

COMMISSION 19: ROTATION OF THE EARTH
(ROTATION DE LA TERRE)

Report of Meetings, 14, 15, 16, and 20 August 1979

PRESIDENT: R. O. Vicente

SECRETARY: D. D. McCarthy

14 August 1979

After opening the meeting, the President asked for a few moments of silence in memory of the members of the Commission who died during the last three years. The Commission then heard reports on recent research. Wm. Markowitz presented a paper entitled "Independent Polar Motions, Optical and Doppler; Chandler Uncertainties". He reported that the true Chandler path, C, is indeterminate; hence it cannot be used to detect or predict earthquakes. The true free period is also indeterminate. Independent techniques, optical and Doppler, were used to separate real variations from observational. Differences in dynamical properties of forced and free oscillations were then used to separate random variations due to the annual motion, A, from those of C. Since 1892.8 the amplitude and phase of C have changed smoothly, and, what is puzzling, independently, the amplitude remained constant during three intervals which total 45 years. Models based on a strongly damped oscillator, beating of two free periods, impulsive torques, and excitation by earthquakes are not in accord with the observations. Chandler damping is weak; Q exceeds 200. Similar secular motions are shown by ILS, IPMS, and Doppler. A theoretical, 18.6-year, forced component, nearly a libration, due to ocean tides was found in ILS and IPMS. This explains in part the empirical 24-year libration. Long series of observations are needed to separate the effects.

O. Calame reported on recent determinations of Universal Time from the EROLD (Earth Rotation from Lunar Distances) campaign. Orroal Observatory has been reporting data obtained from laser ranging to the Moon since October, 1978. These have been combined with data obtained regularly from McDonald Observatory and the accuracy of the Universal Time determinations made from this combined set are of the order of ± 0.2 to ± 0.3 milliseconds for five to ten-day means.

J. Fanselow, in a paper entitled "Measurements of Earth Orientation Using Very Long Baseline Interferometry", discussed the development of this technique by the Jet Propulsion Laboratory using their Deep Space Network. Twenty-eight measurements of Earth orientation have been made between 1971 and 1978, and half of these show an accuracy better than ± 0.025 . He also summarized a catalog of 50 source positions developed in the course of this work.

P. E. G. Paquet read two papers written by D. Djurovic. The first, "Secular and Periodical Variations of UT2-TAI", presented the results from the author's study of Bureau International de l'Heure (BIH) data. Using residuals from a second-order polynomial fit to the UT2-TAI information, he found apparent periodic variations with periods of 7.4, 3.5, 2.3, 1.6, 1.0, and 0.5 years. The author stresses that these periods are not constant and that the variations are particularly large for the 2.3 and 1.6-year terms. In the second paper entitled "Variations of the Seasonal Inequalities and Irregular Fluctuations of UT2-TAI", Djurovic investigated to what extent the annual and semi-annual terms in the rotational speed of the Earth are constant, and determined the epochs and magnitudes of the largest fluctuations in UT2. He found significant deviations in the annual and semi-annual terms and that the formula for UT2-UT1 does not cor-

respond rigorously to the seasonal variation in the Earth's rotation. Significant non-random, non-periodic fluctuations in UT2-TAI were also found to exist.

S. K. Runcorn presented a paper, "Paleontological Determination of Lunar Tidal Friction in the Geological Past", in which he discussed the rotation of the Earth from a geophysicist's point of view. He related recent studies of the length of the day determined from Devonian coral fossils and nautiloid fossils to modern astronomical results. He has concluded that there may have been changes in the lunar tidal torque over geologic time, but that uncertainties in the data still permit the lunar tidal torque to be considered as a constant.

B. Guinot presented a report on the activity of the BIH in the determination of Earth rotation parameters using optical and Doppler data. He showed that there are presently non-uniformities in the data since fewer observations are being made on weekends and that this practice affects the results of the BIH. He also mentioned that the accuracy of both the astrometric and Doppler data appears to be deteriorating and that the new techniques might be used now, even with precisions that are somewhat worse than those which are expected to be achieved eventually. Guinot also reported on the recent adoption of the 1979 BIH System as a replacement for the 1968 system. He stated that systematic errors inherent in the adoption of the 1968 system are removed in the new system, and that, although extensive use was made of the Doppler data in the determination of the new system, purely astrometric data obtained in recent years show the same corrections to the 1968 system. Research activity at the BIH is continuing in the fields of the re-evaluation of the Earth rotation parameters since 1962, determination of polar coordinates and UT1 using artificial Earth satellites, use of EROLD data, and in the theory of the rotation of the Earth.

