8097	233	P	
0925+504	0929+502	09 29 15.44170	50 13 35.9782	692	P	
0925+745	0930+743	09 30 53.78225	74 20 5.9295	231	P	
0927+469	0930+467	09 30 35.08109	46 44 8.6489	131	P	
0927+352	0930+350	09 30 55.27914	35 03 37.6082	472	S	WEAK EXT 45
0929+533	0932+531	09 32 41.15174	53 06 33.7851	380	P	
0930+493	0934+491	09 34 15.76310	49 08 21.7164	398	P	

Table 2 – *continued*

0932+367	0935+365	09 35 31.84056	36 33 17.5617	186	P	
0933+503	0937+501	09 37 12.32879	50 08 52.0753	352	P	
0936+419	0939+416	09 39 49.61629	41 41 54.1869	285	P	
0939+620	0943+618	09 43 14.50251	61 50 33.3428	104	P	
0941+522	0944+520	09 44 52.15670	52 02 34.2164	258	P	
0942+358	0945+355	09 45 38.12074	35 34 55.0776	262	P	
0942+468	0945+466	09 45 42.09361	46 36 50.5928	356	P	
0945+408	0948+406	09 48 55.33870	40 39 44.5833	1338	P	WEAK EXT PA 45
0949+354	0952+352	09 52 32.02616	35 12 52.3929	337	P	
0950+748	0954+745	09 54 47.44405	74 35 57.1405	411	P	
0952+581	0956+578	09 56 22.63332	57 53 55.9031	285	P	WEAK EXT PA 135
0953+398	0956+395	09 56 8.55820	39 35 16.1876	145	S	EXT PA -40 JET
0954+556	0957+553	09 57 38.18251	55 22 57.7336	1545	S	EXT PA -60
0954+658	0958+655	09 58 47.24520	65 33 54.8150	1206	P	VLBI
0955+476	0958+474	09 58 19.67008	47 25 7.8314	881	P	
0955+509	0958+506	09 58 37.80816	50 39 57.4794	232	P	
1008+657	1011+654	10 11 38.18601	65 29 21.3591	115	P	
1010+495	1013+493	10 13 29.93178	49 18 40.9607	111	P	
1010+350	1013+347	10 13 49.61423	34 45 50.7817	367	P	
1011+496	1015+494	10 15 4.13582	49 26 0.6921	248	S	EXT PA -90
1014+615	1017+612	10 17 25.88496	61 16 27.4932	571	P	
1015+359	1018+357	10 18 10.98766	35 42 39.4375	724	P	
1016+635	1019+633	10 19 50.87515	63 20 1.6205	268	P	
1017+436	1020+433	10 20 27.20211	43 20 56.3419	152	P	
1019+429	1022+426	10 22 13.13244	42 39 25.6175	261	P	
1020+400	1023+398	10 23 11.56580	39 48 15.3840	770	P	VLBI
1023+747	1027+744	10 27 24.14856	74 28 26.0966	140	P	
1024+483	1027+480	10 27 13.07883	48 03 13.5184	195	P	
1027+749	1031+746	10 31 22.01973	74 41 58.3261	99	P	
1028+606	1031+603	10 31 44.75486	60 20 30.3506	289	P	
1028+564	1032+561	10 32 2.51417	56 10 56.7164	99	P	
1030+415	1033+412	10 33 3.70810	41 16 6.2300	378	P	VLBI
1030+398	1033+395	10 33 22.06179	39 35 51.0812	509	P	
1030+611	1033+608	10 33 51.42726	60 51 7.3301	427	P	
1030+687	1034+685	10 34 1.11262	68 32 27.1286	111	P	
1031+567	1035+564	10 35 7.03990	56 28 46.7920	778	P	VLBI
1032+509	1035+506	10 35 6.01756	50 40 6.0865	170	P	
1035+430	1038+427	10 38 18.18994	42 44 42.7661	165	P	
1038+528	1041+525	10 41 46.77999	52 33 28.2170	720	P	
1041+536	1044+533	10 44 10.67165	53 22 20.5222	389	P	
1043+541	1046+539	10 46 24.03722	53 54 26.2195	182	P	
1044+719	1048+717	10 48 27.62025	71 43 35.9293	1259	P	
1048+470	1051+467	10 51 15.89637	46 44 17.3555	211	P	WEAK SEC PA 105, 1.5"
1053+704	1056+701	10 56 53.61880	70 11 45.9049	603	P	
1055+433	1058+430	10 58 2.92076	43 04 41.5050	233	P	
1055+567	1058+564	10 58 37.72617	56 28 11.1834	189	P	
1058+726	1101+724	11 01 48.80734	72 25 37.1097	436	S	MAP
1058+393	1101+390	11 01 30.07043	39 04 32.6207	261	P	
1058+629	1101+626	11 01 53.44908	62 41 50.5899	354	P	
1059+599	1102+596	11 02 42.76306	59 41 19.5711	175	P	
1101+384	1104+382	11 04 27.31462	38 12 31.7875	631	S	
1101+609	1104+606	11 04 53.69463	60 38 55.2866	179	P	
1104+728	1107+725	11 07 41.72405	72 32 36.0031	170	P	
1105+437	1108+435	11 08 23.47791	43 30 53.6367	282	P	
1107+607	1110+604	11 10 13.08711	60 28 42.5510	276	P	
1107+485	1110+482	11 10 36.32369	48 17 52.4462	132	P	
1107+443	1110+440	11 10 46.34583	44 03 25.9382	272	P	
1109+350	1112+347	11 12 38.76870	34 46 39.1212	152	P	
1115+416	1117+413	11 17 53.33390	41 20 16.2761	163	P	
1116+603	1119+600	11 19 14.34431	60 04 57.1874	122	P	
1117+543	1120+540	11 20 23.22858	54 04 27.0903	143	S	MAP
1121+661	1124+659	11 24 24.66563	65 55 1.3684	115	P	
1124+455	1126+452	11 26 57.65509	45 16 6.2894	333	P	
1124+571	1127+568	11 27 40.13530	56 50 14.7793	498	P	
1125+366	1127+363	11 27 58.87072	36 20 28.3515	284	P	
1125+596	1128+594	11 28 13.34150	59 25 14.7776	584	P	
1128+385	1130+382	11 30 53.28220	38 15 18.5526	899	P	
1131+730	1134+728	11 34 11.40730	72 49 20.0570	211	P	
1133+704	1136+701	11 36 26.40689	70 09 27.3043	214	P	
1135+480	1138+477	11 38 21.13739	47 45 15.4080	245	P	
1136+408	1139+405	11 39 2.73439	40 32 54.8413	253	P	
1138+644	1141+641	11 41 12.22834	64 10 5.4837	253	P	
1141+668	1143+665	11 43 41.60264	66 33 31.2106	286	P	
1142+446	1145+443	11 45 38.51904	44 20 21.9181	224	S	
1143+590	1146+588	11 46 26.91199	58 48 34.2423	569	P	
1144+542	1146+539	11 46 44.20384	53 56 43.0888	349	P	
1144+402	1146+399	11 46 58.29810	39 58 34.3040	565	P	VLBI
1144+352	1147+350	11 47 22.13022	35 01 7.5258	501	P	
1146+596	1148+594	11 48 50.35909	59 24 56.3620	516	P	
1146+531	1148+529	11 48 56.56863	52 54 25.3311	597	P	
1147+438	1150+435	11 50 16.60186	43 32 5.9077	250	P	
1150+498	1153+495	11 53 24.46599	49 31 8.8345	558	S	
1151+408	1153+406	11 53 54.65938	40 36 52.6172	361	S	WEAK SEC PA 160,0.7"
1151+598	1154+595	11 54 1.36710	59 34 54.1753	157	P	
1152+462	1155+459	11 55 11.00909	45 55 39.6255	219	P	

