

LATEST PROPOSALS OF THE IAU WORKING GROUP ON “NOMENCLATURE FOR FUNDAMENTAL ASTRONOMY”

N. CAPITAINE, Observatoire de Paris, France

and

C. HOHENKERK, HMNAO, UK; A.H. ANDREI, Observatorio Nacional, Brazil; M. CALABRETTA, ATNF, Australia; V. DEHANT, ROB, Belgium; T. FUKUSHIMA, NAO, Japan; B. GUINOT, Observatoire de Paris, France; G. KAPLAN, USNO, USA; S. KLIONER, Lohrmann Observatory, Germany; J. KOVALEVSKY, OCA, France; I. KUMKOVA, Sobolev Astronomical Institute, Russia; C. MA, GSFC, USA; D.D. MCCARTHY, USNO, USA; K. SEIDELMANN, Virginia University, USA; P. WALLACE, CCRLC/RAL, UK

ABSTRACT. 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. This WG is also intended to make related educational efforts to address the issue to the large community of scientists. In this paper, we recall the main nomenclature issues and report on the latest NFA WG recommendations on terminology choices and guidelines that have been supported by explanatory documents, including a NFA IAU 2000 Glossary. In order to introduce the astronomical community to the main NFA recommendations, a WG Resolution proposal will be submitted to the IAU 2006 General Assembly as a supplement to the IAU 2000 resolutions for harmonizing the name of the pole and origin to “intermediate” and for specifying the default orientation of the BCRS and GCRS.

1. INTRODUCTION

The IAU 2000 resolutions on reference systems, which have been implemented by the IERS (International Earth Rotation and Reference Systems Service) Conventions 2003 and SOFA (Standards Of Fundamental Astronomy) (Wallace 2004), have consequences for the whole astronomical community; these include (i) the improvement in the procedures to be used in the realization of the International Celestial Reference System (ICRS), (ii) the use of an improved precession-nutation model, (iii) the use of a new definition of Universal Time, and (iv) the abandonment of the intermediary reference to the ecliptic and equinox.

The IAU Division 1 Working Group on “Nomenclature for Fundamental Astronomy” (NFA), established by the 2000 IAU General Assembly, 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 understood, recognized and adopted by the astronomical community. The terminology and guidelines recommended by the WG have been described in a number of Newsletters and documents (available on a WG web page) and are supported by the NFA explanatory document.

2. THE NOMENCLATURE ISSUES

The IAU 2000 Resolutions are such that, in particular:

- 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 (see Soffel et al. 2003).
- Resolution B1.6 recommends the adoption of the IAU 2000 precession-nutation (Dehant et al. 1999, Mathews et al. 2002) with submilliarcsecond accuracy.
- Resolution B1.7 specifies the definition of the Celestial Intermediate Pole (CIP) as an intermediate pole in the transformation from the GCRS to the International Terrestrial Reference System (ITRS), separating, by convention, nutation from polar motion (see Capitaine 2002).
- Resolution B1.8 recommends that the transformation between the ITRS and the GCRS be specified by the position of CIP in the GCRS, the position of the CIP in the ITRS, and the Earth Rotation Angle (ERA) based on the use of the “non-rotating origin” (Guinot, 1979). UT1 has been defined as linearly proportional to the Earth Rotation Angle (ERA) between these origins on the moving equator.

The implementation of the above resolutions requires using a consistent and well defined terminology associated with the use of (i) the Barycentric and Geocentric celestial reference systems, (ii) the precession-nutation of the CIP and (iii) the new origins on the CIP equator.

3. TERMINOLOGY ASSOCIATED WITH THE NEW EQUATORIAL ORIGIN

The change of the origin on the CIP equator and the use of the ERA corresponds to the use of a new paradigm for the GCRS-to-ITRS transformation that requires specific recommendations on nomenclature. The NFA WG has recognized that using the designation “intermediate” to refer to both the pole and the origins of the new systems, namely the CIP and the Celestial or Terrestrial Ephemeris origins, defined in Resolutions B1.7 and B1.8, respectively, would improve the consistency of the nomenclature. The WG have therefore recommended:

- harmonizing the name of the pole and origin to “intermediate” and therefore changing CEO/TEO to CIO/TIO,
- using “equinox based” and “CIO based” for referring to the classical and new paradigms, respectively,
- choosing “equinox right ascension” and “CIO right ascension” (or “intermediate right ascension”) respectively, for the azimuthal coordinate along the equator in the classical and new paradigms, respectively,
- defining the celestial and terrestrial “intermediate systems”,
- keeping the classical terminology for “true equator and equinox” and
- 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 is 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.

The CIO was originally set close to the mean equinox at J2000.0. However, as a consequence of precession-nutation the CIO moves according to the kinematical property of the non-rotating origin. Similarly, the TIO was originally set at the ITRF origin of longitude and, as a consequence of polar motion the TIO moves according to the kinematical property of the non-rotating origin. The NFA WG has adopted the following designations to locate the CIP and the TIO:

- the CIO locator (denoted s) is the difference between the GCRS right ascension and the intermediate right ascension of the intersection of the GCRS and intermediate equators,
- the TIO locator (denoted s') is the difference between the ITRS longitude and the instantaneous longitude of the intersection of the ITRS and intermediate equators.

