ARCSECOND POSITIONS FOR MILLIARCSECOND VLBI NUCLEI OF EXTRAGALACTIC RADIO SOURCES. II. 207 SOURCES

DAVID D. MORABITO, ROBERT A. PRESTON, AND MARTIN A. SLADE
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91109

DAVID L. JAUNCEY
CSIRO, Division of Radiophysics, Sydney, NSW, Australia

GEORGE D. NICOLSON
CSIR, National Institute for Telecommunications Research, Johannesburg, South Africa

Received 29 March 1983; revised 2 May 1983

ABSTRACT

VLBI measurements of time delay and fringe frequency at 2.29 GHz on baselines of $\sim 10^4$ km have been used to determine the positions of the milliarcsecond nuclei in 207 extragalactic radio sources. Estimated accuracies generally range from $\sim 0\overset{''}{.}1$ to $\sim 1\overset{''}{.}0$ in both right ascension and declination, with all sources having uncertainties $< 4''$ in both coordinates. The observed sources are part of an all-sky VLBI catalog of milliarcsecond radio sources. Arcsecond positions have now been determined for 752 of these sources.

I. INTRODUCTION

A survey is underway to develop an all-sky catalog of radio sources with milliarcsecond components at 2.29 GHz. This is being accomplished by searching for compact components in known extragalactic sources (Morabito, Preston, and Faulkner 1981; Preston and Morabito 1979; Preston *et al.* 1983) with intercontinental VLBI baselines. We have used the VLBI measurements of time delay and fringe frequency at 2.29 GHz to determine the positions of the milliarcsecond nuclei. Previously we determined the positions of 546 nuclei (Morabito *et al.* 1982, paper I). In this paper we determine the positions of an additional 206 nuclei and include an improved position for one source (M104) from paper I. Estimated accuracies in this paper range from $0\overset{''}{.}1$ to $3\overset{''}{.}8$ in both right ascension and declination. The addition of the Australia to South Africa baseline has allowed the survey to continue south of $-45°$ declination. In total we have determined arcsecond positions for 84% of the detected sources.

Arcsecond positions serve as a useful starting point in the construction of a high precision VLBI reference frame as well as allowing unambiguous optical identifications to be made. The positions from this paper and paper I are presently being used as a first step in the formation of a precision reference frame of about 200 sources in which relative radio positions should be determined to milliarcsecond accuracy (Fanselow *et al.* 1979).

II. THE OBSERVATIONS

The observations were performed with pairs of antennas on either California-Australia, California-Spain, or Australia-South Africa baselines (see Table I) in 16 separate observing sessions between 1978 and 1982. A list of experiments appears in Table II. The observations were performed at 2.29 GHz with MK II VLBI recording systems as described in paper I. The length of each observation was a few minutes with 38% of the sources being observed more than once.

TABLE I. Participating observatories.

Location	Designation	Diameter (m)	Baseline length Kilometer	Wavelengths
Tidbinbilla, Australia	DSS 43	64		
			10.6×10^3	8.1×10^7
Goldstone, California	DSS 14	64		
	DSS 13	26		
			8.4×10^3	6.4×10^7
Madrid, Spain	DSS 63	64		
Parkes, Australia	PK	64		
			9.7×10^3	7.5×10^7
Hartebeesthoek, South Africa	HT	26		

 0004-6256/83/081138-08$00.90

TABLE II. Experiment list.

Yr	Experiment Mo	Day	Stations	Number of position calibrator source observations	Number of source positions determined
75	05	30/31	13/43	4	27
78	06	29/30	13/43	8	10
80	02	01	14/43	4	7
80	02	27/28	14/43	3	10
80	03	03	13/63	8	25
80	03	12/13	13/63	13	26
80	03	28	13/63	4	25
80	04	24	PK/HT	9	17
80	04	25	PK/HT	11	14
80	04	25/26	PK/HT	10	14
80	06	19	14/43	6	9
81	05	08	14/43	3	1
82	02	14	43/HT	8	25
82	02	17	43/HT	3	33
82	02	19	43/HT	8	38
82	04	20	43/HT	6	43

TABLE III. List of calibration sources.