Table 2 – *continued*

1153+733	1156+731	11 56 27.25674	73 06 50.1597	130	S	WEAK SEC PA -135, 2.7"
1155+486	1158+484	11 58 26.76904	48 25 16.2350	424	P	
1157+532	1200+530	12 00 6.01074	53 00 37.1177	212	P	
1200+608	1203+605	12 03 3.50786	60 31 19.1301	192	P	
1200+468	1203+465	12 03 31.79837	46 32 55.5608	100	P	
1202+527	1204+524	12 04 36.79951	52 28 41.7816	172	S	WEAK SEC PA -20,0.6", EXT
1204+399	1206+396	12 06 37.05454	39 41 3.7378	228	P	
1205+544	1208+542	12 08 27.49949	54 13 19.5292	280	P	
1206+549	1208+546	12 08 54.25623	54 41 58.1833	262	P	
1206+415	1209+413	12 09 22.78840	41 19 41.3688	486	P	
1208+646	1210+643	12 10 31.63982	64 22 17.4528	96	P	
1213+350	1215+348	12 15 55.60197	34 48 15.2135	726	P	
1214+588	1217+585	12 17 11.02025	58 35 26.2283	473	P	
1216+487	1219+484	12 19 6.41490	48 29 56.1650	657	P	VLBI
1216+639	1219+637	12 19 10.58735	63 44 10.7056	232	P	
1217+713	1220+710	12 20 3.62809	71 05 31.1473	187	S	WEAK EXT PA 90
1218+384	1220+381	12 20 59.23001	38 08 55.6940	256	P	
1218+444	1221+441	12 21 27.04576	44 11 29.6635	435	P	
1221+464	1223+461	12 23 39.33646	46 11 18.6041	171	P	
1222+438	1224+435	12 24 51.50593	43 35 19.2815	251	S	MAP
1223+395	1225+392	12 25 50.57029	39 14 22.6806	377	P	
1225+368	1227+365	12 27 58.72601	36 35 11.8194	369	P	
1226+373	1228+371	12 28 47.42456	37 06 12.0820	868	P	
1226+492	1228+489	12 28 51.76785	48 58 1.2916	270	S	WEAK EXT PA 150
1226+638	1229+635	12 29 6.02558	63 35 0.9862	168	P	
1227+587	1230+585	12 30 7.05648	58 30 7.7706	203	P	
1230+486	1232+483	12 32 34.78825	48 21 32.9436	273	P	
1231+507	1233+504	12 33 49.26763	50 26 22.7795	66	P	
1231+481	1234+478	12 34 13.33020	47 53 51.2307	183	P	
1232+366	1235+363	12 35 5.80759	36 21 19.3080	200	P	
1234+396	1236+393	12 36 51.44906	39 20 27.6937	189	S	SEC PA 80,0.6"
1238+702	1240+699	12 40 34.69891	69 58 30.6159	159	P	
1239+552	1241+549	12 41 27.70425	54 58 19.0397	111	P	
1239+606	1241+603	12 41 29.59068	60 20 41.3195	131	P	
1239+376	1242+373	12 42 9.81383	37 20 5.6807	336	P	
1240+381	1242+378	12 42 51.37049	37 51 0.0126	608	P	
1241+749	1243+747	12 43 45.03236	74 42 37.1275	409	P	
1242+410	1244+408	12 44 49.18793	40 48 6.1375	448	P	
1245+716	1247+714	12 47 9.32701	71 24 20.0176	106	P	
1245+676	1247+673	12 47 33.32999	67 23 16.4568	133	P	
1246+586	1248+583	12 48 18.78472	58 20 28.7144	310	P	
1246+489	1248+486	12 48 50.94950	48 39 53.1543	102	P	
1250+532	1253+530	12 53 11.92132	53 01 11.7266	372	S	EXT PA -160
1252+458	1254+456	12 54 28.82919	45 36 4.3182	91	P	
1254+571	1256+568	12 56 14.23440	56 52 25.2367	255	S	
1256+546	1258+543	12 58 15.60783	54 21 52.1118	135	P	
1257+519	1259+516	12 59 31.17508	51 40 56.2482	183	S	EXT PA -155
1258+507	1300+504	13 00 41.24832	50 29 36.7498	339	P	
1300+485	1302+483	13 02 17.19736	48 19 17.5717	121	P	
1300+580	1302+578	13 02 52.46490	57 48 37.6175	885	P	
1300+693	1302+690	13 02 37.92462	69 02 51.6133	151	S	WEAK EXT PA -40
1302+356	1304+353	13 04 36.06526	35 23 53.8233	124	S	EXT PA 90
1303+557	1306+554	13 06 3.34965	55 29 43.8620	246	P	
1305+502	1308+499	13 08 7.92588	49 57 53.4578	251	P	
1307+562	1309+559	13 09 9.75329	55 57 38.1932	302	P	
1308+471	1310+468	13 10 53.59063	46 53 52.2192	361	P	
1309+555	1311+552	13 11 3.20969	55 13 54.3298	505	P	
1310+487	1312+484	13 12 43.35104	48 28 30.9321	259	P	
1311+552	1313+549	13 13 37.85179	54 58 23.8943	302	P	
1312+533	1314+531	13 14 43.82839	53 06 27.7274	303	P	
1314+677	1316+674	13 16 27.20107	67 26 24.2581	143	P	
1315+415	1317+412	13 17 39.18819	41 15 45.6419	171	P	
1317+625	1319+622	13 19 7.48513	62 17 21.3414	135	P	
1317+520	1319+518	13 19 46.19600	51 48 5.7621	296	P	
1318+508	1320+506	13 20 42.20667	50 36 7.8038	128	P	
1320+394	1322+392	13 22 55.66151	39 12 7.9842	175	P	
1321+410	1324+408	13 24 12.09400	40 48 11.7728	246	P	
1322+479	1324+477	13 24 29.34128	47 43 20.6241	255	P	
1324+574	1326+572	13 26 50.57100	57 12 6.7344	210	P	
1325+436	1327+434	13 27 20.97896	43 26 27.9969	462	S	WEAK EXT PA -65
1325+504	1327+501	13 27 25.12087	50 08 49.1681	299	S	EXT PA 170
1327+504	1329+501	13 29 5.80045	50 09 26.4069	221	P	
1328+523	1330+520	13 30 42.59795	52 02 15.4541	172	P	
1330+476	1332+473	13 32 45.24444	47 22 22.6644	464	P	
1333+459	1335+457	13 35 21.96043	45 42 38.2519	468	P	
1333+589	1335+587	13 35 25.92758	58 44 0.2863	766	P	
1335+552	1337+550	13 37 49.64084	55 01 2.1208	573	P	WEAK SEC PA 45,2.4"
1337+637	1339+634	13 39 23.78121	63 28 58.4253	272	P	
1338+381	1340+379	13 40 22.95185	37 54 43.8391	154	P	
1339+696	1340+693	13 40 48.00694	69 23 22.7213	127	P	
1341+691	1343+689	13 43 0.55201	68 55 17.1596	170	P	
1342+662	1343+660	13 43 45.95763	66 02 25.7486	578	P	
1342+663	1344+661	13 44 8.67907	66 06 11.6490	508	P	
1347+539	1349+536	13 49 34.65654	53 41 17.0389	766	S	
1349+618	1350+615	13 50 38.18609	61 32 48.5170	141	S	WEAK EXT PA 90

Table 2 – *continued*

1352+636	1353+634	13 53 58.84549	63 24 32.4580	109	P	
1357+404	1359+401	13 59 38.09433	40 11 38.2604	311	P	
1400+588	1401+585	14 01 45.69928	58 35 42.2634	210	S	WEAK EXT PA 90
1403+411	1405+409	14 05 7.79486	40 56 57.8466	182	P	
1406+564	1408+562	14 08 12.94658	56 13 32.4875	255	P	
1407+369	1409+367	14 09 9.50748	36 42 8.1821	130	P	
1407+691	1408+689	14 08 19.07650	68 54 50.8283	210	P	
1409+625	1410+622	14 10 35.41892	62 16 47.4069	96	P	
1409+595	1411+592	14 11 21.98557	59 17 4.3020	113	S	MAP
1412+461	1414+459	14 14 14.85256	45 54 48.7298	139	P	
1413+373	1415+371	14 15 28.46657	37 06 21.1789	278	P	
1415+463	1417+461	14 17 8.16081	46 07 5.4483	583	P	
1417+385	1419+383	14 19 46.61407	38 21 48.4841	793	P	
1418+375	1420+373	14 20 0.34071	37 21 34.6723	167	P	
1418+546	1419+543	14 19 46.59750	54 23 14.7870	2187	P	VLBI
1419+469	1421+467	14 21 23.07288	46 45 47.9825	210	P	
1421+482	1423+480	14 23 6.15619	48 02 10.8466	392	P	
1421+511	1423+509	14 23 14.18676	50 55 37.2879	212	P	
1422+473	1424+470	14 24 37.08060	47 05 56.6922	188	P	
1424+366	1426+364	14 26 37.08764	36 25 9.5858	621	P	
1427+543	1429+541	14 29 21.87958	54 06 11.1266	493	S	EXT PA 110
1427+634	1429+632	14 29 5.30753	63 16 4.6557	118	S	WEAK SEC PA 110,2.9"
1428+422	1430+420	14 30 23.74175	42 04 36.5027	220	P	
1428+370	1430+368	14 30 40.58347	36 49 3.8951	267	P	
1429+400	1431+398	14 31 20.53837	39 52 41.5408	244	P	
1432+422	1434+420	14 34 5.69506	42 03 16.0026	295	P	
1435+638	1436+636	14 36 45.80250	63 36 37.8680	858	P	VLBI
1436+445	1438+443	14 38 28.50476	44 18 12.0847	220	P	
1436+373	1438+371	14 38 53.61102	37 10 35.4244	311	P	
1438+501	1439+499	14 39 46.97582	49 58 5.4556	243	P	
1440+635	1441+633	14 41 58.67011	63 18 33.4420	158	P	
1442+637	1443+635	14 43 58.60200	63 32 26.3630	392	P	
1447+536	1448+534	14 48 59.17393	53 26 9.2820	107	P	
1450+455	1452+453	14 52 24.67494	45 22 23.6752	135	P	
1450+641	1451+639	14 51 57.35714	63 57 19.2056	178	P	
1454+447	1455+445	14 55 54.13609	44 31 37.6683	169	P	
1454+510	1456+508	14 56 8.11992	50 48 36.2968	264	P	
1455+421	1457+419	14 57 40.68636	41 58 41.8895	79	S	WEAK SEC PA 135, 1.2"
1456+375	1458+373	14 58 44.79492	37 20 21.6266	370	P	
1459+480	1500+478	15 00 48.65431	47 51 15.5259	686	P	
1504+377	1506+375	15 06 9.53020	37 30 51.1310	1024	P	VLBI
1505+497	1506+495	15 06 44.11341	49 33 55.7908	226	P	
1505+428	1506+426	15 06 53.04195	42 39 23.0400	410	P	
1505+514	1507+512	15 07 11.61585	51 17 16.8458	102	S	
1506+591	1507+589	15 07 47.38610	58 57 27.6481	240	P	
1508+572	1510+570	15 10 2.92255	57 02 43.3632	153	P	
1519+567	1520+565	15 20 19.15571	56 35 55.6373	90	S	MAP
1520+437	1521+436	15 21 49.61404	43 36 39.2661	566	P	
1525+737	1524+736	15 24 41.37202	73 36 0.7778	106	S	
1526+670	1526+668	15 26 42.87323	66 50 54.6171	312	P	
1528+381	1530+379	15 30 16.25295	37 58 31.1601	123	P	
1531+722	1531+721	15 31 33.57679	72 06 41.2196	231	P	
1532+680	1532+679	15 32 43.34256	67 55 13.9924	141	P	
1532+485	1534+483	15 34 4.87272	48 23 40.9059	77	S	MAP
1533+487	1535+486	15 35 14.65398	48 36 59.6969	108	P	
1534+501	1535+499	15 35 52.03949	49 57 39.0837	312	P	
1534+387	1536+385	15 36 13.84707	38 33 28.6010	107	P	
1540+539	1541+538	15 41 25.46406	53 48 13.0371	107	P	
1543+480	1545+478	15 45 8.53027	47 51 54.6667	347	P	
1543+517	1545+515	15 45 2.82440	51 35 0.8780	629	P	
1544+398	1545+396	15 45 53.23312	39 41 46.8573	86	P	
1545+497	1547+496	15 47 21.13841	49 37 5.8100	360	S	
1547+507	1549+506	15 49 17.46880	50 38 5.7890	1266	P	VLBI
1550+582	1551+581	15 51 58.20771	58 06 44.4659	305	P	
1555+455	1557+453	15 57 19.00033	45 22 21.5368	125	P	
1556+745	1556+743	15 56 2.98746	74 20 58.1543	113	P	
1557+565	1558+564	15 58 48.28906	56 25 14.1231	177	P	
1558+595	1559+594	15 59 1.70269	59 24 21.8467	133	P	
1602+576	1603+575	16 03 55.93111	57 30 54.4146	312	P	
1603+573	1604+572	16 04 37.35516	57 14 36.6746	491	P	
1603+698	1603+697	16 03 18.61842	69 45 57.4478	93	P	
1606+403	1608+402	16 08 22.15803	40 12 17.8415	130	P	
1607+563	1608+562	16 08 20.75183	56 13 56.3728	178	P	
1611+425	1613+423	16 13 4.80380	42 23 18.9032	135	P	
1614+466	1616+465	16 16 3.76674	46 32 25.2311	126	P	
1615+364	1616+363	16 16 55.58038	36 21 34.5039	243	P	
1616+366	1618+365	16 18 23.58064	36 32 1.8051	135	S	MAP
1619+491	1620+490	16 20 31.22632	49 01 53.2537	386	P	
1621+392	1623+391	16 23 7.62274	39 09 32.4124	222	P	
1622+665	1623+664	16 23 4.52205	66 24 1.0837	287	P	
1623+569	1624+568	16 24 32.17968	56 52 28.0063	371	P	
1623+578	1624+576	16 24 24.80784	57 41 16.2861	596	P	
1624+416	1625+415	16 25 57.67000	41 34 40.6310	995	S	VLBI, JET PA -10
1625+582	1626+581	16 26 37.23772	58 09 17.6721	172	P	
1627+476	1628+475	16 28 37.50637	47 34 10.4136	100	P	

