

*Latest proposals of the IAU WG on  
"Nomenclature for Fundamental  
Astronomy" (NFA)*

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and

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## *Implementation of the IAU 2000 resolutions*

- *Consequences for the whole astronomical community*
  - improvement in the procedures to be used in the realization of the ICRS
  - improvement of the IAU precession-nutation model,
  - a new definition of Universal Time and its relationship to sidereal time
  - the abandonment of the intermediary reference to the ecliptic and equinox
- *The IERS*
  - has implemented these recommendations
  - provides the data necessary to implement the previous definitions

*The implementation of the IAU 2000 resolutions for various astronomical applications requires that a consistent and well defined terminology is recognized and adopted by the astronomical community for all the quantities based on the new concepts.*

# *IAU WG "Nomenclature for Fundamental Astronomy" (NFA)*

*<http://synte.obspm.fr/iauWGNfa>*

*Created by Division 1 at the 24th IAU General Assembly  
(July 2003)*

## **General task of the Working group:**

*to provide proposals for new nomenclature associated with the  
implementation of the IAU 2000 resolutions and to make related educational  
efforts for addressing the issue to a large community of scientists.*

*step 1) in the work of the WG: **Newsletters + NFA Questionnaire***

*step 2) in the work of the WG: **NFA explanatory documents***

## *Nomenclature issues*

- the Celestial Intermediate Pole (CIP)

*(B1.7 Resolution) : definition of an intermediate pole*

à need for nomenclature associated with the use of the “intermediate” pole and equator

- the IAU2000 precession-nutation *(Mathews et al. 2002)*

*(B1.6 Resolution) : new model at submilliarcsecond accuracy*

à need for nomenclature associated with the use of the precession-nutation of the CIP (including celestial pole offsets at J2000: frame bias)

- definition and use of Celestial and Terrestrial Ephemeris Origins

*(B1.8 Resolution) : introduce a new paradigm for GCRS  $\leftrightarrow$  ITRS transformation*

(GCRS and ITRS positions of the CIP, ERA on the CIP equator)

à need for nomenclature associated with the use of the new origins,

à need for homogenization to « intermediate » (CIO, TIO)

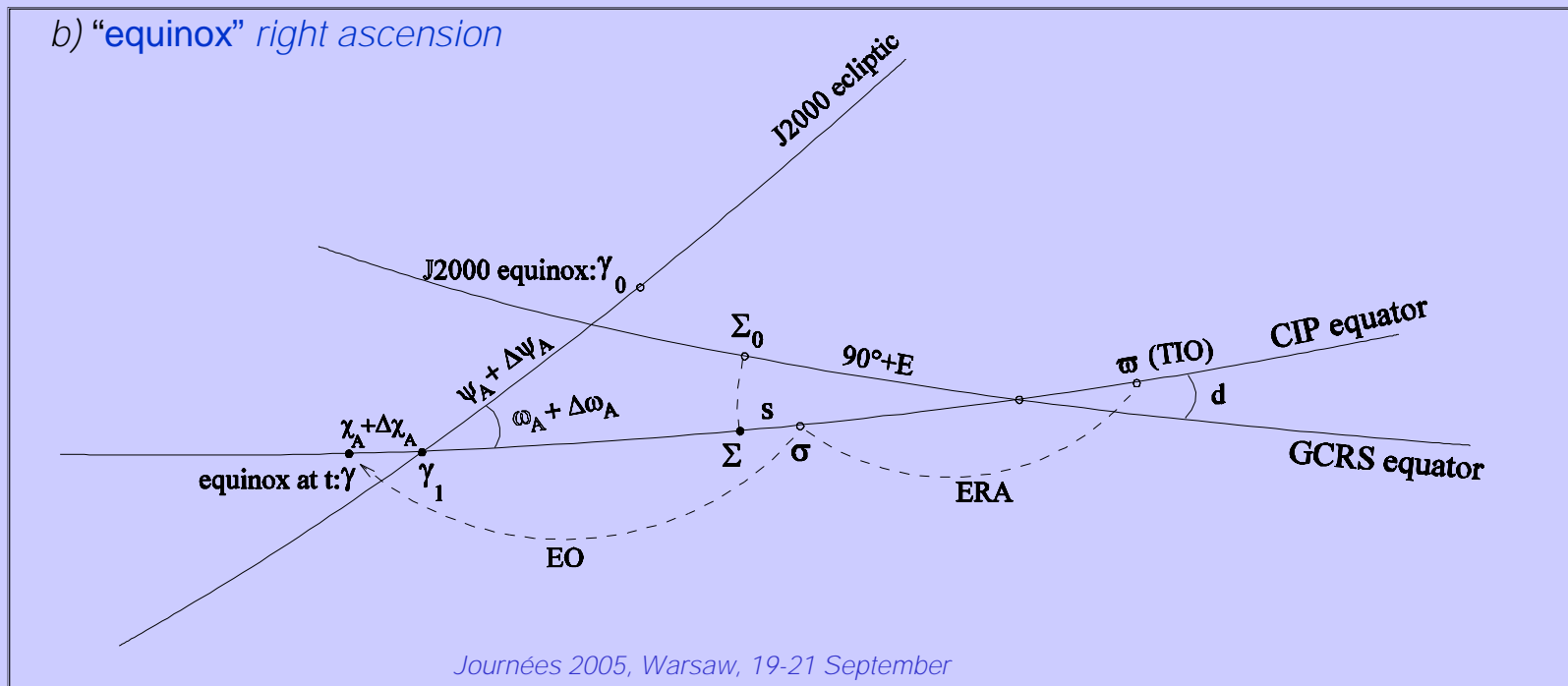
# Nomenclature associated with the change of the origin on the intermediate equator

