ICRF3 – Geodetic Aspects

Robert Heinkelmann[1,✉]

[1]*Helmholtz Centre Potsdam, German Research Centre for Geosciences (GFZ), Telegrafenberg, A17, 14473 Potsdam, Germany*

✉*rob@gfz-potsdam.de*

Abstract

As documented by Resolution B2 of International Astronomical Union 2018, the international celestial reference frame 3 (ICRF3) is the current realization of the international celestial reference system: ICRS. ICRF3 establishes stationary axial directions in space at a precision level of about 10 micro arc seconds. Among all global reference frames, ICRF3 provides the spatial orientation with highest accuracy. The ITRF2014 realization of ITRS, in contrast, establishes reference directions w.r.t. the Earth surface that are approximately two orders of magnitude less precise. The causes of which are attributable to the variety of geodynamical processes that deform the Earth crust continuously. The objects used as reference points in ICRF3 are extragalactic, compact AGN (active galactic nuclei) at distances between about $100 \cdot 10^6$ and $10 \cdot 10^9$ lightyears to our Solar System.

ICRF3 is the third release of ICRS realizations based on very long baseline interferometry (VLBI) observations only. Its main advantage over its predecessor (ICRF2) is that for some hundreds of radio sources, positions are available at several wavelengths. Still, the majority of observations has been obtained at S- and X-band by the IVS (International VLBI Service for Geodesy and Astrometry), but additionally X- and Ka-band (NASA, ESA) and K-band catalogues (VLBA and a baseline between South Africa and Australia) are part of ICRF3 as well. Each wavelengths solution is independent and provides interesting opportunities for comparisons and empirical quality assessments. One of the upcoming tasks will be to establish an ICRS realization for VGOS, the new generation of VLBI ground stations, which again observes at different wavelengths.

Since 2012, the ESA mission Gaia is revolutionizing optical astrometry allowing for a multitude of detailed scientific studies and for improved technical applications. Recently, Gaia has been accepted as the realization of ICRS in optical wavelengths (IAU Resolution B3 2021). Relying on AGN, the ICRF3-SX solution establishes the current datum of Gaia positions. AGN, however, are very faint at optical wavelengths. In order to realize the datum for the bright part of the Gaia dataset properly, D-VLBI observations of radio stars are a promising observing technique.

The presentation will cover general aspects of ICRS and a review of its various realizations. The main part will be a conceptual, qualitative and quantitative description of the ICRF3 including its objects and object categories “defining” and “others” and the associated selection criteria. The presentation will address the role of the celestial frames for astrometry and geodesy. Remaining deficits and new issues coming up through the evolution of equipment from classical S/X-VLBI to modern VGOS will be mentioned as well.

Keywords: *Celestial Reference Frames and Systems, VLBI, VGOS*