Table 2 – *continued*

1629+495	1631+494	16 31 16.54118	49 27 39.5032	626	P	
1629+680	1629+679	16 29 51.83591	67 57 14.9521	224	S	
1630+358	1632+357	16 32 31.25781	35 47 37.7395	179	P	
1633+382	1635+381	16 35 15.49320	38 08 4.5020	2410	S	VLBI
1634+604	1635+603	16 35 37.65589	60 19 56.7530	146	P	
1636+473	1637+472	16 37 45.13069	47 17 33.8364	749	P	
1637+574	1638+573	16 38 13.45650	57 20 23.9810	1309	P	VLBI
1638+540	1639+539	16 39 39.84349	53 57 47.1166	298	P	
1638+398	1640+397	16 40 29.63300	39 46 46.0280	1766	P	VLBI
1641+399	1642+398	16 42 58.81020	39 48 36.9950	5182	P	VLBI
1642+690	1642+689	16 42 7.84860	68 56 39.7580	1193	P	VLBI
1645+410	1646+409	16 46 56.85906	40 59 17.1742	358	P	
1645+635	1645+635	16 45 58.55338	63 30 10.9322	214	P	WEAK EXT ? PA 60
1646+499	1647+498	16 47 34.91239	49 50 0.5825	194	P	
1646+411	1648+410	16 48 29.25797	41 04 5.5545	208	P	
1647+744	1646+743	16 46 15.17158	74 19 11.0929	182	S	EXT PA -65
1650+581	1651+580	16 51 22.86770	58 05 42.4414	101	P	
1651+391	1652+390	16 52 58.51045	39 02 49.8204	336	P	
1652+398	1653+397	16 53 52.21705	39 45 36.6111	1165	S	VLBI, EXT PA 25
1655+534	1656+533	16 56 39.62529	53 21 48.7635	136	P	
1656+482	1657+481	16 57 46.87882	48 08 33.0519	767	S	MAP
1656+571	1657+570	16 57 20.70951	57 05 53.5053	533	S	MAP
1656+477	1658+476	16 58 2.77937	47 37 49.2445	1222	P	
1700+685	1700+685	17 00 9.29376	68 30 6.9590	377	S	EXT PA 80
1704+512	1705+511	17 05 26.41308	51 09 35.3978	136	P	
1705+456	1707+356	17 07 17.75383	35 36 10.5622	329	S	EXT PA -130
1712+493	1713+492	17 13 35.14839	49 16 32.5481	217	S	EXT PA 70
1716+686	1716+686	17 16 13.93808	68 36 38.7403	829	P	
1719+357	1721+357	17 21 9.49097	35 42 16.0669	584	P	
1721+589	1722+589	17 22 36.72685	58 56 22.2657	321	P	
1722+611	1722+610	17 22 40.05775	61 05 59.8006	195	P	
1722+401	1724+400	17 24 5.42882	40 04 36.4605	284	P	
1722+526	1723+526	17 23 39.74658	52 36 48.3984	240	S	WEAK SEC PA 140, 1.0"
1724+609	1724+609	17 24 41.41415	60 55 55.7314	163	P	
1726+455	1727+455	17 27 27.65082	45 30 39.7339	1331	P	
1726+552	1727+551	17 27 23.46926	55 10 53.5449	254	P	
1727+386	1728+386	17 28 59.14169	38 38 26.4566	184	P	
1732+389	1734+389	17 34 20.57880	38 57 51.4450	1192	P	VLBI
1734+363	1735+362	17 35 48.08683	36 16 45.6099	934	P	
1734+508	1735+508	17 35 49.00520	50 49 11.5718	838	P	
1738+499	1739+499	17 39 27.39025	49 55 3.3757	580	P	
1738+451	1740+451	17 40 6.37306	45 06 50.3762	273	P	
1738+476	1739+476	17 39 57.12950	47 37 58.3650	829	P	VLBI
1739+438	1740+438	17 40 48.95145	43 48 16.1578	254	P	
1739+522	1740+521	17 40 36.97810	52 11 43.4090	1300	P	VLBI
1740+478	1741+478	17 41 34.82221	47 51 32.5414	197	P	
1742+378	1743+377	17 43 47.64647	37 47 53.8260	430	P	
1742+402	1744+402	17 44 25.09586	40 14 48.1481	284	P	
1745+643	1746+643	17 46 6.67784	64 21 49.6568	102	P	
1745+624	1746+624	17 46 14.03324	62 26 54.7278	480	S	WEAK SEC PA -135,2.5"
1745+670	1745+670	17 45 54.35770	67 03 49.3016	157	P	
1746+470	1747+469	17 47 26.64725	46 58 50.9294	871	P	
1747+433	1749+433	17 49 0.36037	43 21 51.2888	286	P	
1749+701	1748+700	17 48 32.84050	70 05 50.7690	558	P	VLBI
1751+441	1753+441	17 53 22.64957	44 09 45.6742	832	P	
1752+356	1754+356	17 54 13.67609	35 40 48.5488	134	P	
1753+648	1754+648	17 54 7.59040	64 52 2.6419	196	P	
1755+578	1756+578	17 56 3.62851	57 48 47.9901	272	P	
1755+626	1755+626	17 55 48.43973	62 36 44.1193	142	P	
1758+388	1800+388	18 00 24.76501	38 48 30.6953	1177	P	
1800+440	1801+440	18 01 32.31493	44 04 21.9033	539	S	MAP
1800+459	1802+459	18 02 25.14270	45 57 34.6445	135	P	
1805+616	1806+616	18 06 19.94570	61 41 18.3198	200	P	
1806+456	1808+457	18 08 21.88567	45 42 20.8700	424	P	
1807+698	1806+698	18 06 50.68070	69 49 28.1100	1559	P	VLBI
1809+568	1810+568	18 10 3.32027	56 49 22.9587	441	S	
1811+430	1813+430	18 13 14.68906	43 04 15.6838	388	S	MAP
1812+560	1812+560	18 12 57.66915	56 03 49.1981	108	P	
1812+412	1814+412	18 14 22.70825	41 13 5.6054	375	S	MAP
1815+614	1815+614	18 15 36.79199	61 27 11.6409	220	P	
1815+531	1816+531	18 16 57.07122	53 07 44.4866	166	P	
1817+502	1818+152	18 18 30.51947	15 17 19.7402	232	P	
1820+397	1821+397	18 21 59.69913	39 45 59.6472	263	P	
1822+682	1821+683	18 21 59.49511	68 18 43.0031	139	P	
1823+568	1824+568	18 24 7.06850	56 51 1.4930	1176	P	VLBI
1823+689	1823+689	18 23 32.85712	68 57 52.6111	205	P	
1824+578	1825+578	18 25 41.59937	57 53 5.9505	171	P	
1827+645	1828+645	18 28 9.85831	64 34 16.0377	233	P	
1828+399	1829+399	18 29 56.52027	39 57 34.6902	234	P	
1834+612	1835+613	18 35 19.67558	61 19 40.0233	492	S	WEAK EXT PA -170
1839+406	1840+407	18 40 44.99744	40 42 36.9268	71	P	
1839+389	1840+390	18 40 57.15500	39 00 45.7119	221	P	
1839+548	1840+548	18 40 57.37799	54 52 15.9203	195	S	WEAK EXT PA -175
1842+681	1842+681	18 42 33.64170	68 09 25.2300	838	P	VLBI
1843+356	1845+356	18 45 35.10973	35 41 16.7191	562	P	

