

20. COMMISSION POUR L'OBSERVATION DES POSITIONS ET LE CALCUL DES ÉPHÉMÉRIDES DES PETITES PLANÈTES, DES COMÈTES, ET DES SATELLITES

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MEMBRES: MM. R. G. Aitken, Th. Banachiewicz, E. W. Brown, J. Comas Sola, A. C. D. Crommelin, E. Delporte, L. Fabry, G. Fayet, M. Giacobini, F. Gonnessiat, V. V. Heinrich, K. Hirayama, M. Kamienski, J. Krassowski, J. Lagrula, G. Merton, G. H. Peters, E. Strömngren, P. Stroobant, G. Van Biesbroeck, J. Van der Bilt, L. Volta, H. E. Wood.

1. The previous recommendations of the Commission, confirmed by the General Assembly of the Union through appropriate resolutions (*Transactions*, vol. II, 1925, pp. 199–200, and p. 236) have amply justified themselves by their ready acceptance in international practice. The discussions and reports of the Commission appear to have had a stimulating effect as shown by the revival of interest in appropriate methods of observation and of the reduction of observations, by accomplished research resulting in improved methods of computation of orbits and perturbations, and by the study of cometary and planetary data in relation to the larger problems of evolution and cosmogony. To enable the President of the Commission to prepare an adequate sketch of these advances for presentation at the Leiden meeting, the representative, or, in case of several, the representatives of the adhering countries on Commission 20 were requested to send him the essential data by preparing a brief report on behalf of their respective countries.

2. The subjects falling within the scope of Commission 20 of the Union overlap to a certain extent those of Commission 3, Notations; 4, Ephemerides; 5, Bibliography; 6, Telegrams; and 7, Dynamical Astronomy. Reference to subjects which fall primarily within the scope of these Commissions must by force of circumstances be restricted to a minimum.

3. The principal questions which have been the subject of correspondence are:

A. *The Use of the Equinox of 1950.0 as a Standard Equinox for Cometary and Asteroid Work.*

This proposal on the part of the *Nautical Almanac* has been published in full in the *Monthly Notices of R.A.S.*, June 1926. Mr L. J. Comrie has formulated the following abstract of the proposal:

Instead of changing our equinox of reference continually, the use of the equinox of 1950.0 is advocated as a standard for cometary and asteroid work. The general specifications of the data which should be tabulated by the *Nautical Almanac* in order to facilitate the adoption of such a standard equinox are outlined, and later the details are developed, with special reference to the modern tendency towards the use of calculating machines. A new solution of the corrections for differential precession, nutation, and aberration is offered, also special facilities for reducing right ascension, declination, longitude, latitude, or orbital elements to 1950 or vice versa. Methods of computing special perturbations are discussed on the basis that the planetary material for the best method should be tabulated. The advantages of Cowell's method for general use, with Encke's as an auxiliary, are emphasized.

In the *Nautical Almanac for 1929* the new plan has been put partly into operation by including for the first time:

Longitude, Latitude, and Radius Vector of the Sun, referred to the mean Equinox of 1950.0.

Sun's Co-ordinates, XYZ, referred to the Equator and Equinox of 1950.0. Interpolation Tables, giving coefficients for Bessel's and Everett's formulae.

In this connection attention is called to the recent publication of the Hamburger Sternwarte in Bergedorf, *Präzessions-Tafeln* 1925.0 by Richard Schorr, Director. The many changes involved naturally concern Commission 4 on Ephemerides.

B. It has been suggested that a standard code of telegrams be used internationally. The suggestion is made that the International Astronomical Union should settle on and publish such a code. This is a matter which is of great interest to this Commission. It is desirable that some provision be made in the code for a brief description of objects, particularly comets, specifying character of nucleus, coma, tail, etc. Knowledge of the appearance of a comet is important to the computer of a preliminary orbit from a short arc. The adoption of universal time and mean places has been a great convenience. There appear to be different codes in use and it is reported from Europe that the Central Bureau is reluctant to make further changes.

