NUTATION

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INTRODUCTION OF JD 19: NUTATION

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Due to both precise time measurements and precise geodetic positioning methods (like Very Long Baseline Interferometry (VLBI), Lunar Laser Ranging (LLR), Satellite Laser Ranging (SLR) and Global Positioning System (GPS)), the position of the instantaneous axis of the Earth's rotation in space is measured with a precision better than a tenth of milliarcsecond. Simultaneously the amplitudes of the nutations of the Celestial Ephemeris Pole (CEP) deduced from the observations, i.e. the periodic motions in space of the CEP due to the luni-solar attraction or to other planetary attractions, have also been improved. However, these observed nutation amplitudes differ with respect to the computated ones based on an elliptical, uniformly rotating and deformable Earth responding to the lunar and solar attractions, as adopted by the IAU in 1980. The first session on "Observations and data reduction" dealt with Earth's orientation observations and data analysis for deriving precession and nutations, as well as the associated residuals with respect to the adopted precession constant and nutation series. Comparisons between the different results have been presented including in-phase and out-of-phase components of the prograde and retrograde nutations or of nutations in longitude and in obliquity (see Session 1 of our JD: Newhall et al., McCarthy and Luzum, Herring, and Session2: Gross). These differences "observed – adopted" nutations achieve several milliarcseconds and exhibit periodic as well as secular characteristics.

Definition of the CEP and transformation of CRS (Celestial Reference Frame) to TRS (Terrestrial Reference Frame) have been discussed. They can be improved by considering new better estimations of nutations. In Session 2 the reference frame systems and link between them, via nutation amplitude determination, have been addressed (Capitaine). Rigid Earth nutations are used in a convolution with normalized elastic nutations in order to obtain theoretical nutation amplitudes of a non-rigid Earth. Recently a more precise nutation theory of the rigid Earth, as presented in Session 2

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(Souchay and Kinoshita), has been developed. The nutation amplitudes for a deformable Earth will thus change accordingly.

At the present level of precision it becomes possible to better constrain the internal structure of the Earth mainly responsible for the remaining residuals. Moreover, changes in the coupling mechanisms involved at the interfaces between the different parts of the Earth and changes in the Earth's structure used to compute the theoretical nutations can also induce changes in the periods of the Earth's normal modes which, in turn, induce resonance effects on nutations. In particular, the observed and theoretical values of the Free Core Nutation (FCN, retrograde) and of the Free Inner Core Nutation (FICN, prograde) have been discussed in Session 1 (Herring) and 3 (Mathews and Dehant).

The atmosphere and the oceans play an additional important role in the nutation determination (see Session 2: Gross, and Session 3: Eubanks and Dehant). The magnitude of these contributions must still be improved; in particular, as presented in Session 3, concerning the atmosphere, there is a need to reconcile the torque approach (pressure and wind torque on an ellipsoidal Earth with inverted or non-inverted barometric oceans and with mountains) and the Atmospheric Angular Momentum (AAM) approach. New models can be proposed for better estimation of the loading and attraction effects on nutations. Concerning the ocean contributions, two parts can be considered: (1) the height contribution (loading and attraction of the oceans at the different tidal frequencies), and (2) the current contribution which is usually not yet corrected for.

Fourteen years after adoption of the IAU Nutation Theory many theoretical and observational aspects of nutation as well as the new nutation model have been rediscussed by invited speakers. During the panel discussion (Session 4), we examined the situation in light of the invited talks as well as of the posters. Two recommendations have been worked out as explained in the last paper of Session 3 (McCarthy and Dehant).

Supporting Commission: 19

Co-supporting Commission: 4, 7, 24, 31

Members of the Scientific Organising Committee (SOC):

N. Capitaine (France), J. Chapront (France), V. Dehant (Belgium, convenor), J. Dickey (US), T. Fukushima (Japan), T. Herring (US), H. Kinoshita (Japan), B. Kolaczek (Poland, President of Commission 19), D. McCarthy (US), E. Proverbio (Italy), T. Sasao (Japan), J. M. Wahr (US), Jin Weinjing (Shanghai), Y. Yatskiv (Ukraina).

The four sessions of the JD have been devoted to the following topics:

1. Observations and data reduction.
   - "Determination of precession and nutation from Lunar Laser Ranging analysis."
     J. Dickey (US), J.G. Williams (US) and X.X. Newhall (US)
   - "An analysis of precise observations of precession and nutation."
     D.D. McCarthy (US) and B.J. Luzum (US)
   - "A priori model for the reduction of the nutation observations."
     T. Herring (US)
2. Nutation, precession, and reference frames.
   - "Nutation and reference frame."
     N. Capitaine (France)
   - "Observations of the celestial ephemeris pole."
     R. Gross (US)
   - "Recent results of the nutation theory for a rigid Earth."
     J. Souchay (France) and H. Kinoshita (Japan)
3. Geophysical model of nutation; atmospheric pressure effects on nutation; preparation of the panel discussion.
   - "Current status of geophysical model for nutation."
     P.M. Mathews (US) and V. Dehant (Belgium)
   - "Atmospheric forcing of nutations."
     T.M. Eubanks (US) and V. Dehant (Belgium)
   - The IAU Nutation theory and perspectives of its change.
     D.D. McCarthy (US) and V. Dehant (Belgium)
4. Poster presentation and panel discussion.

