

Division I Working Group on “Nomenclature for Fundamental Astronomy” (NFA)

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Abstract. A Division 1 Working Group on “Nomenclature for Fundamental Astronomy” (NFA) was formed at the 25th IAU GA in 2003 in order to provide proposals for the new nomenclature associated with the implementation of the IAU 2000 resolutions on reference systems. This WG is also intended to make related educational efforts for addressing the issue to the large community of scientists. The activities of the NFA WG since October 2003 have consisted of newsletters, questionnaires, detailed e-mail discussion, and the preparation of WG recommendations and guidelines which are supported by explanatory documents. The NFA documents have been discussed during international meetings in 2004 and 2005. A NFA WG resolution proposal will be submitted to the IAU 2006 GA as a supplement to the IAU 2000 resolutions. The NFA material has been made available on the NFA web site at: <http://syrite.obspm.fr/iauWGnfa/>.

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1. Introduction

The IAU Division 1 Working Group on “Nomenclature for Fundamental Astronomy” (NFA) was established by the 25th IAU General Assembly with the task of preparing a consistent and well defined terminology associated with the implementation of the IAU 2000 resolutions on reference systems and to make related educational efforts to address the issue to the large community of scientists.

2. Background on IAD Resolutions on the reference systems

At its 23rd General Assembly in 1997, the IAU adopted the International Celestial Reference System (ICRS) as specified by IAU Resolution A4, 1991 and the International Celestial Reference Frame (ICRF) (Ma *et al.* 1998) that realizes the ICRS. At the 24th IAU GA in 2000, a number of resolutions were passed that concern the definitions of astronomical reference system and transformations between them: – Resolution B1.3 specifies that the systems of space-time coordinates as defined by IAU Resolution A4 (1991) for the solar system and the Earth within the framework of General Relativity are named the Barycentric Celestial Reference System (BCRS) with Barycentric Coordinate Time (TCB) and the Geocentric Celestial Reference System (GCRS) with Geocentric Coordinate Time (TCG), respectively. It also provides a general framework for expressing the metric tensor and defining coordinate transformations at the first post-Newtonian level (see Soffel *et al.* 2003). – Resolution B1.5 gives a set of formulas for practical transformations between relativistic time scales (see Soffel *et al.* 2003). – Resolution B1.6 recommends the adoption of the new precession-nutation model that is designated IAU 2000 (see Dehant *et al.* 2002, Mathews *et al.* 2002 and McCarthy and

Luzum 2002). – Resolution Bl.7 specifies the definition of the CIP 88 an intermediate pole separating, by convention, the motion of the ITRS pole in the GCRS into (i) the celestial motion of the CIP (precession/nutation), including all the terms with periods greater than 2 days in the GCRS, and (ii) the terrestrial motion of the CIP (polar motion), including all the terms outside the retrograde diurnal band in the ITRS (see Capitaine 2002). – Resolution Bl.8 recommends using the “non-rotating origin” (Guinot, 1979), originally designated CEO (Celestial Ephemeris Origin) and TEO (Terrestrial Ephemeris Origin), as origins on the moving equator in the celestial and terrestrial reference systems, respectively, and defines UT1 as linearly proportional to the Earth Rotation Angle (ERA) between these origin. on the moving equator (Capitaine *et al.* 2000). This resolution recommends that the transformation between the International Terrestrial Reference System (ITRS) and the GCRS be specified by the position of the Celestial Intermediate Pole, CIP, (defined by Resolution Bl. 7) in the GCRS, the position of the CIP in the ITRS, and the ERA (i.e. referred to CEO and TEO). – Resolution Bl.9 provides the conventional linear relation between Terrestrial Time (TT) and TCG (see Soffel *et al.* 2003). Resolutions B1.6, B1.7 and B1.8 came into force on 1 January 2003. The International Earth Rotation and Reference Systems Service (IERS) (see IERS Conventions 2003) and the Standards Of Fundamental Astronomy (SOFA) activity (see Wallace 2004) have made available the models, procedures, data and software to implement these resolutions operationally. Discussion about terminology was first published by Seidelmann and Kovalevsky (2002), Capitaine *et al.* (2003a,b) and Kovalevsky and Seidelmann (2004).

3. Activities of the NFA Working Group

The WG has worked on selecting a consistent and well defined terminology for all the quantities based on the IAU 2000 Resolutions in order that it will be recognized and adopted by the astronomical community for various astronomical application. All the WG documents have been posted on the NFA web site, which includes links to other sites relevant to the WG activities. A special page of the web site provides links to educational documents that explain the NFA issue. There has been detailed WG o-mail discussion on the terminology choices. The agreements reached by the WG on these choices have been reflected in the WG Recommendations which are supported by two explanatory documents. Part A reports on the basis for the IAU Resolutions and their implementation and Part B provides a more detailed description of the proposed terminology. Contained in Part B is the “NFA IAU 2000 Glossary” that provides a set of detailed definitions that best explain all the terms required for implementing the IAU 2000 resolutions. Complementary and supporting material (e.g. a chart of the transformation process from ICRS to observed places of stars) are included in order to facilitate the understanding and implementation of the IAU 2000 resolutions, as well as illustrating the Glossary. The NFA issues and documents have been discussed during international meetings in 2004 and 2005 (See the NFA web page at: <http://syrtel.obspm.fr/iauWGnfa/>). The Almanac Offices have begun to implement the WG recommendations beginning with their 2006 editions (see Hohenkerk 2005).

