

**PART 3**

**REPORTS OF MEETINGS OF COMMISSIONS**



**COMPTES RENDUS DES SÉANCES DES COMMISSIONS**

## COMMISSION 4: EPHEMERIDES (EPHÉMÉRIDES)

### Report of Meetings 19, 20 and 25 August 1970

PRESIDENT: G. A. Wilkins.

SECRETARY: A. T. Sinclair.

The Commission held five meetings, of which the first and fourth were concerned with general matters. The second and third meetings on 20 August, were devoted solely to an open discussion of the resolutions adopted at IAU Colloquium No. 9 on the IAU system of astronomical constants; many members of other Commissions were present. The fifth meeting was held jointly with Commission 31 on time scales and its report appears with those for the meetings of Commission 31.

#### ORGANIZATIONAL MATTERS

It was agreed that the Officers and Organizing Committee for the period 1970–3 should be as follows: President, J. Kovalevsky; Vice-President, R. L. Duncombe; Organizing Committee, V. K. Abalakin, W. Fricke, A. M. Sinzi and G. A. Wilkins. Proposals for 17 new members and Consultants were accepted. It was agreed to remove from the list of members those persons who had not indicated in any way during the past three years their continued interest in the activities of the Commission. The final list of members is given on page 289.

The reports of the President and of the Directors of the national ephemeris offices, which had been previously circulated to all members of the Commission, were accepted; they are published in *Trans. IAU XIV*, 4–9, 1970. The President's suggestion that the Commission should keep under review the comparison between ephemerides and observations was unanimously agreed, although it was noted that Commission 17 had appointed a working group on the figure and motion of the Moon, and wished to resume its interest in the results obtained from observations of occultations by the Moon.

#### INFORMATION BUREAU ON ASTRONOMICAL EPHEMERIDES

The President reported that the proposal of the Working Group on Ephemerides for Space Research for the establishment of an International Information Bureau on Astronomical Ephemerides (see pp. 84, 85 for details) had been provisionally accepted by the Executive Committee of the Union. Further *J. Kovalevsky* had generously agreed to provide appropriate facilities at the Bureau des Longitudes in Paris, and to appoint B. Morando to manage its activities. On the proposal of *R. L. Duncombe* and *F. M. Sadler*, the Commission formally recommended that the Information Bureau should be established. It was then agreed that the Commission's representatives on the joint committee should be R. L. Duncombe and T. Lederle; the other representatives will be appointed by the Bureau des Longitudes and COSPAR Working Group I.

#### IAU WORKING GROUP ON NUMERICAL DATA

The President drew attention to the formation by the Executive Committee of the Union of a Working Group on Numerical Data in Astronomy and Astrophysics. At the open meeting held on 21 August he and T. Lederle had reported briefly on the experiences of Commission 4 in attempting to coordinate the exchange of astronomical ephemerides and positional catalogues. Others had discussed the difficulties of compiling catalogues of physical data and the possibilities of establishing comprehensive data centres which would provide facilities for information retrieval using computer techniques. There seemed to be general agreement to the view that priority should be given to the collection and dissemination of information about the availability of relevant data. The experience

gained in the establishment of the Information Bureau on Astronomical Ephemerides should provide useful guidance for similar activities in other fields. (See report on p. 79).

*M. Davis* reported on the proposals of Commission 7 to set up data and program banks in the field of celestial mechanics; at first the emphasis would be on the collection of general algorithms rather than of machine-dependent programs.

#### LUNAR-RANGING EXPERIMENTS AND DATA

*J. Kovalevsky* reported that, at its meeting in Leningrad in May 1970, COSPAR had set up a working party to encourage international cooperation in all aspects of lunar ranging experiments, including the prompt exchange of observational data. Commission 17 had adopted a resolution (see pp. 141, 142) suggesting that all interested Commissions of the IAU should be represented on the Working Party; its Chairman, C. O. Alley, said that such representation would be welcomed. It was agreed that Commission 4 would support the resolution and that *J. Kovalevsky* should represent the Commission.

