20. COMMISSION DES POSITIONS ET DES MOUVEMENTS DES PETITS PLANETES, DES COMETES ET DES SATELLITES

PRÉSIDENT: M. D. Brouwer.

MEMBRES: MM. Adamopoulos, Arend, Asplind†, Banachiewicz†, Bobone, Boyer, R. Carrasco, Chebotarev, Clemence, Cox, Cunningham, Dawson, Delporte†, Dubyago, Eckert, Edmondson, Fayet, Febrer, Gennaro, Giclas, Grandón, Hagihara, Heinrich, Herget, Hertz, Hirose, Itzigsohn, C. Jackson, Jeffers, Spencer Jones, Kahrstedt, Kamieński, Kepiński, Kopff, Kuiper, Mme Laugier, M. Leuschner†, Mme Levy McDonald, MM. E. L. Martin, Maxwell, Merton, Michkovitch, Mowbray, Nicholson, Oort, A. A. Orlov, Patry, G. Pels, Plavec, Porter, Protitch, E. Rabe, Rasmusen, Reinmuth, Sadler, Schmitt, Schürer, Sconzo, Mme Shajn†, MM. Strobel, Torroja Menendez, Väisälä, van Biesbroeck, van den Bos, Mlle Vinter Hansen, M. Whipple, Mme Yakhontova.

20a. SOUS-COMMISSION POUR L'ETUDE DES COMÈTES PÉRIODIQUES

PRÉSIDENT: Mlle Vinter Hansen.

MEMBRES: MM. Cunningham, Dubyago, Fayet, Kepiński, Merton, van Biesbroeck.

MINOR PLANETS

Observations

Observational activity has continued along essentially the same lines as in previous post-war years. The following observatories that participate in systematic observations of minor planets sent in reports of their activities: Algiers (Boyer), Bloomington (Edmondson), La Plata (Sconzo), Heidelberg (Reinmuth), Johannesburg (Van den Bos), Madrid (Torroja), Nice (Fayet, Mme Laugier, Patry), Simeis (Mrs Shajn), Tokyo and Kyoto (Hirose), Turku (Väisälä), Uccle (Arend and Delporte). The report on activities in the U.S.S.R. (Mrs Yakhontova) states that systematic observations of minor planets are carried on, in addition to Simeis, also at Pulkovo, Alma-Ata, Vilnus, Kiev, Lvov and Tartu.

Van Biesbroeck reports that at the Yerkes and McDonald Observatories a number of faint asteroids have been observed at the request of computers. Aside from these accurately measured positions, semi-accurate ones are being obtained for the thousands of asteroids recorded on the 10-inch Cook plates for Kuiper's (1) survey. About 1200 pairs of plates distributed over twenty-three fields of 40° by 40° each were taken during the years 1950–52. The limiting magnitude is about 16·5. In December 1954 the blinking of these plates was 75 % complete; the measurements for magnitude, motion and position were half completed. About 100 asteroids are found per opposition field, of which about thirty cannot be identified with ephemeris positions. The positions are read directly in equatorial co-ordinates by means of a Wild-T2 theodolite giving angles to a precision of 2″, which suffices for most asteroid work. More than a thousand positions have so far been obtained. For the entire survey, to be completed toward the end of 1955, the total number of measured positions will exceed 3000.

For the Lick Observatory, Jeffers reports that no formal programme for the observation of minor planets is carried out. Some are observed that are important for one reason or another, others are observed on request because they are too faint for instruments used at other observatories.

Kopff and Strobel, reporting for the Astronomisches Rechen-Institut at Heidelberg, include in their report the following requests to observers:

1. To secure unnumbered objects, observers are requested to search for such objects on the basis of search ephemerides published in the *Minor Planet Circulars*.

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2. Observations are requested of numbered minor planets that have not been observed in recent oppositions. A list of numbered planets that have been insufficiently observed is furnished in the annual ephemeris volumes.

3. It is important that observers note if the search for an object was unsuccessful; such reports will draw the attention of computers to planets that need a careful checking of elements used.

Arend and Delporte include in their report a recommendation on magnitudes. It occurs that in the course of the examination of photographic plates a well-identified minor planet is found to have a magnitude appreciably different from that given in the ephemeris. At Uccle the estimated magnitudes are in such cases reported with the measured positions to the Minor Planet Centre in Cincinnati. Other observers are urged to follow the same practice. They further recommend that it would be useful if, for example in the *M.P.C.*, a list were published and kept up to date of all minor planets for which magnitude variations are known, with an indication of the range of variation.

At a number of observatories the first four minor planets are observed regularly either with meridian circles or photographically. These planets promise to be of increasing value in determining fundamental right ascensions and declinations (Clemence (2)). At the Yale Observatory the discussion of the photographic observations of these planets made in the years 1935–48 for this purpose is approaching completion. Spencer Jones reports that they are being observed at the Royal Greenwich Observatory with the astrographic refractor; other observatories that make systematic observations of the planets are those at Leiden, New Haven, Sydney and Washington. This list may be incomplete. Bobone reports that these four bright asteroids are being observed with the meridian circle at Córdoba, along with the Moon and the principal planets.