C. *Dates for Comet Ephemerides.*

The following arrangement has been proposed as to dates for comet ephemerides:

When the number for J.D. elapsed at noon given in *N.A.*, *Am. Eph.* and *C.d.T.* (to the number given in *B.J.* add 0^d.5) divided by 8 gives the rest 5 the corresponding day at 0^h U.T. should be chosen for the computation of comet-ephemerides. In this way we get the same dates as the dates in the ephemerides for minor planets from the Rechen-Institut.

This proposal does not seem to be quite in accord with the plans of the *Nautical Almanac* which prefers 10-day intervals instead of 8-day intervals.

D. *Programme for the Observation of Eros at its next Approach.*

The members of the Commission were requested to make proposals concerning any international programme in which Commission 20 should participate.

4. Members of the Commission were requested to send to the President of the Commission such new proposals as they may desire to have considered at the Leiden meeting so that all proposals may be sent by the President of the Commission within the time specified by the constitution to the Secretary of the Union.

5. *Research Surveys of the Minor Planets.*

The object of the Research Surveys of the Minor Planets is set forth in the *Transactions of the International Astronomical Union*, 2, 1925, pp. 181 and 197. The General Assembly endorsed the continuation and the completion, through international financial co-operation, of the Research Surveys begun at Berkeley. In conference with interested astronomers in different adhering countries after the Cambridge meeting the Chairman received unreserved promises of co-operation but was also assured that actual participation in the preparation of the Research Surveys would involve expense which the adhering countries would be unable to bear. Further obstacles to a distribution of the work internationally presented themselves in the difficulty of maintaining contact among those engaged in the work and in the probable failure of some countries to perform their part of the task within a specified time. With these difficulties in mind the Chairman secured through the National Research Council a liberal grant from a national research foundation for the completion of the Research Surveys under his direction at Berkeley. Systematic work was resumed on July 15, 1926, and the progress has been so satisfactory that the Research Surveys will probably be completed

approximately within the specified period, that is, during 1929. The work is being done under an organization informally known as the Research Bureau on the Minor Planets. A report has been submitted to the Foundation covering the work from July 15, 1926, to October 31, 1927. This report contains a detailed statement of the organization and present status of the work. At that time about 24,000 cards containing classified information concerning the minor planets and about 1200 large sheets containing elements had been completed. About 15,000 sets of elements in all must be extracted from publications. The publications examined cover practically the whole literature on the subject from the beginning, about 1800 A.D., to the present time. The total number of volumes examined was 2159. The information extracted is classified on cards of four different colours representing successive stages of fundamental research. The cards are so arranged as to correspond to a topical outline of material to be printed in the final Research Survey for each planet. The examination of this material requires the elimination of all results which have only temporary value. The manuscript of the Research Surveys of several hundred planets, including the early ones, for which the literature is most extensive, is ready for final revision. The main difficulties encountered arise from the fact that practically every language is represented in the publications and that only research assistants who have the ability to interpret the various investigations under examination can be employed. Important preliminary results have already come out of this work and with its progress its value for the solution of large problems in astronomy has become more and more apparent. With the information on the cards it has been possible for us to make a study of the results obtained by the methods in use at various national research bureaux. These may be presented to the Commission for discussion at the Leiden meeting.

The President of the Commission would greatly appreciate suggestions concerning the material to be included in the final Research Surveys and the form in which it is to be published. In this connection reference may be made to the *Bulletin of the National Research Council*, 4, pt 7, no. 25, December 1922, "Celestial Mechanics, A Survey of the Status of the Determination of the General Perturbations of the Minor Planets," by A. O. Leuschner. A copy of this *Bulletin* was distributed to the members of the Commission prior to the Cambridge meeting.

Dr H. Thiele is associated with the President in the preparation of the research surveys and has immediate supervision over the work of the research assistants.