#### BASIS OF STANDARD TIME SIGNALS

The President introduced a discussion on the proposals of CCIR for changing the basis of the standard-frequency and time-signal emissions by stating that correspondence with members of the Commission had indicated that the majority were agreeable to the emissions being based on the SI-second with step adjustments of exactly one second to maintain approximate agreement with universal time. *H. M. Smith* stated that a CCIR Working Party, of which he was Chairman, had the responsibility for recommending a suitable method for indicating the difference between the transmitted time-scale and universal time; he would welcome the views of Commission 4. *D. H. Sadler* stated that he was strongly opposed to the proposed system, and he considered that insufficient effort had been made to develop techniques appropriate to step adjustments of 0.1 s, which corresponded to the limit of human time-discrimination; he considered that the change would give rise to unnecessary difficulties for navigators and others who required immediately a knowledge of universal time to a precision of 0.1 s. After further general discussion it was agreed that the following resolution, which was proposed by *D. H. Sadler* and *R. L. Duncombe*, should be submitted to the General Assembly:

“The International Astronomical Union, *having noted* the various proposals to modify the present basis of Coordinated Universal Time (UTC) and *wishing to emphasize* that visual observers in astronomical and related fields require a knowledge of Universal Time (UT1) to a precision of the same order, namely 0.1 s, as that of human time discrimination, *formally requests* that the appropriate authorities ensure that adequate means have been provided for making UT1, or the difference UT1-UTC, available to such precision, *before* they permit UTC to depart from UT1 by more than about 0.1 s.”

It was also agreed that the attention of the General Secretary should be drawn to the fact that the Union has not yet been officially informed of the relevant recommendations adopted by CCIR at its twelfth Plenary Assembly in New Delhi in February 1970.

The further discussions on the CCIR proposals, on the supplementary recommendations of Commission 31, and on the methods for the dissemination of the corrections UT1-UTC are included in the report of the Joint Meeting of Commissions 4 and 31 on p. 198.

#### DEFINITION OF THE ASTRONOMICAL UNIT

The President stated that, at the request of the General Secretary of the Union, he had drawn up the following definition of the astronomical unit for transmission to the Bureau International des Poids et Mésures for inclusion in a booklet on the International System (SI) of Units;

“The astronomical unit of distance (UA) is the length of the radius of the unperturbed circular orbit of a body of negligible mass moving around the Sun with a sidereal angular velocity of 0.017202098950 radians per day of 86400 ephemeris seconds”

After discussion it was agreed that there should be a formally recognized definition of the astronomical unit but that alternative definitions should also be considered. There was no general agreement to a common symbol in all languages. *J. Kovalevsky* suggested that the unit should be named the ‘cassini’, while *V. A. Abalakin* suggested the ‘kepler’. *I. I. Shapiro* questioned the need for an independent system of astronomical units of mass, length and time. Finally, all these questions were referred to the Working Group on units and time-scales.

#### IAU SYSTEM OF ASTRONOMICAL CONSTANTS AND RELATED MATTERS

The President gave a brief account of the background to the resolutions that had been adopted at *IAU Colloquium* No. 9, which had been held at Heidelberg during the previous week. (It is hoped that the proceedings and papers will be published in a separate issue of *Celestial Mechanics* early in 1971). The resolutions were then discussed in turn.

“1. Considers that any changes in the precessional constants and in the system of planetary masses be introduced into the national and international almanacs together, at a time that is closely linked with the introduction of the next fundamental star catalogue.”

This is to avoid having two separate discontinuities in the basis of the planetary ephemerides and to ensure that the apparent places of the planets and of the fundamental stars are on the same system.

“2. Recommends that a Working Group be set up to report, in time for consideration in 1973, on the consequences of changes in the precessional constants and on the procedure for the introduction of new values at a later date. The Group should feel free to discuss actual values, if it wishes.”

Although many participants in the Colloquium had been doubtful about the desirability of attempting to adopt new values of the precessional constants in 1973, the final consensus of opinion had been that the Working Group should not be inhibited from recommending new values if the evidence were considered to be sufficiently strong. *J. Kovalevsky* emphasized the importance of investigating and publicizing the full consequences of any changes in the precessional constants before such changes were adopted. *K. C. Blackwell* considered that for those engaged on the determination of proper motions it would be preferable to leave the precessional constant unchanged.