Table 2 – *continued*

1849+499	1850+499	18 50 22.24008	49 59 21.4420	160	P	
1849+670	1849+670	18 49 16.07136	67 05 41.6786	456	P	
1850+402	1852+403	18 52 30.37400	40 19 6.6006	616	P	WEAK SEC PA 45,0.5"
1851+488	1852+489	18 52 28.54751	48 55 47.4774	385	P	
1851+609	1851+610	18 51 52.36217	61 00 38.7854	191	P	
1853+376	1855+377	18 55 27.70568	37 42 56.9859	222	P	
1856+737	1854+738	18 54 57.29825	73 51 19.9100	628	S	WEAK SEC PA 20,1.9"
1902+556	1903+556	19 03 11.60725	55 40 38.4465	174	P	
1904+398	1906+399	19 06 11.42664	39 56 10.0794	132	S	EXT PA 100
1908+484	1909+485	19 09 46.56339	48 34 31.8265	244	S	EXT PA 40
1910+375	1912+376	19 12 25.12308	37 40 36.6587	340	P	
1915+657	1915+658	19 15 23.81933	65 48 46.3946	221	P	
1917+552	1918+553	19 18 10.75069	55 20 38.6154	424	P	
1919+434	1921+435	19 21 9.93443	43 33 41.8568	157	P	
1920+450	1921+451	19 21 54.20482	45 06 26.9046	168	P	
1922+478	1923+479	19 23 27.22984	47 54 16.8423	205	S	MAP
1924+507	1926+508	19 26 6.32190	50 52 57.0209	434	P	
1924+420	1926+421	19 26 31.05043	42 09 58.9914	112	P	
1926+440	1928+442	19 28 21.35162	44 12 1.8782	172	P	
1926+611	1927+612	19 27 30.44283	61 17 32.8767	520	P	
1928+681	1928+682	19 28 20.55019	68 14 59.2469	233	S	
1928+738	1927+739	19 27 48.49520	73 58 1.5710	1981	P	VLBI
1929+596	1930+598	19 30 36.53898	59 48 8.9133	71	P	
1933+655	1933+656	19 33 57.33789	65 40 16.8263	282	P	
1935+360	1937+361	19 37 31.43666	36 07 35.8464	191	P	
1936+714	1936+715	19 36 3.56036	71 31 31.7763	496	P	
1937+630	1938+631	19 38 16.16799	63 07 17.8028	130	P	
1937+381	1939+382	19 39 33.56628	38 17 35.3974	144	P	
1938+371	1939+372	19 39 51.80643	37 13 30.4983	349	P	
1939+429	1940+430	19 40 49.31978	43 04 24.6705	134	P	
1941+413	1942+414	19 42 58.63853	41 29 23.0729	158	P	
1943+546	1944+548	19 44 31.51376	54 48 7.0685	610	P	
1946+708	1945+709	19 45 53.51973	70 55 48.7226	477	P	
1946+358	1948+359	19 48 4.51999	35 56 20.6742	272	P	
1946+395	1948+397	19 48 39.87669	39 42 36.4740	166	P	
1948+505	1949+506	19 49 43.49208	50 41 31.9822	306	P	
1950+573	1951+574	19 51 6.98368	57 27 17.1945	316	P	
1950+727	1949+728	19 49 35.23286	72 52 42.9773	93	P	
1951+498	1952+499	19 52 35.81364	49 58 13.9810	121	S	SEC PA -120, 7.0"
1951+355	1953+356	19 53 30.87589	35 37 59.3678	624	P	
1954+513	1955+515	19 55 42.73860	51 31 48.5480	1773	P	VLBI
1959+650	1959+651	19 59 59.85227	65 08 54.6683	210	P	
1959+437	2001+438	20 01 12.87394	43 52 52.8439	223	P	
2000+472	2002+474	20 02 10.41825	47 25 28.7767	840	P	
2001+449	2002+451	20 02 52.09662	45 06 8.3391	494	P	
2003+662	2003+664	20 03 54.51091	66 25 56.3889	313	P	
2004+443	2005+444	20 05 52.08882	44 28 55.1349	182	P	
2005+642	2006+644	20 06 17.69491	64 24 45.4226	973	P	
2005+403	2007+404	20 07 44.94512	40 29 48.6102	3036	P	VLBI
2007+659	2007+661	20 07 28.77132	66 07 22.5398	489	P	
2007+747	2007+748	20 07 4.38811	74 52 25.3977	210	S	
2009+611	2010+612	20 10 49.28909	61 16 15.1603	331	P	
2010+463	2012+464	20 12 5.63735	46 28 55.7873	593	P	
2010+723	2009+724	20 09 52.30215	72 29 19.3501	774	S	WEAK SEC PA 100,2.2"
2013+508	2014+509	20 14 28.58988	50 59 9.5321	125	P	
2014+463	2015+464	20 15 39.98647	46 28 50.8855	146	P	
2014+527	2015+528	20 15 19.16748	52 53 59.7287	348	P	
2014+657	2014+658	20 14 32.03940	65 53 55.4134	229	S	WEAK EXT PA 150
2015+657	2015+659	20 15 55.36830	65 54 52.6621	548	P	
2017+745	2017+746	20 17 13.07930	74 40 48.0020	341	P	VLBI
2021+614	2022+616	20 22 6.68200	61 36 58.8060	2931	P	VLBI
2022+542	2023+544	20 23 55.84473	54 27 35.8403	1088	P	
2023+503	2025+504	20 25 24.97260	50 28 39.5505	151	P	
2027+464	2029+466	20 29 18.93660	46 36 2.2688	136	P	
2030+547	2031+549	20 31 47.95897	54 55 3.1430	682	P	VLBI
2034+581	2035+583	20 35 23.75351	58 21 18.7589	165	P	
2037+511	2038+513	20 38 37.03510	51 19 12.6650	4205	P	VLBI
2046+535	2047+537	20 47 53.79688	53 43 32.4019	351	P	
2048+361	2050+363	20 50 2.28477	36 19 52.5002	266	P	
2050+364	2052+365	20 52 52.05744	36 35 35.2992	1972	P	
2051+687	2052+689	20 52 0.24770	68 58 15.7320	142	S	WEAK SEC PA 70,0.4"
2051+745	2051+746	20 51 33.73560	74 41 40.4990	287	P	VLBI
2054+611	2055+613	20 55 38.83705	61 22 0.6411	297	P	
2059+560	2100+562	21 00 54.97462	56 12 36.6587	139	S	SEC PA 105,1.4"
2101+600	2102+602	21 02 40.21930	60 15 9.8266	164	P	
2102+677	2102+679	21 02 43.80748	67 58 19.8349	201	P	
2105+598	2106+600	21 06 48.08690	60 04 13.0854	226	S	JET PA -90
2107+353	2109+355	21 09 31.87845	35 32 57.6023	894	P	
2112+374	2114+377	21 14 44.12296	37 42 25.7191	120	P	
2118+443	2120+445	21 20 31.77341	44 34 34.2810	320	P	
2119+664	2120+667	21 20 46.20447	66 42 20.2159	185	P	
2119+709	2119+711	21 19 54.16763	71 10 36.0908	179	S	WEAK EXT PA 20
2121+460	2123+462	21 23 31.82916	46 14 22.9740	161	P	
2121+547	2123+550	21 23 5.31605	55 00 27.3291	209	P	
2124+641	2125+643	21 25 27.44899	64 23 39.3488	1127	P	

Table 2 – *continued*

2128+681	2129+683	21	29	37.78370	68	19	49.1077	163	S	WEAK SEC PA -35,0.4"
2132+406	2134+408	21	34	24.10533	40	50	11.3445	168	P	
2138+389	2140+391	21	40	16.94765	39	11	44.8513	377	P	
2144+568	2146+570	21	46	25.93981	57	03	24.6871	200	P	
2151+431	2153+433	21	53	50.95852	43	22	54.4967	152	P	
2159+505	2201+508	22	01	43.53939	50	48	56.3932	815	P	
2200+420	2202+422	22	02	43.29180	42	16	39.9820	3245	P	VLBI
2201+676	2203+678	22	03	12.62857	67	50	47.6585	330	P	
2202+363	2204+365	22	04	21.09972	36	32	37.0944	296	P	
2202+716	2203+718	22	03	30.46935	71	51	8.5269	122	P	
2206+650	2208+653	22	08	3.11040	65	19	38.7823	262	S	MAP
2207+374	2209+377	22	09	21.42350	37	42	18.2303	654	S	WEAK EXT PA 45,1.5"
2207+517	2209+519	22	09	21.48996	51	58	1.8270	431	P	
2207+356	2209+359	22	09	45.33502	35	56	1.1379	300	S	SEC PA -20,3.5"
2214+350	2216+353	22	16	20.01079	35	18	14.1787	637	P	
2216+415	2218+417	22	18	12.23068	41	46	33.5343	109	S	MAP
2221+625	2223+628	22	23	18.09714	62	49	33.7834	195	P	
2226+440	2228+443	22	28	50.46435	44	19	8.4410	218	S	WEAK SEC PA -100,2.6"
2229+695	2230+697	22	30	36.46765	69	46	28.0657	754	P	
2230+625	2232+628	22	32	22.86554	62	49	36.4362	186	P	
2231+424	2233+427	22	33	32.40564	42	45	39.9300	250	P	
2235+731	2236+733	22	36	38.60028	73	22	52.6646	346	P	
2236+678	2238+680	22	38	15.02835	68	04	59.7580	219	P	
2238+512	2240+515	22	40	19.87848	51	33	11.8111	183	P	
2238+410	2241+413	22	41	7.20544	41	20	11.6178	826	S	WEAK EXT PA -80
2241+406	2244+409	22	44	12.73188	40	57	13.6175	227	P	
2243+357	2246+360	22	46	10.86432	36	01	55.6730	176	P	
2246+370	2248+373	22	48	37.91101	37	18	12.4680	307	P	
2248+555	2250+558	22	50	42.84959	55	50	14.6079	402	P	
2249+402	2251+405	22	51	59.77149	40	30	58.1551	144	P	
2251+704	2252+707	22	52	48.16138	70	43	15.8293	281	P	
2253+417	2255+420	22	55	36.70820	42	02	52.5350	697	P	VLBI
2255+416	2257+419	22	57	22.07215	41	54	16.5165	786	P	
2259+371	2301+374	23	01	27.73664	37	26	49.2445	379	P	
2259+568	2301+571	23	01	26.62868	57	06	25.5078	232	S	MAP
2300+638	2302+640	23	02	41.31646	64	05	52.8582	208	P	
2300+386	2303+388	23	03	4.06630	38	53	48.3698	253	P	
2304+377	2307+380	23	07	0.99753	38	02	42.2297	350	S	
2307+680	2309+683	23	09	26.66851	68	20	10.7439	186	P	
2309+454	2311+457	23	11	47.41079	45	43	56.0250	610	P	
2310+724	2312+726	23	12	19.69977	72	41	26.9243	209	P	
2310+385	2312+387	23	12	58.79503	38	47	42.6683	327	P	
2319+444	2322+447	23	22	20.35854	44	45	42.3727	366	S	EXT PA -15
2320+506	2322+509	23	22	25.98310	50	57	51.9649	1656	P	
2320+689	2322+691	23	22	9.04629	69	11	3.4142	142	P	
2323+478	2325+481	23	25	44.91306	48	06	25.2797	168	S	WEAK EXT PA 100
2327+407	2330+410	23	30	8.86744	41	04	25.0841	72	P	
2329+451	2331+453	23	31	48.96619	45	22	48.9963	119	S	WEAK EXT PA -160
2330+387	2333+390	23	33	2.53305	39	01	12.0185	357	P	
2341+697	2343+700	23	43	43.73597	70	03	19.3981	139	P	
2344+514	2347+517	23	47	4.83795	51	42	17.8770	176	P	
2344+429	2347+431	23	47	22.87341	43	10	53.2365	247	S	MAP
2346+385	2349+388	23	49	20.82620	38	49	17.5725	286	P	
2350+704	2352+707	23	52	52.85522	70	44	48.3337	211	S	WEAK EXT PA -150
2351+550	2353+553	23	53	42.30110	55	18	40.6702	385	P	
2351+456	2354+458	23	54	21.67973	45	53	4.2397	1011	S	MAP
2352+495	2355+498	23	55	9.45870	49	50	8.3420	992	P	VLBI
2356+390	2358+393	23	58	59.85538	39	22	28.3103	326	S	MAP
2356+385	2359+388	23	59	33.18089	38	50	42.3217	278	P	
2358+406	0000+409	00	00	53.08153	40	54	1.8058	379	P	