The Celestial Intermediate Reference System (CIRS) has been specified to be the geocentric reference system related to the GCRS by a time-dependent rotation taking into account precession-nutation. It is defined by the intermediate equator (of the CIP) and CIO on a specific date. It is similar to the system based on the true equator and equinox of date, but the equatorial origin is at the CIO.

4. TERMINOLOGY ASSOCIATED WITH THE USE OF THE BCRS AND GCRS

IAU Resolution B1.3 has defined the systems of space-time coordinates in the framework of general relativity for:

- a) the solar system, called the Barycentric Celestial Reference System (BCRS), which can be considered to be a global coordinate system that contains all distant regions,
- b) the Earth, called the Geocentric Celestial Reference System (GCRS), which can only be considered as a local coordinate system.

However, the NFA WG has recognized that 1) the BCRS definition does not determine the orientation of the spatial coordinates and 2) the natural choice of orientation for typical applications is that of the ICRS. Moreover, the GCRS is defined such that its spatial coordinates are kinematically non-rotating with respect to those of the BCRS and consequently the orientation of the GCRS spatial coordinates is induced by that of the BCRS.

Therefore, a NFA WG Recommendation on the default orientation of the BCRS and GCRS was adopted, 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. Once the BCRS is spatially oriented according to the ICRS, the spatial GCRS coordinates inherit an “ICRS-induced” orientation.

5. ACTIVITIES OF THE NFA WORKING GROUP

Discussion about terminology associated with the IAU 2000 Resolutions was first published by Seidelmann & Kovalevsky (2002), Capitaine et al. (2003a,b) and Kovalevsky & Seidelmann (2004).

Then there has been detailed e-mail discussion within the NFA WG on the terminology choices. The agreements reached by the WG on these choices have been reflected in the WG Recommendations, which are supported by an explanatory document. Part A of this document 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://syrtte.obspm.fr/iauWGnfa/>). The Almanac Offices have begun to implement the WG recommendations beginning with their 2006 editions (see Hohenkerk 2005).

In order to approve the proposed terminology, the WG is preparing to submit to the IAU 2006 General Assembly a Resolution entitled “Supplement to the IAU 2000 Resolutions on reference systems”, including Recommendation 1 *Harmonizing the name of the pole and origin to ‘intermediate’* and Recommendation 2 *The default orientation of the BCRS and GCRS*. A special page of the NFA web site <http://syrtte.obspm.fr/iauWGnfa/> makes available documents with educational purposes relevant to the NFA issue.

REFERENCES

- Capitaine, N., 2002, “Comparison of Old and New concepts: The Celestial intermediate pole and Earth orientation parameters,” IERS Technical Note 29, N.Capitaine et al. (eds), Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie, pp. 35–44.
- Capitaine, N., Chapront, J., Lambert, S., and Wallace, P.T. 2003a, “Expressions for the Celestial Intermediate Pole and Celestial Ephemeris origin consistent with the IAU 2000A precession-nutation model”, A&A 400, pp. 1145–1154.
- Capitaine, N., Wallace, P.T., and McCarthy, D.D. 2003b, “Expressions to implement the IAU 2000 definition of UT1”, A&A 406, pp. 1135–1149.
- Dehant, V., Arias, F., Bizouard, Ch., Bretagnon, P., Brzeziński, A., et al. 1999, “Considerations concerning the non-rigid Earth nutation theory,” *Celest. Mech. Dyn. Astr.*, 72, pp. 245–310.
- Guinot, B., 1979, “Basic Problems in the Kinematics of the Rotation of the Earth,” in *Time and the Earth’s Rotation*, D. D. McCarthy and J. D. Pilkington (eds), D. Reidel Publishing Company, pp. 7–18.
- Hohenkerk, C. 2005, in Proceedings of the “Journées 2004 Systèmes de référence spatio-temporels,” N. Capitaine (ed), Observatoire de Paris, pp. 168–171.
- IERS Conventions (2003) 2004, IERS Technical Note 32, D.D. McCarthy and G. Petit (eds), Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie.
- Kovalevsky, J. & Seidelmann P.K. 2004, *Fundamentals of Astrometry*, Cambridge University Press.
- Mathews, P. M., Herring, T. A., and Buffett B. A., 2002, “Modeling of nutation-precession: New nutation series for nonrigid Earth, and insights into the Earth’s Interior”, *J. Geophys. Res.* 107, B4, 10.1029/2001JB000390.
- Seidelmann, P.K. and Kovalevsky, J. 2002, “Application of the new concepts and definitions (ICRS, CIP, and CEO) in fundamental astronomy”, A&A 392, pp. 341–351.
- Soffel, M., Klioner, S., Petit, G., Bretagnon, P., Capitaine, N., et al. 2003, “Explanatory supplement for the IAU 2000 resolutions on relativity”, *AJ* 126, pp. 2687–2705.
- Wallace P.T. 2004, SOFA software support for IAU 2000, AAS Meeting 204, #28.02, May 2004.