COMMISSION 4: EPHEMERIDES

President: E. Myles Standish Jr., Secretary C.Y. Hohenkerk

Commission 4 held one business meeting, August 9, 2000.

Officers, 2000–2003 : President: Jean Chapront; Vice-President: George A Krasinsky.

Organizing Committee

V K Abalakin	J-E Arlot	J Chapront	T Fukushima	C Y Hohenkerk
J H Lieske	G H Kaplan	H Kinoshita	G A Krasinsky	He Miao-Fu
H Schwan	P K Seidelmann	E M Standish		

New Members

John A Bangert, US Naval Observatory
Fu Yanning, Purple Mountain Observatory
Teodoro Lopez Moratalla, Real Inst y Obs de la Armada
Elena Pitjeva, Institute of Applied Astronomy

The Division I Chairs, P.K. Seidelmann (outgoing) and N. Capitaine (incoming) were welcomed. Apologies were received from Krasinsky, Schwan, and Moratalla.

Commission Website Standish commented that during his presidency, he saw that the job of the Commission was to create ephemerides and make them available to the astronomical community and to the general public. Thus, a website (http://ssd.jpl.nasa.gov/iau-comm4) has been established, listing where to obtain various ephemerides, computer programs, and observational data, as well as related papers, meetings of interest, membership information, and links to related sites. Members are encouraged to contribute to this website.

Reports from Various Institutions.

Astronomical Institute, Prague. Vondrak reported that the Czech Republic has been, independently, producing an Astronomy Year Book since 1981, consisting of about 100 pages with a diskette. It contains all the standard information for N50° E15° and is based on the VSOP82 ephemerides.

Bureau des Longitudes Arlot reported that since June 1998 the BdL had become part of the Institut de mécanique céleste et de calcul des éphémérdes. All of their printed publications continue. They still run MINTEL to answer the questions from the public through the phone network. There is a developing web service for calculating positions and physical ephemerides. A web interconnection to add solar system objects is in preparation. Data bases of natural planetary satellites, osculating elements for observable comets, and astrometric data of planets are being developed. The lattermost is managed with JPL. Most of the theoretical models, constants, and physical parameters are available via ftp. Other publications include *Introduction aux éphémérides*, *Les éclipses de Soleil* and *Le calendrier républician*. Ephemerides continue to be developed; in particular, developing VSOP2000 which includes general relativity, and fitting observations of natural satellites to dynamical models.

Astronomisches Rechen Institut Schwan, in a transmitted report, told that *Apparent Places of Fundamental Stars* (APFS) is now a small booklet with explanation and apparent places of 54 stars. The 2000 APFS booklet has been distributed with *Time-independent Auxiliary Tables*, information that does not change with time. The latter will not be re-distributed each year. The web address of the full edition is www.ari.uni-heidelberg.de/ariapfs. The main catalogue used is the Sixth Catalogue of Fundamental Stars, although the web also allows use of the Hipparcos catalogue. The web implementation also gives daily apparent places with and without inclusion of the short period nutation terms.

Jet Propulsion Laboratory Standish reported that planetary and lunar ephemeris work continues at JPL at a modest level. DE200 remains the standard ephemeris used in the world's almanacs; it covers the period, 1600-2169. DE405 and DE406 come from the same numerical integration which covered the interval, 3000 BC to 3000 AD. They represent JPL's most recent ephemeris. DE405 is represented with full precision polynomials and covers 1600-2200. DE406 covers the full integration period, 3000 BC to 3000 AD, but it is represented with less precise interpolating polynomials (maximum interpolating errors for DE406: 1 m for the moon; 25 m for the planets). These ephemerides are available on a CD-ROM obtainable from the publisher Willmann-Bell. The CD-ROM contains DE200, DE405, and DE406 in unix binary format, and DE200 and DE405 in ASCII format. Another CDROM, this one containing DE406 in ASCII format, is available (ems@smyles.jpl.nasa.gov).

JPL Solar System Dynamics Group maintains its own website, (http://ssd.jpl.nasa.gov); this includes the interactive ephemeris maker, "Horizons", which allows a user to create a custom-built ephemeris of any solar system body with a known orbit; the access is via www, telnet, or email.

US Naval Observatory Bangert reported that ephemeris activities at USNO are concentrated in the Astronomical Applications (AA) Department. Publication of *The Astronomical Almanac* (AsA), *The Nautical Almanac*, The (U.S.) *Air Almanac*, and *Astronomical Phenomena* continued as a joint activity between Her Majesty's Nautical Almanac Office (UK) and the U.S. Nautical Almanac Office. Revision of the AsA is in progress. Version 1.5 of the Multiyear Interactive Computer Almanac (MICA), covering years 1990-2005, was released in 1998. Version 2.0 of the Naval Observatory Vector Astrometry Subroutines (NOVAS), in both Fortran and C, was released in June 1999. USNO/AE98, a set of ephemerides for 15 large asteroids covering years 1800-2100, was released in June 1999. Determinations were made for the masses of 1 Ceres, 2 Pallas, and 4 Vesta. Newcomb, a new software system for generating modern fundamental ephemerides of major solar system bodies is under development. Further information on products and research, in addition to a variety of practical astronomical data, can be found on the AA Department web site (http://aa.usno.navy.mil/AA/).