## Using the CIO

- a) **Earth Rotation Angle:**  $\text{ERA} = \theta = k \text{ UT1}$ , such that  $d\theta/dt = \omega$
- b) "intermediate" right ascension or "CIO" right ascension
- c) *CIO locator* : quantity  $s$  ( $= \sigma \Sigma_0$ )

## Using the equinox (with implicit use of CIO)

- a) **Sidereal time:**  $\text{GST} = \text{GMST (UT1, TT)} + \text{"equation of the equinoxes"}$   
 $= \theta (\text{UT1}) + \text{"equation of the origins" (EO)}$



## *Nomenclature associated with the use of the BCRS and GCRS*

**IAU Resolution B1.3 : Clarification of IAU's 1991** definition of the coordinate systems  
in the **framework of GR** : *distinction between the celestial systems*

- a) for Solar System (**BCRS**) which can be considered to be  
*a global coordinate system* that contain all the 'far away regions'
- b) for the Earth (**GCRS**) which can only be considered as a  
*local coordinate system*

*Questions: relationship between ICRS, BCRS? Orientation of the BCRS axes ?*

*Result of the work of the WG on  
"Nomenclature for Fundamental Astronomy" (NFA)*

*October 2003-September 2005 à Draft documents for the IAU 2006 GA*

- **NFA WG Recommendations and guidelines (discussed at the *Journées 2004*)**
- **Draft Resolution entitled « Supplement to the IAU 2000 Resolutions on Reference frames to be submitted to the IAU 2006 GA (Recommends 1 and 2)**
- **Explanatory documents for supporting NFA recommendations**
  - *NFA/A : Basis for the IAU Resolutions and their implementation*
  - **NFA/B: Explanation of the proposed terminology**

*has been prepared through detailed WG e-mail discussion*

## *NFA/B: Explanation of the proposed terminology*

### *1) NFA IAU 2000 Glossary*

**Provides a set of detailed definitions that best explain all the terms required for implementing the IAU 2000 resolutions. Includes a few newly proposed terms, and terms that have some impact on the definitions, as well as some more general definitions.**

*some of the definitions prior to the IAU 2000 resolutions may not be compliant with relativity*

*although some definitions are provided with capitals this does not mean that they must be used with capitals*



## *NFA/B: Explanation of the proposed terminology*

*2) Table containing the categorized list of terms*

*3) Chart of the transformation process from ICRS to observed places of stars to illustrate the various stages showing the BCRS ->GCRS->ITRS transformation in GR (Resolution B1.3) and the parallel CIO and equinox based processes (Resolution B1.8)*

*4) List of abbreviations, acronyms and symbols*

**complementary and supporting material to facilitate the understanding and implementation of the IAU 2000 resolutions, as well as illustrating the Glossary**

# *The NFA IAU 2000 Glossary*

## **detailed discussion**

*Barycentric Celestial Reference System (BCRS)*  
*Barycentric Dynamical Time (TDB)*  
*Barycentric Ephemeris Time (Teph)*  
*Celestial Intermediate Origin (CIO)*  
*Celestial Intermediate Reference System (CIRS)*  
*CIO locator*  
*CIO right ascension and declination*  
*epoch*  
*equation of the origin (EO)*  
*equinox right ascension*  
*Geocentric Celestial Reference System (GCRS)*  
*Geocentric Terrestrial Reference System (GTRS)*  
*ICRS place*  
*intermediate equator*

*intermediate place*  
*Intermediate right ascension*  
*International Celestial Reference Frame (ICRF)*  
*International Celestial Reference System (ICRS)*  
*International Terrestrial Reference Frame (ITRF)*  
*International Terrestrial Reference System (ITRS)*  
*Julian century*  
*Julian date*  
*Julian year*  
*right ascension*  
*Terrestrial Intermediate Origin (TIO)*  
*Terrestrial Intermediate Reference System (TIRS)*  
*Terrestrial Time (TT)*  
*TIO locator*