A list proposed by astronomers in the U.S.S.R. for a similar purpose, more specifically in relation to Zverev's catalogue of faint stars, contains the ten planets 1, 2, 3, 4, 6, 7, 11, 18, 39 and 40. A recommended procedure for photographic observations has been issued by Mrs Yakhontova. These recommendations include the request that participating observatories send information on completed work to the Commission of the Catalogue of Faint Stars at Pulkovo before 1 December of each year. Mrs Yakhontova states that it would be desirable that more observatories, especially in the southern hemisphere, take part in this project. For the present report it may suffice to state that several of the observatories that regularly observe the planets 1, 2, 3 and 4 have placed the six additional planets on the observing programme.

Other minor planets that are being observed acccurately at some observatories for specific purposes are (51) Nemausa, (433) Eros, (619) Triberga and (1566) Icarus. Clemence reports that in Washington the planets 10, 24, 31, 48, 49, 52, 57, 62, 65, 76, 86, 87, and 90 are being observed; the old observations have been collected and are being reduced to a uniform system. These minor planets were shown by G. W. Hill to be particularly suitable for determining the mass of Jupiter. It is expected that with the aid of electronic calculators it will soon be possible to calculate orbits of the requisite precision.

Ephemerides

Four years have elapsed since the annual volumes of ephemerides issued by the Institute of Theoretical Astronomy at Leningrad were adopted for general use. Each year the Minor Planet Centre at Cincinnati has issued an English translation of the explanatory material contained in the volume as well as corrections to ephemerides for which computations made elsewhere differed from the data published in the Leningrad volume. It was expected (3) that within a few years the new policy should reduce materially the number of minor planets for which corrections to the Leningrad volume must be furnished. This expectation has proved to be correct. For the year 1955, the list of corrections has become very short. This indicates the success of the present arrangement, an essential feature of which is that the Leningrad volume makes use of and acknowledges contributions of ephemerides by computers anywhere in the world.

At the Institute for Theoretical Astronomy numerical integrations with perturbations by Jupiter and Saturn are being carried out, forward to 1970, for about 700 minor planets. Most of these are in the outer parts of the asteroid ring. For 320 planets at smaller distances from the sun approximate general perturbations by the methods of Brendel or Bohlin are used. These perturbations have been tabulated with interval $0^{y}\cdot 2$ forward to 1963.

The Astronomisches Rechen-Institut at Heidelberg contributes importantly to the programme of providing improved ephemerides. At Heidelberg approximately 700 minor planets are being cared for, the great majority with special or general Jupiter perturbations. Orbit corrections are carried out with the aid of Jupiter perturbations furnished by the Cincinnati Observatory, mostly perturbations in the elements, carried forward to 1975. In order to avoid duplication, most of the ephemerides for these planets are computed at Leningrad from data furnished by Heidelberg; at Heidelberg the ephemerides are computed only for planets that are on a much smaller special programme. Similar working agreements exist with other centres, generally on a smaller scale.

While there is ample cause for satisfaction with what has been accomplished along these lines during the past three years, there is one complication that will need careful consideration. The use of punched-card computing machines at Leningrad has made it efficient for the Institute to compute all ephemerides based on unperturbed elliptic elements as a routine programme. Such ephemerides are no longer wanted from computers elsewhere except those based on improved elements not yet available at Leningrad. This has only gradually become generally known. In the meantime it has caused disappointments to contributors of unperturbed ephemerides that were neither used nor acknowledged in the ephemeris volumes.

No one will deny that the programme as a whole is best served by making full use of the computing facilities at Leningrad. On the other hand, it is equally compelling to recognize that computers in other institutions wish to continue making useful contributions. Many members of the commission dealt with this problem in their reports. Its consideration is one of the more urgent topics for discussion at the Dublin Meeting.

In view of the fact that circumstances have changed considerably since the present plan was inaugurated, a revision of the assignment of planets for ephemeris computations is called for. For ephemeris purposes all minor planets may be divided into three categories:

1. Those for which the Leningrad Institute and its regular co-workers compute perturbations and ephemerides.
2. Those for which the perturbations and ephemerides are computed in other centres.
3. Those for which at present no perturbations are computed.

Irrespective of the present assignments, all planets in the third category for which arrangements can be made to transfer them to the second category should be assigned accordingly, while those remaining are the responsibility of the Leningrad Institute to be included in the first category as opportunity permits. This solution was proposed by Herget.

In the report from the Institute for Theoretical Astronomy at Leningrad, Mrs Yakhontova expresses the hope that further developments of computational techniques will in the future permit to give up the computation of unperturbed ephemerides and proceed with the calculation of the ephemerides of all planets with perturbations. Provisional work is already in progress at Leningrad. It is then remarked that, parallel with the perturbation calculations, a considerable task of orbit correction remains to be done. Available data on 1 January 1954 show that for 266 minor planets the observed and ephemeris positions differed by more than 4^{m} in right ascension.