Source	Source	Source	Source
P0003 − 00[a]	P0727 − 11	DW1555 + 00	OY − 172.6
	P0743 − 006[c]	P1610 − 77[d]	
0016 + 73[b]	4C7107	3C345	P2245 − 328
P0104 − 408	OJ287	NRAO530	P2345 − 16
P0106 + 01	3C212[c]	P1741 − 038	
P0113 − 118	4C39.25	1749 + 70[b]	
P0332 − 403	P1104 − 445		
P0402 − 362	P1127 − 14	1803 + 78[b]	
P0438 − 43	P1144 − 379	OV − 236	
P0537 − 441	1150 + 81[b]	1928 + 73[b]	
DA193	3C273	P1933 − 400	
P0605 − 08	3C274[c]	2007 + 77[b]	
0615 + 82[b]	P1333 − 33[c]	P2134 + 004	
0716 + 71[b]	3C309.1	P2215 + 02[a]	
P0723 − 008[c]			

All positions from Fanselow *et al.* (1981) unless footnoted. Footnote key:
[a] McEwan, Browne, and Crowther (1975).
[b] Waltman *et al.* (1981).
[c] Morabito *et al.* (1982).
[d] Jauncey, D. L. *et al.* (in preparation).

III. METHOD OF POSITION DETERMINATION

The details of position determination for this set of sources closely follow the analysis given in paper I, except for three differences.

(1) The data for the 207 sources reported in this paper were reduced using the Caltech/JPL VLBI Mark II correlator and post-correlation software, whereas the data in paper I were reduced using the NRAO Mark II correlator and post-correlation software.

(2) Increased accuracy in modeling of the troposphere and earth rotation parameters yielded a smaller scatter in the time delay and fringe frequency residual. Typical residual values for the rms time delay scatter were ~10 ns and for the rms fringe frequency scatter ~0.1 mHz. The observed scatter was assumed to be an estimate of the random measurement error. Earth rotation corrections were obtained from final smoothed values of UT1-UTC and polar motion from Bureau International de l'Heure (BIH).

(3) Due to improved modeling of the troposphere and earth rotation parameters, 0″3 rather than 0″5 was added in a root-sum-square manner to formal estimates of right ascension and declination uncertainty in each experiment to account for unmodeled effects.

As in paper I, observations of sources with well-known positions allowed instrumental delays and frequency offsets to be determined. At least three such calibration sources per experiment were spread in time among the sources whose positions we wished to determine (see Table II). A list of the 44 calibration sources utilized appears in Table III. 28 of the calibration source positions have been determined with VLBI by Fanselow *et al.* (1981) and can be referred to the FK4 reference frame (Fricke and Kopff 1963) with an accuracy of 0″1. Other calibration source positions came from (1) Waltman *et al.* (1981), eight sources, 0″1 accuracy, (2) Paper I, five sources, 0″5 accuracy, (3) McEwan, Brown, and Crowther (1975), two sources, 1″ accuracy, and (4) Jauncey *et al.* (in preparation), 1 source, 0″1 accuracy.

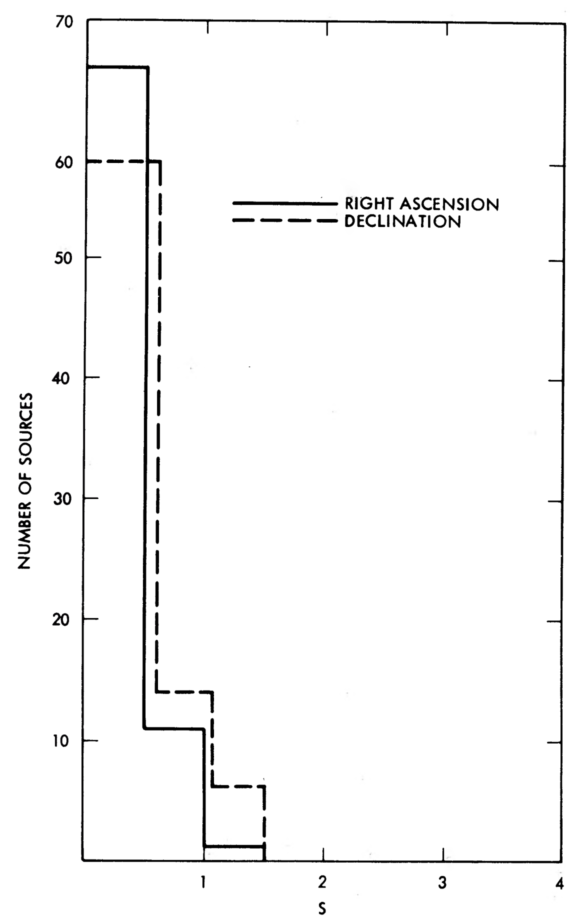

FIG. 1. Comparison of position estimates for 78 multiply observed sources. For each source, S is the ratio of the weighted rms scatter of individual position coordinate estimates about the mean value to the weighted rms estimate of the uncertainty in that position coordinate.