## *The Glossary: a few examples (1)*

- Celestial Intermediate Reference System (CIRS): 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. Since the acronym for this system is close to another acronym (namely ICRS), it is suggested that wherever possible the complete name is used.
- intermediate right ascension and declination: angular coordinates measured in the celestial intermediate reference system at a specified date. They specify a geocentric direction that differs from the ICRS direction by annual parallax, gravitational light deflection due to the solar system bodies, except the Earth, annual aberration, and the time-dependent rotation describing the transformation from the GCRS to the celestial intermediate reference system. They are similar to apparent right ascension and declination when referring to the equinox based system. Note that intermediate declination is identical to apparent declination.

## The Glossary: a few examples (2)

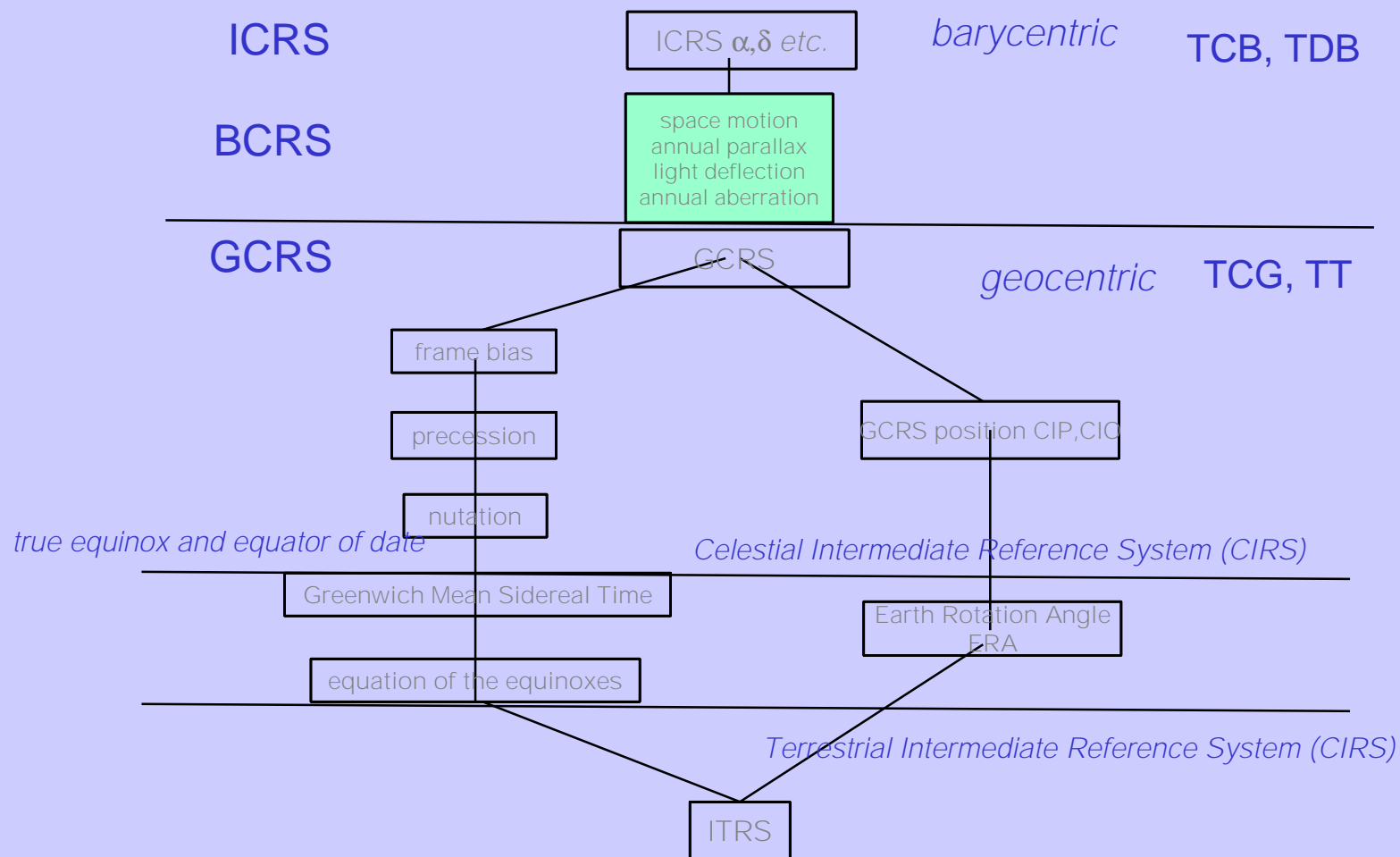
Celestial Intermediate Origin (CIO): origin for right ascension on the intermediate equator in the celestial intermediate reference system. It is the non-rotating origin in the GCRS that is recommended by the IAU 2000 Resolution B 1.8, where it was designated the Celestial Ephemeris Origin. The CIO was originally set close to the GCRS meridian and throughout 1900-2100 stays within 0.1 arcseconds of this alignment.

equation of the origins: distance between the equinox and the CIO along the intermediate equator; it is the CIO right ascension of the equinox; alternatively the difference between the Earth rotation angle and Greenwich apparent sidereal time (ERA – GAST).