It thus appears that the views expressed by Herget and Mrs Yakhontova are not far apart. With so much agreement, it should not be difficult to arrive at a division of labour agreeable to all concerned.

A complaint that appeared in many reports from members of the commission concerns the exclusive use of the Russian language in the ephemeris volumes. The point is stressed that these volumes are now used internationally and that it is a decided inconvenience to many of the users that the names of planets and authors of elements are given in cyrillic characters. A request for the use of latin characters was expressed during the Rome meeting, but has remained unheeded.

Minor planet circulars

Herget reports that the *Minor Planet Circulars* have been issued in the most expeditious manner that could be devised. The multilith printing is of high quality on high-grade rag paper. The preparation of the material printed is under the immediate supervision of E. Rabe.

Observations and orbit improvements made in the U.S.S.R. are not contributed in manuscript for publication in the *M.P.C.* Instead they are published in the *Astronomical Circulars of the Academy of Sciences of the U.S.S.R.*, the *Publications of the Pulkovo Observatory*, and the *Publications of the Crimean Astrophysical Observatory*. According to information received by the President of the Commission during a visit to Leningrad in 1954, this policy is followed in order to avoid duplication. As a consequence, the computer who wishes to obtain complete information concerning observations and orbit improvements of particular minor planets must consult both the *Minor Planet Circulars* and the Russian publications.

Reinmuth urges that the *M.P.C.* be published at shorter intervals. He comments that, unlike the *A.R.I. Circulars* formerly issued from Berlin-Dahlem, the present *Circulars* do not furnish information concerning current observations of interest to observers. As a consequence it happens frequently that several observatories photograph the same planet simultaneously or nearly so. If the *Minor Planet Circulars* were published more frequently, the observers would also contribute their observations more promptly. This would eliminate unnecessary duplications and bring greater over-all efficiency.

Herget comments in his report on the fact that the main delay is in receiving material from observers. The Minor Planet Centre has occasionally issued mimeographed *Provisional Air Circulars*, but there have not been many occasions which required this. He proposes that, to avoid duplication and unobserved gaps, the observers will have to develop a plan in which they parcel out the sky amongst themselves in advance.

Index of observations

At the Minor Planet Centre a punched card index of observations of minor planets described in *M.P.C.* 191 has been kept up to date. This index now includes the 6500 accurate observations recently published by the Astronomisches Rechen-Institut at Heidelberg. The Centre is prepared to furnish listings made from this index to computers. For many purposes the annual listings of references to observations published in the *Astronomische Jahresberichte* continue to be of great value, but by their nature they cannot include the most recent information.

Identities

The interest in identities has continued and has produced further valuable results. As stated in the report for the Rome Meeting, this work was in progress by Patry at Nice, by Kippes at Glattbach, and by Michkovitch at Belgrade. It has continued in the same centres. Patry (4) published a catalogue of 785 circular orbits computed for unnumbered asteroids observed between 1901 and 1940. The list of successes is too long to be given in full. Among the interesting results of the work is the gradual shrinking of the list of numbered minor planets observed in only one opposition. Of the older planets discovered before 1914 and previously observed in the discovery opposition alone, the planets 400, 459, 515, 650, 728 and 750 have been recovered in recent years. Thus the list of objects lost since 1914 which numbered sixteen a few years ago is now reduced to ten. The entire list of numbered asteroids observed in only one opposition has been reduced from over eighty in 1940 to about thirty at present. A good part of this improvement has been due to the patient search for identities, followed by perturbation calculations and orbit corrections.

Equally striking is the recognition of identities among the unnumbered objects in different oppositions that has led to the numbering of new planets. An example is the planet (1587). The record begins with the identity indicated by Patry (5), 1949 EA = 1933 SF_1, elements from *A.N.* **251**, 238, with $\Delta M = -7^\circ\!.81$ in 1949. Then follows its identification with 1941 FB by Kippes (6) and with 1935 UG by Patry (7). Aided by a search ephemeris furnished by Kippes on the basis of unperturbed elements derived from three oppositions, 1933, 1941, 1949, the planet was observed in 1951. Special Jupiter perturbations by Hansen's method were then computed at Cincinnati, and a differential correction from observations in five oppositions, 1933, 1935, 1941, 1949, 1951 was carried out by S. Böhme (8) at Heidelberg. The planet was numbered (1587) in *M.P.C.* 882. Other examples of similar successes could be quoted.

The Astronomisches Rechen-Institut at Heidelberg, in co-operation with the Cincinnati Observatory, has taken an active part in this work. For numerous unnumbered objects observed in two or more oppositions, the Cincinnati Observatory furnished Jupiter perturbations. At Heidelberg the orbit corrections were computed and search ephemerides furnished for future oppositions. These are regularly published in the *M.P.C.* Kopff's report emphasizes that the perturbation calculations furnished by the Cincinnati Observatory have been of great value in this work.