The foregoing statement was transmitted in substance to members of the Commission. In reply very few detailed reports on behalf of the adhering countries were received. The American Section of the International Astronomical Union passed the following resolutions:

Recommendation A. That the American Section approves of the proposal to bring before Committee 4 (Ephemerides) the question of the use of 1950.0 as a standard equinox for cometary and asteroid work.

Recommendation B. That the American Section recommends that the question of amending the standard international code for telegrams be carefully considered by the appropriate committee at the Leiden meeting.

Recommendation C. Voted to transmit Committee resolution C "the American Section is favourable to the adoption of the same fixed dates for comet as for minor planet ephemerides chiefly to facilitate comparisons" to the Committee on Ephemerides (4) as coming from the American Section.

An announcement relating to Recommendation B was promulgated in March, 1926, by Prof. Harlow Shapley with the following preamble:

In order to promote a more rapid exchange of information between Europe and America concerning the discovery of comets and of minor planets of special interest and concerning early observations and preliminary orbits, Prof. Strömngren, Chairman of Commission 6 (Telegrams), and Prof. Leuschner, Chairman of Commission 20 (Minor Planets, Comets, etc.), of the International Astronomical Union, and the undersigned (Shapley) have agreed tentatively to introduce the following plan of intercommunication and of charges.

The plan provides for various forms of subscription to cables.

As the reports of observatories usually appear in full in other places and as it would be impracticable to include in a report to the Union an adequate survey of the progress made in the last triennium in the field of the Commission's activities, only a few of the more definite comments on the various questions referred to above are here given.

Mr J. Comas Solá:

Je trouve avantageux le projet de rapporter à l'équinoxe de 1950-0 les éléments des astéroïdes et comètes, de même que donner dans les éphémérides les coordonnées du Soleil pour le même équinoxe.

Il me semble que le code de télégrammes, tel qu'il est actuellement dans le Bureau Central d'Europe, est bien suffisant et bien clair; et que, partant, il ne faut pas le changer. Seulement je crois qu'il serait utile, comme vous dites, de spécifier les caractères du noyau, tête, queue, etc., de la comète nouvellement découverte ou observée.

Je crois qu'il est préférable de conserver l'intervalle de 8 jours dans les éphémérides d'astéroïdes. Pour les comètes, ceci dépendrait, dans chaque cas, de la vitesse de l'astre et du degré d'exactitude qu'on veut donner au calcul. Il serait très recommandable que le calcul des éphémérides des astéroïdes du Rechen-Institut, de Berlin, fût prolongé d'un intervalle de 8 jours de plus *avant* l'opposition, de façon que la date de celle-ci fût symétrique par rapport aux extrémités de l'éphéméride. Ainsi, on pourrait commencer plutôt l'observation de chacun des astéroïdes.

Quant aux observations d'Eros, je crois que dans l'Assemblée de Leyde on pourra établir le projet d'observations combinées et des méthodes à suivre.

Mr L. J. Comrie:

In the article which I contributed recently to the *Monthly Notices* on the "Use of a Standard Equinox in Astronomy," I put forward the advantages of Cowell's method for special perturbations and drew attention to the fact that the origin used must be the centre of gravity of the planets whose perturbations are being considered. That is to say if we omit the perturbations of Uranus and Neptune we must also omit these planets when forming the origin...

With regard to the proposed star catalogue list (*Transactions*, 2, p. 198), I am hoping to get this in the *B.A.A. Handbook for 1929*, which goes to Press in another four months. My idea is not to give an exhaustive list, for which one could consult Valentiner, Ristenpart (*G.F.H.*), or Schorr's *Lexikon*, but rather to give what I would call a working list of the best and most easily accessible catalogues. To give a very complete list would, I think, defeat the purpose I have in mind... My whole idea is to encourage the use of such good modern catalogues as those of Greenwich 1900, Greenwich 1910, Abbadia, Toulouse, Berlin 1920, and Schlesinger.

