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DIVISION I: FUNDAMENTAL ASTRONOMY
(ASTRONOMIE FONDAMENTALE)

Commission 4: Ephemerides
Commission 7: Celestial Mechanics and Dynamical Astronomy
Commission 8: Positional Astronomy
Commission 19: Rotation of the Earth
Commission 24: Photographic Astronomy
Commission 31: Time

1. INTRODUCTION

The last three years have been marked by changes, highlights and progress. Organizationally, commission 7 has joined Division I and plans proceed for commissions 8 and 24 to merge in 2000. They have had a common vice president during this triennium. Sadly, the Royal Greenwich Observatory was closed after over 200 years, but Her Majesty's Nautical Almanac Office has continued at Rutherford Appleton Laboratory. In St Petersburg, Russia, the Institute of Theoretical Astronomy was abolished, with some of the personnel relocated to the Institute of Applied Astronomy and Pulkova Observatory. In Paris, France, the Bureau des Longitudes was reorganized as the Institute of Celestial Mechanics–Bureau des Longitudes as part of the Paris Observatory.

The Division has supported three colloquia: 172: "Impact of Modern Dynamics in Astronomy" in Namur, Belgium, 173: "Evolution and Source Regions of Asteroids and Comets" in Tatranska Lomnica, Slovak Republic, and 178: "Polar Motion: Historical and Scientific Problems" in Cagliari, Italy.

The following working groups with designated chairmen were established for the triennium: International Celestial Reference System chaired by Francois Mignard, General Relativity for Space-time Reference Systems and Metrology chaired by Gérard Petit, Relativity for Celestial Mechanics and Astrometry chaired by Michael Soffel, Astronomical Standards chaired by Toshio Fukushima, IUGG & IAU Working Group on Precession and Nutation chaired by Veronique Dehant, IAU/IUGG/COSPAR Working Group on Cartographic Coordinates and Rotational Elements of the Planets and Satellites chaired by Kenneth Seidelmann, Division III & I Working Group on Near Earth Objects chaired by David Morrison, and Comm 8 & 24 Working Group on AC and CdC Plates chaired by Alain Fresneau.

2. HIGHLIGHTS

Ephemerides (Commission 4). E.Myles Standish, Pres. Commission 4 has established a website (http://ssd.jpl.nasa.gov/iau-comm4/) which contains information about how to obtain different types of ephemerides, observational data to which ephemerides are adjusted, a list of membership, and reports of Commission activity. The Commission also notes the closing of the Royal Greenwich Observatory. Details may be found in the Commission Report.

Celestial Mechanics (commission 7). Claude Froeschle, Pres. Research in Celestial Mechanics, for the past three years, has mainly focused on the understanding of Chaos in all its aspects. The always larger number of potential applications (meteors, KBO, NEA, asteroids of the main belt, but also exoplanets or galactic motions) and the development of new efficient tools, like the symplectic integrators, have allowed the passage from qualitative models (for example the transfer mechanisms) to real quantitative results (like the calculation of lifetimes). This important step has contributed to (re)create collaborations between theoreticians and observers (for example, in the prediction of catastrophic impacts) and to situate the Celestial Mechanics in a wider scientific context.

Astrometry (Commissions 8 and 24) Heiner Schwan and Elena Schilbach, Pres. The Hipparcos and Tycho star catalogs were released, setting new standards for astrometric accuracy. First highly precise observations yielding the determination of close binary orbits were made with the Navy Prototype Optical Interferometer near Flagstaff. The combination of the Hipparcos and Tycho data with old AC observations allowed to produce the catalogues (ACT, TRC) with one million accurate proper motions. From digitized Schmidt plate surveys stellar positions in the ICRF were obtained for about half a billion stars (USNO-A2.0 Catalogue). Feasibility studies were carried out for future space projects (GAIA, SIM, FAME, DIVA) which will allow astrometric measurements of many millions of stars at sub-milliarcsecond level.

Rotation of the Earth (Commission 19). Dennis McCarthy, Pres. The IERS was reorganized. The GPS data have come to dominate the determination of polar motion and make significant contributions to the determination of UT1. We see high-frequency polar motion (diurnal/sub-diurnal) causing us to reconsider the definition of the celestial ephemeris pole. Earth orientation is now determining the celestial reference system. The quality of observations continues to improve. There has been progress in the non-rigid Earth nutation models.