Kopff and Strobel also describe a card catalogue compiled at Heidelberg of the elements of all numbered and unnumbered planets, ordered according to longitude of the ascending node and inclination. This compilation was extended by computing elliptic elements for older objects with at least three accurate observations as well as for new objects, mostly those discovered at the Königstuhl Sternwarte at Heidelberg. This card catalogue is particularly designed to aid in the search for identities on the basis of similarity of the elements.

Many of the elements of unnumbered planets have appeared in the *Minor Planet Circulars*. Patry suggests the publication of an index to the elements contained in the first thousand *Minor Planet Circulars*, and wishes that such compilations be published more frequently, perhaps every year or every two years. Sconzo repeats the recommendation, made by him three years ago, that a list of elements of unnumbered objects be published. Herget comments that if the commission feels strongly that such a list be published, it should be done by printing from punched cards. The Cincinnati Observatory offers to prepare the punched cards. In the interest of completeness, assistance is desired in collecting data from all sources outside the *Minor Planet Circulars* and the *Astronomische Nachrichten*. The list should also contain an index of known identities.

This subject may be further explored at the Dublin Meeting. Perhaps the preparation for publication of a list of elements may be considered in relation to that of a new *Identifizierungnachweis der Kleinen Planeten* to bring up to date G. Stracke's volume which extended to 1938. Preparatory work for this undertaking has been taken in hand at the Astronomisches Rechen-Institut at Heidelberg.

Newly numbered asteroids

Herget reports that the more stringent requirements for numbering have not been a serious deterrent, as forty-one planets have been numbered since 1947. The likelihood that any will become lost is very small. Identities account for nine planets recently numbered, and more will follow when the objects concerned are re-observed once more for a check. This has become the standard procedure.

Other activities of the Minor Planet Centre

Many of the activities of the Minor Planet Centre have been reviewed in earlier sections of this report. There are additional aspects of its work that merit further mention.

Aside from the regular routine work, the principal effort of the Minor Planet Centre has been in the use of electronic computing machines for various purposes. Herget has devised a method of computing the preliminary orbit of a newly discovered object from three observations on the IBM 701 in one minute of operating time, with about 15–20 min. of hand preparation in advance. Recently fourteen unidentified objects observed at Bloomington were computed in this manner in 14 min. of machine time. From the results, Dr P. Musen identified the lost planet (515) Athalia, which had not been observed since its discovery in 1903. The same list led to the recovery of (1475), not observed since its discovery in 1938, and to the identification of another object which had a large ephemeris correction.

Perturbation calculations at Cincinnati have been made more efficient by the use of newer computing machines. For Strömgren's method the IBM 607 is now used to great advantage as compared with the 604 that was employed previously. Recently completed was a programme that involved the computation of first-order perturbations by Jupiter for 96 asteroids for about 25,000 dates. Herget has prepared a programme of perturbation calculations by Hansen's method on the UNIVAC that promises to be extremely efficient, much more so than previous efforts by this method with IBM 604 for the computation of the disturbing forces and 701 for the integrations.

Orbit improvements

The perturbation calculations at Cincinnati are part of a co-operative programme with the Astronomisches Rechen-Institut at Heidelberg and with collaborators elsewhere, who improve the elements and provide search ephemerides for insecure objects. The Minor Planet Centre is also prepared to compute differential corrections of orbits by the method of Eckert and Brouwer on the IBM card programmed calculator. The method has been used successfully on a small number of orbits. In collaboration with computers in other centres this promises to develop into a fruitful project. It is required that the accurate residuals be determined in advance by hand computation. In addition, the following input data to the machine must be furnished: ρ, $\cos\alpha$, $\sin\alpha$, $\cos\delta$, $\sin\delta$, $\cos E$, $\sin E$, and $m = -1{\cdot}5k\,(t-t_0)\,a^{-\frac{3}{2}}$.

Similarly at Leningrad, with the co-operation of other centres in the U.S.S.R., a programme of orbit improvement is making progress. During the past three years this work resulted in the improvement of 65 orbits. Of these, 13 were obtained at the Institute for Physics of the Latvian Academy of Sciences. Tables of special perturbations in elements by Jupiter and Saturn (9) were published by this Institute.

Now in progress at the Institute for Theoretical Astronomy at Leningrad are the orbit corrections of 120 planets of the Hecuba type for which numerical integrations with punched card machines had been computed previously. The punched card machines are also used for various calculations necessary for the orbit improvement.

Publications

It would be impossible within the allotted space for this report to list all the publications that have a relation to the minor planet work. Reference may be made to a short account of progress in research on minor planets during the years 1947–52 (10) that was published in 1954. It is intended to publish such reviews every year.

Some new work in the field of general perturbations is to be noted. An analytical theory of Ceres was developed by V. Proskurin. This theory is to include the perturbations by all the principal planets. The first-order theory (11) was published in 1952. The evaluation of the terms of higher order is approaching completion.

