Arcsecond Positions for Milliarcsecond VLBI Nuclei of Extragalactic Radio Sources. Part I: 546 Sources

D. D. Morabito, R. A. Preston, and M. A. Slade
Tracking Systems and Applications Section

D. L. Jauncey
C.S.I.R.O., Division of Radiophysics,
Sydney, NSW, Australia

VLBI measurements at 2290 MHz on baselines of ~10^4 km between Deep Space Network stations have been used to identify sources that are suitable for precision astrometric applications. In addition, the observations are used to determine the positions of the milliarcsecond nuclei in 546 extragalactic radio sources. Estimated accuracies generally range from ~0".5 to 1".0 in both right ascension and declination, with ~6% of the sources having estimated uncertainties ≥3".5 in at least one position component. Arcsecond positions serve as a useful starting point in the construction of high-precision VLBI reference frames, and are also important for unambiguous determination of optical counterparts to compact radio sources.

I. Introduction

Two of the quantities that may be measured by very long baseline interferometry (VLBI) are time delay and fringe frequency. Time delay is defined as the difference in time of arrival of signals from a celestial radio source at two antennas plus an instrumental delay. Fringe frequency is defined as the difference in the doppler shift of the received signals as induced by Earth rotation plus the local oscillator frequency offset between the two antennas. A measurement of time delay places the position of an observed source along a particular arc in the sky if the contribution due to instrumental delay can be removed. Correspondingly, a measurement of fringe frequency places the position of the source along a generally different sky arc if the contribution due to instrumental local oscillator frequency offset can be removed. These arguments assume that baseline coordinates and atmospheric effects are known. Observations of sources with accurately known positions allow instrumental delays and frequency offsets to be determined. Hence, a measurement of time delay and fringe frequency can be used to uniquely determine the right ascension and declination of a source.

This technique was first described by Cohen and Shaffer (1971) (Ref. 1), who determined the positions of 35 compact sources with typical accuracies of 1" to 3". More accurate positions for ~10^2 compact sources have been determined with the VLBI technique of "bandwidth synthesis," which provides extremely accurate measurements of time delay (Refs. 2, 3). In this article we use relatively crude time delay measurements along with fringe frequency measurements to determine the positions of the milliarcsecond nuclei in 546 extragalactic sources with accuracies of generally ~1".

The observations were not performed primarily for position measurements, but were part of the development of an all-sky VLBI catalog of milliarcsecond radio sources at 2290 MHz sponsored by the Deep Space Network Advanced Systems Program (Ref. 4). The catalog is being formed by searching for

VLBI components in known extragalactic radio sources. The catalog will eventually contain about 10^3 sources and will be useful in the creation of high-precision celestial reference frames and in investigations into the nature of compact extragalactic radio sources. We expect to determine arcsecond positions for a large majority of those sources, which will constitute at least an order-of-magnitude improvement in positional accuracy for most of the sources.

Arcsecond positions serve as a useful starting point in the construction of high-precision VLBI reference frames. VLBI reference frames are used for ΔVLBI navigation (Ref. 5), clock synchronization (Ref. 6) and baseline determination between widely separated Deep Space Stations (Refs. 7, 8) and measurement of Earth rotation orientation (Ref. 9). The results of this article are presently being utilized as a first step in the formation of a VLBI reference frame of about 100-200 sources in which relative source positions will probably be determined to $\sim 10^{-3}$" by means of high-accuracy bandwidth synthesis time delay measurements (Refs. 2, 10). The arcsecond measurements are also being used for unambiguous determination of optical counterparts to the compact radio sources and for identifying the location of the compact source in more extended optical or radio objects.

II. The Observations

The observations were performed with pairs of antennas within NASA's Deep Space Network on either California-Australia or California-Spain baselines (see Table 1) in 30 separate observing sessions between 1974 and 1978. A list of experiments appears in Table 2. The observations were performed at 2290 MHz with right circular polarization. The receiver chain generally consisted of an S-band traveling wave maser, followed by a special phase stable S-band VLBI receiver which converted the RF signal to an IF of 50 MHz. The NRAO Mark II VLBI recording system then recorded a 1.8-MHz data bandwidth by digitally sampling at a 4-Mbs rate (Ref. 11). Digital sampling and phase stability of the receiver chain were controlled by rubidium or hydrogen maser atomic clocks. Each source was observed for a few minute interval with most sources being observed only once.

III. Method of Position Determination

A. The Measurement of Time Delay and Fringe Frequency

Values of time delay and fringe frequency were obtained with the NRAO Mark II VLBI cross-correlation processor and postprocessor programs. Each observation was broken into a number of 30-second segments. For each segment residual values were calculated between measured values of time delay and fringe frequency and premeasurement estimates of these quantities. All usable segments of each observation were then averaged to produce mean values of time delay and fringe frequency residuals and corresponding rms scatters. Typical values for the rms time delay residual scatter were 30 nsec and for the rms fringe frequency residual scatter, ~2 mHz. These scatters were assumed to be estimates of random measurement error unless the values appeared unrealistically low, in which case default values of 20 nsec and 2 mHz were used.

B. Theoretical Models of Time Delay and Fringe Frequency

To estimate source positions, we must have theoretical models for the quantities of time delay (τ) and fringe frequency (ν). Such models may be expressed by:

$$\tau = \tau_g + \tau_t + \tau_i$$

$$\nu = \nu_g + \nu_t + \nu_i$$

where τ_g and ν_g are the geometric contributions, τ_t and ν_t are the tropospheric contributions, and τ_i and ν_i are the instrumental contributions. No ionospheric contributions were considered since (1) the contribution of the unmodeled ionosphere is generally no larger than the assumed random measurement errors in time delay and fringe frequency, and (2) ionospheric contributions are difficult to estimate.

The geometric contribution to time delay is merely the dot product of a unit vector in the source direction and the baseline vector in light seconds, corrected to account for the Earth not being in the same rotational position when a particular wavefront arrives at each of the two antennas (Ref. 1). The geometric contribution to fringe frequency is merely the time derivative of τ_g (in Hz). The uncertainty in the baseline vector coordinates between Deep Space Network antennas is ~1 m (3 nsec), which is negligible compared to the assumed random measurement errors in time delay and fringe frequency.

The tropospheric contribution to time delay was determined by calculating the effective tropospheric signal delay at each antenna according to a cosecant elevation angle dependence and then differencing the resultant values. The zenith values of the dry and wet components of the tropospheric delay were assumed to be 6.7 and 0.5 nsec, respectively. Errors in the troposphere model should amount to $\lesssim$1 nsec in zenith path length delay and when mapped to the observed elevation angles are insignificant compared to the assumed random measurement errors in time delay and fringe frequency.

C. Calibration of Instrumental Delays and Frequency Offsets

Observations of sources with well-known positions allowed instrumental delays and frequency offsets to be determined. For each experiment, such calibration sources were scattered in time among the sources whose positions we wished to determine. A list of the 82 calibration sources utilized appears in Table 3. References from which the calibration source positions were obtained appear in Table 4. Most of the calibration source positions are VLBI determined and can be referenced to the FK4 reference frame (Ref. 12) with an accuracy of ~0.″1 (Ref. 10). However, a few calibration source positions are optically determined and may have uncertainties as high as 1.″0 in the FK4 reference frame.

At least four position calibration sources were employed per experiment. Table 2 displays the number of calibration sources used in each experiment as well as the number of source positions determined. Within an individual experiment, the time delay and fringe frequency residuals of calibration sources often exhibited nearly linear drifts with time over the experiment. For each experiment, a straight line was fit in a weighted least-mean-square sense through the time delay residuals of the calibration sources. This resulted in estimates of instrumental time delay and instrumental time delay rate. In a similar manner, a straight line was fit to the fringe frequency residuals of the calibration sources, resulting in estimates of instrumental frequency offset and instrumental frequency offset rate. In each experiment, the scatters of the delay and fringe frequency data points about the straight line fits are consistent with the estimated data uncertainties.

