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The third realization of the International Celestial Reference Frame by very long baseline interferometry

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Abstract

© P. Charlot et al. 2020. A new realization of the International Celestial Reference Frame (ICRF) is presented based on the work achieved by a working group of the International Astronomical Union (IAU) mandated for this purpose. This new realization follows the initial realization of the ICRF completed in 1997 and its successor, ICRF2, adopted as a replacement in 2009. The new frame, referred to as ICRF3, is based on nearly 40 years of data acquired by very long baseline interferometry at the standard geodetic and astrometric radio frequencies (8.4 and 2.3 GHz), supplemented with data collected at higher radio frequencies (24 GHz and dual-frequency 32 and 8.4 GHz) over the past 15 years. State-of-the-art astronomical and geophysical modeling has been used to analyze these data and derive source positions. The modeling integrates, for the first time, the effect of the galactocentric acceleration of the solar system (directly estimated from the data) which, if not considered, induces significant deformation of the frame due to the data span. The new frame includes positions at 8.4 GHz for 4536 extragalactic sources. Of these, 303 sources, uniformly distributed on the sky, are identified as "defining sources"and as such serve to define the axes of the frame. Positions at 8.4 GHz are supplemented with positions at 24 GHz for 824 sources and at 32 GHz for 678 sources. In all, ICRF3 comprises 4588 sources, with three-frequency positions available for 600 of these. Source positions have been determined independently at each of the frequencies in order to preserve the underlying astrophysical content behind such positions. They are reported for epoch 2015.0 and must be propagated for observations at other epochs for the most accurate needs, accounting for the acceleration toward the Galactic center, which results in a dipolar proper motion field of amplitude 0.0058 milliarcsecond yr-1 (mas yr-1). The frame is aligned onto the International Celestial Reference System to within the accuracy of ICRF2 and shows a median positional uncertainty of about 0.1 mas in right ascension and 0.2 mas in declination, with a noise floor of 0.03 mas in the individual source coordinates. A subset of 500 sources is found to have extremely accurate positions, in the range of 0.03-0.06 mas, at the traditional 8.4 GHz frequency. Comparing ICRF3 with the recently released Gaia Celestial Reference Frame 2 in the optical domain, there is no evidence for deformations larger than 0.03 mas between the two frames, in agreement with the ICRF3 noise level. Significant positional offsets between the three ICRF3 frequencies are detected for about 5% of the sources. Moreover, a notable fraction (22%) of the sources shows optical and radio positions that are significantly offset. There are indications that these positional offsets may be the manifestation of extended source structures. This third realization of the ICRF was adopted by the IAU at its 30th General Assembly in August 2018 and replaced the previous realization, ICRF2, on January 1, 2019.

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Keywords

Astrometry, Galaxies: nuclei, Quasars: general, Radio continuum: general, Reference systems, Techniques: interferometric

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