A study by C. A. Chebotarev (12) concerns orbits in the vicinity of commensurabilities with Jupiter. A periodic orbit, called 'absolute orbit', determined by mechanical quadrature serves as intermediate orbit. The variations from this orbit are obtained in the form of short analytical expressions with numerical coefficients. The method has been developed for the commensurabilities 2/3 and 1/3, and applied to the motion of (153) Hilda with representation during 75 years within the limits set by the author. It has also been applied to other asteroids of the Hilda type.

At the Tokyo Observatory, Y. Kozai has continued his study of the motion of (279) Thule (13) and has published a new discussion of the theory of secular perturbations of minor planets (14).

It may be remarked that the availability of rapid calculating machines has not benefited the construction of general theories of minor planets as impressively as it has the field of special perturbation calculations. This is primarily due to the difference in character of the machine operations, which is vastly more complicated for the construction of general theories.

Among the accurate special perturbation calculations published may be mentioned Boyer's (15) work on (173) Ino, Herrick's (16) on (1566) Icarus, while Kahrstedt reports that he has connected the observations of (1221) Amor in the observed oppositions 1932, 1940 and 1948 in a single corrected orbit with Hansen perturbations.

Sadler reports that a new volume of planetary co-ordinates for the equinox of 1950 is in preparation. It will cover the years 1960–80, and is scheduled to be published in 1956.

An important contribution by Herget (17) is 'Solar Co-ordinates, 1800–2000', which furnishes the geocentric co-ordinates of the Sun and the heliocentric co-ordinates of the barycentre Earth-Moon referred to equinox and equator of 1950.0. The data are based on Newcomb's *Tables of the Sun*. The interval is four days; in addition the data are given for the odd ten-day multiples.

Among publications concerned with methods of special perturbations may be listed articles by S. Herrick (18) and by P. Musen (19), while Sconzo reports that a study by him on this subject is to appear in *Boll. Unione Mat. Italiana*. Reference is also made to a forthcoming study by Sadler on the relative merits of various methods of special perturbations, noted in the section Comets of this report.

Miscellaneous comments

At the Rome meeting no decisive vote concerning the desirability of publishing annual charts was taken. They were discontinued because of the considerable amount of labour required for their preparation. Only one member (Michkovitch) expressed the wish that they be continued in view of the usefulness of these charts to observers and identifiers.

Merton calls attention to the frequent use of ρ for geocentric distance while Commission 3 recommended Δ. He proposes that Commission 20, after seeking the concurrence of Commission 7, ask Commission 3 to amend the existing recommendation (20) and approve the use of ρ to denote geocentric distance instead of, or as an alternative to, Δ.

Michkovitch proposes that the commission request observers to supply for newly discovered objects not only the observed positions but also the daily motion and the magnitude.

Comets

Observational activity has continued as in previous years. Several reports comment on the great value of the efforts of Van Biesbroeck at the Yerkes and McDonald Observatories and Jeffers and Miss Roemer at the Lick Observatory to extend the observations of faint comets over the longest possible arc. In the southern hemisphere the situation is much less favourable.

At the Leiden Observatory the calculation of original values of $1/a$ for nearly parabolic orbits was continued, principally under the supervision of E. H. Bilo. This work has now been completed for the comets: 1892 II, 1905 IV, 1910 III, 1914 III, 1915 II, 1917 III, 1919 V, 1925 VI, 1927 IV, 1930 IV, and 1937 IV.

The annual reports by Merton published in the *Monthly Notices of the R.A.S.* give such complete accounts on the status of computations of definitive and original orbits of non-periodic comets that an account of this important activity appears unnecessary.

On periodic comets the report by Miss Vinter Hansen (Sub-commission 20*a*) and the annual reports by Merton are available. It may be permissible to give special mention to the work on two comets. S. G. Makover at Leningrad has studied the motion of periodic comet Encke-Backlund over the period 1937–51. The normal places in this interval and the observations in 1953 are well represented. M. Kamienski has continued his exhaustive investigation of the periodic comet Wolf (1). He has now investigated its motion over nearly 200 years.

Kamienski recommends that the orbit of Halley's comet be computed backward with electronic computing machines. He proposes that in a first stage the observations of the apparitions 1910, 1835, 1759 should be connected, to be followed by the inclusion of the observations in 1682. The ultimate aim would be to extend the integration backward to A.D. 451, and possibly to 622 B.C. or 2320 B.C.

J. Bouška (21) has published a 'Catalogue of comets observed during the period 1936–1949', a continuation of Yamamoto's *Preliminary General Catalogue of Comets*. Yamamoto (22) himself has published two supplements to bring his *Catalogue* up to 1953.0.

H. Q. Rasmusen and O. K. Hesselberg (23) have published 'An appropriate method for integration of the motion of periodic comets'.

Sadler writes that in the forthcoming volume of *Planetary Co-ordinates 1960–1980* he intends to include a comparative study of various methods for computing accurate and approximate perturbations of cometary orbits. Though some fairly clear-cut conclusions have been reached, it was considered too early for a definitive report on this investigation.