TABLE IV. Source positions.

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
P 0002-478	0	2	2.978	0.033	-47	53	1.81	0.30
0014+81	0	14	4.473	0.151	+81	18	28.71	0.22
0018+72	0	18	34.482	0.107	+72	56	3.93	0.24
P 0019-00	0	19	51.665	0.020	- 0	1	41.88	0.32
P 0022-423	0	22	15.413	0.020	-42	18	41.12	0.21
0027+70	0	27	17.026	0.083	+70	21	6.26	0.31
P 0034-01	0	34	30.555	0.020	- 1	25	37.78	0.36
P 0035-02	0	35	47.176	0.020	- 2	24	9.45	0.30
P 0036+03	0	36	44.176	0.020	+ 3	3	24.54	0.43
P 0047-579	0	47	48.238	0.064	-57	54	46.83	0.30
P 0055-01	0	55	1.572	0.020	- 1	39	39.40	0.34
P 0056-572	0	56	38.640	0.041	-57	15	22.07	0.30
P 0131-522	1	31	3.633	0.022	-52	15	26.40	0.17
P 0133-203	1	33	13.577	0.025	-20	24	4.01	0.44
0149+71	1	49	20.814	0.057	+71	0	20.76	0.24
B2 0149+33	1	49	40.027	0.024	+33	35	46.85	0.31
0153+74	1	53	4.339	0.054	+74	28	5.69	0.21
0159+72	1	59	13.059	0.057	+72	18	29.24	0.23
P 0202-76	2	2	1.005	0.422	-76	34	26.34	0.30
0205+72	2	5	26.907	0.050	+72	15	16.40	0.22
GC 0206+35	2	6	39.339	0.032	+35	33	41.36	0.40
P 0208-512	2	8	56.970	0.019	-51	15	7.53	0.17
0212+73	2	12	49.935	0.050	+73	35	40.15	0.21
P 0214-522	2	14	17.229	0.029	-52	14	5.49	0.21
P 0219-637	2	19	37.871	0.062	-63	43	59.84	0.21
P 0220-349	2	20	49.570	0.028	-34	55	4.67	0.35
GC 0223+34	2	23	9.735	0.027	+34	8	1.56	0.33
P 0226-038	2	26	21.984	0.021	- 3	50	57.25	0.42
P 0229-398	2	29	51.990	0.017	-39	49	0.15	0.18
P 0230-790	2	30	28.852	0.139	-79	1	0.77	0.21
P 0232-04	2	32	36.512	0.022	- 4	15	8.90	0.65
P 0235-618	2	35	37.782	0.034	-61	49	13.47	0.21
P 0244-452	2	44	4.579	0.023	-45	12	13.34	0.21
GC 0248+43	2	48	18.504	0.027	+43	2	56.98	0.34
P 0252-549	2	52	0.273	0.023	-54	54	2.27	0.17
P 0302-623	3	2	48.181	0.034	-62	23	3.71	0.21
P 0308-611	3	8	51.298	0.027	-61	9	58.24	0.17
P 0312-77	3	12	56.328	0.205	-77	3	0.15	0.30
P 0316-444	3	16	13.353	0.056	-44	25	11.24	0.30
DW 0326+27	3	26	56.037	0.026	+27	46	0.31	0.33
P 0332-403	3	32	25.244	0.026	-40	18	24.04	0.30
P 0334-546	3	34	36.057	0.029	-54	40	16.95	0.21
OE 367	3	40	14.804	0.029	+36	12	44.47	0.42
P 0355-66	3	55	27.892	0.095	-66	54	11.43	0.22
P 0355-483	3	55	52.505	0.027	-48	20	49.14	0.21
GC 0402+37	4	2	29.854	0.029	+37	55	26.85	0.42
0403+76	4	3	59.196	0.067	+76	48	52.75	0.25
P 0414-341	4	14	16.908	0.028	-34	10	26.06	0.37
3C 119	4	29	7.937	0.027	+41	32	8.24	0.31
P 0431-512	4	31	4.407	0.043	-51	15	42.11	0.23
P 0437-454	4	37	30.667	0.025	-45	28	12.26	0.22
P 0446-519	4	46	35.030	0.049	-51	56	13.75	0.23
P 0448-392	4	48	0.452	0.017	-39	16	15.74	0.18
P 0450-469	4	50	27.871	0.024	-46	58	16.45	0.21
P 0454+039	4	54	8.935	0.020	+ 3	56	14.71	0.41
P 0454-81	4	54	18.188	0.176	-81	5	54.13	0.21
P 0454-46	4	54	24.188	0.031	-46	20	38.47	0.23

