2005 French Ephemerides: Implementation of new Constants and Theories

Fienga, A., Arlot, J.-E., Berthier, J., Hestroffer, D.,
Lainey, V., Simon, J.-L., Vachier, F., Vaubaillon, J.

Institut de mécanique céleste et de calculs des éphémérides - Observatoire de Paris

Abstract: With the implementation of the new IAU resolutions, the IMCCE wants also to regenerate its ephemerides. Since 1984, no major modification was made in the IMCCE-BDL publications. The IAU recommandations for implementing the XXIVth General Assembly resolutions are then a good opportunity. In this poster, the major modifications expected to be made in the 2005 Connaissance des Temps and in the other 2005 publications of the IMCCE-BDL are presented: new planetary ephemerides, new satellite ephemerides, original ephemerides of meteor showers and of course implementations of the new IAU resolutions.

1 Introduction

The IMCCE-BDL produces ephemerides of planets, satellites, comets and asteroids, available via the Internet (`http://www.bdl.fr`), via the Minitel (3615 bdl) or via classic publications (Connaissance des Temps, Annuaire du Bureau des longitudes), via the Internet (`http://www.bdl.fr`) or via the Minitel (3615 bdl). Since 1984 and the implementation of the VSOP82 solution of planetary motions, no major modification or implementation was done in the IMCCE-BDL ephemerides. However, because of the IAU recommandations for implementing the XXIVth General Assembly resolutions and also because of the constant improvement of the techniques of observations and the correlated need of accuracy of the professional users of our ephemerides, it appears that a complete modification of the theories and the constants used for the publications was needed. After a quick presentation of the new IAU recommandations, we present the new original theories and the new services (meteor shower forecasting), set up at the IMCCE.

2 Implementing the IAU resolutions in the IMCCE ephemerides

The IAU 2000 has adopted several resolutions, some of which involving important changes in the ephemerides: coordinates and metrics of the (BCRS) and (GCRS), relation between TCB and TCG and new definition of TT, precession-nutation model IAU 2000, new concepts such as the Celestial Intermediate Pole (CIP), the Celestial Ephemeris Origin (CEO) etc.. The impact of the IAU resolutions on the IMCCE ephemerides will be the following. Positions will be given in the ICRF, following IAU 2000 resolution, with associated transformations for the precession and nutation. Therefore, the precession-nutation model IAU 2000A will be introduced in the Web server of the IMCCE and in the Connaissance des Temps and the other ephemerides of the IMCCE beginning with the editions for 2005. The masses of the IERS92 system will be used. The

time used in the theories of the celestial bodies build at the IMCCE will be TCB. Beginning with the edition 2005, the time argument of the ephemerides of the Connaissance des Temps will be TAI. The coordinates of the CIP and the parameters linked to the CEO will be computed on the Web server. For the physical ephemerides, the new rotational elements for the planets and satellites issued of Seidelmann et al. (2002) will be used.

3 New Ephemerides of Planets, Satellites and Meteors

The new planetary solution is an analytical solution of the motion of the planets of the solar system, including Pluto, fitted to observations. The time scale is TCB and the main characteristics of the model (Moisson et Bretagnon, 2001) include a relativistic model (Brumberg, 1991), mutual planetary and lunar perturbations, IERS 1992 planet masses and asteroid perturbations (a few hundreds). No solar flattening is included. The modeling of the perturbations induced by the main belt asteroids on the Mars orbit is a complex problem (several kilometers uncertainties over a decade). Different models will be investigated. The mean internal accuracy of our analytical solution is about 7 km (0.01 for Mercury, 0.60 for Mars and 23 km for Neptune), the external precision would be about 40 mas (4 for Mercury, 2 for Mars and 100 mas for Neptune). Thanks to VLBI spacecraft tracking observations, the planetary solution is directly linked to ICRF and for optical observations, IAU recommandations (precession-nutation IAU 2000A) will be applied.

For Saturn satellites, a new dynamical model, named TASS, of the main Saturnian satellites has been developed (Duriez & Vienne 1997). For the first time, this analytical model, fitted on more than 50000 astrometric observations over 110 years, deals with the complete dynamical problem of the motion of the eight major satellites, including the oblateness of Saturn and the solar perturbations. The main interest of this theory is its ability to remain accurate on long intervals of time. Programs are already available on the bdl ftp server. The internal accuracy is below ten kilometers and thanks to recent comparisons with CCD astrometric observations, the external accuracy has been estimated to 40 mas. We intend to introduce this model in Connaissance des Temps for 2005.

Using a model taking into account new effects such as satellites' oblateness (Lainey et al. 2001) coupled with techniques like frequency analysis and classical analytical development, we develop a new semi-analytical theory of the Galilean satellites motion, inlcuding mainly the satellites and Jupiter oblateness and the solar perturbations. We expect to obtain an internal precision of about ten kilometers. Original IMCCE ephemerides of JV Amalthea, JXIV Thebe, JXV Adrastea and JXVI Metis are under development. The dynamical model is based on an eleven-bodies problem, numerically integrated, disturbed by the oblateness of the primary and relativistic effects. Fit to observations is performed using a 20-year set of optical, spatial and IR observations. The standard deviation in the O-C of the satellites positions is approximately 200 mas. With more accurate observations and improved stellar catalogs, it should be possible to reduce them to 50 mas. The IMCCE original ephemerides of the JVI to JXIII and JXVII are modelized as described in (Rocher et Chapront, 1996). The ephemerides are fitted to observations. Extension of the observation sets and creation of ephemerides for new discovered objects are the future evolution of the outer satellite IMCCE service.

Concerning Neptune satellites, we are going to put on the web server the ephemerides of Triton, Nereid and Proteus (Le Guyader, 1993). These ephemerides are numerical integration of their motion from 1800 to 2050.

The new Meteor shower forecasting service of the IMCEE publications is dedicated to professional and non-professional users. We are now able to give the

ephemerides of time of the maximum, and of the level of the storm of the showers, such as Leonids. We take into account the path of the parent body close to the sun, the population of dust grains ejected, the ejection process, the orbit of each particle (radiation pressure, Poynting-Robertson drag, and eventually seasonal Yarkovsky force), the encounter with the Earth at the right epoch, the profile encountered, and some statistical consideration to extrapolate the real level of the shower.

References

Brumberg, V.: 1991, Essential Relativistic Celestial Mechanics. IOP Publishing LTD.

Moisson, X, Bretagnon, P.: 2001, Celes. Mech. Dyn. Astr., 80, 205.

Duriez, L. , Vienne, A.,: 1997, A&A, 324, 366.

Lainey, V., Vienne, A., Duriez, L. : 2001, Celes. Mech. Dyn. Astr., 81, 115.

Le Guyader, Cl.: 1993, A&A, 272, 687.

Rocher, P., Chapront, J.: 1996, Celes. Mech. Dyn. Astr., 311, 710.

Seidelmann, P.K., Abalakin, V.K., Bursa, M., Davies, M.E., de Bergh, C., Lieske, J.H., Oberst, J., Simon, J.-L., Standish, E.M., Stooke, P., Thomas, P.C.: 2002, Celes. Mech. Dyn. Astr., 82, 83.