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VLBI Astrometry of 22 Southern Hemisphere Radio Sources

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Abstract

Milliarcsecond accurate radio positions for 22 Southern Hemisphere extragalactic sources are reported. These positions are derived from Mark III Very Long Baseline Interferometry observations made between 2003 February and 2003 August. The results presented here supplement an ongoing project to increase the sky density of Southern Hemisphere sources in order to better define the International Celestial Reference Frame and to provide additional phase reference sources with accurate positions for use in astrophysical observations. The positions for all 22 sources are south of $\delta = -30°$ (positions for ten of the sources are south of $\delta = -60°$) and represent the largest group of new milliarcsecond accurate astrometric positions for sources in this declination range since the initial definition of the ICRF. The reported positions have average formal uncertainties of 0.5 milliarcseconds in right ascension and 0.6 milliarcseconds in declination.

1. Introduction

The United States Naval Observatory (USNO) and the Australia Telescope National Facility (ATNF) are leading a collaboration in a continuing Very Long Baseline Interferometry (VLBI) research program in Southern Hemisphere astrometry and source imaging. The goals of this program are to increase the sky density of International Celestial Reference Frame (ICRF) sources in the Southern Hemisphere by adding new sources with milliarcsecond accurate positions and to image all Southern Hemisphere ICRF sources at least twice for structure monitoring. Initial results of the precise astrometry are reported here. Results of the imaging will be reported elsewhere.

Despite its significance and stated accuracy, the ICRF suffers from a deficit of sources [1], particularly in the Southern Hemisphere. Of the 212 ICRF defining sources, less than about 30% are in the Southern Hemisphere. This non-uniform distribution between the northern and southern sky is due primarily to the fact that most VLBI arrays are physically located in the Northern Hemisphere. As a result, astrometric/geodetic observations have historically concentrated on Northern Hemisphere sources.

There have been two extensions/updates [2, 3] of the ICRF since its initial definition by [1]. One of the primary objectives of extending the ICRF was to provide positions for extragalactic radio sources observed since the ICRF was defined. However, because the new observations concentrated primarily on Northern Hemisphere sources, only four of the 109 new sources reported by [2, 3] have positions south of $\delta = -30°$.

To increase the sky density of Southern Hemisphere sources in the ICRF, we have initiated a program of dedicated Southern Hemisphere VLBI observations with the specific intent of obtaining accurate positions for new Southern Hemisphere sources, i.e., sources not previously reported with coordinates in the ICRF. In this paper, we use astrometric VLBI data obtained between 2003 February and 2003 August to estimate milliarcsecond accurate positions for 22 new Southern Hemisphere sources. Positions for these new sources are reported in the frame of the ICRF.

2. Observations

In order to identify new extragalactic radio sources to be added to the ICRF, survey observations of selected Australia Telescope Compact Array calibrator sources were interspersed among our VLBI imaging observations. The survey observations were made at a frequency of 8.4 GHz and used the S2 VLBI recording system. Candidate sources were selected based on positive detection on baselines either between Australia and South Africa or between Australia and Hawaii. A total of 29 possible astrometric targets were identified. Dedicated astrometric Mark III VLBI observations were scheduled on 2003 February 5 using a VLBI array consisting of the 64 meter antenna at Parkes, Australia (PARKES), the 26 meter antenna at Hobart, Tasmania (HOBART), the 34 meter antenna at Kashima, Japan and the 20 meter antenna at Kokee Park, HI. Observations on 2003 May 20 used an array consisting of the 26 meter antenna at Hartebeesthoek, South Africa (HART), HOBART and PARKES. Observations on 2003 August 9 and 2003 August 20 used an array consisting of HART and the 70 meter Deep Space Network antenna at Tidbinbilla, Australia. All observations were correlated at the Washington Correlator.

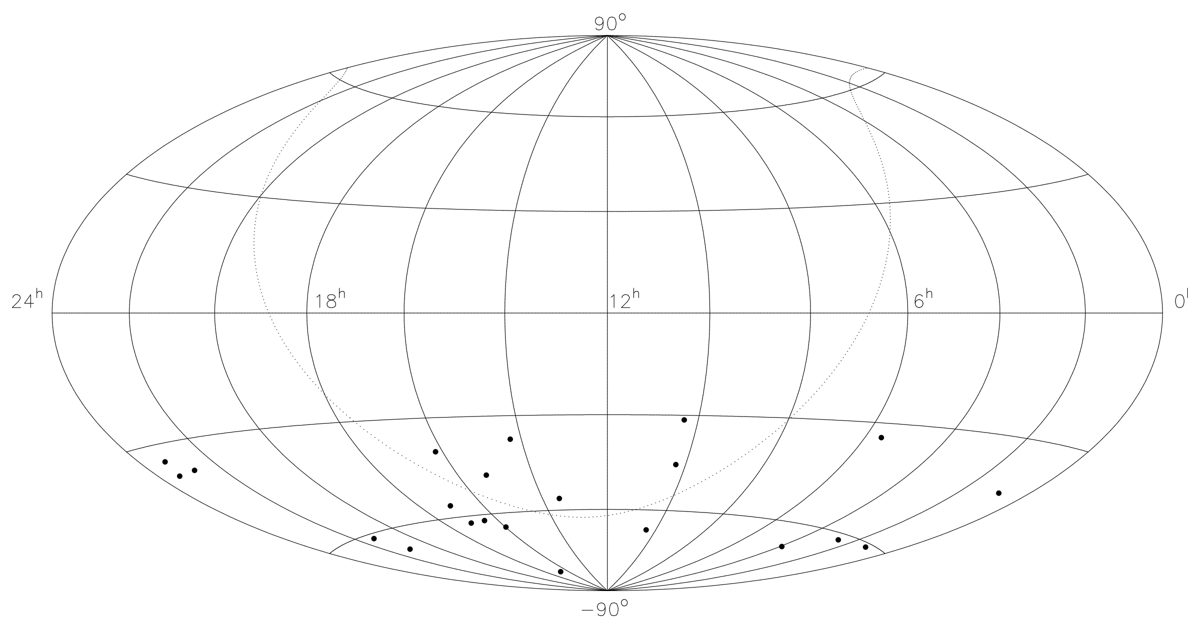

Figure 1. Distribution of sources on an Aitoff equal-area projection of the celestial sphere. The dotted line represents the Galactic equator.