TABLE IV. (continued)

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
0454+84	4	54	57.212	0.147	+84	27	53.01	0.21
P 0459+135	4	59	43.842	0.021	+13	33	56.20	0.31
P 0503-608	5	3	24.298	0.090	-60	53	56.16	0.31
P 0509+152	5	9	49.674	0.024	+15	13	49.21	0.41
P 0514-459	5	14	19.327	0.022	-45	59	58.50	0.18
P 0521-262	5	21	17.209	0.035	-26	16	52.90	0.55
P 0522-611	5	22	0.426	0.066	-61	10	41.35	0.31
P 0523-570	5	23	48.149	0.056	-57	1	27.40	0.23
P 0524-460	5	24	6.001	0.020	-46	0	28.01	0.18
0532+82	5	32	31.216	0.136	+82	36	53.05	0.23
P 0537-158	5	37	17.184	0.037	-15	52	5.10	0.35
P 0543-735	5	43	2.748	0.072	-73	33	31.98	0.18
0604+72	6	4	39.237	0.053	+72	49	27.21	0.23
P 0622-441	6	22	2.686	0.033	-44	11	22.97	0.22
P 0629-418	6	29	37.684	0.034	-41	52	14.26	0.30
0633+73	6	33	6.438	0.074	+73	27	35.75	0.31
P 0637-75	6	37	23.422	0.065	-75	13	37.38	0.15
0718+79	7	18	8.892	0.082	+79	17	22.60	0.22
P 0722+145	7	22	27.228	0.127	+14	31	7.94	1.81
P 0736+01	7	36	42.553	0.020	+ 1	43	59.44	0.31
0740+82	7	40	33.222	0.187	+82	49	24.17	0.22
P 0743-67	7	43	22.189	0.052	-67	19	9.09	0.31
P 0757-737	7	58	1.046	0.150	-73	44	57.34	0.30
0824+11	8	24	22.311	0.026	+11	2	19.22	0.37
0830+11	8	30	29.914	0.028	+11	33	52.30	0.37
P 0842-75	8	42	6.608	0.635	-75	29	19.76	0.40
P 0851+071	8	51	8.451	0.023	+ 7	6	11.84	0.33
P 0907-023	9	7	13.129	0.020	- 2	19	16.43	0.31
P 0915-213	9	15	10.447	0.026	-21	18	56.88	0.32
P 0925-203	9	25	33.523	0.021	-20	21	44.65	0.30
P 0931-114	9	31	8.908	0.020	-11	26	4.59	0.30
P 0932+02	9	32	43.652	0.021	+ 2	17	12.21	0.73
0950+74	9	50	4.573	0.113	+74	50	7.67	0.22
P 0957+00	9	57	43.824	0.020	+ 0	19	48.94	0.32
1003+83	10	3	25.911	0.307	+83	4	56.52	0.30
P 1020-103	10	20	4.181	0.083	-10	22	33.40	0.99
1023+747	10	23	13.015	0.121	+74	43	43.43	0.31
1027+74	10	27	13.502	0.424	+74	57	22.48	0.31
P 1030-357	10	30	52.089	0.035	-35	46	27.46	0.31
P 1032-199	10	32	37.372	0.021	-19	56	2.19	0.31
P 1034-058	10	34	16.967	0.049	- 5	50	16.28	0.95
P 1034-374	10	34	38.242	0.026	-37	28	39.66	0.30
1039+81	10	39	27.818	0.128	+81	10	23.54	0.21
1044+71	10	44	49.741	0.047	+71	59	26.72	0.21
P 1046-409	10	46	22.645	0.038	-40	58	7.69	0.33
1053+70	10	53	27.729	0.045	+70	27	47.78	0.21
1053+81	10	53	36.302	0.108	+81	30	35.41	0.17
P 1057-79	10	57	49.877	0.406	-79	47	47.60	0.31
1058+72	10	58	20.119	0.060	+72	41	44.72	0.22
P 1102-242	11	2	19.825	0.023	-24	15	13.82	0.30
P 1103-006	11	3	58.359	0.020	- 0	36	40.84	0.31
1104+72	11	4	17.980	0.080	+72	48	49.95	0.22
P 1105-680	11	5	17.769	0.139	-68	4	35.70	0.31
P 1106+023	11	6	11.190	0.020	+ 2	18	56.23	0.31
P 1110-217	11	10	21.668	0.024	-21	42	8.72	0.33
P 1116-46	11	16	6.200	0.032	-46	17	50.01	0.22
P 1120-274	11	20	28.477	0.026	-27	26	20.21	0.30