Mr A. C. D. Crommelin:

I fully admit the advantage of using the 1950 equinox for definitive elements of comets; but I am a little doubtful of the advantage of using them for preliminary elements, or for finding ephemerides. If they are used for these, then I think all pub-

lished positions of comets, whether telegraphed or printed, should also be referred to equinox of 1950.

The present standard of precedence (at least in Europe) for the naming of comets goes by the order in which the discovery of a comet is communicated to Copenhagen or Kiel. I suggest that precedence of nomenclature should be decided by the date of communication of the discovery to the principal observatory in the country or province of the discoverer.

Mr V. V. Heinrich:

In addition to a very complete report on investigations in celestial mechanics, Prof. Heinrich directs attention to an investigation by Emile Buchar of the orbit of Minor Planet 1055, which has a commensurability of $7/2$ with Jupiter. (*Publications de l'Institut Astronomique de l'Université Charles de Prague, Série II, No. 8, 1927.*)

Buchar uses a method of differential correction of the position and velocities at a fixed date in contrast to the methods of Schönfeld and Bauschinger, as suggested by Andoyer in his *Cours de Mécanique Céleste*. Subsequently the perturbations are developed with Bohlin's method with the aid of Strömberg's tables.

Mr R. T. A. Innes:

If the Ephemerides gave us the planetary coordinates referred to a fixed equinox and to the centre of gravity of the Solar System, then Cowell's Method could be applied with great ease to any planetary body—of course it is only from four days to four days or a multiple thereof but the work is so simple, straightforward and self-checking that its continuity is nothing. I could compute the places of say Jupiter and Saturn for three centuries with precision for a smaller labour than Hill's.

Nevertheless, I am not urging the total abolition of the analytical method to which I have given much attention.

Your memorandum is excellent and requires no comment. Nevertheless, I enclose some notes in the hope that they may be useful.

Use of the Equinox 1950.0.

Sometimes this would be 25 years away from the date of observation. This would mean that in reducing for parallax the place near time of observation must also be used.

I think that Standard Equinoxes 25 years apart would be more convenient, 1875, 1900, 1925, 1950... then the maximum time would only be 13 years and the correction for parallax but slightly affected.

Alternatively, the *N.A.* might be asked to use the Standard Equinox of 1950 and the *B.J.* to use that of 1925 until 1937-38. The present Sonnenkoordinaten table of the *B.J.* should be retained.

Dates for Comet Ephemerides.

I am in favour of 8-day intervals, or rather of 2^n -day intervals because of the ease of interpolation to halves.

Programme for Eros.

A geocentric dynamical ephemeris is suggested. It avoids the errors due to the solar ephemeris and to errors in the count of time.

During the time of close approach, the differential perturbations due to planets, other than the Earth, nearly mutually cancel—as was the case with comet Pons-Winnecke 1927, June 25—July 2.

Mr G. Merton:

It seems that it is high time a standard code was used by all astronomers and that the International Astronomical Union should settle on and publish such a code.

Mr P. Stroobant and Mr E. Delporte:

Nous sommes partisans de l'emploi de l'équinoxe 1950.0.

Nous sommes d'avis de conserver le mode actuel de transmission. Dans certains cas, par exemple pour les comètes, il suffirait d'ajouter un mot comme indication supplémentaire: p. ex., queue, noyau, stellaire, etc.

Il est question que l'administration belge des télégraphes réduira à cinq lettres l'étendue des mots admis en langage conventionnel.

L'intervalle de 8 ou 10 jours pour les éphémérides n'a guère d'importance, mais dans le cas où cela serait possible, quand le mouvement de l'astre est rapide, on pourrait réduire l'intervalle à la moitié du nombre normal de jours, donc à 4 ou 5.