“3. Considers that no changes be made in the series for nutation until a decision is made about the precessional constants, but considers that a new theory of nutation be developed, based upon a more realistic model of the Earth and consistent with recent developments of the tidal potential.”

*P. J. Melchior* drew attention to the possible derivation by a simple arithmetical process of a series for the nutation from a harmonic development (such as that by A. T. Doodson) of the tidal potential. Recent work on the tides took account of the nonrigid structure of the Earth and led to results that are in closer accord with observation than the adopted series for the nutation. A new and extensive development of the tidal potential by D. E. Cartwright would provide a suitable basis for the nutation.

“4. Recommends that no changes in the basis of the ephemerides published in the national almanacs be made before 1980.”

This delay before the possible introduction of new constants is required to allow adequate time for the preparation of new fundamental catalogues and ephemerides, for the subsequent preparation of derived data and explanatory material for publication, and for their printing, proofreading and distribution well in advance of the year to which the data refer. It seems unlikely that the pre-

paration, at the Astronomisches Rechen-Institut, of a new fundamental catalogue will require the use of final constants until 1976, and so publication will not take place until 1978. In normal circumstances the almanacs for 1980 would be scheduled for publication not later than the end of 1978, although the distribution of the data for the first part of the *Astronomical Ephemeris* would take place in 1975 or 1976. *R. L. Duncombe*, in a reply to a question by *D. H. Sadler*, confirmed that the resolution implied no change in the theories to be used and, in particular, that a new theory for Mars should not be introduced before 1980.

“5. Recognizes the need for ephemerides of higher precision for use in many applications and recommends that Commission 4 seeks ways by which a standard set of such ephemerides may be made available in machine-readable form as often as is practicable, together with adequate documentation.”

*D. H. Sadler* drew attention to the likelihood that the ephemerides printed in the almanacs would not be used for the comparison with observations once ephemerides of higher precision were available and that this would lead to confusion. (This can be largely avoided if the new ephemerides are only used where the additional precision is *necessary* for the proper interpretation of the observations as, for example, when looking for variations in the periods of pulsars.) *R. L. Duncombe* considered that the Directors of the national ephemeris offices should propose, after consultation with other interested organizations, how best to implement this resolution.

“6. Recommends that a Working Group be set up to specify, in time for consideration in 1973, the basis for the planetary ephemerides to be published in the almanacs for 1980 onwards, and suggests that ephemerides on this basis be made available in machine-readable form at the earliest opportunity.”

*D. H. Sadler* considered that the resolution would permit the introduction of the new ephemerides before they had been considered by the Commission in 1973. The President stated that this was certainly not the intention; it was merely hoped to shorten the period for which the special ephemerides referred to in the previous resolutions would be required.

“7. Considers that further changes in the values of the primary constants adopted in 1964 should not be made at the Brighton meeting, and endorses the values of the secondary constants compiled by IAG in ‘Geodetic Reference System 1967’ (special publication of *Bulletin Geodesique*, 1970).”

The new values of the constants adopted in the 1964 appeared to be of adequate accuracy for the purposes for which the system is used, although there had been some criticism of the choice of primary constants. *J. Kovalevsky* explained that the second part of the resolution had been included to meet the wishes of the International Association of Geodesy that only one set of extra figures for the secondary geodetic constants be recognized.

“8. Recommends that a Working Group be set up to review the definition of ephemeris time, its relation to other time scales, and the possible effects of changes in the primary constants on its definition and determination.”

In addition to investigating the full effects on astronomical time-scales of the earlier change in the constant of aberration and of any future changes in the precessional constants and planetary masses, it is desirable that the Group consider carefully the extent to which the ephemeris time-scale should be more closely related to the atomic time-scale. *T. C. Van Flandern* drew attention to the results of an analysis of occultation observations which suggested that the currently adopted values of the secular accelerations of the Sun and Moon would lead to a large acceleration of ephemeris time, as determined from the Moon, with respect to atomic time. (See also report of Joint Meeting of Commission 4 and 31 on p. 198.)