CIO locator (denoted  $s$ ): the difference between the GCRS right ascension and the intermediate right ascension of the intersection of the GCRS and intermediate equators. The CIO was originally set close to the mean equinox at J2000.0. As a consequence of precession-nutation the CIO moves according to the kinematical property of the non-rotating origin. The CIO is currently located by using the quantity  $s$ .

TIO locator (denoted  $s'_{\oplus}$ ): the difference between the ITRS longitude and the instantaneous longitude of the intersection of the ITRS and intermediate equators. The TIO was originally set at the ITRF origin of longitude. As a consequence of polar motion the TIO moves according to the kinematical property of the non-rotating origin. The TIO is currently located using the quantity  $s'_{\oplus}$  whose rate is of the order of 50 mas/cy which is due to the current polar motion.

# Transformation from ICRS to observed places of stars



## Draft Resolution to be submitted to the IAU GA 2006

### Recommendation from the Division I IAU Working Group on “Nomenclature for Fundamental Astronomy” (NFA)

#### *Supplement to the IAU 2000 Resolutions on reference frames*

#### **RECOMMENDATION 1. Harmonizing the name of the pole and origin to “intermediate”**

The XXVIth General Assembly of the IAU

#### NOTING

- 1) the adoption of resolutions IAU B1.1 through B1.9 by the IAU General Assembly of 2000, and
- 2) that the International Earth rotation and Reference Systems service (IERS) and the Standards Of Fundamental Astronomy (SOFA) activity have made available the models, procedures, data and software to implement these resolutions operationally, and that the Almanac Offices have begun to implement them beginning with their 2006 editions.

#### RECOGNISING

that using the designation “intermediate” to refer to both the pole and the origin of the new systems linked to the Celestial Intermediate Pole and the Celestial or Terrestrial Ephemeris origins, defined in Resolution B1.7 and B1.8, respectively would improve the consistency of the nomenclature, and

that the name “Conventional International Origin” with the potentially conflicting acronym CIO is no longer commonly used to refer to the reference pole for measuring polar motion as it was in the past by the International Latitude Service,

## RECOMMENDS

that the designation “intermediate” be used to describe the elements of the moving reference system defined in the 2000 IAU Resolutions,

that the terminology “Celestial Intermediate Origin” (CIO) and “Terrestrial Intermediate Origin” (TIO) be used in place of the previously introduced “Celestial Ephemeris Origin” (CEO) and “Terrestrial Ephemeris Origin” (TEO), and

that authors carefully define acronyms used to designate elements of astronomical reference systems to avoid possible confusion

## **RECOMMENDATION 2. Default orientation of the BCRS and GCRS**

The XXVIth General Assembly of the IAU

### **NOTING**

- (1) the adoption of resolutions IAU B1.1 through B1.9 by the IAU General Assembly of 2000, and
- (2) that the International Earth rotation and Reference Systems service (IERS) and the Standards Of Fundamental Astronomy (SOFA) activity have made available the models, procedures, data and software to implement these resolutions operationally, and that the Almanac Offices have begun to implement them beginning with their 2006 editions, and
- (3) that, in particular, the systems of space-time coordinates defined by IAU 2000 Resolution B1.3 for (a) the solar system (called the Barycentric Celestial Reference System, BCRS) and (b) the Earth (called the Geocentric Celestial Reference System, GCRS) have begun to come into use, and
- (4) the conclusions of the IAU Working Group on “Nomenclature for Fundamental Astronomy”

(A mention to the RCMAM WG should be added here)



## RECOGNISING

- (1) that the BCRS definition does not determine the orientation of the spatial coordinates,
- (2) that the natural choice of orientation for typical applications is that of the ICRS,
- (3) that the GCRS is defined such that its spatial coordinates are kinematically non-rotating with respect to those of the BCRS,

## RECOMMENDS

that the BCRS definition is completed with the following: “For all practical applications, unless otherwise stated, the BCRS is assumed to be oriented according to the ICRS axes. The orientation of the GCRS is defined by the ICRS-oriented BCRS.”