Satellites

There has been an increase of both observational and theoretical interest in satellites.

Mars

Kuiper reports that a good series of photographic observations of the satellites of Mars was made with the 82-inch reflector of the McDonald Observatory in June and July 1954. A summary of work on the motions of these satellites has been published by M. P. Kazachevsky (24), who has begun new analytical work on this problem.

Jupiter

Eclipses of the Galilean satellites are being observed at several observatories. An account of photo-electric observations of eclipses was given by Takenouchi (25).

The fifth satellite was successfully photographed by van Biesbroeck at the McDonald Observatory near three elongations in February 1954. These observations have been submitted for publication in the *Astronomical Journal*. Jeffers reports that he found the satellite not particularly difficult to observe visually in 1949, but that it has been a more difficult object in subsequent oppositions. This experience suggests that the satellite's brightness may vary, perhaps depending on the position of Jupiter in its orbit.

At the Cordoba Observatory Bobone has continued making accurate photographic measurements of the sixth satellite. Van Biesbroeck has measured the distant satellites of Jupiter in two oppositions. At the Institute for Theoretical Astronomy theoretical work is in progress on the motions of VI, VII and X. The numerical integration of the motion of satellite VIII has been continued at Leningrad, and ephemerides have been published annually in the *Astr. Circ. Acad. Sci. U.S.S.R.* The Cincinnati Observatory published ephemerides for satellites VIII, X and XI for the opposition 1954–55 (26).

Saturn

Sir Harold Jeffreys (27) published a paper on the masses of Saturn's satellites, in which the results by H. and G. Struve and J. Woltjer are re-discussed. A revision of the theory of the motion of Phoebe was published by P. E. Zadunaisky (28). Theoretical work on the motions of Saturn's satellites is reported to be in progress at the State Sternberg Astronomical Institute.

Uranus

At the same Institute the study of the motions of Ariel, Umbriel, Titania and Oberon has been undertaken by A. A. Orlov. Articles by him related to this subject have appeared (29). Mention should also be made of an article on the equations of motion for satellites by G. N. Duboshin (30).

Neptune

A study of the motion of Triton has been undertaken by Miss Jocelyn R. Gill at the Yale Observatory. Observational material not used in the discussion by Eichelberger and Newton (31) includes the accurate photographic observations by Alden in 1939–41. Van Biesbroeck reports that Nereid has now been observed for five years with the 82-inch reflector of the McDonald Observatory. A discussion of this orbit is in progress. The studies of the motions of these two satellites are expected to yield independent determinations of the mass of the planet.

At the Yerkes Observatory a series of photographic observations of the satellites of Saturn and Uranus were made by D. L. Harris III. Further observational programmes on satellites are planned. The United States Naval Observatory and the Yale Observatory are jointly carrying out the discussion of the measurements of a large collection of photographic observations of Saturn's satellites made with the Yale refractor in the southern hemisphere. In the report by Kulikov on satellite work in the Soviet Union the need for systematic observations of satellites is expressed. The reports received indicate that there is no lack of observational activity at the present time. The principal difficulty appears to be with the completion of the measurements, reductions and publication of the results.

DIRK BROUWER
President of the Commission

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20*a*. Sub-Commission on Short-Period Comets

The main work of the sub-commission is to arrange for the calculation of orbits and ephemerides of short-period comets so as to avoid, as far as possible, the duplication of computations. It is therefore of great importance that astronomers who undertake such work aiming at providing a prediction for the next apparition of a comet keep this sub-commission informed whether they will be able to fulfil their obligations. If, for some reason, they should feel unable to do so, the sub-commission should be notified of this failure at the earliest possible moment. It may then be possible to have a serviceable prediction produced through the agency of the very helpful computers of the British Astronomical Association.

Computers are also reminded that they should make known to the Telegram Bureau of the International Astronomical Union their intention to provide a prediction; this Bureau will then insert a notice on the *I.A.U. Circulars* (address: Observatory, Östervold 3, Copenhagen K, Denmark). Such a notice will help computers to get in touch with observers who may provide them with necessary observations for a satisfactory revision of first or preliminary orbits and thus ensure a reliable prediction. Some observers, for instance Professor van Biesbroeck, are of remarkable help in their observational work, as they try to follow the comets over the longest possible arc.

The following table lists the comets for which the sub-commission has had information that revised orbits or predictions are being computed.