“9. Recommends that the next standard equinox be that of 2000.0 and that it be introduced in the next fundamental catalogue.”

Although *A. M. Sinzi* argued that the next standard epoch should be that of 2050.0, there appeared to be general agreement with the recommendation, which leaves unspecified the frequency of subsequent changes.

"10. Recommends that the Working Group on Precessional Constants should also consider the desirability of changing the mean places of stars by the effects of the *E*-terms of aberration when the next new fundamental catalogue is produced."

The wording of the resolution was criticized on the grounds that the nature of the change was not precisely specified; the President stated that this had been done deliberately as this was a matter for the Group to consider very carefully. Any change from the current practice would lead to a change in the mean place of each star, but should greatly simplify the theory and practice of aberration corrections.

"11. Urges that the observational data of the International Latitude Service be made available on a uniform system in machine-readable form as soon as is practicable, for use in the determination of nutations."

"12. Urges that the promising techniques of radio interferometry and laser ranging be developed for astrometric purposes, that regular observations by radar of the positions of planets be made to help resolve the uncertainties in the orbits and masses of the planets, and that the observational data be made available to the scientific community as soon as possible."

"13. Urges that all significant observational data be preserved in machine-readable form, in as raw a state as is practicable."

The President pointed out that these resolutions went well beyond the field of responsibility of Commission 4, but they had arisen naturally from the discussions at the Colloquium. *D. H. Sadler* considered that such resolutions were not helpful to committees responsible for the allocation of funds to different projects as they did not take account of relative values and costs. *P. J. Melchior* stated that Commission 19 had set up a working group to implement resolution 11.

At the final meeting the President suggested that the Commission should endorse the resolutions of Colloquium No. 9 as a whole, on the understanding that this did not imply complete acceptance of all details. This was agreed without objection. In order to avoid administrative complications it was agreed that the Commission should be responsible for the three working groups suggested in resolutions 2, 6 and 8, but that the members of the groups need not be members of Commission 4 since it is hoped to cover the interests of other commissions. The terms of reference of each group would be drawn up so as to include the related problems that had arisen during the meetings of the Commission. It was agreed that the convenors of the three groups should be as follows:

Working Group on Precessional Constants: *W. Fricke*

Working Group on Planetary Ephemerides: *R. L. Duncombe*

Working Group on Units and Time-Scales: *G. A. Wilkins*

Further, the membership of the groups should be decided by the new President (*J. Kovalevsky*), who will be an ex-officio member of the three groups, and the respective convenors. It is intended that all three groups should endeavour to publish reports by the end of 1972 in ample time for consideration before the IAU General Assembly in 1973.

#### PREPARATION AND DISTRIBUTION OF EPHEMERIDES

*G. A. Wilkins* reported that H. M. Nautical Almanac Office had recently distributed copies of the advanced data for *A.E.* 1974 and 1975 in the form of reduced-size Xerox copies of computer listings; it appeared that the quality of reproduction was considered to be adequate.

*R. L. Duncombe* reported that the determination of the constants of Clemence's theory of Mars was almost complete, but that full publication would probably require another year.

*T. Lederle* stated that some minor changes were to be made in the Introduction to *Apparent*

*Places of Fundamental Stars*, and he would be grateful for assistance in translating them into other languages. Further the tables for the components of double stars will be improved in the volumes for 1975 onwards. A continuation from 1975 to 2000 of the tables of double stars given in FK4 is available on request.

It was agreed that the new President should consult with the Directors of the national ephemeris offices to determine how best to prepare and make available a set of ephemerides of higher precision than those published in the almanacs (see resolution 5 above).