15 August 1979

R. O. Vicente opened a joint meeting of Commissions 19 and 31 (Time) with some introductory remarks concerning Project MERIT (Monitoring of Earth's Rotation and Intercomparison of Techniques). The President of Commission 19 stressed the need for communication between investigators using different techniques, and that the geophysical implications resulting from this project will be quite important for developing countries.

G. A. Wilkins, the Chairman of the Joint Working Group on the Determination of the Rotation of the Earth presented the report of the Group. He stated that the Group had been set up by the Presidents of Commissions 19 and 31 on the recommendation of IAU Symposium No. 82 (Time and the Earth's Rotation) which was held at Cadiz, Spain in May, 1978. The members of the Group were chosen to represent a wide range of interests and countries and are as follows: L. Aardoom, R. J. Anderle, W. E. Carter, B. Elsmore, M. Feissel, W. J. Klepczynski, Yu. L. Kokurin, Y. Kozai, W. G. Melbourne, F. Nouel, P. E. G. Paquet, E. C. Silverberg, D. E. Smith, G. Veiss, R. O. Vicente, G. A. Wilkins, Ya. S. Yatskiv, K. Yokoyama. The advice and assistance of several other persons has also been obtained.

The Group held its first meeting at Columbus, Ohio, on 5-6 October 1978 following the "GEOP" Conference. The meeting was attended by nine members and several other interested persons. The Group decided to prepare a proposal for a special period of international collaboration in order to Monitor the Earth's Rotation and Intercompare the Techniques of observation and analysis. An introduction to the project was widely circulated a few months ago. Forty copies of the "Draft Proposal for Project MERIT" were recently distributed by post. Unfortunately the 120 copies sent by air freight to Montreal were not available on 15 August, but they were distributed on 16 and 17 August.

The Group's proposal specifies two principal objectives for Project MERIT. The first objective is to provide a basis for recommendation on the future international services for Earth rotation; for this purpose the Group will intercompare the techniques, identify the requirements of users, and specify the standards to be met. The second objective is to obtain and analyze new, precise data on Earth rotation in order to improve our knowledge and understanding of this important phenomenon, which has many applications. A day-to-day knowledge of Earth rotation (i.e. the direction of the axis of rotation, or polar motion, and the orientation of the prime meridian, or Universal Time) is required for surface and air navigation, for land and geodetic surveying, for the navigation of spacecraft and for fundamental astrometry. In addition, it is required for research in the dynamics of the Earth-Moon system, for determining indirectly properties of the Earth's interior (such as density, elasticity, and viscosity), and for studying interactions between the core and mantle and the effects of earthquakes and winds. Although Project MERIT will last for only a limited period, it is hoped that the results obtained will be of both immediate and lasting value and will lead to the continuing provision of data that are more precise, more accurate, and more frequent than those currently available, bearing in mind that the services must be economical and not critically dependent on a single national organization.

The draft program envisages that the remainder of 1979 will be spent in completing the proposal, seeking support and starting the detailed planning. In the second half of 1980 there will be short campaigns of observation, reduction and analysis by all techniques with the principal aim of studying the arrangements that would be required to use the new techniques for a regular service. During 1981/2 the results of the short campaign will be reviewed, planning for the main campaign will be continued, and new equipment and software will be installed and commissioned. The main campaign will be held during 1983/4 and will last at least one year so that seasonal effects can be determined. The full analysis of the data and comparison of the results will require much additional effort, but it is expected that clear recommendations about the future services will be made in 1985.

In order that Project MERIT shall go ahead it is first of all necessary that the scientific Unions, especially the IAU and IUGG, make clear their support for its objectives and program. Then the Group will need to obtain international financial support for meetings and comparatively minor common expenses so that the work can be properly planned and coordinated. Then it will be necessary to confirm that national support for the observational work and for the reduction and analysis of the data will be obtained - already the Group has clear indications that support will be provided for such an international project. Finally the Group needs the active support of many individuals to take part in the organizational work of planning the project and reviewing the results, and so to ensure that the full benefits are gained from the observations obtained during the period of Project MERIT.