	Name of comet	Period (years)	Last apparition seen	Next apparition	Computer
1.	Encke	3·3	1954	1957	Makover (Luss)
2.	Grigg-Skjellerup	4·9	1952	1957	(Dinwoodie)
3.	Honda-Mrkos-Pajdusáková	5·0	1954	1958	Schmitt (Merton)
4.	du Toit 2	5·3	1945	1955	Hurukawa
5.	Tempel 2	5·3	1951	1957	(Luss)
6.	Neujmin 2	5·4	1926	?	Mitrofanova
7.	Schwassmann-Wachmann 3	5·4	1930	?	Astr. Inst. Leningrad
8.	Tuttle-Giacobini-Kresák	5·5	1951	1956	Kresàk (Foxell, Goodchild)
9.	du Toit-Neujmin-Delporte	5·5	1941	1957	Boyeva
10.	Tempel 1	6·0	1879	?	Schrutka-Rechtenstamm
11.	Pons-Winnecke	6·1	1951	1957	(Porter)
12.	Kopff	6·2	1951	1957	Képinski
13.	Tempel-Swift	6·3	1908	1957?	Ramensky(?), Kanda

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	Name of comet	Period (years)	Last apparition seen	Next apparition	Computer
14.	Harrington-Wilson	6·4	1951	1958	(Beart, Merton)
15.	Forbes	6·4	1948	1955	(Beart)
16.	Harrington (Wolf 2?)	6·5	1952	1958	Wiśniewski
17.	Schwassmann-Wachmann 2	6·5	1955	1961	Rasmusen
18.	Reinmuth 2	6·6	1954	1960	Rabe (Calway)
19.	Giacobini-Zinner	6·6	1946	1959	Dinwoodie
20.	d'Arrest	6·6	1950	1956	Recht (Calway)
21.	Wirtanen	6·7	1954	1961	Merton, Kanda
22.	Daniel	6·8	1950	1957	(Hirose and Takenouchi, Sumner)
23.	Harrington 2	6·9	1953	1960	(Brady)
24.	Brooks 2	6·9	1953	1960	Dubyago
25.	Finlay	6·9	1953	1960	(Merton)
26.	Borelly	7·0	1953	1960	(Sumner)
27.	Holmes	7·0	1906	?	Koebcke
28.	Faye	7·4	1955	1962	Zseverzsev
29.	Wolf 2	7·6	1924	1955	Kanda, Przybylski
30.	Reinmuth 1	7·7	1951	1958	Kanda
31.	Jackson-Neujmin	8·0	1936	1962	Poulkova
32.	Oterma	8·0	Observed every year		Oterma, Herget
33.	Schaumasse	8·2	1952	1960	(Sumner)
34.	Wolf 1	8·3	1950	1959	Kamienski
35.	Comas Solá	8·6	1952	1961	Vinter Hansen
36.	Väisälä	10·5	1949	1960	Oterma
37.	Gale	10·8	1938	1960	(Dinwoodie)
38.	Neujmin 3	10·9	1951	1962	(Julian)
39.	Tuttle 1	13·6	1939	1967	(Dinwoodie)
40.	Van Biesbroeck	14·1	1954	1968	(Cunningham)
41.	du Toit 1	14·8	1944	1959	Bobone
42.	Schwassmann-Wachmann 1	16·3	Observed every year		Herget
43.	Neujmin 1	17·7	1948	1966	Poulkovo (Luss)
44.	Crommelin	27·8	1928	1956	(Porter)
45.	Stephan-Oterma	38·0	1942	1980	Oterma
46.	Westphal	61·7	1913	1975	Koebcke
47.	Olbers	69·6	1887	1956	Rasmusen
48.	Pons-Brooks	71·6	1954	2025	Herget
49.	Halley	76·0	1910	1986	Bobone
50.	Herschel-Rigollet	156·0	1939	2095	Rigollet

Names placed in brackets mean that the computer has provided an orbit for the last apparition or return of the comet or proposes to do so, and it is hoped that he will provide the prediction for the coming apparition, although he has not directly said so.

The following comets which are expected to return shortly appear to be in need of computers to obtain accurate or definitive orbits for them. It is expected that computers of the B.A.A. will provide provisional predictions for these and some of the other comets.

				Computers of provisional predictions
Johnson (1949 II)	6·9	1949	1956	Julian
Whipple (1948 VI)	7·4	1948	1956	Dinwoodie
Ashbrook-Jackson (1948 IX)	7·5	1948	1956	Candy, Beart
Shajn-Schaldach (1949 VI)	7·8	1949	1957	Foxell, Goodchild

Astronomers who wish to provide accurate predictions for these four comets, or any other periodic comet not yet taken care of, are kindly requested to make their intentions known to the President of the sub-commission.

JULIE M. VINTER HANSEN
President of the Sub-commission

Report of meeting. 2 September 1955

PRESIDENT: Prof. D. Brouwer.

SECRETARY: Dr P. Herget, with the assistance of Dr S. Arend.

Arend also served as interpreter during the first hour, until the arrival of Mrs S. D. Gossner. The President regretfully remarked upon the death of three members: B. Asplind, T. Banachiewicz and A. O. Leuschner. The President presented an agenda, which was adopted.

Comets

A proposed change of the name of the sub-commission to 'Orbits and Ephemerides of Comets' was presented. Merton and Hirst suggested other shortened names. Since no formal resolution was required, the President announced that the final decision would be influenced by the opinion of the General Secretary. The Chair announced the request of Miss Julie Vinter Hansen to retire from the presidency of the sub-commission. The secretary recorded the indebtedness of the commission to her for more than fifteen years of patient, effective, and devoted service in providing for cometary prediction computations. Her latest report is contained in the Draft Report.