The President drew attention to the resolutions of Commission 16 concerning new systems of planetographic coordinates for Mercury and Venus (see p. 128); they were approved, subject to detailed examination. *R. L. Duncombe* offered to prepare ephemerides on this basis at the U.S. Naval Observatory and to consider publishing them in *USNO Circulars* until such time as they could be introduced into the *A.E.*

#### PRINTING TECHNIQUES

*R. Haupt* described the facilities of the Linotron 1010 filmsetter that was now being used by the U.S. Naval Observatory for the production of navigational almanacs and tables; the system gives results of high quality, and it is very flexible and reliable. (Later, after the meeting had been formally closed, a film about the Linotron 1010 filmsetter was shown.) *G. A. Wilkins* mentioned that the use of Monophoto filmsetter for the preparation of the first part of *A.E.* 1972 has not been as successful as the early trials had indicated, owing to errors in tape conversion and difficulties in the preparation of overlays, and the final results would be below the usual standards; the use of a Linotron 505 filmsetter was now under trial.

The President closed the meeting by thanking all members and others who had helped to further the activities of the Commission during his period of office.

#### ANNEX

### PROPOSAL (OF JULY 1969) FOR THE ESTABLISHMENT OF AN 'INTERNATIONAL INFORMATION BUREAU ON ASTRONOMICAL EPHEMERIDES'

#### *Introduction*

This proposal for the establishment of an 'International Information Bureau on Astronomical Ephemerides' is submitted to the IAU Executive Committee by the President of IAU Commission 4 (Ephemerides), after consultation with the Chairman of COSPAR Working Group I (Tracking and Telemetry of Satellites). The proposal originated from a meeting of the IAU Working Group on Space Ephemerides that was held during the period of the twelfth Plenary Meeting of COSPAR in Prague in May 1969; members of both IAU Commission 4 and COSPAR Working Group I attended this meeting.

Throughout this proposal the term astronomical ephemerides shall be deemed to refer only to: ephemerides of the coordinates of the Moon, the major planets, the four principal minor planets, and the natural satellites; star catalogues of a positional character; collected observations of the positions of these bodies. The proposal is primarily concerned with such ephemerides that exist in machine-readable form.

Although IAU Commission 4 has done much to reduce unnecessary duplication of effort in the production of fundamental ephemerides, there is no doubt that the increased demands for improved

ephemerides for radio astronomy and for space research have resulted in much duplication of effort. This has been due partly to a lack of knowledge about the availability of ephemerides and partly to an apparent reluctance (sometimes stemming from administrative difficulties) on the part of some institutions to make new ephemerides available to others. It is believed that the establishment of an internationally sponsored organization of the type that is now proposed will help to overcome both of these obstacles to the exchange of astronomical ephemerides.

#### *Purpose*

The principal aim is to provide information to the international scientific community on the availability of astronomical ephemerides for use in astronomical and space research in order to facilitate cooperation between institutions and individuals and to avoid unnecessary duplication of effort.

#### *Activities*

The Bureau shall:

- (a) receive details of astronomical ephemerides that are currently available or in course of preparation;
- (b) maintain indexed lists of such ephemerides and of cooperating institutions and individuals;
- (c) publish from time to time information bulletins giving summary lists, details of significant new ephemerides and other relevant information; and
- (d) answer requests for information about the availability of ephemerides in printed or machine-readable form.

In addition the Bureau may, in appropriate circumstances:

- (a) make recommendations to cooperating institutions as to convenient standards for the specification and supply of ephemerides; and
- (b) receive details of, and answer questions about, new determinations of astronomical constants, but the Bureau is not expected to carry out original work in this field.

#### *Establishment*

The establishment of the Bureau shall be dependent on the offer by a suitable European institution (preferably one already engaged on the production of astronomical ephemerides) to act as sponsor and provide the services of suitable staff and appropriate office facilities. It is expected that the demands on the Service would require only part-time activity by one astronomer with appropriate secretarial assistance. It is suggested that IAU should contribute towards the costs of postage and of the duplication or printing of the information bulletins; an annual sum of 200 dollars is expected to be sufficient for such purposes.

The day-to-day activities of the Bureau shall be the responsibility of a Manager, who shall act on the advice of the Chairman for the time being of a small joint committee containing 2 representatives of IAU Commission 4, and one each of COSPAR Working Group I and of the sponsoring institution. The Manager shall report to IAU Commission 4 at every General Assembly.

It is hoped that the Bureau can begin its operations soon after the IAU General Assembly in August 1970.