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The Radio Reference Frame

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Abstract. The Radio Reference Frame, defined by the radio positions of a large number of extragalactic sources, marks a milestone in the production of a global, self-consistent, quasi–inertial celestial reference frame accurate at the milliarcsecond level. A brief review of the current status and future direction of the project is presented.

1. Introduction

Astronomical reference frames precisely define the astronomical coordinate systems required for many astrophysical, geophysical, and navigational activities. The primary advantage of an astronomical reference frame based on observations of compact extragalactic radio sources is that, due to their great distances, the sources comprising a radio frame should exhibit little or no proper motion. By comparison, the accuracies of stellar reference frames degrade with time, since the proper motions of the stars defining the frames are imprecisely known.

The Radio Reference Frame (RRF) is a catalog of quasar positions derived from radio wavelength VLBI observations. The frame derived from these observations defines the most precise astronomical reference frame currently available, providing the basis for all high accuracy reference frames, at any wavelength.

1.1. History, Current Status, Future

The Radio Reference Frame is based on observations which began in 1979, continuing to the present. The International Earth Rotation Service (IERS), created by the International Astronomical Union (IAU) and the International Union of Geodesy and Geophysics (IUGG), has been involved with these observations since 1988. A portion of the mission of the IERS is to create, maintain, and provide links to a reference frame based on quasar positions; the RRF.

A milestone in the establishment of the RRF was attained in 1995 with the publication of the catalog of Johnston et al. (1995), who presented a RRF based on 560 quasars with positional accuracies better than 3 mas. The IAU's Working Group on Reference Frames (WGRF) has recently completed a follow-up catalog, the International Celestial Reference Frame (ICRF). The ICRF is expected to be adopted by the IAU as the fundamental reference frame, replacing the stellar based FK5 catalog. The ICRF is based on observations of 608 sources taken between Aug. 1979 and July 1995. The median positional uncertainty of the 608 sources in the IRCF is 0.8 mas. The positions of the 212 defining sources of the ICRF (sources used to define the axes of the frame) are depicted in Figure 1.

Images of a limited number of RRF sources have suggested that a potentially significant fraction of RRF quasars may exhibit jet or lobe structures, and that changes in these structures may effect the accuracy of the RRF. Although the RRF database spans nearly 20 years, most sources comprising the RRF have never been imaged, primarily because most observations were conducted with VLBI arrays unsuited for imaging. However, it appears likely that potentially significant improvements to the accuracy of the ICRF may be attained by incor-

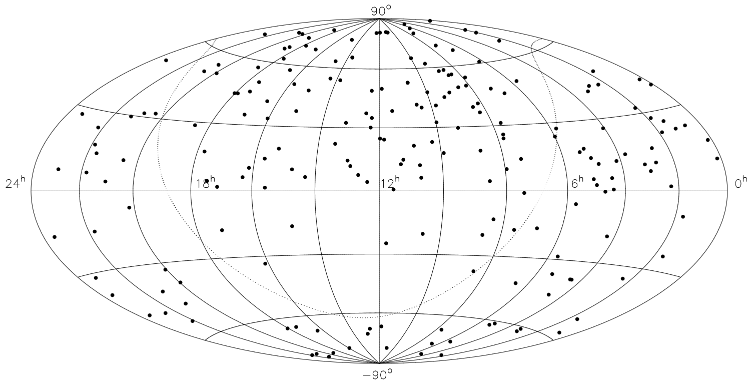

Figure 1. Positions of the 212 defining sources of the ICRF plotted on an equal area projection of the celestial sphere. The dotted line represents the location of the galactic plane.

porating corrections for source structure effects. Toward this end, Fey, Clegg, & Fomalont (1996) and Fey & Charlot (1997) have presented VLBA images of a number of RRF sources; the latter have calculated delay corrections derived from the particular structures of individual sources, and have also presented their work in this volume (Fey & Charlot, these Proceedings, p. 387). Fey et al. (private communication) have recently obtained VLBA observations that will complete the first epoch imaging of all RRF sources (approximately 400 sources) north of $-20°$ declination. The USNO maintains an on-line image database of RRF sources that is freely available to the astronomical community, in advance of formal publication. The database consists of optical and radio images, the latter, derived from both VLBA and Geodetic-VLBI observations. The database may be accessed via the WWW address *http://maia.usno.navy.mil/rorf/*

Although the quasars comprising the RRF do not exhibit proper motions, many are known to be variable. Even apparently stable sources can exhibit variability which impacts the their continued suitability for use in the RRF. Because of the potential for variability of both flux density and emission structures, maintenance of the ICRF will involve periodic imaging and non-imaging observations of ICRF sources, and the incorporation of corrections for source structures into the frame. In addition, new sources must be observed and incorporated into the frame, for the purpose of densification, and to assist in tying the frame to other wavelengths. Densification of the number of RRF defining sources is required, particularly in the southern hemisphere (see Figure 1). Maintenance of the ICRF is the responsibility of the IERS. The IERS, in turn, has designated the National Earth Orientation Service (a group composed of the USNO, NASA-GSFC, and NOAA-GL) as the VLBI Coordinating Center responsible for conducting the observations required for maintaining and improving the ICRF.

References

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