3. Analysis

Accurate astrometric positions were estimated at the USNO using the Goddard Space Flight Center analysis system consisting of the astrometric and geodetic VLBI reduction software CALC and SOLVE. The radio positions reported here are based upon a general solution similar to that for the ICRF and its extensions except that all applicable dual frequency 2.3 GHz and 8.4 GHz Mark III VLBI data available through the end of 2003 August, including the four dedicated experiments described in Section (3), were used. This data set consisted of 3 899 468 group delay measurements from 3 562 24-hour observing sessions. Similar to the ICRF solution, the primary geodetic parameters, the station positions, were estimated separately for each session in the solution. The weighting of the data followed the ICRF solution. The solution described here differed from that of the ICRF and extension solutions in that the delay rate observable was not used, only the group delay observable was used. Additionally, the troposphere was modeled using the NMF mapping function. The post-fit weighted root-mean-square residuals of the final solution were 22.23 ps for delay with a reduced χ^2_ν of 0.923. Additional information on the analysis can be found in [4].

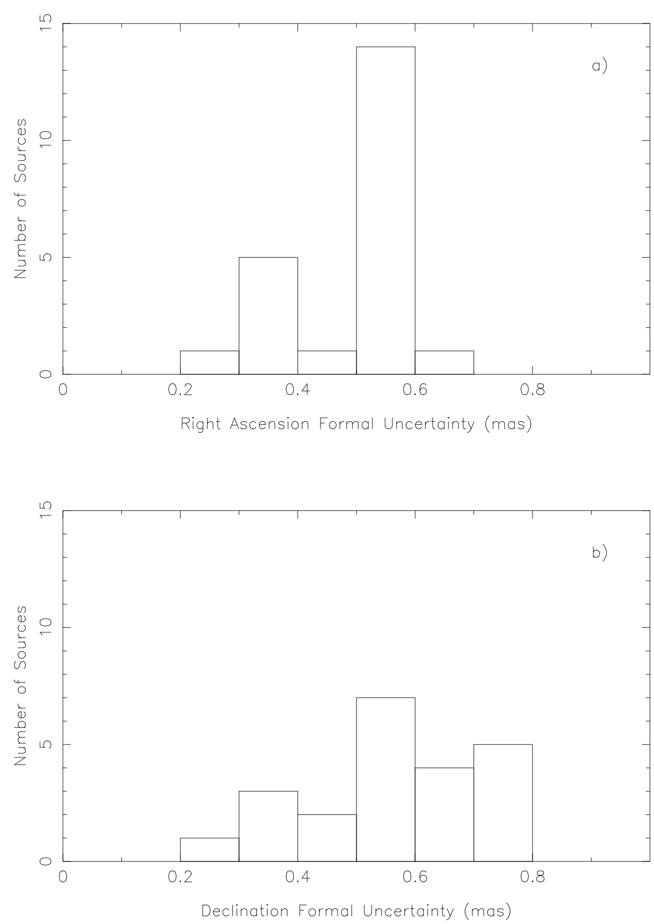

Figure 2. Distribution of position formal uncertainty in a) Right Ascension and b) Declination.

Table 1. Optical Identification of Sources

Source	**ID**	m_v.	z
PKS 0048–427	Q	19.98	1.749
PKS 0107–610	Q	21.4	
PKS 0235–618	Q	17.8	
PKS 0355–669	Q	18.7	
PKS 0534–340	G	18.3	0.684
PKS 1012–448			
PKS 1016–311	Q	17.58	0.794
PKS 1022–665			
PKS 1325–558			
PKS 1412–368	G	22.5	
PKS 1511–476			
PKS 1554–643	G	17.0	
PKS 1606–398	Q	20.9	0.518
PKS 1624–617			
PKS 1633–810	Q	18.0	
PKS 1657–562			
PKS 1659–621			
PKS 2102–659	G	21.0	
PKS 2117–614			
PKS 2244–372	Q	19.0	2.252
PKS 2314–340	Q	18.5	3.1
PKS 2321–375	Q	18.9	0.37

4. Results

The primary result obtained from the least-squares solution is the set of invariant source positions and their formal uncertainties. Of the initial 29 sources, no successful observations (group delay measurements) were obtained for the source PKS 0201–440. The sources PKS 1045–620, PKS 1109–567, PKS 1505–496, PKS 1600–489, PKS 1646–506 and PKS 2205–636 had too few successful observations to be useful at the present time. The remaining 22 sources were observed with 10 or more successful observations obtained during at least two or more 24-hour observing sessions. Positions for these sources are listed in [4]. The distribution on the sky of the new sources is shown in Figure 1. Note that the positions for all 22 sources are south of $\delta = -30°$. Additionally, the positions for ten of the sources are south of $\delta = -60°$. The distribution of the position formal uncertainties is shown in Figure 2. The formal uncertainties of the positions were *not inflated* as was done for the ICRF and its extensions. The estimated positions have average formal uncertainties of 0.5 milliarcseconds in right ascension and 0.6 milliarcseconds in declination.

Optical information including identification, visual magnitude and redshift (where known) for all 22 sources are listed in Table 1.

References

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