Following this report by Wilkins, D. Mulholland described the operation of the EROLD campaign. He explained that a two-phase operation was planned, the first phase being the operation of one station for the determination of Universal Time from lunar laser ranging data on a quasi-daily basis. This has been accomplished through the regular operation of the McDonald Observatory. The second phase calls for at least two stations to be operated with quasi-daily frequency. Although data is now available from Orroal since October, 1978, the frequency of the observations is not yet sufficient to begin the second phase. Observational data is now being contributed from the Crimean Astrophysical Observatory also.

R. J. Anderle reported on the possible use of the Doppler satellite technique for the determination of UT1. In an experiment involving the use of 110 days of data in 1977 a systematic error of about 6 milliseconds over a thirty-day period was found in the UT1 estimates derived from Doppler ranging to artificial satellites.

F. Nouel presented a paper entitled "MEDOC Experiment or Polar Motion from Satellite Doppler Tracking Network" in which he described the status of this campaign to determine polar coordinates using Doppler satellite techniques. This program is designed to determine polar coordinates by means of a civilian agency. Comparison of the MEDOC results with the DPMS (Doppler Polar Motion Service) results shows rather good agreement, with the MEDOC polar coordinates showing slightly more scatter due to the smaller number of reporting ground stations. Nouel suggested that in the future a replacement satellite solely for the determination of polar coordinates should be considered if the present navigational satellites are replaced by the Global Positioning System (GPS).

16 August 1979

A joint meeting with Commissions 4, 7, 8, and 31 was held. (See report of Commission 4.)

20 August 1979

In a business meeting, lists of new members and consultants were approved. S. Yumi announced his retirement from the International Latitude Observatory at Mizusawa, Japan, and K. Yokoyama was appointed to replace him as Director of the Central Bureau of the International Polar Motion Service (IPMS). In other business, the President reported that a letter was sent to the General Secretary requesting IAU sponsorship of the Second International Colloquium on Reference Coordinate Systems for Earth Dynamics to be held in Poland in September, 1980. A resolution in support of the astrometric work of Hipparcos was passed as was a resolution thanking S. Yumi for his work as Director of the IPMS.

In a scientific session following the business meeting, S. Yumi and K. Yokoyama presented reports on the work of the IPMS and the Working Group for Polar Coordinates. The Working Group has completed the task of re-reducing the past observations of the International Latitude Service (ILS) since 1899, and these data are now available on magnetic tape from the Central Bureau of the International Polar Motion Service at the International Latitude Observatory, Mizusawa-Shi, Iwate-Ken, 023 Japan. This information has already been sent to sixty addressees and the details of the computations are scheduled to be published soon. Yumi stressed that although the computational work was done mainly at the International Latitude Observatory of Mizusawa, many institutions and individuals cooperated in this work. Yokoyama reported that in the reduction of these data, a constant of $0''.087$ was added to the mean latitudes of all of the ILS stations. Such a change does not change the position of the Conventional International Origin (CIO), but it will be reflected in a change of the z-term. In discussion, Wm. Markowitz pointed out that the station latitudes used for the definition of the CIO were adopted for the standardization of the calculation of the polar coordinates and should not be considered as the astronomical mean latitudes of the stations.

In the report of the IPMS, it was mentioned that the results presently being obtained with the new observational techniques are being investigated for possible inclusion in the IPMS system at a future date. Currently the IPMS publishes polar coordinates determined only from the observational results of the ILS stations as well as polar coordinates determined from latitude observations of the stations reporting to the IPMS and a series which makes use of both time

and latitude observations. A precision of ± 0.15 for a monthly value of the polar coordinates is typical for the IPMS data. A new observing list for the ILS visual zenith telescopes to be used from 1980-92 was presented. Yumi reported that three stations of the ILS have now been equipped with photographic zenith tubes, and that the Ukiah station will receive a photographic zenith tube from the U. S. Naval Observatory. The 65-cm PZT of the U. S. Naval Observatory will take the place of the Gaithersburg visual zenith tube in the future. It was also mentioned that the IPMS has computed a series of UTL-TAI data from the reported astronomical data and that this information will be published in a forthcoming Publication of the International Latitude Observatory of Mizusawa. Reporting on the work of the Mizusawa Observatory, Dr. Yumi stated that, in addition to the regular observations with the visual zenith telescope, PZT, floating zenith telescope, Danjon astrolabe, and Doppler tracking of navigational satellites, work is also progressing on the use of the Tsubokawa automatic astrolabe. Future work in the area of laser ranging and VLBI is also being investigated.