TABLE IV. (continued)

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
P 1133-681	11	33	46.785	0.134	-68	10	29.41	0.30
P 1133-739	11	34	1.524	0.323	-73	59	8.91	0.31
P 1142-225	11	42	50.234	0.026	-22	33	51.75	0.33
P 1143-287	11	43	54.800	0.024	-28	42	37.96	0.31
P 1143-331	11	43	57.498	0.039	-33	12	2.60	0.45
P 1145-676	11	45	9.366	0.058	-67	37	1.66	0.35
P 1148-671	11	48	46.744	0.068	-67	11	29.38	0.22
P 1203-26	12	2	58.823	0.022	-26	17	22.59	0.30
P 1207-399	12	6	59.486	0.020	-39	59	31.49	0.18
P 1221-82	12	21	25.115	0.163	-82	56	33.54	0.31
1221+80	12	21	47.662	0.218	+80	56	41.03	0.21
P 1236-684	12	36	44.606	0.095	-68	29	2.18	0.31
M 104	12	37	23.378	0.013	-11	20	55.04	0.21
P 1240-294	12	40	30.049	0.028	-29	26	57.05	0.35
P 1250-330	12	50	14.899	0.025	-33	3	42.65	0.31
P 1251-71	12	51	40.129	0.063	-71	22	3.72	0.31
P 1256-229	12	56	27.621	0.023	-22	54	28.09	0.31
1305+80	13	5	22.143	0.191	+80	24	21.27	0.18
P 1347-218	13	47	28.024	0.024	-21	49	49.70	0.34
P 1349-439	13	49	52.576	0.029	-43	57	54.04	0.30
P 1349+027	13	49	58.378	0.020	+ 2	47	33.84	0.44
P 1351+021	13	51	18.912	0.020	+ 2	6	37.46	0.32
1357+76	13	57	42.177	0.133	+76	57	53.05	0.30
P 1406-267	14	6	58.442	0.024	-26	43	27.76	0.32
1436+76	14	36	4.574	0.317	+76	18	23.82	0.36
P 1438-347	14	38	20.331	0.027	-34	43	57.60	0.32
1448+76	14	48	56.492	0.078	+76	13	33.81	0.22
P 1451-400	14	51	20.602	0.018	-40	0	22.46	0.22
P 1509+022	15	9	43.717	0.020	+ 2	14	32.10	0.31
P 1549-79	15	49	28.382	0.211	-79	5	17.75	0.30
P 1602+01	16	2	12.955	0.020	+ 1	25	58.69	0.32
P 1602-00	16	2	21.909	0.020	- 0	10	57.17	0.32
P 1603+00	16	3	38.909	0.020	+ 0	8	30.12	0.36
P 1610-77	16	10	51.750	0.104	-77	9	52.60	0.30
1616+85	16	16	22.349	3.021	+85	9	26.04	0.42
P 1635-035	16	35	41.407	0.020	- 3	34	8.85	0.43
1637+82	16	37	56.847	0.332	+82	38	18.48	0.23
P 1706+006	17	6	11.695	0.020	+ 0	38	54.89	0.31
P 1718-649	17	18	46.160	0.022	-64	57	47.87	0.12
P 1719-729	17	19	52.046	0.089	-72	57	18.81	0.22
P 1732-598	17	32	2.807	0.046	-59	50	6.38	0.30
P 1733-56	17	33	24.401	0.045	-56	31	39.93	0.32
P 1758-651	17	58	25.634	0.037	-65	7	40.83	0.21
P 1800-709	18	0	36.223	0.099	-70	58	44.21	0.24
P 1815-554	18	15	35.184	0.044	-55	22	38.16	0.31
P 1823-455	18	23	31.139	0.034	-45	34	19.00	0.33
P 1831-711	18	31	41.335	0.078	-71	11	14.56	0.30
P 1853-534	18	52	59.134	0.042	-53	28	58.63	0.31
P 1925-610	19	25	40.692	0.034	-61	2	24.34	0.22
P 1929-457	19	29	8.055	0.034	-45	43	5.21	0.30
P 1935-692	19	35	11.833	0.116	-69	14	52.50	0.39
P 1936-623	19	36	52.756	0.067	-62	18	21.43	0.30
P 1941-554	19	41	23.321	0.038	-55	28	6.09	0.23
1946+70	19	46	12.035	0.072	+70	48	21.66	0.25
P 2004-447	20	4	25.155	0.031	-44	43	28.51	0.30
P 2005-489	20	5	46.605	0.034	-48	58	43.55	0.30
2007+77	20	7	20.428	0.094	+77	43	57.95	0.30