per cent less than that seen on short baselines. These sources should therefore be used with caution, especially at low frequencies where the extended structure will probably be more prominent relative to the core.

In Table 3 we list the names and parameters of sources for which we present maps in Fig. 2. Column 1 gives the source name, Column 2 gives the rms noise in the map in mJy per beam and Column 3 gives the peak brightness in mJy per beam. Some of these sources are class S objects listed in Table 2 which have structures which cannot be described simply. The contour levels for all the figures are multiples (-2, -1, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512) of the bottom contour level which is set at three times the rms noise level in the map. In Table 4 we list a further 45 sources which also do not meet our criteria for calibrators but whose structures are relatively simple on this scale. The layout of Table 4 is the same as that of Table 2.

We have estimated the accuracy of our positions from the observations listed in Section 4.1. First we compared the positions of 35 sources observed during the snow storm with repeat measurements made later in good conditions; both sets of observations were taken in the afternoon. The rms position difference is 18 milliarcsec. Secondly we compared the positions of seven sources around 16 hr RA measured on

Table 3. Noise and peak brightnesses of sources in Fig. 2. Col. 1: name; Col. 2: 3σ noise level in mJy/beam; Col. 3: peak brightness in the map in mJy/beam.

1	2	3
0035+367	1.28	139.5
0144+487	0.71	143.2
0218+357	2.25	791.8
0253+633	0.58	24.4
0325+395	0.68	177.7
0422+578	0.95	63.8
0458+476	0.94	136.2
0510+559	0.69	278.5
0538+474	1.96	580.0
0655+699	2.23	222.0
0829+425	0.74	50.7
0901+428	1.31	372.2
0927+586	0.69	55.8
1044+476	1.18	139.4
1058+726	0.93	349.9
1117+543	0.69	110.1
1222+438	0.68	207.9
1342+553	0.67	34.4
1409+595	0.71	94.5
1438+385	0.40	499.7
1454+593	0.71	119.6
1519+567	0.83	83.0
1532+485	0.55	64.5
1550+703	0.82	96.4
1616+366	0.80	88.4
1656+482	1.19	714.5
1656+571	0.94	501.7
1800+440	1.00	501.8
1811+430	0.84	275.4
1812+412	0.77	302.6
1922+478	0.69	188.9
1925+398	0.78	77.3
1934+366	1.43	413.4
1938+666	0.82	132.2
2206+650	0.85	237.3
2216+415	0.62	92.3
2259+568	0.66	200.2
2339+489	0.58	70.2
2344+429	0.57	216.0
2351+456	1.05	954.8
2356+390	0.73	306.2
2356+701	0.61	61.6

two days when the observing conditions were good; both sets of observations were taken before dawn. We find an rms difference of 5 milliarcsec. As expected, the astrometric performance of the VLA depends on weather conditions, and fortunately the weather and the observed phase stability of the data were good for all but the first few hours of our observations. The phase stability at the VLA is also statistically about 50 per cent worse in the day than in the night (Sramek 1990). 18 milliarcsec rms therefore represents an upper limit to, and 5 milliarcsec rms a lower limit to the internal consistency of our positions. To check that bandwidth smearing is not a significant problem, we observed the primary calibration source 1633+382 at three different offsets (60, 90 and 120 arcsec) from the phase centre. The differences with respect to the VLBI position are 3.0, 7.5 and 16.5 milliarcsec respectively. As the initial positions from the Green Bank survey have an rms accuracy of about 30 arcsec and very few have errors > 90 arcsec, we do not believe that bandwidth smearing makes a significant contribution to our overall positional error budget.

The best check on our absolute positional accuracy (as opposed to internal consistency) is obtained by comparing our positions for the 11 target sources in the present survey area which are also listed in the most up-to-date JPL catalogue of VLBI astrometric positions (Sovers *et al.* 1988 plus supplements supplied by the JPL group). These sources were observed and the data treated in an identical way to our other target sources. The rms difference between our position measurements and the catalogue values is ~8 milliarcsec in both RA and Dec. As the VLBI positions are believed to be accurate to ~1 milliarcsec, we conclude that our absolute positional accuracy is about 12 milliarcsec rms, about in the middle of the internal consistency limits described above. It is noteworthy that when we compare our positions with those of the 58 sources in our area which are listed in the VLA Calibration Manual as position code C, we obtain an rms difference of 50 milliarcsec in RA and 67 milliarcsec in Dec. Our positions are, therefore, more accurate than those of the great majority of sources in the current VLA list.

6 CONCLUSIONS

We have produced a list of 800 sources suitable for use as phase calibrators for MERLIN and other interferometer arrays. All have flux densities at 8.4 GHz $\geqslant$ 100 mJy and have $\geq$ 80 per cent of their flux density in a compact component, and now have positions known to an rms accuracy of about 12 milliarcsec. This major increase in the astrometric accuracy compared with the current VLA calibrator list has been achieved simply. We used the VLA in single snapshot mode, calibrated every 6 min, and relied on the grid of sources with astrometric positions determined by VLBI to calibrate the phases. Standard VLA software was used throughout the analysis. The major difficulties encountered in the analysis were associated with large errors in some of the positions we derived from the Green Bank survey. For our present purposes the final positional accuracy we achieved with single VLA snapshots is adequate. Presumably, however, one could obtain significantly more accurate positions if snapshot observations at many different hour angles were combined.

Encouraged by our results we are extending the survey to another part of the sky. We have observed another set of flat-spectrum radio sources with the same selection criteria in the region of sky between $20° \leq \delta \leq 35°$ and $\delta \geq 75°$, the sample at high declination being selected from the Kühr *et al.* (1981) catalogue. We will be glad to send the catalogue to interested astronomers. The contact email address is alok@star.jb.man.ac.uk.