D. Position Determination

For each observation of a noncalibration source, residuals were formed between the measured values of time delay and fringe frequency and the corresponding values predicted by the best premeasurement models for these quantities. After these residuals were corrected for instrumental effects (see III-C), a least-mean-square differential correction scheme was used to estimate corrections to source position in right ascension and declination as well as the uncertainties associated with these corrections. In this calculation of the position uncertainty estimates, only the random errors in the measurement of time delay and fringe frequency were considered. To account for unmodeled effects, 0.″5 was added in a rss manner to the formal estimates of right ascension and declination uncertainty for each experiment but one (75-06-17), to which we added 1.″0. Since the position correction vector was calculated in coordinates precessed to the date of the experiment, the resultant new source position was subsequently precessed back to 1950.0 coordinates.

IV. Results

The calculated positions of 546 sources and the corresponding uncertainties are shown in Table 5. The positions are referenced 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 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 70 multiply observed sources, the rms value of this ratio is ~0.6 for both right ascension and declination. In addition, the individual ratio values never exceed 1.6.

For 35 sources, we could compare our position estimates with higher accuracy position estimates (Refs. 10, 13, 14). Figure 2 displays the ratio of the absolute value of the difference between our source position estimate and the more accurate value to our estimate of position uncertainty. For these 35 sources, the rms value of this ratio is ~1.3 for both right ascension and declination, but declines to ~0.9 if we eliminate one source (P2145+06) whose ratios are anomalously high. For both right ascension and declination, the value of the ratio exceeds 2.0 for only 3 sources, reaching a maximum value of 5.6. Hence, these position estimate comparisons along with the multiple observation comparisons indicate our position uncertainty estimates are realistic.

Figures 3(a) and 3(b) show histograms of the number of sources versus estimated position uncertainty for declination and right ascension, respectively. Estimated accuracies generally range from ~0.″5 to 1.″0 in both right ascension and declination, but ~6% of the sources have uncertainties $\geq$3.″5 in at least one position component. Most of the sources with high uncertainties were near the equator where the position-measuring technique can have lower sensitivity (see Ref. 1).

V. Summary

Positions for the milliarcsecond VLBI nuclei of 546 extragalactic sources have been determined to an accuracy of ~1″. The reliability of the determined positions has been demonstrated by testing the repeatability of multiple observations on the same source and by position comparisons with more accurate radio catalogs.

Acknowledgments

We appreciate the assistance of G. Trager in data processing and L. J. Skjerve, D. J. Spitzmesser, and the personnel of the Deep Space Network for aid in performing the observations.

References

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

2. 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 Nicolson, G., *Time and the Earth's Rotation*, IAU Symp. 82, D. Reidel, p. 199, 1979.

3. Clark, T. A., Hutton, L. K., Marandino, G. E., Counselman, C. C., Robertson, D. J., Shapiro, I. I., Wittels, J. J., Hinteregger, H. F., Knight, C. A., Rogers, A. E. E., Whitney, A. R., Niell, A. E., Ronnang, B. U., and Rydbeck, O. E. H., 1976, *Astron. J.*, 81, p. 599.

4. Preston, R. A., Morabito, D. D., Williams, J. G., Slade, M. A., Harris, A. W., Finley, S. G., Skjerve, L. J., Tanida, L., Spitzmesser, D. J., Johnson, B., Jauncey, D. L., Bailey, A., Denise, R., Dickenson, J., Livermore, R., Papij, A., Robinson, A., Taylor, C., Alcazar, F., Luaces, B., and Munoz, D., "Establishing a Celestial VLBI Reference Frame – I. Searching for VLBI Sources," *DSN Progress Report 42-46*, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1978.

5. Brunn, D. L., Preston, R. A., Wu, S. C., Siegel, H. L., and Brown, D. S., "VLBI Spacecraft Tracking System Demonstration: Part I, Design and Planning," *DSN Progress Report 42-45*, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1978.

6. Mulhall, B. D. L., "DSN VLBI System Status and Plans," *DSN Progress Report 42-46*, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1978.

7. MacDoran, P. F., "Radio Interferometry for International Study of the Earthquake Mechanism," *Acta Astronautica*, Vol. 1, pp. 1427-1444, 1974.

8. Niell, A. E., Ong, K. M., MacDoran, P. F., Resch, G. M., Morabito, D. D., Claflin, E. S., and Dracup, J. F., "Comparison of a Radio Interferometric Differential Baseline Measurement with Conventional Geodesy," *Tectonophysics*, 52, pp. 49-58, 1979.

9. Shapiro, I. I., et al., "Transcontinental Baselines and the Rotation of the Earth Measured by Radio Interferometry," *Science*, 186, pp. 920-922, 1974.

10. 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., *Reference Coordinate Systems for Earth Dynamics*, pp. 351-357, D. Reidel, 1981.

11. Clark, B. G., Proc. of the I.E.E.E., 61, p. 1242, 1973.

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

13. Elsmore, B., and Ryle, M., *M.N.R.A.S.*, 174, p. 411, 1976.

14. Wade, C. M., and Johnston, K. J., *Astron. J.*, 82, p. 791, 1977.

Table 1. Participating Deep Space Station (DSS) observatories

Location	Designation	Diameter, m	Baseline Length	
			Kilometers	Wavelengths
Tidbinbilla, Australia	DSS 42	26		
	DSS 43	64	10.6×10^3	8.1×10^7
Goldstone, California	DSS 13	26		
	DSS 14	64	8.4×10^3	6.4×10^7
Madrid, Spain	DSS 61	26		
	DSS 63	64		

Table 2. Equipment list

Experiment Yr	Mo	Day	DSS stations	Number of position calibrator sources	Number of source positions determined
74	07	31	14/42	6	6
74	08	13	14/42	4	11
75	06	17	14/42	4	19
75	08	24	14/42	4	15
75	09	15	14/42	6	17
75	09	21	13/63	8	27
76	10	26A	13/43	9	21
76	10	26B	13/43	6	20
76	11	09	13/63	4	8
76	11	11	13/63	9	22
76	11	14	13/43	5	28
77	02	12	13/43	5	8
77	02	25	13/43	6	26
77	04	21	13/43	4	14
77	04	22	13/43	5	18
77	06	15	13/43	4	18
77	09	11	14/61	4	8
77	09	28	13/63	7	48
77	10	11	13/63	8	20
77	10	27	13/43	5	16
77	11	01	13/43	4	27
77	11	21	13/43	6	20
77	12	11	13/43	4	21
77	12	13	13/43	5	28
78	01	09	13/43	5	57
78	02	20	13/43	5	21
78	03	14	13/63	4	24
78	03	21	13/63	4	37
78	04	04	13/63	4	32
78	04	16	13/43	5	11

Table 3. List of calibration sources

Source	Position reference	Source	Position reference	Source	Position reference
P 0104–408	1	4C 55.16	1	NRAO 512	1
P 0106+01	1	OJ 287	1	3C 345	1
P 0113–118	1	B2 0912+29	13	P 1645+17	2
DA 55	1	4C 39.25	1	DW 1656+05	1
3C 48	13	AO 0952+17	1	NRAO 530	1
DW 0224+67	1	OK 290	13	P 1741–038	1
GC 0235+16	1	3C 232	13	3C 371	1
3C 84	1	GC 1004+14	6	3C 395	13
P 0332–403	1	P 1104–445	1	OV-236	1
NRAO 140	1	P 1116+12	5	P 1933–400	1
CTA 26	1	P 1127–14	1	OV-198	1
NRAO 150	1	B2 1215+30	13	P 2012–017	11
P 0402–362	1	ON 231	1	P 2021–330	12
P 0420–01	1	3C 273	1	3C 418	13
P 0428+20	13	3C 274	2	GC 2047+09	10
3C 119	13	3C 275.1	7		
3C 120	1	3C 279	1	P 2134+004	1
P 0438–43	1	3C 286	13	P 2137+20	10
NRAO 190	1	P 1354+19	8	P 2145+06	1
3C 138	13	OQ 208	13	VRO 42.22.01	1
3C 147	13	OQ 172	13	CTA 102	1
DA 193	1	OR 103	1	OY-172.6	1
P 0605–08	1	P 1510–08	1	P2245–328	1
P 0607–15	1	GC 1514+19	13	3C 454.3	1
P 0736+01	3	P 1514–24	9	GC 2254+07	13
OI 363	1	P 1546+027	3	P 2319+07	4
DW 0742+10	1	DW 1555+00	1	P 2345–16	1
OJ 425	1	DA 406	1		