3. WORKING GROUPS

Report of the ICRS Working Group. F. Mignard, Chairman. The Working Group on the International Celestial Reference System (ICRS) was established during the IAU General Assembly held in Kyoto in 1997 with the goal of coordinating the work of astronomers to qualify, use, extend and promote the ICRF. The WGICRS comprises 36 members of whom 16 are from the US and 7 from France. The WG is organized around six well identified tasks directed by a task leader, and each member of the WG has expressed personal interest in at least one of these tasks.

T_1 Maintenance and extension of the ICRS C. Ma
T_2 Densification in optics S. Urban
T_3 Ties with previous and new catalogues F. Mignard
T_4 Link to the dynamical system M. Standish
T_5 Computational consequences N. Capitaine
T_6 Relation with IERS F. Arias

During the last two years significant work has been done in each of the six tasks. Several websites have been developed to facilitate information exchanges, accessible through the WG main site: http://wwwrc.obs-azur.fr/cerga/mignard/WG_IAU/wg_home.html.

A letter was published in A&A about the adoption of the ICRS in order to inform the astronomical community of the breakthrough, to show the conceptual difference with the usual dynamical-equatorial system, and to stress the practical consequences for the general users.

The subgroup on maintenance and extension of the ICRF had extensive discussions on the conceptual basis for the extension to define a procedure for periodically updating the catalog. A first extension of the conventional frame has been produced and published in the IERS Annual Report for 1998. It includes observations carried out since July 1995 and refines the position of candidate sources, adding 600,000 observations to the solution. Also

59 new sources appear for the first time in the extension. The new frame is constrained to have no-net-rotation with respect to the ICRS.

Regarding the densification in optics, there are numerous observational projects going on virtually everywhere: USNO UCAC, the 2MASS and DENIS projects, the Tycho-2 Catalogue close to completion, work at the Shanghai Astronomical Observatory, the Yale Southern Proper Motions project.

The dynamical reference frame is represented by the ephemerides of the planets, Moon and Sun. The solar system ephemeris at JPL and Bureau des Longitudes are now adjusted onto the International Celestial Reference Frame (ICRF). A major effort is being undertaken to tie the inner planets directly to the ICRF via VLBI observations of spacecrafts (Magellan, Phobos) and with the lunar laser ranging through its connection with the Earth rotation. The positions of ICRS pole and equinox relative to their dynamical definitions have been monitored and the results published in the issues of the IERS Annual Report, as well as the parameters of transformation from/to the terrestrial system. The orientation is believed to be accurate at the 1 milliarcsecond (mas) level.

The relationship between FK5 and other catalogues, supposed to be in the FK5 system, with the ICRS has been investigated in detail with results published in the Astronomical Journal or Astronomy and Astrophysics. A convenient transformation between the two systems, including the zonal differences, has also been provided.

The computational consequences of the adoption of the ICRS appear essentially in the relationship between ICRS and International Terrestrial Reference Frame (ITRF) and involves a significant theoretical effort in order to redefine the Celestial Ephemeris Pole (CEP). A full session of the Journées 1998 "Systemes de reference spatio-temporels" held in Paris was devoted to this topic which was again taken up during the Journées 1999 in Dresden. The proceedings of the Journées 1998 include the presentations and much of the ensuing discussions.

Report of BIPM/IAU Joint Committee on relativity for space-time reference systems and metrology. Gérard Petit, chairman. At the Kyoto General Assembly, the IAU endorsed, by its Resolution B3 (1997), the creation of the Joint Committee on Relativity for space-time reference systems and metrology (JCR). It followed a proposal by the BIPM recognizing that metrology could not be separated from the definition and realization of space-time reference systems, when studying the consequences of the increasing accuracy in the realization of the SI units, and particularly of the SI second. The web site of the JCR (www.bipm.fr/WG/CCTF/JCR) is updated with each Circular and contains the headlines of the JCR work.

