

USNO Analysis Center for Source Structure Report

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Abstract

This report summarizes the activities of the United States Naval Observatory Analysis Center for Source Structure for calendar year 2001. The report forecasts activities planned for the year 2002.

1. Analysis Center Operation

The Analysis Center for Source Structure is supported and operated by the United States Naval Observatory (USNO). The charter of the Analysis Center is to provide products directly related to the IVS determination of the “definition and maintenance of the celestial reference frame.” These include, primarily, radio frequency images of ICRF sources, intrinsic structure models derived from the radio images, and an assessment of the astrometric quality of the ICRF sources based on their intrinsic structure.

The web server for the Analysis Center is hosted by the USNO and can be accessed by pointing your browser to

http://rorf.usno.navy.mil/ivs_saac/

The primary service of the analysis center is the Radio Reference Frame Image Database (RRFID), a web accessible database of radio frequency images of most ICRF sources with declination greater than -30 degrees. Source structure information is provided in the form of synthesis images and source models suitable for evaluating sources for astrometric and/or geodetic use and for long-term monitoring of sources. The RRFID currently contains over 2700 images of over 440 sources and can be accessed from the Analysis Center web page or directly at

<http://www.usno.navy.mil/RRFID/>

The Analysis Center currently has a program of active research investigating the effects of intrinsic source structure on astrometric position determination. Results of this program are published in the scientific literature.

2. Current Activities

The USNO has, since mid-1996, hosted the Radio Reference Frame Image Database (RRFID), a web accessible database of radio frequency images of most ICRF sources with declination greater than -30 degrees. Images are available at both S-band (13 cm) and X-band (3.6 cm), the standard frequencies used for VLBI astrometric and geodetic observations. Observations are taken from both the geodetic/astrometric database and from RDV observations. The RDV experiments are a joint collaboration between the USNO, Goddard Space Flight Center and the National Radio Astronomy Observatory (NRAO). During each 24 hour RDV session, about 70 ICRF sources are observed at S/X band using the NRAO Very Long Baseline Array (VLBA) antennas together with up to 10 additional geodetic antennas. An example of the images available from the RRFID is shown in Figure 1. Since the inception of the USNO Analysis Center in December 1999, four VLBA RDV

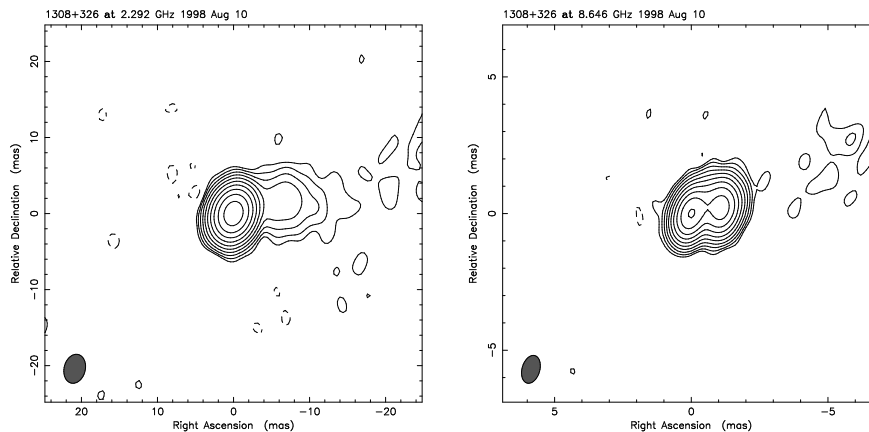


Figure 1. VLBI radio frequency images at 13 cm wavelength (left panel) and 3.6 cm wavelength (right panel) of the ICRF source 1308+326 taken from the USNO Radio Reference Frame Image Database.

experiments have been processed and imaged. These include the RDV07, RDV08, RDV09 and RDV10 sessions. Processing of RDV12 and RDV14 is under way.

The resulting intrinsic source structure information from the RRFID provides a valuable resource for evaluating the astrometric suitability of the extragalactic sources used to define the ICRF. Fey & Charlot (2000, *Astrophysical Journal Supplement Series*, Vol. 128, pp. 17–83) used RRFID data to quantify the magnitude of the expected effect of intrinsic source structure on astrometric bandwidth synthesis VLBI and presented their results in the form of a “Structure index” for the observed sources. The structure index can be used as an estimate of the astrometric quality of the sources based on intrinsic structure. Fey et al. (2001, *Astronomical Journal*, Vol. 121, pp. 1741–1751) evaluated the database of radio observations of the ICRF sources to determine the optimum candidates, in terms of their radio properties, for use as radio/optical frame tie sources. The radio data used included radio source position uncertainties derived from new least-squares astrometric analyses of dual-frequency bandwidth synthesis group-delay observations taken from the astrometric/geodetic database, radio source positional stability information also derived from new least-squares astrometric analyses, and intrinsic radio source structure information. Results were presented in the form of a radio astrometric quality. The distribution of radio astrometric quality for 392 ICRF sources is shown in Figure 2. Note the significant difference in radio astrometric quality of sources in the Southern Hemisphere as opposed to sources in the Northern Hemisphere.