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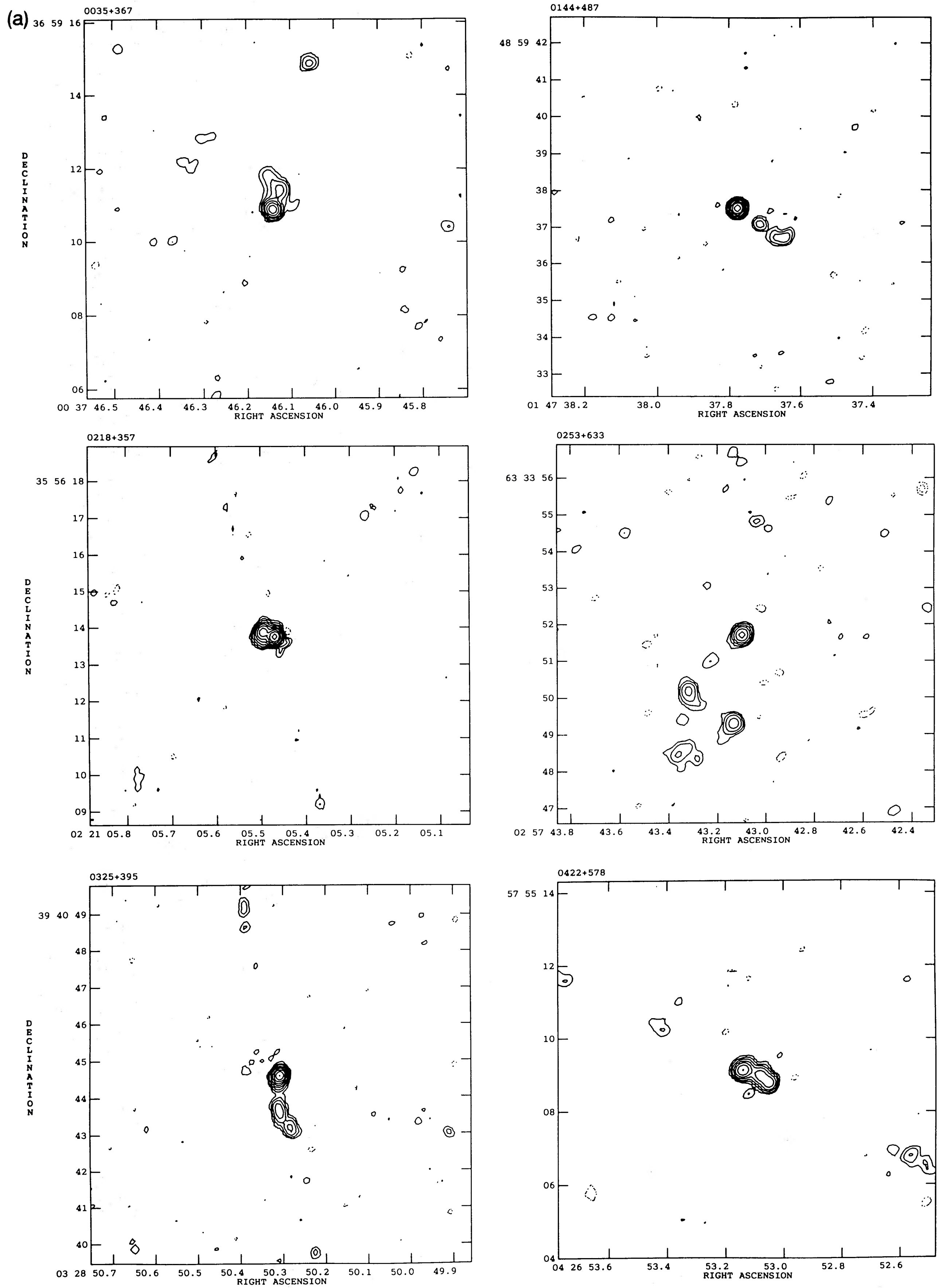

Figure 2. Contour maps of sources with structure found in the survey. The minimum contour level, given in Table 3, is 3 times the rms noise in the map. The contour levels are multiples (−2, −1, 1, 2, 4, 8, 16, 32, 64, 128, 256 and 512) of the minimum contour level.