4. NFA WG Recommendations and guidelines on terminology

(a) *Using existing terms (e.g. right ascension) in extended ways for the terminology associated with the new paradigm with a clear specification, rather than introducing new names.*

(b) Using “equinox based” and “CIO based” for referring to the classical and new paradigms, respectively. Comment: the “Celestial/Terrestrial Intermediate Origin” with the acronym CIO/TIO is proposed here as the updated terminology to replace the IAU 2000 “Celestial/Terrestrial Ephemeris Origin” with the acronym CEO/TEO (see below items 3. and 4. and the proposed Resolution).

(c) Using “intermediate” to describe (i) the moving geocentric celestial reference system defined in the IAU 2000 Resolutions (i.e. containing the CIP and the CIO), and (U) the moving terrestrial system containing the CIP and the TID). Comment: the term “intermediate” has been chosen to specify that these systems are intermediary systems between the geocentric celestial system and the terrestrial system, which are realized by using the models, constants and procedures that are conventionally accepted it conventionally separates the instantaneous celestial orientation of the Earth into components we label polar motion (in the terrestrial system) and precession-nutation (in the celestial system).

(d) Harmonizing the name of the pole and the origin to “intermediate” and therefore changing CEO/TEO to CIO/TID.

(e) Using “system” in a broad sense rather than “frame” in this context of the intermediary system/frame.

(f) Using special designations for particular realizations of the intermediate celestial system. Comment: this applies for example to “the IAU 2000A system” to designate the system which is realized by transforming the geocentric celestial system GCRS to the intermediate system using the IAU 2000A precession-nutation and associated frame biases at J2000 (the GCRS being transformed from the BCRS by using the coordinate transformation specified in the IAU 2000 Resolution B1.3).

(g) Keeping the classical terminology for “true equator and equinox” (or “true equinox based”) for the classical equatorial system.

(h) Choosing “equinox right ascension” and “CIO right ascension”, respectively (or “RA with respect to the equinox/or CIO”), for the azimuthal coordinate along the equator in the classical and new paradigms, respectively. (Note that right ascensions and declinations with respect to the ICRS are usually designated by α_{ICRS} , δ_{ICRS}). Comment: This is to be specified only once in the presentation of appear if there is some risk of misunderstanding. Afterwards, “right ascension” alone is sufficient.

(i) Giving the name “equation of the origins” to the distance between the CIO and the equinox along the intermediate equator, the sign of this quantity being such that it represents the CIO right ascension of the equinox, or equivalently, the difference between the Earth Rotation Angle and Greenwich apparent sidereal time.

(j) Retaining “apparent places” and “mean places” in the equinox based system.

(k) Not introducing “apparent intermediate places” in the CIO based system, but introducing instead “intermediate places”.

(l) Using “ITRF zero-meridian” to designate the plane passing through the geocenter, ITRF pole and ITRF x-origin and using, if necessary, “TID meridian” to designate the moving plane passing through the geocenter, the CIP and the TID.

(m) Fixing the default orientation of the BCRS so that for all practical applications, unless otherwise stated, the BCRS is assumed to be oriented according to the ICRS axes. Comment: Once the BCRS is spatially oriented according to the ICRS, the spatial GCRS coordinates get an “ICRS-induced” orientation.

(n) Merging Barycentric Dynamical Time (TDB) with Barycentric Ephemeris Time (Teph) so that TDB is a linear function of TCB and the rate of TDB as defined by a particular ephemeris is as close as possible to that of TT for the time span covered by that particular ephemeris.

Additional points – *Considering a terminology associated with other types of apparent places, although it may be required for specific use, has not been considered as being essential for common astronomical use and is therefore not part of the NFA WG terminology recommendations. - No WC consensus having been reached for having strict rules for using or not using capitals for names for origins, poles and systems, no recommendation on this issue is proposed by the WG. The policy adopted throughout the NFA document is to capitalize those terms that are defined in IAU or IUGG resolutions.*

5. NFA WG Resolution Proposal to the IAU

In order to introduce the astronomical community to the main WG recommendations, a Resolution proposal to the IAU has been prepared as a supplement to the IAU 2000 resolutions on reference systems for 1) harmonizing the name of the pole and origin to “intermediate” and 2) specifying the default orientation of the BCRS and GCRS.

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