Table 4. References for calibration sources

1. 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., Young, L. E., *Reference Coordinate Systems for Earth Dynamics*, 351-357, D. Reidel Publishing Company, 1981.
2. Burbidge, G. R., and Crowne, A. H., *Ap. J. Suppl. Series*, 40, p. 583, 1979.
3. Burbidge, G. R., Crowne, A. H., and Smith, H. E., *Ap. J. Suppl. Series*, 33, p. 113, 1977.
4. Veron, M. P., and Veron, P., *Astr. Ap.*, 42, p. 1, 1975.
5. Kristian, J. and Sandage, A., *Ap. J.*, 162, 391, 1970.
6. Wills, D., and Wills, B. J., *Ap. J. Suppl. Series*, 31, p. 143, 1976.
7. Adgie, R. L., Crowther, F. H., and Gent, H., *M.N.R.A.S.* 159, p. 233, 1972.
8. Veron, M. P., *Astr. Ap.*, 20, p. 471, 1972.
9. Hunstead, R. W., *Nature*, 233, p. 401, 1971.
10. Hoskins, D., Murdoch, H. S., Adgie, R. L., Crowther, F. H., and Gent H., *M.N.R.A.S.*, 166, p. 235, 1979.
11. Wall, J. L., *Ap. J.* (Letters), 15, p. 101, 1973.
12. Veron, M. P., and Veron, P., *Astr. Ap. Suppl.*, 29, p. 149, 1977.
13. Fanselow, J. L., private communication, 1980.

Table 5. Source positions

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
GC 0003+38	00	03	22.368	0.035	+38	03	33.37	0.52
NRAO 5	00	03	40.241	0.081	-06	40	16.63	1.15
P 0005-239	00	05	27.468	0.033	-23	55	59.91	0.46
P 0005-262	00	05	53.498	0.045	-26	15	53.14	0.65
III ZW 2	00	07	57.865	2.108	+10	41	30.48	34.51
GC 0007+17	00	07	59.377	0.035	+17	07	37.75	0.54
P 0008-264	00	08	28.858	0.036	-26	29	14.58	0.50
GC 0010+40	00	10	54.332	0.042	+40	34	56.75	0.69
P 0011-046	00	11	20.643	0.102	-04	40	32.65	1.39
GC 0012+31	00	12	29.879	0.037	+31	59	32.94	0.55
GC 0019+05	00	19	58.289	0.220	+05	51	22.30	3.73
P 0019+058	00	19	58.291	0.129	+05	51	22.17	2.31
OB 357.7	00	22	46.685	0.046	+39	02	58.58	0.71
OB 338	00	24	02.809	0.036	+34	52	06.29	0.53
OB 343	00	26	34.849	0.104	+34	39	57.97	2.02
P 0027+056	00	27	11.367	0.098	+05	38	05.40	1.80
P 0035+23	00	35	19.774	0.047	+23	50	42.43	0.62
GC 0035+12	00	35	41.931	0.045	+12	11	01.69	0.68
P 0047+023	00	47	08.930	0.060	+02	20	43.11	1.33
P 0048-09	00	48	09.003	0.925	-09	45	08.94	14.36
P 0048-071	00	48	36.190	0.061	-07	06	20.65	0.91
P 0048-427	00	48	48.972	0.067	-42	40	52.15	0.83
DW 0055+30	00	55	05.632	0.033	+30	04	56.66	0.51
P 0055-059	00	55	32.966	0.045	-05	56	03.66	0.71
P 0056-00	00	56	31.839	0.069	-00	10	08.84	21.28
0104+321	01	04	39.247	0.053	+32	08	44.33	0.87
P 0106+01	01	06	04.589	0.031	+01	19	00.04	0.61
P 0108-079	01	08	19.018	0.046	-07	57	37.67	0.70
GC 0108+38	01	08	47.275	0.045	+38	50	32.78	0.65
GC 0109+22	01	09	23.595	0.043	+22	28	44.24	0.60
GC 0110+31	01	10	03.792	0.090	+31	52	24.02	2.35
P 0111+021	01	11	08.614	0.058	+02	06	23.99	1.05
P 0112-017	01	12	43.935	0.045	-01	42	55.24	0.77
P 0115+02	01	15	43.683	0.036	+02	42	18.76	0.66
GC 0116+08	01	16	24.203	0.098	+08	14	05.26	5.67
P 0118-272	01	18	09.508	0.043	-27	17	07.38	0.58
P 0119+11	01	19	03.134	0.042	+11	34	08.51	0.68
GC 0119+04	01	19	21.482	0.034	+04	06	42.62	0.52
GC 0119+24	01	19	54.290	0.039	+24	46	51.68	0.73
P 0122-00	01	22	55.304	0.035	-00	21	33.58	0.55
P 0123+25	01	23	57.269	0.038	+25	43	27.49	0.65
3C 43	01	27	15.017	0.033	+23	22	52.34	0.50
P 0130-17	01	30	17.637	0.067	-17	10	11.21	0.71
OC-259	01	35	17.119	0.046	-24	46	08.92	0.64
P 0136+176	01	36	59.331	0.039	+17	37	56.03	0.58
P 0139-09	01	38	55.651	1.515	-09	43	32.68	23.65
P 0142-278	01	42	44.980	0.047	-27	48	35.53	0.62
GC 0144+20	01	44	13.602	0.039	+20	55	26.58	0.58
OC 079	01	46	45.625	0.038	+05	40	59.27	0.58
GC 0148+27	01	48	37.349	0.042	+27	29	49.99	0.83
P 0150-334	01	50	56.961	0.041	-33	25	10.81	0.55
P 0156-14	01	56	18.093	0.233	-14	27	36.50	3.33
3C 57	01	59	30.304	0.117	-11	46	59.06	1.44
P 0201+113	02	01	06.076	0.055	+11	20	21.98	0.82
P 0202+14	02	02	07.449	0.036	+14	59	50.12	0.58
DW 0202+31	02	02	09.663	0.037	+31	58	10.25	0.55
P 0202-17	02	02	34.481	0.046	-17	15	39.24	0.59

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
OD 120	02	11	59.754	0.046	+17	08	51.86	0.91
P 0216+011	02	16	32.566	0.068	+01	07	11.71	1.15
P 0217-189	02	17	00.337	0.039	-18	56	24.57	0.57
3C 66A	02	19	29.995	0.045	+42	48	29.65	0.63
P 0219-164	02	19	38.310	0.037	-16	28	55.46	0.56
3C 66B	02	20	01.732	0.056	+42	45	54.59	0.87
GC 0221+06	02	21	50.047	0.051	+06	45	49.17	0.85
P 0229+13	02	29	02.532	0.038	+13	09	40.70	0.67
P 0234-301	02	34	21.633	0.047	-30	06	56.09	0.64
CTD 20	02	34	55.593	0.034	+28	35	11.28	0.50
GC 0235+16	02	35	52.647	0.025	+16	24	03.69	0.38
GT 0236+61	02	36	53.910	0.218	+61	01	39.13	2.21
P 0237-027	02	37	13.721	0.176	-02	47	32.84	2.37
GC 0237+04	02	37	14.427	0.067	+04	03	29.31	1.00
P 0237-23	02	37	52.787	0.047	-23	22	06.45	0.61
P 0238-084	02	38	37.382	0.056	-08	28	09.38	0.77
OD 166	02	39	47.109	0.040	+10	48	16.22	0.63
P 0240-217	02	40	19.234	0.402	-21	45	09.63	3.57
GC 0250+17	02	50	46.337	0.038	+17	53	29.97	0.56
OD 094.7	02	56	46.979	0.066	+07	35	45.50	0.86
OE 400	03	00	10.114	0.034	+47	04	33.64	0.51
GC 0301+33	03	01	35.678	0.039	+33	37	04.74	0.66
OE 110	03	06	20.942	0.048	+10	17	51.56	0.78
MN 0309+41	03	09	44.793	0.038	+41	08	48.67	0.59
P 0312+10	03	12	38.352	0.197	+10	01	40.84	2.20
CTA 21	03	16	09.132	0.050	+16	17	40.20	0.86
3C 84	03	16	29.567	0.036	+41	19	51.86	0.52
P 0317+188	03	17	00.064	0.041	+18	50	42.10	0.58
P 0319+12	03	19	08.153	0.086	+12	10	32.31	0.80
P 0327-241	03	27	43.892	0.036	-24	07	23.15	0.54
P 0329-255	03	29	00.470	0.043	-25	34	53.23	0.70
P 0346-163	03	46	21.706	0.068	-16	19	23.84	0.80
P 0348-120	03	48	48.961	0.249	-12	02	18.08	3.45
CTD 26	04	00	03.589	0.036	+25	51	46.55	0.53
P 0400-319	04	00	23.602	0.035	-31	55	42.04	0.52
P 0403-13	04	03	13.983	0.130	-13	16	18.17	1.55
P 0405-385	04	05	12.020	0.037	-38	34	26.07	0.53
P 0405-12	04	05	27.445	0.052	-12	19	32.44	0.67
P 0405-331	04	05	38.518	0.087	-33	11	42.40	0.83
GC 0406+12	04	06	35.472	0.037	+12	09	49.28	0.57
P 0406-127	04	06	45.218	0.091	-12	46	37.39	1.15
3C 109	04	10	54.890	0.047	+11	04	40.32	0.65
P 0413-21	04	13	53.539	0.046	-21	03	49.86	0.59
P 0414-189	04	14	23.323	0.052	-18	58	29.50	0.59
3C 111	04	15	00.602	0.035	+37	54	19.52	0.54
P 0420+022	04	20	16.107	0.053	+02	12	28.83	1.10
OF 036	04	21	32.765	0.113	+01	57	31.63	2.14
P 0422+00	04	22	12.516	0.041	+00	29	16.65	0.70
P 0423+051	04	23	57.289	0.042	+05	11	36.40	0.72
P 0425+048	04	25	08.626	0.062	+04	50	29.55	1.33
P 0426-380	04	26	54.701	0.035	-38	02	52.21	0.51
P 0434-188	04	34	48.942	0.048	-18	50	47.96	0.58
DW 0436+50	04	36	49.749	0.219	+50	22	20.48	2.52
P 0439-337	04	39	41.941	0.042	-33	45	44.06	0.55
GC 0444+63	04	44	42.345	0.056	+63	26	55.93	0.65
P 0446+11	04	46	21.222	0.053	+11	16	17.61	0.84
P 0451-28	04	51	15.084	0.044	-28	12	28.80	0.60