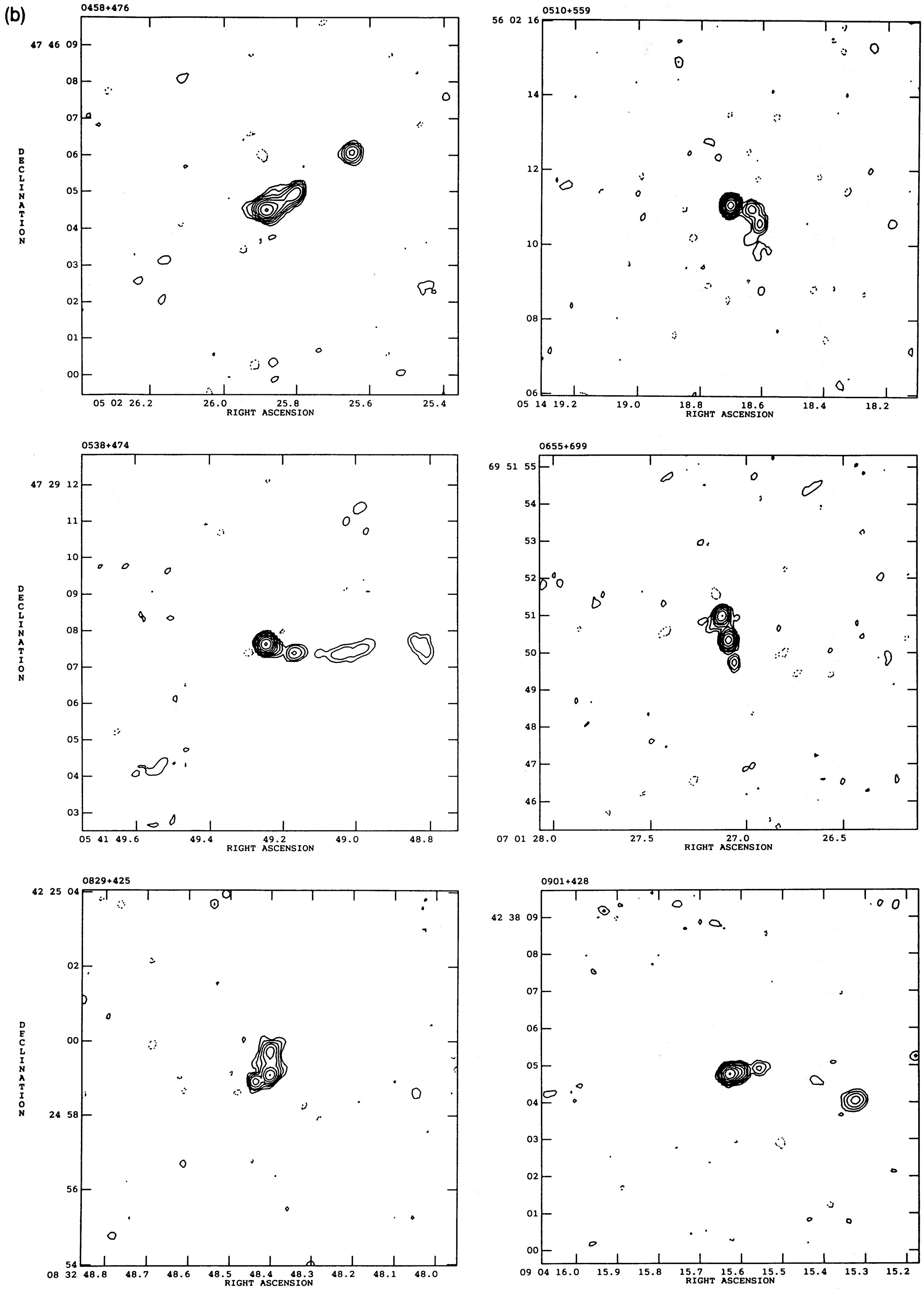

Figure 2 – *continued*

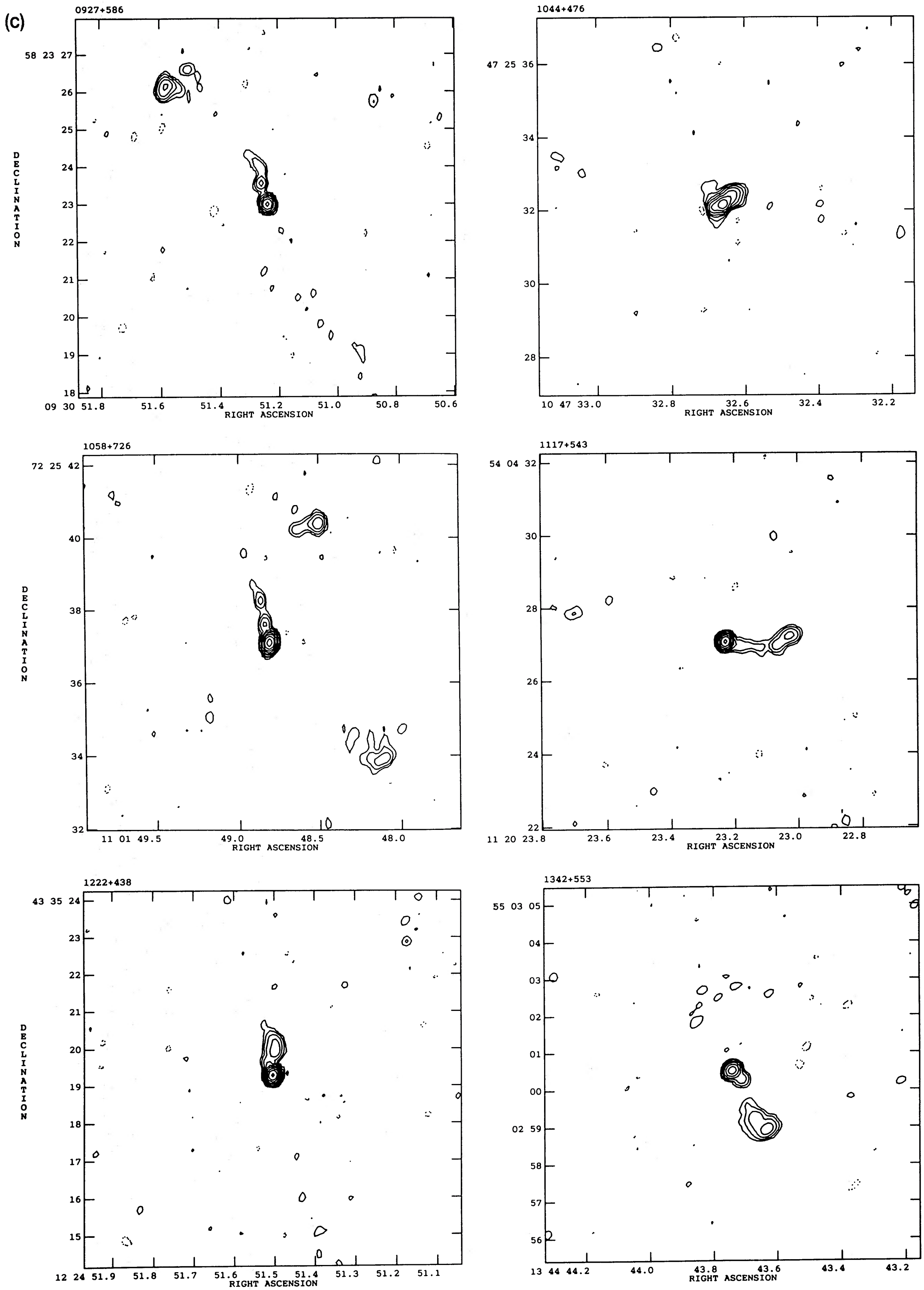

Figure 2 – *continued*

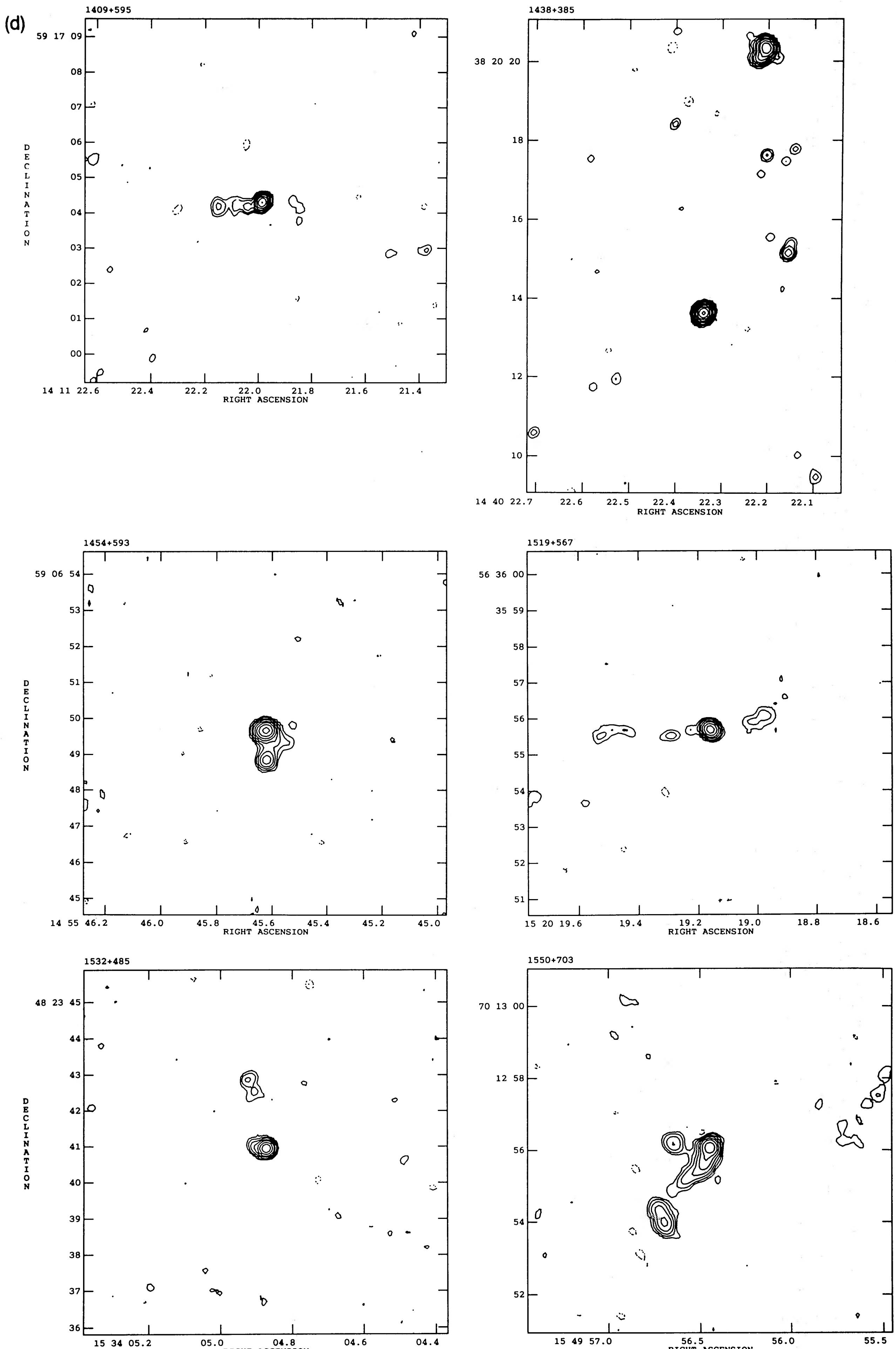

Figure 2 - *continued*

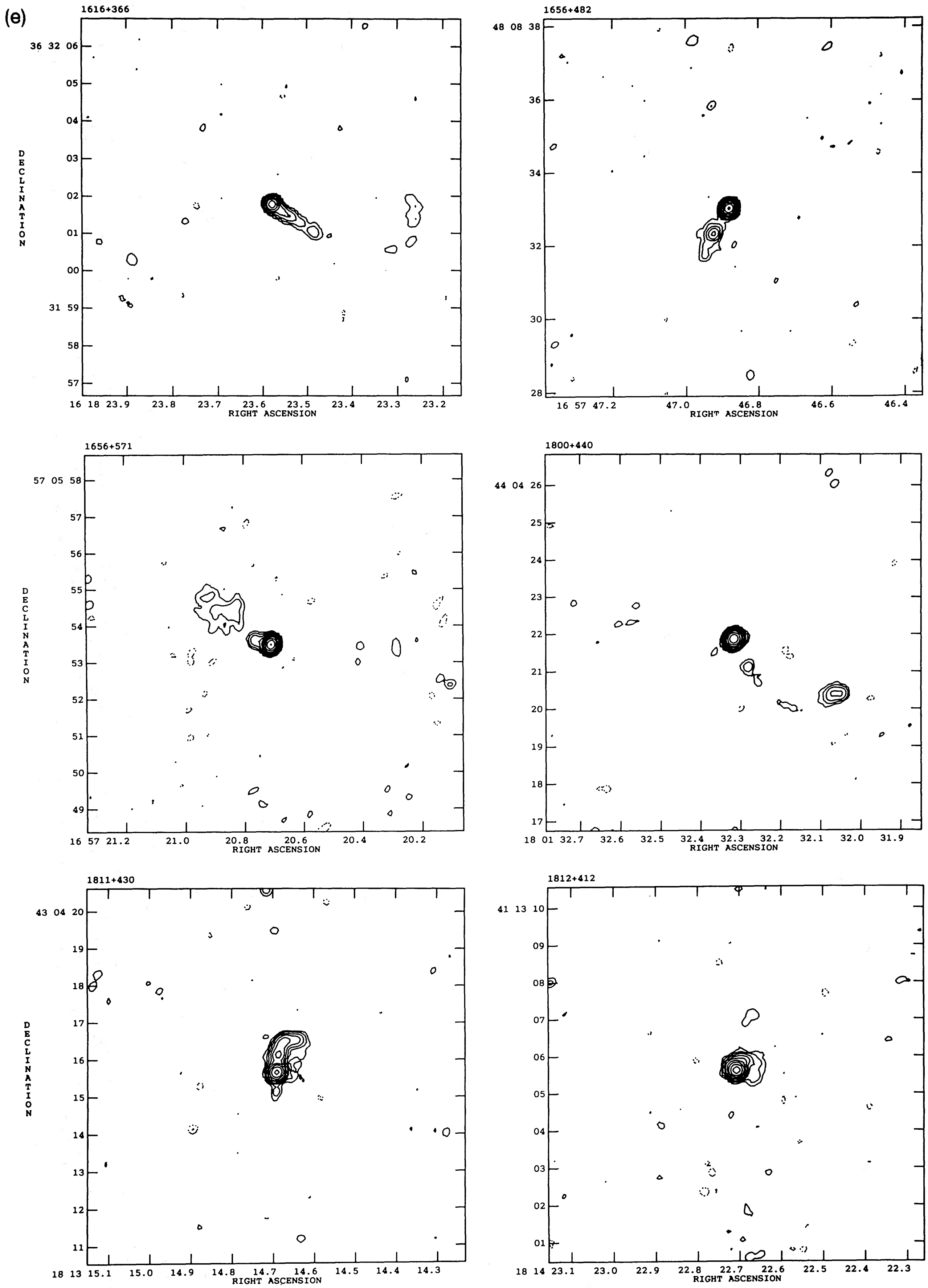

Figure 2 – *continued*

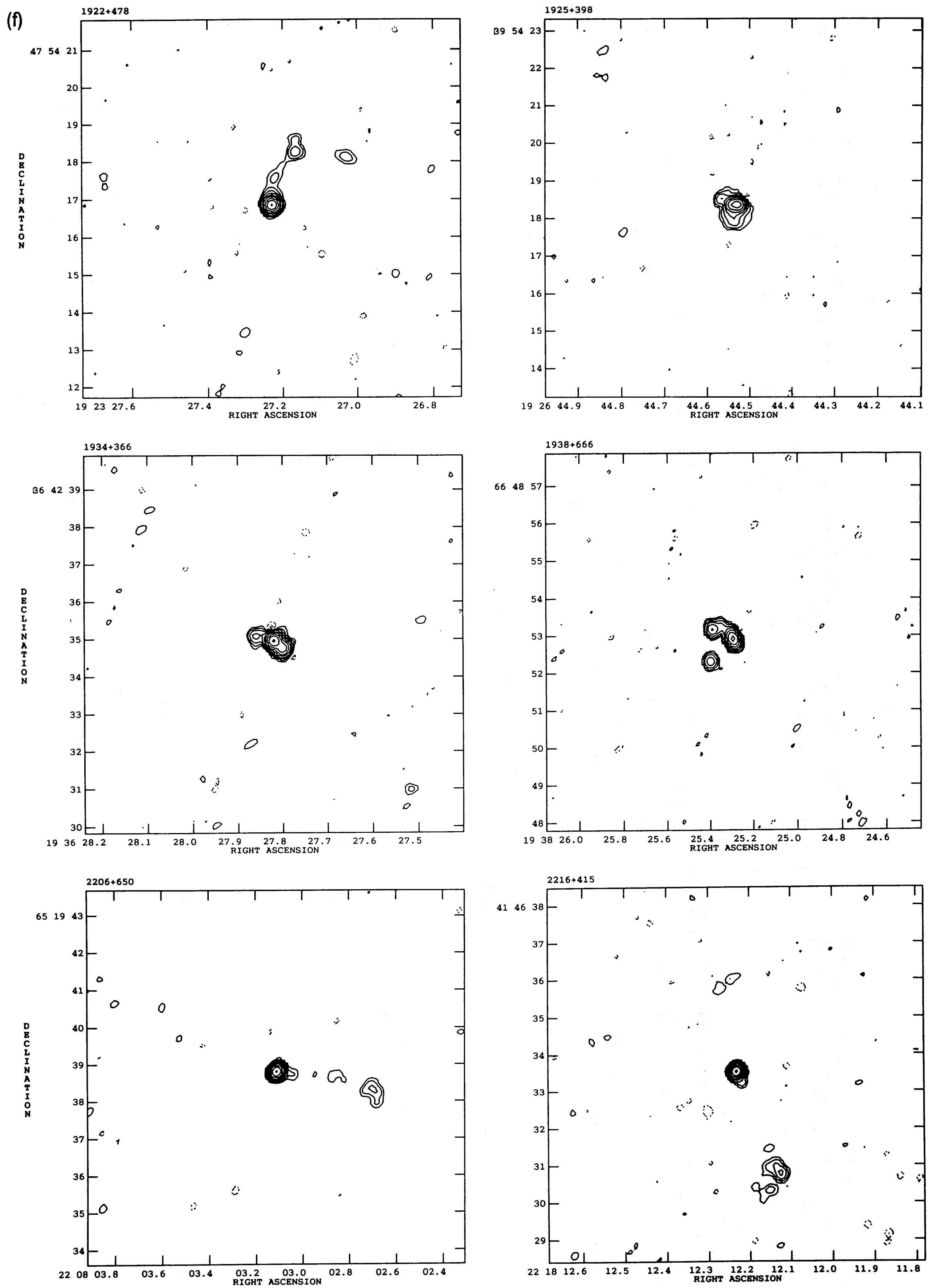

Figure 2 – *continued*

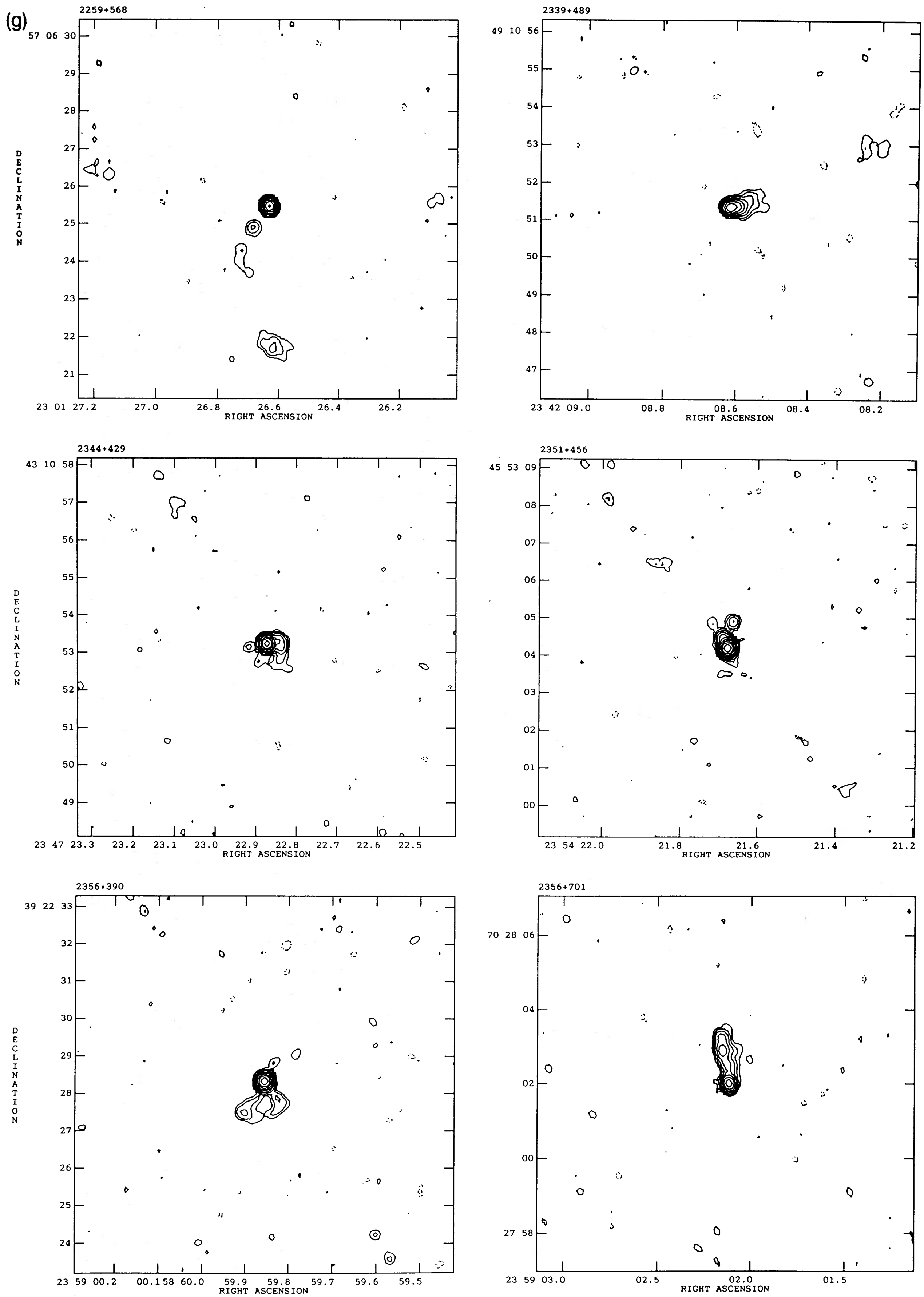

Figure 2 – *continued*

Table 4. List of sources found in the survey which are not suitable as calibrators. The layout is the same as Table 2.

1	2	3	4	5	6	7
0028+537	0031+540	00 31 1.75468	54 01 50.5868	419	D	PA 20,0.25"
0035+367	0037+369	00 37 46.14372	36 59 10.9280	240		MAP
0055+555	0058+558	00 58 15.55956	55 48 30.9140	111	D	PA -165,2"
0100+532	0103+535	01 03 11.00427	53 33 0.2842	80		EXT PA 12
0110+401	0113+404	01 13 17.78004	40 26 13.1005	168	D	PA 20.0, 0.5"
0112+518	0115+521	01 15 56.87414	52 09 13.0342	104	D	PA -25, 0.65"
0205+722	0209+724	02 09 51.79208	72 29 26.6686	549		EXT PA 20
0218+357	0221+359	02 21 5.47016	35 56 13.7225	1208	D	MAP
0253+633	0257+635	02 57 43.09745	63 33 51.7292	51		MAP
0422+578	0426+579	04 26 53.13660	57 55 9.1544	145		MAP
0458+476	0502+477	05 02 25.88525	47 46 4.5393	315		MAP
0535+424	0538+424	05 38 34.32819	42 26 33.8211	89	D	PA 122, 1.7"
0546+726	0552+726	05 52 52.99716	72 40 45.1288	267	D	PA -40, 0.6"
0638+357	0641+356	06 41 35.85425	35 39 57.6234	138		EXT PA -40
0655+699	0701+698	07 01 27.09343	69 51 50.3361	437		MAP
0813+557	0817+556	08 17 34.31114	55 37 18.2445	167		
0817+710	0822+708	08 22 16.76488	70 53 7.9785	146		EXT PA -65
0821+394	0824+392	08 24 55.48368	39 16 41.8978	1483		EXT PA -50