List of the posters

- COMPARISON OF THE DIFFERENT SYSTEMS OF TIME CORRECTIONS ΔT.
E.Y. Aleshkina (Institute of Applied Astronomy, Russian Academy of Science, Zhdanov street 8, 197042 St.-Petersburg, Russia)
- RELATIONSHIPS BETWEEN THE EXTRAGALACTIC CELESTIAL REFERENCE SYSTEM ANS THE PRECESSION- NUTATION THEORY.

E.F. Arias (Central Bureau of IERS, France, Observatorio Naval Buenos Aires y Observatorio de la Plata, Argentina)

- ATMOSPHERIC EXCITATION OF NUTATION ESTIMATED FROM THE 4-TIMES DAILY EFFECTIVE ANGULAR MOMENTUM DATA.

A. Brzezinski (Space Research Centre, Polish Academy of Sciences, Bartycka 18A, 00-716 Warsaw, Poland)

- THE FCN PARAMETERS DETERMINED FROM THE MAXIMUM ENTROPY SPECTRAL ANALYSIS OF THE VLBI NUTATION DATA.

A. Brzezinski (Space Research Centre, Polish Academy of Sciences, Bartycka 18A, 00-716 Warsaw, Poland)
E. Groten (Institute of Physical Geodesy, Technical University Darmstadt, Petersenstr. 13, D-64287 Darmstadt, Germany)

- ON THE LUNI-SOLAR PRECESSION CONSTANT.

V. Dehant (Observatoire Royal de Belgique, 3, avenue circulaire, B-1180 Brussels, Belgium)
N. Capitaine (Observatoire de Paris, 61, avenue de l'Observatoire, F-75014 Paris, France)

- ATMOSPHERIC PRESSURE EFFECT ON PRECESSION.

V. Dehant (Observatoire Royal de Belgique, 3, avenue circulaire, B-1180 Brussels, Belgium)
Ch. Bizouard (Observatoire de Paris, 61, avenue de l'Observatoire, F-75014 Paris, France)
J. Hinderer, H. Legros, M. Lefftz (Institut de Physique du Globe de Strasbourg, 5, rue Rene Descartes, F-67084 Strasbourg, France)

- WHY IS THERE POSSIBLY ENERGY NEAR THE FCN AND THE FICN?

V. Dehant, K. Degryse, F. Roosbeek (Observatoire Royal de Belgique, 3, avenue circulaire, B-1180 Brussels, Belgium)
J. Souchay, Observatoire de Paris, 61, avenue de l'Observatoire, F-75014 Paris, France)

- VARIABILITIES ON EARTH'S ROTATION INDUCED BY EL-NINO AND LA NINA EVENTS.

M.A. El-Shahawy (University of Cairo-GIZA, Egypt)

- ALTERNATIVE CONCEPT OF PARAMETERIZATION OF THE EARTH'S ORIENTATION TESTED IN GEODETIC VLBI DATA ANALYSIS.

R. Haas (Geodetic Institute of the University of Bonn, Nuβallee, 17, D-53115 Bonn, Germany)

- THE NUTATION OF THE RIGID EARTH FROM TIDAL DEVELOPMENTS.

T. Hartmann (Lehrstuhl f. Theoret. Astrophysik der Univ. Tuebingen, Auf der Morgenstelle, 10, CD 7400 Tuebingen, Germany)

- TIME VARIABLE SPECTRA OF THE SHORT PERIODIC NUTATION CORRECTIONS OBTAINED BY THE LVBI TECHNIQUE.

B. Kolaczek, W. Kosek (Space Research Centre, Polish Academy of Sciences, ul. Bartycka 18A, 00716 Warsaw, Poland)

- CORRECTION TO PRECESSION DERIVED FROM CATALOG COMPARISONS.

C. Ma (Goddard Space Flight Center, Code 921, Greenbelt, Maryland 20771, USA)
H. Walter (Astronomisches Rechen-Institut, Monchhofstr. 12-14, D-69120 Heidelberg, Germany)

- ONCE MORE ON THE CHANDLER WOBBLE OF POLAR MOTION.

L.V. Rykhlova (Institute of Astronomy (INASAN), Russian Academy of Sciences, Moscow, Russia),
G.S. Kurbasova (Simeiz Department of Astrophysical Observatory, Crimea, Ukraina)

- RIGID EARTH NUTATION FROM A TIDAL GENERATING POTENTIAL.

F. Roosbeek, V. Dehant (Observatoire Royal de Belgique, 3, avenue circulaire, B-1180 Brussels, Belgium)

- COMPACT CHEBYSHEV POLYNOMIAL REPRESENTATION OF NEW NUTATION THEORIES.

A. A. Trubitsina (Russia)

- THE EARTH'S POLAR MOTION AS AN INDICATOR OF THE DYNAMICAL STATE OF THE SOLAR SYSTEM.

G.J. Vasileva, V.A. Kuzmina (The Main astronomical observatory RAN, Pulkovo, St.-Petersburg)

- DETERMINATION OF THE CELESTIAL POLE OFFSET BY OPTICAL ASTROMETRY.

J. Vondrak, C. Ron (Astronomical Institute, Bocni II, 14131 Prague 4, Czech Republic)

- ESTIMATION OF EARTH ORIENTATION PARAMETERS USING THE GLOBAL POSITIONING SYSTEM (GPS).

R. Weber, G. Beutler, E. Brockmann, M. Rothacher (Astronomical Institute, University of Bern, Switzerland)

- SOME ASPECTS OF DIRECT DETERMINATION OF THE FCN.

Y. Yatskiv (Main Astronomical Observatory, Academy of Sciences, Kiev 127, Ukraina)