Table 5 (contd)

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
P 0454+06	04	54	26.459	0.043	+06	40	29.35	0.74
OF-292	04	54	57.299	0.036	-23	29	28.28	0.53
P 0456+060	04	56	08.200	0.054	+06	03	33.15	0.98
P 0457+024	04	57	15.549	0.049	+02	25	05.45	1.06
P 0458-02	04	58	41.353	0.043	-02	03	34.19	0.76
GC 0459+06	04	59	34.814	0.039	+06	04	51.42	0.70
OG 003	05	00	45.184	0.039	+01	58	53.80	0.65
P 0511-220	05	11	41.822	0.037	-22	02	41.38	0.54
0528-250	05	28	05.156	0.049	-25	05	44.19	0.55
OG-247	05	28	05.215	0.037	-25	05	44.65	0.54
P 0528+134	05	28	06.755	0.036	+13	29	42.29	0.56
GC 0537+53	05	37	13.514	0.046	+53	10	54.20	0.58
GC 0554+58	05	54	52.468	0.039	+58	03	50.87	0.59
P 0555-132	05	55	44.054	0.361	-13	17	46.55	5.37
3C 151	06	00	56.855	0.039	+44	14	10.76	0.61
GC 0601+57	06	01	22.080	0.049	+57	53	31.97	0.69
OH 404.1	06	02	20.043	0.035	+40	30	25.69	0.54
GC 0602+67	06	02	41.842	0.357	+57	20	50.18	2.95
P 0606-223	06	06	53.379	0.048	-22	19	46.31	0.62
GC 0611+48	06	11	15.403	0.041	+48	20	02.25	0.63
OH 119.5	06	11	31.724	0.310	+13	55	06.70	4.56
GC 0636+68	06	36	47.653	0.047	+68	01	27.14	0.56
P 0637-337	06	37	31.171	0.045	-33	43	12.82	0.60
OH 368.8	06	41	26.319	0.043	+39	17	55.12	0.68
OH 471	06	42	53.070	0.037	+44	54	30.23	0.56
OH 577.1	06	46	04.123	0.049	+60	05	14.13	0.61
GC 0650+37	06	50	35.278	0.042	+37	09	27.21	0.63
OH-090	06	53	41.212	0.041	-03	19	11.68	0.78
GC 0707+47	07	07	02.539	0.044	+47	37	07.92	0.59
OI 417	07	10	03.990	0.050	+43	54	28.65	0.70
OI 318	07	11	05.643	0.034	+35	39	51.90	0.52
3C 179	07	23	04.272	0.042	+67	54	52.87	0.53
DW 0723-00	07	23	17.854	0.039	-00	48	55.45	0.74
OI 446	07	27	24.120	0.045	+40	56	11.0	0.70
P 0727-11	07	27	57.994	0.056	-11	34	51.20	0.83
GC 0729+25	07	29	52.690	0.041	+25	55	07.84	0.85
GC 0730+50	07	30	04.377	0.052	+50	28	39.88	0.79
GC 0731+47	07	31	20.702	0.043	+47	56	44.47	0.64
GC 0733+30	07	33	04.637	0.044	+30	01	04.16	0.87
P 0733-17	07	33	31.244	0.100	-17	29	04.04	1.32
P 0735+17	07	35	14.109	0.027	+17	49	08.88	0.53
P 0736-06	07	36	30.325	0.492	-06	20	05.21	8.08
B2 0738+27	07	38	20.932	0.041	+27	13	48.32	0.56
B2 0742+31	07	42	30.731	0.039	+31	50	16.25	0.64
P 0743-006	07	43	21.055	0.044	-00	36	56.26	0.85
B2 0745+24	07	45	35.789	0.070	+24	07	54.48	1.04
OI 478	07	46	39.932	0.050	+48	22	30.51	0.69
P 0748+126	07	48	05.016	0.035	+12	38	45.56	0.94
GC 0748+33	07	48	41.037	0.040	+33	21	03.39	0.60
OI 582	07	49	06.446	0.040	+54	00	46.23	0.59
OI-187	07	52	05.439	0.420	-11	39	30.14	7.03
P 0754+100	07	54	22.601	0.043	+10	04	39.40	0.64
GC 0802+21	08	02	42.673	0.076	+21	15	27.26	1.14
GC 0804+49	08	04	58.388	0.043	+49	59	23.05	0.52
GC 0805+41	08	05	33.657	0.038	+41	01	33.14	0.65
P 0805-07	08	05	49.634	0.050	-07	42	24.02	0.91
P 0808+019	08	08	51.155	0.026	+01	55	50.80	0.73