Although not directly related to source structure analysis, the USNO Analysis Center is currently conducting an investigation of the effects of VLBA RDV data on astrometric position estimation and Earth orientation parameter estimation. Results can be found at

http://rorf.usno.navy.mil/vlba_rdv/

The USNO and the Australia Telescope National Facility (ATNF) are collaborating in a VLBI research program in Southern Hemisphere source imaging and astrometry using USNO, ATNF

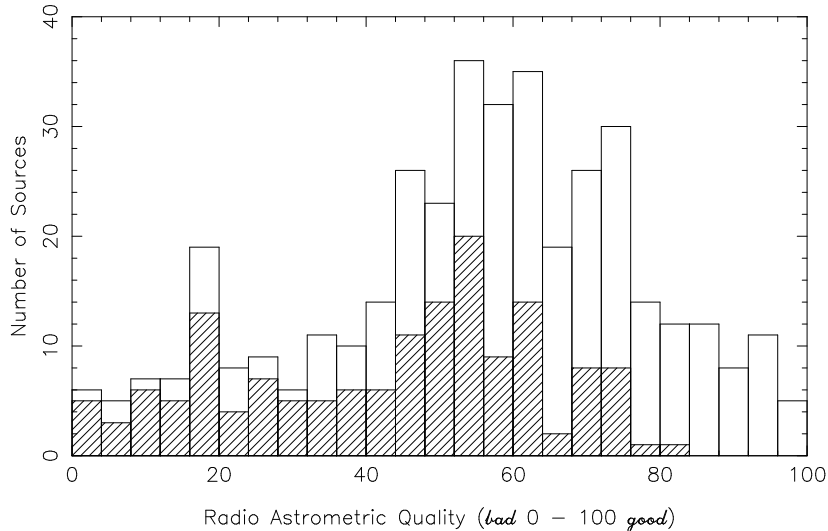


Figure 2. Distribution of radio astrometric quality for 392 ICRF sources listed in Table 1 of Fey et al. (2001). The astrometric quality is based on criteria described in the text and ranges from zero for the worst astrometric sources to 100 for the best astrometric sources. Sources with declinations south of the Celestial Equator are shown hatched. The median of the distribution is 57.

and ATNF-accessible facilities. These observations are aimed specifically toward improvement of the ICRF in the Southern Hemisphere. Plans include strengthening 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 provide a strong tie between the Northern and Southern Hemisphere through the overlap with common sources measured from the north. Several 24 hour imaging sessions and two 24 hour astrometric sessions have been carried out. Imaging results will be made available on the RRFID web site as they become available. The astrometric experiments are awaiting correlation.

3. Staff

The staff of the Analysis Center is drawn from individuals who work at the USNO. The staff and their responsibilities are:

| Name | Responsibilities |
|------------------|--|
| Alan L. Fey | Primary scientific contact, Web and data base design and content, Webmaster, Web server administration, VLBA data analysis (imaging), structure analysis |
| David A. Boboltz | VLBA data analysis (imaging), structure analysis |
| Ralph A. Gaume | Liaison to the ICRF Product Center of the IERS |
| Kerry A. Kingham | Web and data base design and content, Webmaster, Web server administration, geodetic data analysis (imaging), Mark 4 interface to imaging software, structure analysis |

4. Future Activities

The following activities are planned:

- Continue imaging of VLBA RDV experiments
- Make additional astrometric and imaging observations in the Southern Hemisphere in collaboration with ATNF partners
- Continue research into the effects of intrinsic source structure on astrometric position determination

5. Relevant Publications

Publications of relevance to Analysis Center activities can be found in the scientific literature, e.g.:

- “Extragalactic Radio Source Selection for Use in Directly Linking Optical Astrometric Observations to the Radio Reference Frame,” Fey, Alan L., Boboltz, David A., Gaume, Ralph A., Eubanks, T. Marshall, & Johnston, Kenneth J., *Astronomical Journal*, March 2001 (Vol. 121, Pages 1741–1751).
- “VLBA Observations of Radio Reference Frame Sources. III. Astrometric Suitability of an Additional 225 Sources,” Fey, Alan L. & Charlot, Patrick, *Astrophysical Journal Supplement Series*, May 2000 (Vol. 128, No 1, Pages 17–83).
- “Geodetic VLBI Observations of EGRET Blazars,” Piner, B. Glenn & Kingham, Kerry A., *Astrophysical Journal*, November 1998, (Vol. 507, No. 2, Pages 706–725).
- “The Proper Motion of 4C 39.25,” Fey, A. L., Eubanks, T. M., & Kingham, K. A., *Astronomical Journal*, December 1997, (Vol. 114, No. 6, Pages 2284–2291).
- “VLBA Observations of Radio Reference Frame Sources. II. Astrometric Suitability Based on Observed Structure,” Fey, Alan L. & Charlot, Patrick, *Astrophysical Journal Supplement Series*, July 1997 issue (Vol. 111, No. 1, Pages 95–142).
- “VLBA Observations of Radio Reference Frame Sources. I.,” Fey, A. L., Clegg, A. W., & Fomalont, E. B., *Astrophysical Journal Supplement Series*, August 1996 issue (Vol. 105, No. 2, Pages 299–330).