Eros. L'observatoire d'Uccle a déterminé en 1926-27 et 1927-28 les coordonnées des étoiles de repère figurant sur la liste publiée par le Dr Kopff dans *A.N.* n° 5375 et entre les déclinaisons de + 48° et de + 20°. Ce catalogue sera publié bientôt dans les *Annales* de l'Observatoire. Des clichés actuellement au nombre de 39 sur 75 et couvrant la trajectoire d'*Eros*, entre les mêmes limites, ont été pris à l'équatorial photographique de la carte du ciel.

Pendant la période de l'opposition les coordonnées d'*Eros* seront observées au cercle méridien de Repsold et seront prises à l'équatorial photographique de la carte du ciel.

L'étude publiée dans le *Bulletin of the National Research Council* (4, pt. 7) nous paraît parfaite à tous égards et il serait à souhaiter qu'elle soit étendue à toutes les petites planètes.

Mr J. Van der Bilt:

There is one point which I consider of great importance, but which, I fear, cannot yet be treated at the Leiden meeting. This point is the desirability of a "plan of selected objects" for the study of the asteroids. I am convinced that our Commission ought to co-operate with the Commission on theoretical investigations in order to get a number of selected minor planets, say 200 or 300, whose orbits cover various demands. Then we ought to have an efficient co-operation, whereby certain objects are assigned to certain observatories, which shall be responsible for getting exact normal positions along the longest arc obtainable. . . .

I am sure that science will profit more from exact, continuous observation of 200 selected objects than from the few haphazard places of twice or three times that number. . . . (The statistics of observations of minor planets for 1924 and 1925 were submitted in this connection to show that there exists at present very little system or co-operation.)

Unfortunately, the preliminary report in behalf of Commission 20 was not mailed in time to Messrs Banachiewicz, Wood, and Krassowski, so that their replies are not available.

Although it was voted by the Commission at the Cambridge meeting that all proposals which were submitted regarding international co-operation on minor planets be accepted in principle and referred to the President for co-ordination, it has not been found practicable up to the present time to make much progress in this direction. Recently, however, the activities of various observatories and minor planet bureaux have defined themselves somewhat definitely so that the problem of co-ordination which is so essential to avoid duplication and to insure progress in the right direction, will more readily solve itself in the next triennium on the basis of informal suggestions or definite proposals which may develop out of the discussions of the Commission at the Leiden meeting.

As *agenda* for the meeting of Commission 20 the President proposes the substance of this report.

A. O. LEUSCHNER
President of the Commission

APPENDIX I

Par N. Commendantoff

Une certaine expérience acquise par les travaux concernant les orbites planétaires à l'Institut Astronomique de Leningrad me permet d'énoncer quelques conclusions sur les méthodes suivies (méthode d'extrapolation des coordonnées rectangulaires due à Prof. Noumeroff et celle de la rectification des éléments osculateurs par le même auteur):

1. Stabilité d'une série des coordonnées extrapolées contre la croissance possible des erreurs d'arrondissement et possibilité de l'employer dans le calcul des éphémérides approchées pour des dizaines d'années.

2. Réunion de la simplicité remarquable de la méthode avec la précision entièrement satisfaisante des résultats—circonstance très favorable au calcul exact des perturbations pour les nombreuses orbites planétaires; d'ailleurs, possibilité de disposer sans aucune peine des valeurs troublées des coordonnées pour le calcul des forces perturbatrices.

3. Deux approximations du procédé d'intégration comme un nombre indispensable et suffisant, en général, pour tenir compte des termes d'ordre supérieur pair; cette condition remplie, on peut se servir d'intervalles d'intégration bien considérables pour diverses orbites planétaires (p. ex. 40–120 jours (Ekard-Achilles)).

4. Facilité d'un calcul d'exactitude plus grande: perturbations de Jupiter et de Saturne, termes f_6 et f_8 , coordonnées à 7 décimales; on se borne dans la première approximation à 6 décimales, en laissant aussi de côté les termes f ; les différences établies des coordonnées II–I servent comme vérification très simple du calcul.

5. Grande utilité de cette méthode simple pour le calcul approché des perturbations des nouvelles planètes, en employant les éléments de la découverte.