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
OJ 320	08	12	10.708	0.041	+36	44	27.46	0.66
P 0812+02	08	12	47.287	0.040	+02	04	12.76	0.76
3C 197.1	08	17	59.852	0.116	+47	12	19.95	1.41
P 0820+22	08	20	28.601	0.081	+22	32	43.60	1.32
GC 0820+29	08	20	36.578	0.052	+29	38	10.61	0.95
GC 0820+56	08	20	53.196	0.044	+56	02	27.44	0.58
GC 0821+39	08	21	37.307	0.037	+39	26	28.24	0.54
P 0823+033	08	23	13.566	0.025	+03	19	15.07	0.59
4C 35.20	08	24	26.606	0.044	+35	35	00.75	0.76
G 256.6+0.6	08	26	12.011	0.079	-37	21	06.28	0.86
B2 0827+24	08	27	54.397	0.040	+24	21	07.52	0.69
OJ 448	08	28	48.014	0.034	+49	23	32.65	0.51
MA 0829+04	08	29	10.927	0.044	+04	39	50.40	2.83
OJ 451	08	30	31.977	0.037	+42	34	19.49	0.57
4C 55.16	08	31	04.400	0.046	+55	44	41.33	0.56
GC 0833+58	08	33	23.779	0.049	+58	35	30.19	0.61
GC 0834+25	08	34	42.304	0.038	+25	04	54.18	0.71
4C 71.07	08	36	21.630	0.046	+71	04	21.92	0.53
3C 207	08	38	01.729	0.051	+13	23	05.71	0.84
GC 0839+18	08	39	14.177	0.068	+18	46	25.66	1.03
GC 0850+58	08	50	50.150	0.047	+58	08	55.73	0.57
OJ 287	08	51	57.311	0.070	+20	17	57.34	1.04
GC 0854+21	08	54	04.725	0.066	+21	23	17.83	1.22
3C 212	08	55	55.533	0.052	+14	21	24.75	1.09
OJ 499	08	59	40.021	0.039	+47	02	56.72	0.56
P 0859-14	08	59	55.059	0.085	-14	03	39.93	1.15
GC 0900+42	09	00	58.735	0.044	+42	50	01.42	0.57
GC 0902+49	09	02	00.394	0.040	+49	02	49.46	0.60
3C 216	09	06	17.253	0.031	+43	05	59.12	0.43
P 0906+01	09	06	35.308	0.080	+01	33	46.53	1.55
GC 0913+39	09	13	39.507	0.045	+39	07	02.28	0.59
OK 630	09	17	40.299	0.052	+62	28	38.45	0.54
P 0920-39	09	20	48.221	0.046	-39	46	42.35	0.58
P 0922+005	09	22	35.978	0.996	+00	33	25.50	15.88
4C 39.25	09	23	55.319	0.036	+39	15	22.43	0.56
MC 0938+119	09	38	31.740	0.044	+11	59	12.51	0.75
VRO 40.09.02	09	45	50.106	0.036	+40	53	43.09	0.54
GC 0954+65	09	54	57.840	0.049	+65	48	15.43	0.59
OK 492	09	55	08.534	0.044	+47	39	28.50	0.60
GC 1007+41	10	07	26.129	0.040	+41	47	25.76	0.61
OL 318	10	10	54.780	0.044	+35	00	44.05	0.74
GC 1013+20	10	13	59.370	0.034	+20	52	47.38	0.51
OL 331	10	18	24.120	0.044	+34	52	28.90	0.75
GC 1019+42	10	19	13.452	0.047	+42	54	34.61	0.72
OL 333	10	19	39.881	0.041	+30	56	15.08	0.72
P 1020+191	10	20	11.792	0.041	+19	08	45.48	0.58
GC 1020+40	10	20	14.553	0.041	+40	03	26.83	0.55
P 1021-00	10	21	56.201	0.092	-00	37	41.67	1.90
GC 1030+41	10	30	07.796	0.042	+41	31	34.52	0.58
GC 1030+39	10	30	27.529	0.040	+39	51	19.80	0.63
OL 553	10	31	55.974	0.042	+56	44	18.38	0.61
P 1034-293	10	34	55.794	0.039	-29	18	26.78	0.54
OL 064.5	10	38	40.908	0.048	+06	25	58.65	0.78
OL 564	10	38	43.161	0.043	+52	49	09.64	0.59
3C 245	10	40	05.956	0.066	+12	19	15.26	0.96
OL 569	10	41	07.014	0.046	+53	38	05.63	0.61
P 1054+004	10	54	41.940	0.058	+00	28	06.60	1.15

Table 5 (contd)

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
P 1055+20	10	55	37.509	0.039	+20	07	54.73	0.80
P 1055+01	10	55	55.320	0.040	+01	50	00.44	3.45
GC 1058+39	10	58	42.210	0.044	+39	20	39.97	0.70
B2 1101+38	11	01	40.532	0.034	+38	28	42.25	0.51
GC 1104+16	11	04	36.631	0.045	+16	44	16.62	0.72
GC 1106+38	11	06	43.450	0.045	+38	00	47.12	0.74
OM 316.3	11	09	49.557	0.048	+35	19	58.42	0.86
GC 1111+14	11	11	21.293	0.038	+14	58	47.97	0.60
P 1123+26	11	23	14.839	0.035	+26	26	49.46	0.56
GC 1128+38	11	28	12.509	0.041	+38	51	51.97	0.57
P 1128-047	11	28	57.464	0.095	-04	43	45.43	1.68
P 1130+009	11	30	46.169	0.104	+00	57	27.12	1.82
P 1136-13	11	36	38.509	0.078	-13	34	05.40	1.12
P 1143-245	11	43	36.362	0.040	-24	30	52.73	0.55
GC 1144+54	11	44	04.564	0.048	+54	13	22.96	0.59
GC 1144+40	11	44	21.024	0.030	+40	15	14.16	0.47
P 1144-379	11	44	30.956	0.070	-37	55	30.77	1.02
OM-076	11	45	18.141	0.304	-07	07	58.16	4.49
P 1146-037	11	46	22.431	0.040	-03	47	30.39	0.81
1146-037	11	46	23.515	6.465	-03	47	46.60	99.16
P 1148-00	11	48	10.217	0.199	-00	07	41.83	49.55
P 1148-171	11	48	30.248	0.127	-17	07	17.58	1.68
OM 484	11	50	47.975	0.041	+49	47	50.08	0.58
GC 1155+48	11	55	52.098	0.042	+48	41	57.62	0.60
P 1156-094	11	56	38.936	0.188	-09	24	08.03	2.27
GC 1156+29	11	56	57.764	0.034	+29	31	25.74	0.53
P 1157-215	11	57	18.317	0.039	-21	32	11.51	0.56
ON-001	12	00	00.434	0.744	-05	11	19.78	13.36
GC 1204+28	12	04	55.092	0.055	+28	11	40.67	0.75
B2 1211+33	12	11	32.812	0.047	+33	26	26.11	0.63
P 1213-17	12	13	11.692	0.043	-17	15	05.40	0.58
GC 1213+35	12	13	24.812	0.040	+35	04	55.25	0.61
1216-010	12	16	00.977	0.563	-01	03	14.22	9.13
ON 428	12	16	38.577	0.039	+48	46	35.23	0.55
P 1217+02	12	17	38.302	0.393	+02	20	21.52	7.59
3C 270.1	12	18	03.909	0.017	+33	59	50.53	0.23
P 1218-02	12	18	49.941	0.041	-02	25	11.50	0.97
P 1219+04	12	19	49.404	0.142	+04	29	51.11	2.76
P 1222+21	12	22	23.405	0.035	+21	39	22.64	0.59
3C 272.1	12	22	31.597	0.023	+13	09	49.86	0.43
ON 343	12	25	30.760	0.036	+36	51	47.11	0.55
3C 273	12	26	33.190	0.106	+02	19	44.51	1.72
3C 274	12	28	17.575	0.017	+12	40	01.80	0.26
P 1229-02	12	29	26.299	3.249	-02	07	37.63	51.70
P 1236+077	12	36	52.292	0.042	+07	46	45.30	0.68
P 1237-10	12	37	05.638	0.301	-10	06	34.94	4.45
M 104	12	37	24.051	0.074	-11	21	05.05	0.70
GC 1240+38	12	40	27.031	0.042	+38	07	25.0	0.68
ON-073	12	43	28.787	0.100	-07	14	23.37	1.44
P 1244-255	12	44	06.720	0.041	-25	31	26.91	0.57
P 1252+11	12	52	07.699	0.063	+11	57	21.47	0.92
ON-392	12	55	15.163	0.081	-31	39	04.64	1.10
ON 393	12	55	35.463	0.049	+32	45	23.0	0.62
P 1256-220	12	56	13.849	0.044	-22	03	21.22	0.62
P 1257+145	12	57	51.551	0.041	+14	33	28.59	1.31
GC 1300+58	13	00	47.122	0.048	+58	04	43.23	0.61
P 1302-035	13	02	08.755	0.050	-03	29	59.06	1.09
P 1302-102	13	02	55.453	0.163	-10	17	10.11	2.38
GC 1307+56	13	07	05.094	0.042	+56	13	36.15	0.59
B2 1308+32	13	08	07.637	0.068	+32	36	58.29	1.01
OP 114	13	08	39.190	0.054	+14	33	42.76	1.53
OP-322	13	13	20.055	0.069	-33	23	09.34	1.02
OP 326	13	15	17.798	0.031	+34	41	02.63	0.43
GC 1325+43	13	25	10.559	0.040	+43	41	59.45	0.55
P 1327-311	13	27	29.954	0.045	-31	07	31.28	0.56
3C 287.1	13	30	20.519	0.060	+02	16	07.61	1.48
OP 151	13	31	10.012	0.043	+17	04	25.40	0.72
GC 1333+45	13	33	15.705	0.045	+45	57	56.21	0.66
GC 1333+58	13	33	36.446	0.161	+58	59	17.45	1.83
P 1333-33	13	33	47.177	0.069	-33	42	39.75	0.89
DW 1335-12	13	34	59.772	0.056	-12	42	09.15	0.66
GC 1335+55	13	35	55.220	0.034	+55	16	15.61	0.45
1336-237	13	36	15.717	0.045	-23	46	01.08	0.56
P 1336-260	13	36	32.449	0.049	-26	05	18.18	0.61
P 1337-033	13	37	37.868	0.051	-03	20	10.94	1.04
GC 1337+63	13	37	46.107	0.051	+63	44	08.74	0.60
GC 1342+662	13	42	17.899	0.057	+66	17	27.75	0.54
GC 1342+663	13	42	41.034	0.058	+66	21	12.94	0.54
P 1345+12	13	45	06.366	0.162	+12	32	17.09	1.99
GC 1347+53	13	47	42.576	0.030	+53	56	08.34	0.42
P 1348-289	13	48	55.863	0.048	-28	57	29.58	0.62
DW 1349-14	13	49	10.786	0.050	-14	34	27.14	0.75
3C 292	13	49	18.777	0.328	+64	46	19.06	2.40
P 1349-439	13	49	52.541	0.039	-43	57	54.26	0.55
P 1351-018	13	51	32.120	0.100	-01	51	21.28	1.62
P 1352-104	13	52	06.895	0.188	-10	26	21.87	3.50
P 1354-174	13	54	21.999	0.041	-17	29	24.20	0.56
OP-192	13	54	28.564	0.050	-15	12	51.40	0.61
GC 1355+44	13	55	38.215	0.051	+44	08	34.12	0.61
P 1402-012	14	02	11.401	0.063	-01	16	03.48	1.04
P 1402+044	14	02	29.968	0.047	+04	29	55.40	0.77
DW 1403-08	14	03	21.605	0.145	-08	33	48.57	2.33
P 1404-342	14	04	57.172	0.051	-34	17	14.81	0.61
P 1406-076	14	06	17.847	0.097	-07	38	15.16	1.39
GC 1406+56	14	06	32.107	0.041	+56	27	43.40	0.56
P 1413+135	14	13	33.861	0.065	+13	34	17.87	1.02
OQ 323	14	13	56.281	0.070	+34	58	29.47	0.72
4C 46.29	14	15	13.437	0.057	+46	20	55.49	0.79
3C 298	14	16	38.780	0.067	+06	42	20.84	1.02
GC 1418+54	14	18	06.180	0.032	+54	36	58.05	0.43
P 1424-41	14	24	46.725	0.071	-41	52	54.44	1.03
P 1427+109	14	27	43.692	0.036	+10	56	46.75	0.76
OQ 546	14	27	44.043	0.039	+54	19	29.67	0.54
OQ-151	14	30	10.654	0.037	-17	48	24.12	0.55
P 1430-155	14	30	36.138	0.088	-15	35	35.10	1.25
P 1435-218	14	35	18.688	0.078	-21	51	57.91	0.81
GC 1435+63	14	35	37.228	0.034	+63	49	35.78	0.42
P 1437-153	14	37	11.426	0.338	-15	19	00.08	4.55
OQ 363	14	38	22.519	0.058	+38	33	03.16	0.67
OQ 366	14	39	54.033	0.065	+32	47	05.41	0.76
3C 303 EAST	14	41	24.831	0.062	+52	14	18.61	0.84
P 1441+25	14	41	43.568	0.052	+25	14	24.33	0.62
P 1446-16	14	45	28.334	0.038	-16	07	56.43	0.59
P 1449-012	14	49	12.561	0.049	-01	15	18.20	1.16