TABLE IV. (continued)

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
2010+72	20	10	16.194	0.050	+72	20	20.82	0.22
P 2022-702	20	22	20.971	0.175	-70	17	9.67	0.35
P 2025-538	20	25	48.485	0.028	-53	49	9.48	0.22
P 2036-577	20	36	5.898	0.042	-57	45	47.41	0.22
P 2044-02	20	44	34.223	0.020	- 2	47	25.99	0.31
P 2052-47	20	52	50.125	0.026	-47	26	19.61	0.21
P 2056-369	20	56	32.104	0.033	-36	57	37.29	0.33
P 2058-425	20	58	42.240	0.022	-42	31	6.07	0.22
P 2105-48	21	5	24.687	0.075	-48	58	32.36	0.33
P 2109-811	21	9	15.991	0.660	-81	6	22.82	0.32
2136+82	21	36	2.190	0.178	+82	25	38.62	0.23
P 2139+02	21	39	39.584	0.023	+ 2	48	45.48	0.67
P 2146-78	21	46	36.334	0.117	-78	21	10.41	0.21
2155-304	21	55	58.321	0.023	-30	27	54.47	0.30
P 2204-54	22	4	26.295	0.027	-54	1	15.02	0.21
2205+74	22	5	8.831	0.136	+74	21	41.93	0.23
P 2205-636	22	5	10.069	0.156	-63	40	30.90	0.35
2207+74	22	7	41.445	0.134	+74	8	53.82	0.28
P 2217+018	22	17	57.958	0.024	+ 1	49	45.62	0.88
2229+69	22	29	11.643	0.042	+69	31	2.79	0.22
P 2232-488	22	32	11.475	0.028	-48	51	30.81	0.22
P 2243-03	22	43	36.312	0.020	- 3	16	26.03	0.36
P 2311-477	23	11	3.004	0.064	-47	45	32.46	0.36
P 2314-409	23	14	2.006	0.037	-40	57	44.66	0.31
P 2314+03	23	14	2.226	0.020	+ 3	48	56.56	0.38
P 2324-02	23	24	19.582	0.020	- 2	18	43.96	0.31
P 2326-477	23	26	33.717	0.019	-47	46	51.76	0.18
P 2326-502	23	26	36.011	0.034	-50	12	13.45	0.30
P 2327-459	23	27	54.722	0.036	-45	56	31.42	0.31
P 2329-415	23	29	37.842	0.055	-41	35	11.90	0.33
P 2332-017	23	32	46.422	0.020	- 1	47	45.37	0.31
P 2333-528	23	33	28.781	0.040	-52	52	58.43	0.30
P 2335+03	23	35	34.273	0.021	+ 3	10	12.18	0.54
P 2351-006	23	51	35.377	0.020	- 0	36	29.42	0.31
P 2352-455	23	52	53.312	0.050	-45	30	7.95	0.34
P 2355-534	23	55	18.190	0.025	-53	27	55.98	0.21

IV. RESULTS

The calculated positions of 207 sources and the corresponding uncertainties are shown in Table IV. The positions are referred to the equinox of 1950.0 and elliptical aberration terms are included so as to agree with past astronomical convention. The source positions and position uncertainties for sources which were multiply observed were estimated from a weighted average.

Seventy-eight sources were observed two or more times, and the scatters in their position estimates are consistent with the estimated uncertainties. Figure 1 displays a histogram of the ratio of the weighted rms scatter of the individual position coordinate estimates from the mean position of each multiply observed source, to the weighted rms estimate of position coordinate uncertainty. For the 78 multiply observed sources, the rms value of this ratio is 0.4 for right ascension and 0.5 for declination. Thus there is excellent agreement between the multiple observations of each source.