6. Emploi possible de la méthode au calcul des éphémérides non troublées, ce qu'on effectuera très aisément sans tenir compte des termes f (voir les tables dans *J. des O.*).

7. D'autre part, une nouvelle forme des coefficients différentiels résout assez simplement le problème de la correction des éléments osculateurs, en se basant sur les observations de plusieurs oppositions.

8. Possibilité et importance du calcul des coefficients différentiels, en se servant des valeurs troublées des coordonnées.

9. Quatre oppositions différentes au moins comme un nombre indispensable pour séparer suffisamment toutes les corrections cherchées des éléments.

10. La haute précision des éléments obtenus moyennant les précautions ci-dessus est confirmée par la comparaison du calcul (série des coordonnées extrapolées troublées) aux observations postérieures.

11. On parvient à l'exactitude demandée des positions observées non seulement en établissant des lieux normaux (cas assez rare pour la plupart des astéroïdes), mais aussi en adoptant simplement les données des observations photographiques précises (Alger, à présent aussi Pulkowo), après les avoir confirmées par les observations micrométriques voisines.

Ainsi nous sommes amenés aux conclusions suivantes:

1. En raison de la simplicité de la méthode d'extrapolation, son emploi plus étendu dans le calcul des perturbations des astéroïdes et des comètes est désirable.

2. La précision des résultats rend la méthode appropriée aussi aux recherches théoriques spéciales sur le mouvement troublé.

3. Les éléments osculateurs assez sûrs, à part leur valeur pratique évidente, seraient utiles pour la détermination des constantes d'intégration dans les théories générales (absolues) des perturbations.

APPENDIX 2

I. Constantes de Gauss

Dans le but de faciliter le calcul des éphémérides approchées (astéroïdes ou comètes), G. Fayet a calculé et se propose de publier prochainement une table, ayant pour arguments Ω , i , qui fournit, par simple interpolation, les valeurs des constantes de Gauss:

A , B , C avec l'approximation de $0^{\circ}.01$. $\log \sin a$; $\log \sin b$; $\log \sin c$, avec 4 décimales.

La table est calculée pour 1930, mais une petite table corrective, ayant pour argument $d\epsilon$, permet de l'utiliser sans difficulté pour une très grande période de temps.

2. Coordonnées héliocentriques des petites planètes

G. Fayet a entrepris une recherche d'ensemble concernant les proximités d'astéroïdes.

A cette occasion, il a été conduit à effectuer pour chaque petite planète dont l'orbite est assez bien connue (basée sur au moins deux oppositions) les calculs suivants:

Pour les valeurs équidistantes 0° , 10° , 20° , ..., 350° de la longitude héliocentrique l , il a calculé:

$\log r \cos b$ (4 décimales).

$\log r \sin b$ (3 décimales).

t (3 décimales).

v (à $0^{\circ}.01$).

M (à $0^{\circ}.01$).

x , y , z , à 2 décimales.

En particulier ces tableaux permettent de trouver très rapidement les dates des oppositions successives de chaque astéroïde.

Environ 100 planètes sont ainsi calculées. L'ensemble, qui comportera au moins 700 planètes, sera achevé à la fin de 1929, mais M. Fayet ne pourra probablement pas le publier aussitôt parce qu'il ne dispose pas de crédits suffisants.

M. Fayet serait tout disposé à calculer, par la même occasion, d'autres données numériques qui seraient jugées utiles et il accueillera avec empressement toutes suggestions que ses collègues des autres observatoires voudraient bien lui adresser à ce sujet.

APPENDIX 3

Dr Crommelin stated that he is engaged in preparing perturbation factors which would give the perturbations by the large planets of comets whose eccentricity ranges from 0.37 to 0.84. The method of Bauschinger is followed; the numerical values of the factors are given at intervals of $7\frac{1}{2}^{\circ}$ of the comet's mean anomaly. These tables should be completed in a few months, and will be offered to the R.A.S. as a Memoir.