Table 5 (contd)

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
P 1451-375	14	51	18.325	0.070	-37	35	22.59	1.02
GC 1452+30	14	52	25.043	0.039	+30	08	06.0	0.62
MA 1456+04	14	56	29.176	0.030	+04	28	09.21	0.55
3C 309.1	14	58	56.591	0.173	+71	52	11.12	0.70
GC 1459+48	14	59	07.246	0.038	+48	03	03.80	0.54
P 1502+036	15	02	35.485	0.223	+03	38	10.20	3.20
OR 306	15	04	12.951	0.038	+37	42	23.59	0.55
P 1504-167	15	04	16.384	0.068	-16	40	58.96	0.81
P 1508-05	15	08	14.986	0.040	-05	31	49.45	0.66
P 1511-100	15	11	02.241	0.043	-10	00	51.03	0.65
P 1511-210	15	11	03.939	0.040	-21	03	48.47	0.57
P 1514+00	15	14	06.816	0.037	+00	26	00.32	0.78
P 1518+047	15	18	44.877	0.122	+04	41	03.69	2.33
P 1519-273	15	19	37.286	0.071	-27	19	30.55	1.04
OR 342	15	25	16.899	0.079	+31	25	47.74	1.21
P 1532+01	15	32	20.250	0.035	+01	41	00.49	0.58
P 1535+004	15	35	42.576	0.040	+00	28	50.46	0.85
GC 1538+14	15	38	30.062	0.075	+14	57	24.66	1.03
DW 1543+00	15	43	36.212	0.052	+00	35	42.37	1.03
P 1546+027	15	46	58.339	0.054	+02	46	05.38	0.99
OR 580	15	47	52.270	0.046	+50	47	09.31	0.62
DW 1548+05	15	48	06.945	0.058	+05	36	10.96	1.07
OR 181	15	48	21.179	0.027	+11	29	47.26	0.45
P 1550-269	15	50	59.814	0.041	-26	55	51.10	0.58
OR 186	15	51	12.021	0.045	+13	05	41.04	0.82
P 1555-140	15	55	33.722	0.052	-14	01	26.38	0.63
P 1556-245	15	56	41.217	0.063	-24	34	10.73	0.88
B2 1600+33	16	00	11.905	0.041	+33	35	09.72	0.75
GC 1604+31	16	04	10.594	0.041	+31	32	47.80	0.71
P 1604-333	16	04	22.159	0.042	-33	23	10.45	0.59
P 1606+10	16	06	25.384	0.037	+10	36	59.89	0.61
P 1614+051	16	14	09.088	0.042	+05	06	53.84	0.69
4C 36.27	16	15	06.135	0.043	+36	28	53.95	0.58
P 1615+029	16	15	19.141	0.045	+02	53	58.23	1.69
DW 1616+06	16	16	36.581	0.034	+06	20	12.80	0.99
P 1622-253	16	22	44.123	0.095	-25	20	51.69	1.25
P 1622-29	16	22	57.241	0.045	-29	44	41.25	0.67
DA 411	16	24	18.271	0.042	+41	41	23.51	0.59
P 1625-141	16	25	56.548	0.425	-14	08	56.0	6.54
GC 1633+38	16	33	30.625	0.041	+38	14	09.98	0.62
GC 1636+47	16	36	19.159	0.044	+47	23	28.76	0.65
GC 1637+57	16	37	17.409	0.046	+57	26	15.70	0.57
3C 345	16	41	17.630	0.040	+39	54	10.31	0.60
3C 346	16	41	34.434	0.030	+17	21	20.89	0.42
P 1647-296	16	47	29.449	0.047	-29	38	41.30	0.62
P 1648+015	16	48	31.563	0.045	+01	34	25.98	0.85
DA 426	16	52	11.739	0.026	+39	50	24.81	0.38
DW 1656+05	16	56	05.593	0.042	+05	19	48.47	2.57
GC 1656+34	16	56	12.266	0.054	+34	47	60.0	1.28
1656+48	16	56	24.991	0.039	+48	13	04.71	0.57
1656+47	16	56	43.969	0.048	+47	42	15.79	0.67
P 1657-261	16	57	47.698	0.044	-26	06	29.39	0.55
P 1705+018	17	05	02.784	0.043	+01	52	25.0	1.78
OT-111	17	06	40.114	0.041	-17	25	08.62	0.55
GC 1714+21	17	14	03.727	0.058	+21	55	28.25	0.69
GC 1716+68	17	16	27.782	0.070	+68	39	48.29	0.55
GC 1717+17	17	17	00.339	0.034	+17	48	08.07	0.60

