

CHAPTER 2 CELESTIAL REFERENCE SYSTEM

The IERS Celestial Reference Frame (ICRF) is based on the coordinates of extragalactic objects determined by VLBI and is a realization of a system of directions which are consistent with those of the FK5 (Fricke, *et al.*, 1988). The origin of right ascension of the frame was implicitly defined in the initial realization (Arias, *et al.*, 1988) by the adoption of the right ascensions of 23 radio sources in catalogs obtained by the Goddard Space Flight Center, the Jet Propulsion Laboratory, and the National Geodetic Survey. These catalogs had been compiled by fixing the right ascension of 3C273B to the usual (Hazard, *et al.*, 1971) conventional FK5 value ($12^{\text{h}} 29^{\text{m}} 6^{\text{s}}.6997$ at J2000.0). A recent re-analysis of the same observations (Soma, *et al.*, 1990) gives a value which does not differ significantly from the conventional one ($0^{\text{s}}.078 \pm 0^{\text{s}}.105$). Using the right ascensions of 28 extragalactic objects in the FK5 System given by Ma, *et al.* (1990), one finds a shift of the ICRF origin relative to the FK5 of $0^{\text{s}}.009 \pm 0^{\text{s}}.017$. On the other hand, the accuracy of the FK5 origin of right ascensions can be estimated to be $\pm 0^{\text{s}}.055$ based on the evaluations given by Fricke (1982) and Schwann (1988). Thus the IERS origin of right ascensions is consistent with that of the FK5 within the uncertainty of the latter. Comparing VLBI and LLR Earth orientation and terrestrial frames shows that the IERS origin of right ascensions is consistent with the dynamical equinox of the JPL ephemeris DE200 within $\pm 0^{\text{s}}.01$ (Finger and Folkner, 1992; Charlot, *et al.* 1991)

The ICRF polar axis points in the direction of the mean pole at J2000.0 as defined by the IAU conventional models for precession and nutation (see Chapters 1 and 4). As a result of the inaccuracy of the conventional models, it is shifted from the expected exact position of the mean pole at J2000.0 by about $0^{\text{s}}.016$ in the direction to 0^{h} and $0^{\text{s}}.001$ in the direction to 6^{h} based on Steppe, *et al.*, 1991, and the *IERS Annual Report for 1990*.

The IERS celestial reference system is barycentric through the appropriate modelling of observations by the IERS Analysis Centers (see Chapters 4 and 14). The condition that the sources have no proper motion is also applied by the Analysis Center. Checks are regularly performed to insure the validity of this constraint (Ma and Shaffer, 1991) to avoid spurious motions of some fiducial objects. The ICRF should eventually be linked astrometrically to the HIPPARCOS reference frame to unify the radio and optical coordinate systems at the level of $\pm 0^{\text{s}}.001$ in direction and $\pm 0^{\text{s}}.001/\text{year}$ in rotation (Arias, 1990).

Several extragalactic frames are produced each year by independent VLBI groups. Selected realizations are compared and combined to form the ICRF consistent with the Earth Orientation Parameters and the IERS Terrestrial Reference Frame, ITRF (see

Chapter 3). The algorithm used for the combination is designed primarily to maintain the three directions of axes fixed for successive realizations. The initial definition of the system and the maintenance process is described by Arias and Feissel (1990).

New realizations of the IERS celestial reference system are produced whenever justified by progress in the observations or in modelling. The source coordinates are published in the IERS Annual Report. Successive realizations produced up to now have maintained the initial definition of the axes within $\pm 0''0001$.

The realization of the celestial reference system published in the Annual Report of IERS for 1990 contains 396 sources in three categories, primary, secondary and complementary. A subset of sources dubbed primary are selected to fix the global orientation of the frame. They are chosen on the basis of consistency of their estimated coordinates in the various individual frames, after removing the relative rotations. Their rms position uncertainty in the IERS frame, derived from this consistency, is $\pm 0''0003$. The other sources common to the two frames but with larger position discrepancies, are considered secondary; there are 122 of them in the realization described here. Altogether in the primary and secondary categories 109 sources have position uncertainties smaller than $\pm 0''0005$, fifty between $\pm 0''001$ and $\pm 0''003$, and twenty over $\pm 0''003$. Finally, the ICRF includes 217 complementary sources, which were available from only one individual catalogue.

The observational history and the physical properties of the sources are described in *IERS Technical Note No. 7* (1991). The red-shifts span the interval 0.1-2.5 quite evenly. The total flux is, in general, over 1 Jansky. The spectral indices are between -0.8 and +1.4. The distribution in optical magnitudes peaks around the 18th visual magnitude. Some of the IERS sources have been mapped at S and X bands (e.g. Charlot, 1990). The primary sources mapped show no significant structure at the angular scale of $0''001$.

The consistency of the IERS series of the Earth Orientation Parameters with the given realizations of the ICRF and of the ITRF is at the level of $\pm 0''001$. Evaluations of the discrepancies are given each year in the *IERS Annual Report*.

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