After the membership was established (Autumn 1997), the first task was to specify the goals and the sharing of work in the collaboration between the JCR and the WG on Relativity in Celestial Mechanics and Astrometry (RCMA). The first two Circulars of the JCR were devoted to that task. A common document was established with the RCMA: a "List of issues" (document jcrissue.html on the JCR web site) discussing as much as possible all topics that may be addressed by the two Working bodies. The discussions that took place in the JCR (as of Summer 1999) are summarized in the Circulars 3 to 5. From them, we may draw some conclusions that should be discussed to eventually become resolutions submitted to the IAU. These are: Provide, in order to remove ambiguities in the IAU(1991) formalism, clear definitions for LB and LC based on differential formulas. In addition, provide in retrospect a good definition for TDB by choosing a specific value for LB. Recommend NOT to use these constants for coordinate transformations when utmost accuracy is needed. Specify an extended conventional metric for the barycentric system in the formalism of General Relativity without parameterization and the associated formula for transformation between coordinate time TCB-TCG. Several options may be discussed for the gauge condition, with the harmonic gauge possibly being the best choice. The conditions of application should be specified (0.2 ps in time, 5x10-18 in rate, spatial domain of validity). Turn a specific value of LG into a defining constant for TT, instead of using

the geoid. Choosing for $LG = W_0/c^2$ the same value of W_0 as a defining constant for a new Geodetic Reference System, would provide a homogeneous and consistent set of conventions, and a relativistic definition of the geoid.

Report of the WG on Non-rigid Earth Nutation Theory. Veronique Dehant, Chairman. The WG on 'Non-rigid Earth Nutation Theory' was created 6 years ago and is at the end of its term. We present here the report of the activities of this WG. We have worked and discussed particular points of interest for the nutations of a non-rigid Earth. We have worked on 6 levels: (1) seismic models used, (2) Earth's transfer function, (3) nutations for a rigid Earth, (4) convolution between the Earth's transfer function and the nutations for a rigid Earth, (5) atmospheric and oceanic effects on nutations, and (6) comparison of the theoretical nutations with the observations.

One of the main conclusions from the comparison with the observations is that interchange of three existing rigid Earth nutation series (SMART97 of Bretagnon et al. 1998, Astron. Astrophys. 329 pp 329-338; REN2000 of Souchay and Kinoshita 1997, Astron. Astrophys. 312 pp 1017-1030; and RDAN97 of Roosbeek and Dehant 1998, Celest. Mech. Dynamical Astron. 70 pp 215-253) does not change the residuals of the non-rigid Earth nutation series at an observational level. On the other hand, the choice of the transfer function is found to be fundamental in the sense that observable differences still exist between these functions. It is believed that the transfer function provided by Mathews et al. (1999, in preparation) is a good compromise between a complete theoretical numerical integration incorporating all the effects which influence the nutation at the tenths of mas level (such as Dehant and Defraigne, 1997, J. Geophys. Res., 102, pp. 27,659-27,688, if modeling of dissipation at the CMB were included), and a model fit to the observations (such as the one provided by Herring for the IERS Conventions 1996). Indeed, while Mathews et al's model is based on a fit to the observations, the parameterization is chosen to have a physical meaning. Important efforts are still needed in the computation of the oceanic and atmospheric effects on nutations. In particular, the models used for the atmosphere and the associated indirect effects of the oceans are still not perfect. Because there are important differences in the diurnal atmospheric forcing derived from different sets of data, large efforts are thus still needed in this area.

Report of the WG on Relativity in Celestial Mechanics and Astrometry. Michael Soffel, Chairman. We have continuously worked on a (living) RCMA document that eventually should contain all relevant formulas and relativity models in fully explicit form plus explanations and reasons for fixing certain degrees of freedom. Meanwhile proposals for IAU recommendations concerning relativity in the problem of astronomical reference frames have been formulated. They concern: 1. the general form of the metric tensor in the barycentric and geocentric reference systems and the gauge of spatial variables, 2. the gauge of the time variables, 3. the split of the geocentric metric potentials into an inertial-, a tidal- and a self-part, 4. the choice of post-Newtonian potential coefficients and 5. the transformation between barycentric and geocentric coordinates. These proposals will now be discussed among WG/JC members and presented at the conferences in Dresden (Les Journées 1999 & IX Lohrmann Kolloquim) and Washington (IAU Coll. 180). All activities of the WG can be followed on its WEB site: http://rcswww.urz.tu-dresden.de/~clohrmobs/iauwg.html

4. WEB SITE

The Division has maintained a web site with links to the IAU, commissions, working groups, and meeting web sites. The location of the Division Web site has been http://aries.usno.navy.mil/ad/iau.html.

P. Kenneth Seidelmann
President of the Division

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