

The Celestial Reference System and Frame of the International Earth Rotation Service

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Abstract. Since 1988 we elaborate, at the Central Bureau of the International Earth Rotation Service, a combined celestial reference frame on the basis of positions of extragalactic radio sources obtained with the VLBI technique. IERS Celestial Reference frame is defined and maintained following the recommendations of the International Astronomical Union.

1. Introduction

Since January 1988 the International Earth Rotation Service (IERS) is charged to maintain a comprehensive reference system for application in global geodynamics, in space navigation and orbit maintenance, and in astronomy. Its operation is based on VLBI observation and analysis, in conjunction with other techniques: Lunar Laser Ranging (LLR), Satellite Laser Ranging (SLR) and Global Positioning System (GPS). The IERS Celestial Reference System is materialized by VLBI positions of extragalactic radio sources. The tie between IERS terrestrial and celestial reference frames is accurately provided by the time series of Earth Orientation Parameters (EOP).

2. The IERS Celestial Reference Frame

IERS Celestial Reference frame is defined following the philosophy adopted by the International Astronomical Union (IAU). The origin of the IERS celestial reference system is located at the barycenter of the solar system through appropriate modeling of observations by the analysis centers which provide individual catalogues. The orientation of axes of the system was defined in the first realization of IERS celestial reference system (ARIAS *et al.*, 1988). The maintenance process applied in the successive realizations constrains the axes to remain aligned to the original directions. The individual radio source coordinates combined in IERS realizations of the extragalactic reference system are evaluated in global solutions which simultaneously adjust parameters describing the motion of the celestial pole relative

to its conventional position. This procedure, implemented by the VLBI laboratories, makes the source coordinates independent from the errors in the precession and nutation conventional models; it gives also the position of the polar axis of the IERS celestial system relative to the mean pole at J2000.0, as predicted by the precession-nutation corrections derived from the same analysis. The origin on the equator of the IERS celestial system was implicitly defined in the initial realization (ARIAS *et al.*, 1988) by adopting the right ascensions of 23 radio sources in catalogues compiled by fixing the right ascension of the quasar 3C273B (1226 + 023) to the usual conventional value (HAZARD *et al.*, 1971).

3. Realization of the IERS Celestial Reference Frame

The IERS celestial frame is established on the extragalactic compact radio sources observed in the VLBI programs participating in IERS. The axes of the frame are maintained fixed to those in the initial IERS realization through the coordinates of a set of fiducial objects (primary sources). These objects are selected by applying statistical, geometrical and physical criteria to the individual coordinates. Five individual VLBI catalogues contributed to the last IERS realization (IERS, 1993). It is materialized by the equatorial coordinates of 153 primary sources, plus 351 sources which densify the frame. The 504 sources in RSC (IERS) 93 C 01 are homogeneously distributed in declination ($-82^\circ < \delta < +86^\circ$). The algorithm of combination consists on a classical three rotation model plus three additional unknowns which try to absorb mean residuals in declination (IERS, 1993).

4. Tie of ICRF with other Frames

In order to allow its use in the various fields of astronomy, the IERS celestial reference frame is tied, or in process to be tied, with the major reference frames of other types; the Hipparcos galactic frame, the FK5 conventional frame, the planetary dynamical frame and the terrestrial conventional frame. The tie between the extragalactic VLBI and Hipparcos frames can be achieved by the positions of radio stars determined with both techniques. An initial simulation of the tie on the basis of these observations was performed by ARIAS *et al.* (1991), leading to an estimated accuracy of ± 1 to 2 mas on the initial tie and ± 0.5 mas/year on its time evolution. A better link is actually expected because of the improved accuracy for both the VLBI and Hipparcos positions. The link to the FK5 frame was evaluated from FK5 positions for 28 extragalactic radio sources (MA *et al.*, 1990), all of them having precise positions in the ICRF. The tie between the ICRF and the planetary dynamical frame through the combined analysis of VLBI and LLR observations has 3 mas accuracy. The Earth Orientation Parameters (EOP) evaluated in IERS analysis provide the tie between IERS terrestrial and celestial reference frames. This tie is available daily with an accuracy of 0.5 mas (FEISSEL *et al.*, 1993).

5. Summary

The IAU recommended that efforts be made to elaborate a list of primary radio sources which will define the directions of axes of the primary celestial frame, and a list of secondary sources candidate to become primary in the future. In agreement with these recommendations IERS regularly evaluates the astrometric quality of VLBI results and implements the IERS celestial system. The celestial system of IERS is maintained at the level of 0.1 mas. Over 300 objects in the last realization have positions within ± 0.5 mas.

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