National Astronomical Observatory, Japan Fukushima reported that their previous title was the Tokyo Observatory. They continue to produce the official Government Calendar, Almanacs and the Scientific Handbook. JPL's DE405 will not be used until the 2003 almanac which should be available in 2002. However, at present, the Hydrographic Department still produces the more detailed almanacs. There is effort for pubic outreach via a public relations centre and a world wide web site receiving about 40,000 hits a month.

Department of Fundamental Astronomy, Paris Observatory Chapront reported on the activities of the Lunar Analysis Centre (POLAC). Their general activities are the treatment and validation of LLR observations at CERGA and contributions to IERS/ILRS. Their main area of work is on Lunar theory and ephemerides and involves improvements of the orbital and rotational motion of the Moon and the fit to LLR observations. The improvements include the semi-analytical solution, ELP, with the new planetary perturbations on the Moon and librations, which complements the semi-analytical solution of M. Moons. Fitting to LLR observations gives improvements to all relevant parameters. The main results for the past 2 years include the positioning of the inertial mean ecliptic of J2000.0 with respect to (1) mean Celestial Ephemeris Pole, (2) the International Celestial Reference System, (3) JPL numerical integrations DE200, DE403, DE405, and (4) correction to the IAU precession constant. Other activities involve the improvement of planetary theories over 6000 years on the basis of DE406, and the development of compact Poisson series ephemerides of Pluto. Collaborations with the astronomical community include providing positions and velocities of the Earth, planetary tables valid over 2000 years, solar eclipses, etc.

International Lunar Occultation Centre, Tokyo Sengoku reported that the Hydrographic Department of Japan took over the International Lunar Occultation Centre (ILOC) from the Royal Greenwich Observatory in 1981 in response to the request of Commission IV of the IAU. Since 1981, 188,901 lunar occultation data have been reported to ILOC from 2343 stations, 8965 observers from 49 countries (as of 2000 June 28). Annually, about 10,000 lunar occultation data are reported from about 300 stations. Predictions of lunar occultations are mailed to about 300 observers every year. The reported data are analysed and sent back to the observers through the annual report of the ILOC, which is also available on line at (http://www.jhd.go.jp/cue/KOHO/iloc/obsrep/).

HM Nautical Almanac Office Bell reported that at the end of 1998, on the closure of the

Royal Greenwich Observatory, the Office moved to the Rutherford Appleton Laboratory under the supervision of P.T. Wallace. Staff numbers were reduced by one third, but current publication schedules were maintained and, in the case of *The Astronomical Almanac*, in collaboration with USNO, brought forward.

Four new publications have been produced including the *RGO Eclipse Guide*, *NavPac, Compact Data 2001-2005*, and *Planetary and Lunar Coordinates 2001-2020*. HMNAO operates on a purely commercial basis and has to survive, without government support, on the sales of its publications; principally, *The Nautical Almanac* and data services. A memorandum of understanding between HMNAO and USNO has been signed allowing increased co-operation between both Nautical Almanac Offices.

Institute of Applied Astronomy, St Petersburg Pitjeva reported on the planetary and lunar ephemerides, EPM2000, which has been produced by a simultaneous numerical integration of the equations of motion of the nine major planets, the Sun, the Moon, lunar physical librations and 300 asteroids from 1886 – 2006. They were fit to over 80,000 observations, including American and Russian radar observations of the inner planets obtained from 1961-1997, Mariner-9 tracking data, Viking-1 and -2 lander data, Pathfinder ranging and differenced range, and all radio observations of Jupiter and spacecraft at Jupiter.

The values of all relevant astronomical constants were obtained in the fitting process. The rms of the post-fit residuals of the radar observations are 1.4 km for Mercury, 0.7 km for Venus and Mars; they are 8 m for the Viking landers and 4 m for the Pathfinder lander.

In conjunction with EPM2000 a numerical theory of the motion of the Moon has been developed by Aleshkina, Krasinsky and Vasilyev by fitting a 30-year set of lunar laser ranging data.

Yagudina reported on behalf of Krasinsky, chief of the Laboratory for Ephemeris Astronomy (LAE). The LAE has been constructing planetary and lunar ephemerides by processing ranging observations to the planets, the Moon, and the Galilean satellites, including optical observations of the Galilean satellites made in the Hipparcos system (ephemerides of the satellites are modeled by a numerical integration). Some inconsistency of the VLBI-based positions of Jupiter with the optical data have been noticed. This is possibly due to the dynamical theories of Jupiter and its satellites, and therefore some refinements are needed. Thus an approximate method to account for the effect of the Galilean satellite system upon the motion of the barycenter of the Jupiter system has been developed.

These investigations are carried out using ERA, the ephemeris and dynamical astronomy package for any celestial body (both natural and artificial), the manual of which is presented.

Closing Remarks

The meeting ended with a vote of thanks to Standish, the outgoing President.