The Chair announced that Dr J. G. Porter had consented to accept the vacant position. Porter expressed his high esteem of Miss Vinter Hansen's work and his dependence upon all collaborators for the success of the programme. He described the proposed general comet catalogue to be prepared by the British Astronomical Association in accordance with the resolution adopted at the last meeting in Rome. The following resolution was adopted unanimously:

Commission 20 approves the proposal of the British Astronomical Association to publish a comprehensive general catalogue of comet orbits, replacing Galle's Kometenbahnen, with complete modern data. The Commission recommends that the sum of 1400 dollars be granted to the British Astronomical Association to defray in part the cost of publishing this catalogue.

Herget described the possibility of his providing perturbation computations, made on a small electronic computer, to anyone working on short-period comet orbits. Porter described the forthcoming volume of Planetary Co-ordinates from 1960–80; the Introduction will contain a comparison of various methods of perturbation computations. Merton presented a communication from Kamieński recommending the joint formation of a sub-commission between 20 and 41 to deal with the use of Halley's Comet in establishing ambiguous chronological times. It was moved and carried to transmit this communication to Commission 41. Witkowski announced the formation by the Polish Academy of Sciences of a sub-commission on Short Period Comets, with Kepiński as president, Kamieński, and Bielichi.

The Draft Report on Short-Period Comets was adopted.

The Draft Report on Minor Planets was adopted with one modification introduced by Nemiro.

Observations

The Chair announced that Commission 7 had adopted the resolution proposed by Herrick and printed on p. 102 of this volume, and had recommended it to the attention of observers in Commission 20. Herget commented on the objections of observers to the tardy appearance of the Minor Planet Circulars. A concerted effort must be made to reverse the vicious circle which exists, and the observers must begin by transmitting information more rapidly. Edmondson reported on the Indiana observing programme, which is directed toward the recovery of objects on the critical list. Fricke proposed the following resolution, and it was adopted unanimously:

Commission 20 recommends that the observational programme of minor planets which has been undertaken by Dr Edmondson and his associates at the Goethe Link Observatory of

Indiana University should be continued in the future, because of its importance for the recovery of objects that lack sufficient observations. It is hoped that continuing financial support will be received.

Chang reported on the recent work of the Nanking observatory.

Computations

Herget reported on the agreements reached at a preliminary meeting for the assignment of ephemeris computations. Leningrad has accepted 105 planets formerly on the Heidelberg list, and a few other individual planets may be shifted upon agreement with the Minor Planet Centre. Otherwise, the lists remain much the same as formerly. Fricke described an agreement between Heidelberg and Leningrad whereby some of the ephemeris computations would be performed by the latter, thus leaving Heidelberg free to complete more improvements of the elements.

Herget reiterated the opportunities described in the Draft Report for collaboration in securing electronic computations from Cincinnati. Michkovitch inquired about a comprehensive plan for ephemerides of unnumbered planets. Herget described Rabe's new graphical representation of all data concerning such planets. Rabe requested co-operation in securing ephemerides for unnumbered planets from other computers. The graphical representation includes nearly all planets which have been observed more than two times.

Publications

Fricke described the plans of the Astronomisches Rechen-Institut to publish an up-to-date edition of the 'Identifizierungnachweis' before 1957. Herget announced that a collection of elements of all unnumbered planets would be published at Cincinnati if other collaborators would search the literature other than the A.N. and the M.P.C.'s. In particular, Subbotin offered to collect and transmit the information from Russian literature as soon as possible. Fricke assured the co-operation of the Astronomisches Rechen-Institut.

Brouwer remarked upon the appearance of the 1956 ephemeris volume with the planet names given in latin letters, following the request formulated at the last meeting. The appreciation of this change by all members of the commission was expressed by generous applause.

Rabe urged the transmission of information to the Centre so that provisional designations can be assigned. Brouwer reaffirmed the importance of transmitting all data for inclusion in the M.P.C.'s so that they may truly become a complete repository of all minor planet information. Schmitt discussed the need for immediate and extended ephemerides of newly-discovered objects, and Herget offered to compute these if the observations are transmitted promptly.

Brouwer discussed the need for some form of publication of the extensive electronic computations and differential corrections which are being carried on; and Herget described the possibilities if microfilm is used. The following resolution was adopted:

Commission 20 recommends that the Minor Planet Centre in Cincinnati continue issuing the Minor Planet Circulars, and that a sum of 750 dollars per annum be made available to the Minor Planet Centre for defraying the necessary expenditure.

Arend paid a tribute to the high value of the Yale and Hamburg star catalogues in positional work, but stressed the need for the most accurate proper motions attainable.

Brouwer expressed his thanks to the members of the commission for their co-operation during his term, which is now concluded. The Secretary expressed the sentiments of the members in commending Brouwer for his patience and persistence in prosecuting the work of the commission, especially during the trying times in the early years of his term.

There was generous applause as the meeting adjourned.