In addition to the 207 sources listed in Table IV, we also reobserved 22 sources whose positions were reported in paper I. For these 22 sources, Fig. 2 shows a histogram of the absolute value of the difference in each position coordinate between the two papers divided by the RSS error of the position coordinate uncertainties. There is excellent agreement between the common sources. The calculated ratio has a rms value of 1.3 for right ascension and 1.0 for declination. For one source, M104, an erroneous position was given in paper I. The position for M104 cited in Table IV should be used instead.

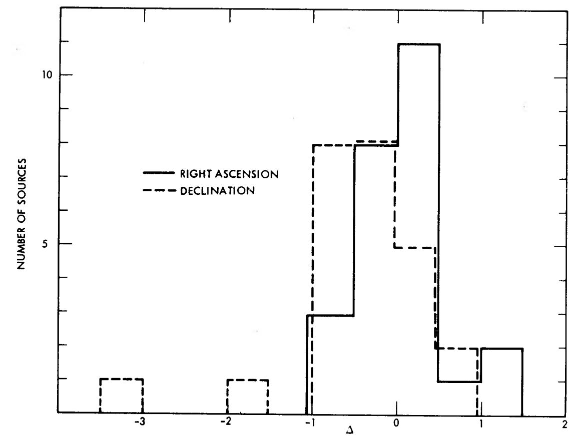

FIG. 3. Comparison of position estimates with other radio positional catalogs. For each source, Δ is the ratio of the difference between our source coordinate estimate and the other catalog value to the RSS of the uncertainties of both catalogs.

For 25 sources, we could compare our position estimates with other position estimates of better or similar accuracy (Waltman *et al.* 1981; Ulvestad *et al.* 1981; Perley 1982). Figure 3 displays the ratio of the value of the difference between our source position estimate and the other catalog value to the RSS of the position uncertainties of both catalogs. For these 25 sources, the rms value of this ratio is 0.5 for right ascension and 0.9 for declination. For both right ascension and declination, the value of the ratio never exceeds 3.2. The bias offsets between our position estimates relative to those of the other catalogs for these 25 sources are $0^{s}005 \pm 0^{s}008$ for

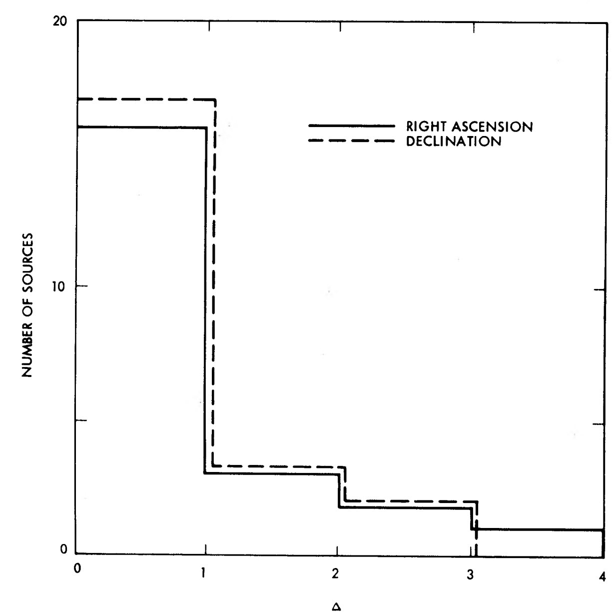

FIG. 2. Comparison of position estimates with 22 sources common with paper I (Morabito *et al.* 1982). For each source, Δ is the ratio of the absolute value of the difference between the source coordinate estimate in this set of data and the source coordinate estimate cited in paper I to the weighted rms estimate of the uncertainty in that position coordinate.

