A Southern Hemisphere Observing Program to Strengthen the ICRF

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Abstract

We outline a program of planned Southern Hemisphere astrometry and imaging observations aimed specifically toward improvement of the International Celestial Reference Frame.

1. The Observations

We plan to strengthen the ICRF in the Southern Hemisphere by a) increasing the reference source density with additional S/X band (2.3/8.4 GHz) bandwidth--synthesis astrometric VLBI observations, and b) VLBI imaging at 8.4 GHz of ICRF sources south of $\delta = -20^\circ$. These observations will allow us to determine the contribution of the intrinsic source structure to the measured positions, to investigate possible systematic errors in source positions, and to provide a strong tie between the Northern and Southern Hemisphere through the overlap with common sources measured from the north.

1.1. Astrometry

Our earlier S/X band Southern Hemisphere VLBI astrometry program (Russell et al. 1994; Reynolds et al. 1994; Johnston et al. 1995) proved most successful in providing the fundamental Southern Hemisphere reference frame for the ICRF, as well as the basis for the southern component of the Australia Telescope Compact Array reference frame currently in use. We plan to continue this successful astrometry program by repeated observations of $\sim$ 150 Southern Hemisphere ICRF sources, both to better define the reference frame and to provide high quality sources for phase referencing observations. We note that much of the present VLBA observations are now undertaken in phase referencing mode. Details of the planned observations are as follows:

- ATNF Long Baseline Array Proposal submitted and approved
- Mark III/IV format
- Standard dual-frequency S/X band
- Correlated at Washington (USNO)
• About 150 sources
• 2–3 24hr experiments per year for 5 years
• Array of telescopes
  – Parkes and/or Tidbinbilla (Australia)
  – Hobart (Tasmania)
  – Hartebeesthoek (South Africa)
  – Kashima (Japan)
  – Kokee Park (USA)
  – Syowa (Antarctica)
  – TIGO (South America)

1.2. Imaging

A program of multi–epoch imaging of all the Northern Hemisphere sources of the ICRF is currently underway using the VLBA, with promising early results. We plan to extend this important work to the Southern Hemisphere by imaging at 8.4 GHz, with milliarcsecond resolution, ~ 200 ICRF sources. Over the proposed five year lifetime of the program we plan for two observations of each source separated by one to two years in order to determine component proper motions. Details of the planned observations are as follows:

• ATNF Long Baseline Array Proposal submitted and approved
• S2 format
• Standard X band frequency
• Correlated at Epping (ATNF)
• About 200 sources
• 2–3 24hr experiments per year for 5 years
• Array of telescopes
  – Narrabri (Australia)
  – Mopra (Australia)
  – Parkes and/or Tidbinbilla (Australia)
  – Ceduna (Australia)
  – Hobart (Tasmania)
  – Hartebeesthoek (South Africa)
  – Kashima (Japan)
  – Kokee Park (USA; S2 on loan from ATNF)
2. Motivation for Observations

Despite its significance and stated accuracy, the International Celestial Reference Frame (ICRF) (Ma et al. 1998) suffers from a deficit of defining sources in the Southern Hemisphere. Defining sources are those that set the initial direction of the ICRF axes and were chosen based on their observing history and the stability and accuracy of their position estimates. Of the 212 ICRF defining sources, less than 30% are in the Southern Hemisphere. This is illustrated in Figure 1 which shows the ICRF defining sources on an Aitoff equal area projection of the celestial sphere. In order to control local deformations of the ICRF, it is crucial to increase the density of sources in the Southern Hemisphere. Although systematic effects should be greatly reduced in frames derived from extragalactic radio sources, there is no a priori reason to assume that the radio frame will be completely free of systematic errors.

![Diagram of ICRF defining sources](image)

Figure 1. The distribution of ICRF defining sources on an Aitoff equal area projection of the celestial sphere. The dotted line represents the Galactic equator. Note the deficit of defining sources in the Southern Hemisphere.

Fey et al. (2000) have used up-to-date radio astrometric and ancillary data to evaluate the extragalactic sources which make up the ICRF in terms of their suitability for use by the Space Interferometry Mission as radio/optical frame tie sources. As a general result, they present an estimate of the radio astrometric quality of the sources based on an evaluation of the available radio data. This estimate of astrometric quality is shown in Figure 2 plotted versus declination. As can be seen in this figure, the astrometric quality of the sources rapidly decreases for sources south of the celestial equator. Additional high quality astrometric observations are needed to improve the quality of these sources and to improve the ICRF.

It is well known that the extragalactic radio sources which comprise the ICRF have variable emission structure on angular scales larger than the precision of their position estimates. The Very Long Baseline Array (VLBA) telescope of the National Radio Astronomy Observatory has been used successfully to image ICRF sources in the Northern Hemisphere (Fey & Charlot 2000 ...
Figure 2. The distribution of radio astrometric quality as defined in Fey et al. (2000) with respect to source declination for the extragalactic radio sources in the ICRF. Note the decrease in astrometric quality for sources in the Southern Hemisphere.

and references therein), at least for sources with $\delta > 30^\circ$. The resultant VLBA images have been used to calculate a source “Structure Index” (SI) based on the analysis of Charlot (1990). The SI can be used in conjunction with other data to obtain an estimate of the astrometric quality of the sources. SI values for 388 ICRF sources are reported by Fey & Charlot (2000). Continued viability of the ICRF at a high level of accuracy requires measuring and monitoring of the sources for changes in intrinsic structure.

3. References