SOURCE NAME	RIGHT ASCENSION HR	MIN	SEC	ERROR	DECLINATION DEG	MIN	SEC	ERROR
B2 1721+34	17	21	32.026	0.037	+34	20	41.29	0.59
GC 1722+40	17	22	27.154	0.057	+40	07	16.53	0.96
GC 1725+12	17	25	47.639	0.042	+12	18	03.40	0.62
P 1725+044	17	25	56.345	0.126	+04	29	27.97	2.19
GC 1726+45	17	26	01.190	0.043	+45	33	04.57	0.58
GC 1732+09	17	32	35.668	0.040	+09	28	51.63	0.96
GC 1734+50	17	34	36.730	0.047	+50	50	59.72	0.64
GC 1739+52	17	39	29.005	0.038	+52	13	10.40	0.53
GC 1743+17	17	43	22.261	0.036	+17	21	07.87	0.58
1749+701	17	49	03.426	0.070	+70	06	39.47	0.59
GC 1751+28	17	51	45.376	0.038	+28	48	36.95	0.54
OT 486.4	17	51	53.691	0.039	+44	10	17.71	0.57
P 1756+237	17	56	55.940	0.031	+23	43	55.96	0.40
OT 398	17	58	44.702	0.039	+38	48	32.19	0.58
OU 401	18	00	03.217	0.038	+44	04	18.51	0.54
P 1806-458	18	06	15.187	0.056	-45	53	16.65	0.63
GC 1806+45	18	06	56.515	0.039	+45	41	47.28	0.56
GC 1807+27	18	07	13.637	0.048	+27	57	35.39	0.66
P 1821+10	18	21	41.640	0.048	+10	42	44.10	0.73
GC 1823+56	18	23	14.950	0.055	+56	49	18.10	0.67
GC 1830+28	18	30	52.381	0.042	+28	31	16.97	0.64
GC 1842+68	18	42	43.374	0.059	+68	06	19.96	0.54
3C 390.3	18	45	37.651	0.151	+79	43	06.14	0.52
GC 1848+28	18	48	29.082	0.046	+28	21	38.64	0.57
3C 395	19	01	02.320	0.037	+31	55	13.84	0.60
OV-213	19	08	12.599	0.060	-20	11	57.12	0.74
OV-214	19	08	55.657	0.175	-21	07	47.74	1.92
OV-236	19	21	42.437	0.211	-29	20	29.04	2.70
P 1922-341	19	22	00.987	0.043	-34	06	59.05	0.55
OV 239.7	19	23	49.766	0.035	+21	00	23.62	0.38
GC 1926+61	19	26	49.649	0.050	+61	11	21.11	0.53
P 1936-15	19	36	36.118	0.052	-15	32	40.91	0.74
P 1937-101	19	37	12.665	0.064	-10	09	39.73	1.07
OV 080	19	47	40.528	0.312	+07	59	30.02	5.52
P 1953-325	19	53	48.363	0.235	-32	33	48.89	2.63
OV 591	19	54	22.488	0.040	+51	23	46.32	0.52
P 1954-388	19	54	39.009	0.043	-38	53	13.31	0.55
P 2000-330	20	00	13.015	0.038	-33	00	13.04	0.54
P 2008-159	20	08	25.909	0.092	-15	55	38.27	1.21
OW-015	20	08	33.727	0.033	-06	53	02.05	0.53
P 2012-017	20	12	39.820	0.135	-01	46	45.21	3.94
OW 637	20	21	13.380	0.058	+61	27	18.22	0.58
P 2029+121	20	29	32.626	0.071	+12	09	29.45	0.95
OW 551	20	30	29.133	0.033	+54	44	49.21	0.39
OW 154.9	20	32	58.529	0.059	+10	45	42.67	0.71
P 2037-253	20	37	10.747	0.040	-25	18	26.36	0.56
OW-174	20	44	30.850	0.037	-16	50	10.04	0.56
GC 2047+09	20	47	20.777	0.066	+09	52	02.11	0.84
P 2047+039	20	47	36.001	0.096	+03	56	34.78	1.32
P 2053-044	20	53	12.821	0.029	-04	28	19.40	0.52
P 2053-323	20	53	20.802	0.056	-32	20	20.30	0.72
P 2058-297	20	58	00.910	0.041	-29	45	14.98	0.57
P 2059+034	20	59	08.126	0.051	+03	29	39.29	1.01
P 2106-413	21	06	19.396	0.042	-41	22	33.58	0.57
OX 131	21	18	41.548	0.041	+18	48	40.36	0.60
P 2123-463	21	23	13.267	0.038	-46	18	49.59	0.53
R 2126-15	21	26	26.759	0.043	-15	51	50.29	0.60

Table 5 (contd)