0829+425	0832+424	08 32 48.40113	42 24 59.0838	135		MAP
0901+428	0904+426	09 04 15.62764	42 38 4.7727	501		MAP
0910+442	0913+440	09 13 53.36615	44 02 57.1951	116		JET PA -35
0916+718	0921+716	09 21 23.94334	71 36 12.4167	158	D	PA 100,0.4"
0922+645	0926+643	09 26 53.15370	64 19 35.5792	186		SEC PA 15, 5"
0927+586	0930+583	09 30 51.23593	58 23 23.0286	103		MAP
0945+664	0949+662	09 49 12.16518	66 14 59.5874	783	D	PA 35,1.5"
1016+573	1020+570	10 20 3.25252	57 05 7.8756	276	D	PA 35, 0.7"
1044+476	1047+474	10 47 32.66213	47 25 32.1086	308		MAP
1241+735	1243+732	12 43 11.21561	73 15 59.2589	135		JET PA -30.0
1242+364	1244+361	12 44 49.69489	36 09 25.6624	122	D	PA 40,0.5"
1306+360	1308+357	13 08 25.28601	35 46 57.3416	538		
1342+553	1344+550	13 44 43.74210	55 03 0.5112	69		MAP
1438+385	1440+383	14 40 22.33653	38 20 13.6273	825	D	MAP
1454+593	1455+591	14 55 45.62641	59 06 49.6569	188		MAP
1538+613	1539+612	15 39 48.09143	61 13 56.2889	199		EXT PA 75
1550+703	1549+702	15 49 56.45228	70 12 56.0715	186		MAP
1645+379	1647+378	16 47 25.74468	37 52 18.0528	170	D	PA 0, 1.2"
1724+399	1726+399	17 26 32.66150	39 57 2.2437	195	D	PA -135, 1"
1750+509	1751+509	17 51 32.58918	50 55 37.8469	119	D	PA -60,0.8"
1925+398	1926+399	19 26 44.53489	39 54 18.3629	162		MAP
1934+366	1936+367	19 36 27.81691	36 42 34.9884	628		MAP
1938+666	1938+668	19 38 25.28898	66 48 52.9152	224		MAP
2205+389	2207+392	22 07 46.07195	39 13 50.3526	183		EXT PA 90
2246+447	2248+450	22 48 24.89616	45 02 29.5692	126	D	
2339+489	2342+491	23 42 8.61368	49 10 51.3862	125		MAP
2356+701	2359+704	23 59 2.12568	70 28 2.0239	133		MAP

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