V. Milovanovic presented a paper in which he discussed the possibility of further improvements to the newly re-reduced ILS polar coordinates. He pointed out that these data have not been corrected for differential temperature effects on the spirit levels. Milovanovic also suggested a method for determining the temperature gradient along the level, from the data, since temperatures along the level were not recorded at the time of the observations.

S. Debarbat reported on the measurement of Earth tide effects at Centre d' Etudes et de Recherches Geodynamiques et Astronomiques (CERGA). Geophysical measurements were made at different locations at the observatory and these appeared to be independent of the location.

P. Brosche discussed his research on the effect of ocean tides on the rotation of the Earth during geological times. Using models for the location and depth of the oceans at different periods in the Earth's history, he finds that the lunar tidal torque in the Cretaceous was about half of the present value. Brosche concludes that it is not possible to use just a simple power law to describe the effects of the lunar tidal torque on the rotation of the Earth in the past.

L. Randic presented a paper on the asymmetry in the determinations of polar coordinates from the observations in the northern and southern hemispheres. Comparing results from the BIH with those determined from observations at the Cape of Good Hope and Santiago, he showed that an apparent asymmetry in the polar path does exist.

S. H. Ye reported on the programs and instrumentation for the determination of Earth rotation parameters in the People's Republic of China. An astro-geodynamic project is in progress to measure geodynamic phenomena, maintain an accurate reference frame, and to detect geophysical motion. Observations are being made with three photo-electric transit instruments, three Danjon astrolabes, four photoelectric astrolabes, and one photographic zenith tube, and a number of visual zenith telescopes. A laser ranging network is being updated, and it is expected that ranging data from the LAGEOS satellite accurate to 20 cm will be available in one to three years. A VLBI network is planned to be completed in about five years.

RESOLUTIONS

Commission 19,

Noting with regret that Dr. Shigeru Yumi is resigning as Director of the Central Bureau of the International Polar Motion Service, at Mizusawa,

Thanks Dr. Yumi for his services in directing the work and the staff of the

Central Bureau for 18 years, during which time the IPMS polar motion was established with high accuracy and the ILS polar motion since 1899.9 was revised on a homogeneous basis, and for the prompt publication of results needed for astronomy, geodesy, and geophysics.

The above resolution was unanimously approved by the Commission. Other resolutions discussed and approved by the Commission are included in the reports of other Commissions and are published in this volume.

JOINT MEETING OF COMMISSIONS 19 AND 31 ON 15 AUGUST 1979
TO CONSIDER THE REPORT OF THE WORKING GROUP ON THE DETERMINATION
OF THE ROTATION OF THE EARTH

Summary of presentation by the Chairman of the Group (Dr. G.A. Wilkins)

The Chairman of the Joint Working Group on the Determination of the Rotation of the Earth stated that the Group had been set up by the Presidents of Commissions 19 and 31 on the recommendation of IAU Symposium No. 82 (on Time and the Earth's Rotation), which was held at Cadiz, Spain, in 1978 May. The members of the Group were chosen to represent a wide range of interests and countries and are as follows:

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Resolution adopted at the joint meeting of Commissions 4, 19 and 31 on 20 August 1979.

Commissions 4, 19 and 31

endorse the proposal of the joint working group on the determination of the rotation of the Earth for a special period of international collaboration in the monitoring of Earth-rotation and in the intercomparison of the techniques of observation and analysis,

recognize that the responsibility for the organization of this project MERIT should be shared with the International Union of Geodesy and Geophysics, and

request that the national and international organizations concerned give full technical and financial support to the development of the proposal and to the implementation of the project.