SOURCE NAME	RIGHT ASCENSION				DECLINATION			
	HR	MIN	SEC	ERROR	DEG	MIN	SEC	ERROR
P 2126-185	21	26	33.890	0.043	-18	34	32.51	0.60
P 2127-096	21	27	38.415	0.053	-09	40	50.29	0.90
P 2127+04	21	28	02.673	0.047	+04	49	03.35	0.92
P 2128-12	21	28	52.698	0.046	-12	20	20.76	0.72
P 2131-021	21	31	35.227	0.126	-02	06	41.57	2.04
P 2135-248	21	35	45.384	0.040	-24	53	28.49	0.56
P 2137+20	21	37	27.860	0.057	+20	57	57.89	1.16
P 2140-048	21	39	59.970	0.078	-04	51	27.59	1.18
OX-173	21	43	38.849	0.052	-15	39	37.11	0.71
OX 074	21	44	42.487	0.066	+09	15	50.91	1.00
P 2145+06	21	45	36.566	0.086	+06	43	33.18	1.39
P 2147+14	21	47	59.332	0.095	+14	35	44.85	1.14
P 2149-306	21	49	00.619	0.039	-30	42	00.80	0.55
OX 081	21	49	02.057	0.057	+06	55	21.11	0.86
OX 082	21	49	07.663	0.047	+05	38	07.38	0.71
P 2149+17	21	50	02.236	0.036	+17	20	29.58	0.55
OX-192	21	55	22.322	0.294	-15	15	15.63	4.59
P 2200-238	22	00	07.743	0.057	-23	49	41.67	0.56
VRO 42.22.01	22	00	39.387	0.038	+42	02	08.57	0.55
GC 2201+17	22	01	03.350	0.028	+17	11	15.38	0.45
P 2201+04	22	01	46.297	0.267	+04	25	30.31	4.58
OY 313	22	07	34.085	0.036	+35	41	14.93	0.53
P 2208-137	22	08	42.892	0.037	-13	42	59.46	0.60
P 2209+08	22	09	32.269	0.039	+08	04	25.44	0.78
P 2209+236	22	09	45.661	0.053	+23	40	50.35	0.60
P 2210+01	22	10	05.067	0.238	+01	38	00.92	4.01
GC 2214+35	22	14	07.035	0.028	+35	03	15.01	0.39
P 2215+02	22	15	15.707	0.427	+02	05	07.13	7.11
P 2216-03	22	16	16.406	0.042	-03	50	41.07	0.74
P 2221-116	22	21	28.616	0.052	-11	41	35.70	1.03
3C 446	22	23	11.045	0.043	-05	12	17.43	0.74
P 2223+21	22	23	14.768	0.054	+21	02	50.03	0.83
P 2227-08	22	27	02.263	0.053	-08	48	16.47	0.83
P 2227-399	22	27	44.970	0.105	-39	58	16.23	1.15
P 2229-17	22	29	41.003	0.081	-17	14	29.78	1.10
P 2233-148	22	33	53.999	0.026	-14	48	57.18	0.42
GC 2234+28	22	34	01.726	0.036	+28	13	23.20	0.51
GC 2236+12	22	36	06.142	0.085	+12	27	12.73	1.16
P 2239+096	22	39	19.853	0.031	+09	38	09.87	0.54
OY-268	22	40	41.708	0.040	-26	00	14.17	0.56
P 2245-128	22	45	14.125	0.035	-12	53	11.37	0.59
P 2245+029	22	45	26.015	0.048	+02	54	51.08	1.69
GC 2246+20	22	46	34.629	0.069	+20	51	11.66	0.83
P 2247+13	22	47	16.051	0.035	+13	15	15.84	0.56
GC 2251+24	22	51	44.393	0.034	+24	29	24.16	0.55
GC 2251+13	22	51	51.879	0.055	+13	25	48.73	0.88
P 2252-089	22	52	27.533	0.027	-09	00	05.40	0.45
GC 2253+41	22	53	19.857	0.042	+41	46	51.64	0.63
P 2254+024	22	54	44.626	0.037	+02	27	13.85	1.03
OY 492	22	55	04.662	0.040	+41	38	13.21	0.49
P 2255-282	22	55	22.460	0.037	-28	14	25.72	0.55
2256+017	22	56	24.708	0.229	+01	47	35.38	3.92
P 2300-307	23	00	22.087	0.039	-30	46	21.59	0.56
P 2300-18	23	00	23.374	0.155	-18	57	34.42	1.75
P 2303-052	23	03	40.121	0.077	-05	16	02.02	1.58
P 2307+10	23	07	57.555	0.030	+10	39	12.86	0.53
P 2311-452	23	11	21.897	0.030	-45	12	10.78	0.40
P 2312-319	23	12	06.365	0.028	-31	55	01.31	0.39
GC 2318+04	23	18	12.148	0.030	+04	57	22.86	0.65
P 2318-195	23	18	14.337	0.177	-19	35	58.10	2.32
GC 2319+31	23	19	28.291	0.055	+31	47	39.98	0.67
B2 2319+27	23	19	32.005	0.039	+27	16	18.66	0.58
OZ 533	23	20	06.010	0.045	+50	41	24.03	0.64
P 2320-021	23	20	30.352	0.192	-02	07	15.02	3.61
P 2320-035	23	20	57.380	0.052	-03	33	31.93	0.90
P 2325-150	23	25	11.594	0.045	-15	04	27.26	0.60
GC 2327+33	23	27	45.965	0.037	+33	32	03.46	0.55
P 2328+10	23	28	08.805	0.055	+10	43	45.16	0.78
OZ 347	23	28	17.891	0.051	+31	39	00.25	0.71
P 2329-16	23	29	02.119	0.082	-16	13	26.82	1.16
P 2329-384	23	29	18.905	0.038	-38	28	21.47	0.53
P 2330+083	23	30	25.058	0.033	+08	21	35.74	0.58
OZ-252	23	31	17.903	0.044	-24	00	15.40	0.57
P 2335-18	23	35	20.659	0.028	-18	08	57.66	0.46
P 2335-027	23	35	23.076	0.047	-02	47	32.53	0.98
3C 465	23	35	59.006	0.041	+26	45	16.21	0.56
P 2337-334	23	37	16.646	0.040	-33	26	54.66	0.53
GC 2337+26	23	37	58.271	0.042	+26	25	18.71	0.72
GC 2338+33	23	38	27.403	0.040	+33	02	24.44	0.56
P 2344+09	23	44	03.773	0.032	+09	14	05.51	0.46
HIA 2344+092	23	44	32.986	0.076	+09	14	05.48	1.17
P 2349-01	23	49	22.357	0.085	-01	25	55.43	1.84
OZ 486	23	51	49.977	0.042	+45	36	22.79	0.55
OZ-187	23	51	55.724	0.099	-15	29	50.87	1.42
P 2352-04	23	52	17.807	0.043	-04	21	45.32	1.01
DA 611	23	52	37.795	0.050	+49	33	26.60	0.73
P 2354-11	23	54	55.762	1.555	-11	41	58.52	24.54
P 2355-106	23	55	36.969	0.042	-10	36	50.89	0.67
P 2356+196	23	56	12.584	0.038	+19	38	38.36	0.67
GC 2356+38	23	56	59.832	0.072	+38	34	00.25	0.65

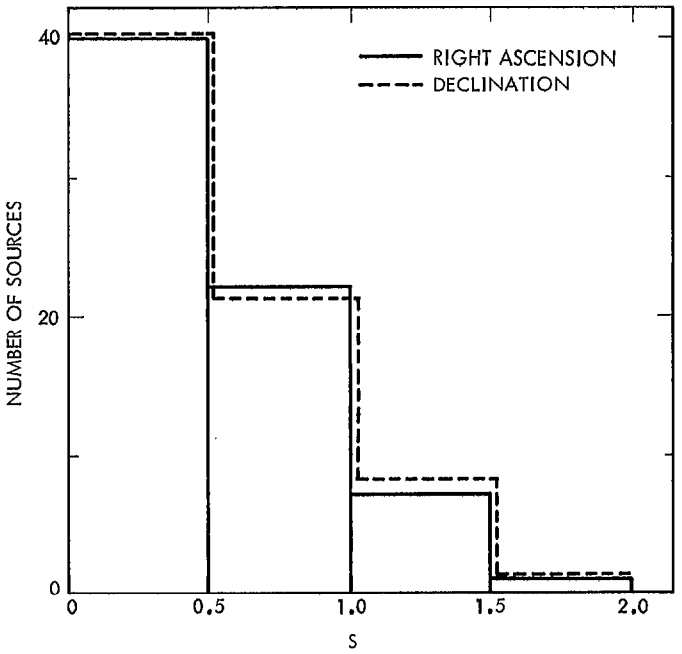

Fig. 1. Comparison of position estimates for 70 multiply observed sources. For each source, S is the ratio of the weighted rms scatter of individual position coordinate estimates about the mean value to the weighted rms estimate of the uncertainty in that position coordinate

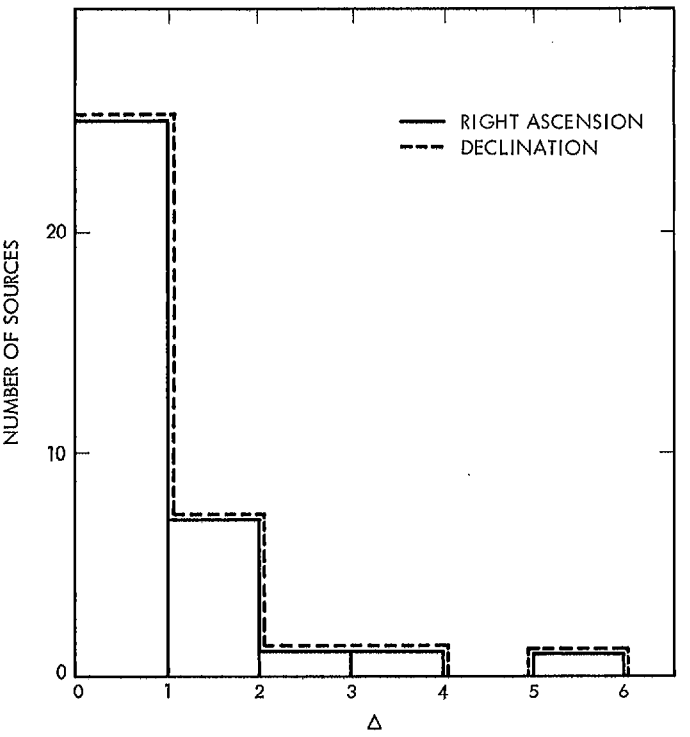
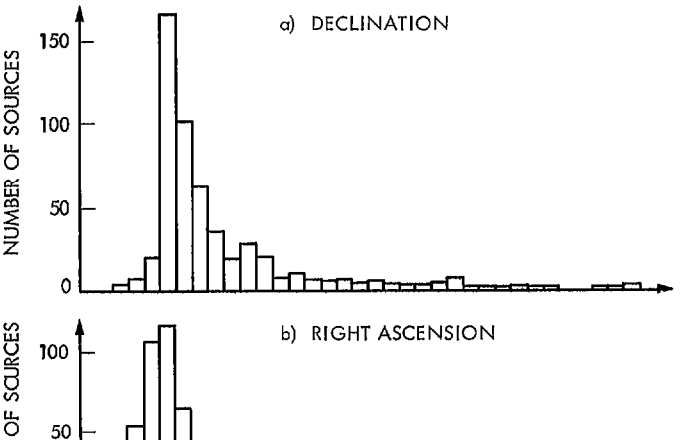
Fig. 2. Comparison of position estimates with more accurate radio positional catalogs. For each source, Δ is the ratio of the absolute value of the difference between our source coordinate estimate and a more accurate value to our estimate of uncertainty in that coordinate