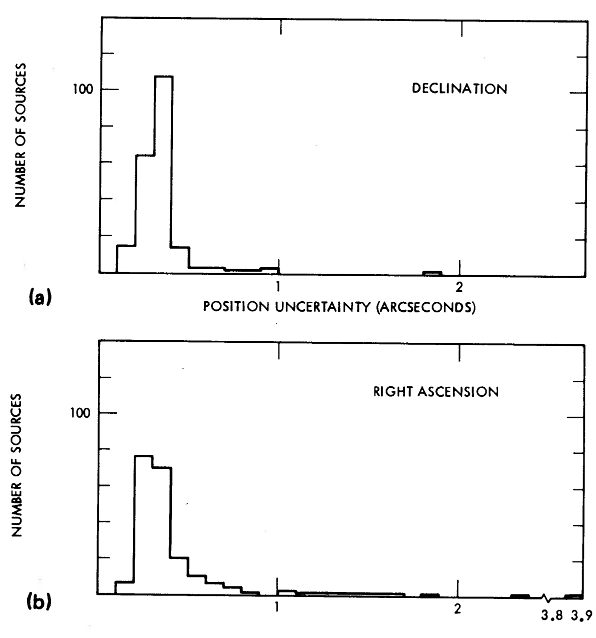

FIG. 4. Histogram of number of sources vs estimated position uncertainty.

right ascension and $-0\overset{''}{.}11 \pm 0\overset{''}{.}06$ for declination. Hence, these position estimate comparisons along with the multiple observation comparisons indicate our position uncertainty estimates are realistic.

Figures 4(a) and 4(b) show histograms of the number of sources versus estimated position uncertainty for declination and right ascension, respectively. Estimated accuracies range from $\sim 0\overset{''}{.}1$ to $3\overset{''}{.}8$ in both right ascension and declination. Most of the sources with high uncertainties were near the equator where the position measuring technique can have lower sensitivity (see Cohen and Shaffer 1971).

V. SUMMARY

Positions for the milliarcsecond nuclei of 207 extragalactic sources have been determined to an accuracy of $\sim 0\overset{''}{.}1$ to $3\overset{''}{.}8$ in both right ascension and declination. The reliability of the determined positions has been demonstrated by testing the repeatability of multiple observations on the same source and by comparing the results with other radio catalogs. Arcsecond positions have now been determined for 752-milliarcsecond nuclei.

Note added in proof. The QS0 now identified with the source P1935 − 692 has been found to have a redshift of 3.15 [D. L. Jauncey and A. Savage (private communication)].

We appreciate the assistance of G. Trager and J. Faulkner in data processing, and L. J. Skjerve, D. J. Spitzmesser, and the personnel of the Deep Space Network, Hartebeesthoek Radio Astronomy Observatory and Australian National Radio Astronomy Observatory at Parkes for aid in performing the observations. This work was funded in part by NASA Contract NAS-7-918.

REFERENCES

Clark, B. G. (1973). Proc. IEEE **61**, 1242.

Cohen, M. H., and Shaffer, D. B. (1971). Astron. J. **76**, 91.

Fanselow, J. L., Thomas, J. B., Cohen, E. J., MacDoran, P. F., Melbourne, W. G., Mulhall, B. D., Purcell, G. H., Rogstad, D. H., Skjerve, L. J., Spitzmesser, D. J., Urech, J., and Nicholson, G. (1979). *Time and the Earths Rotation*, IAU Symp. 82 (Reidel, Dordrecht), p. 199.

Fanselow, J. L., Sovers, O. J., Thomas, J. B., Bletzacker, F. R., Kearns, T. J., Cohen, E. J., Purcell, G. H. Jr., Rogstad, D. H., Skjerve, L. J., and Young, L. E. (1981). *Reference Coordinate Systems for Earth Dynamics* (Reidel, Dordrecht), pp. 351–357.

Fricke, W., and Kopff, A. (1963). Veroeff. Astron. Rechen-Institut, Heidelberg, No. 10.

McEwan, N. J., Browne, I. W. A., and Crowther, J. H. (1975). Mon. Not. R. Astron. Soc. **80**, 1.

Morabito, D. D., Preston, R. A., Slade, M. A., and Jauncey, D. L. (1982). Astron. J. **87**, 517 (Paper I).

Morabito, D. D., Preston, R. A., and Faulkner, J. (1981). In *The Telecommunications and Data Acquisition Progress Reports*, 42–66, Sept. and Oct. 1981, Jet Propulsion Laboratory, Pasadena, California, p. 30.

Perley, R. A. (1982). Astron. J. **87**, 859.

Preston, R. A., and Morabito, D. D. NASA Conference Publications 2115, Proceedings of a Conference held at MIT, Cambridge, Massachusetts, June 19–21, 1979.

Ulvestad, J., Johnston, K., Perley, R., and Fomalont, E. (1981). Astron. J. **86**, 1010.

Waltman, E., Johnston, K. J., Spencer, J. H., Pauliny-Toth, I., Schraml, J., and Witzel, A. (1981). Astron. Astrophys. **101**, 49.