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

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INTRODUCTION

The outstanding feature of minor planet research during this triennium has been the completion of orbit improvements on a large scale, both by the Institute of Theoretical Astronomy at Leningrad and by the Cincinnati Observatory. This in turn improves the accuracy and the reliability of the published ephemerides. The increasing impact of the more widespread use of electronic computers is also becoming evident. Much good continues to come from the work of Dr O. Kippes in establishing identifications; and L. Boyer has rejuvenated the program of identities of the late A. Patry. Also considerable recent success along these lines has come from C. M. Bardwell at Cincinnati. The dominant problem continues to be in the area of observations. One reason is that nearly all significant observations now need to be in the range of one or two magnitudes fainter than have formerly been useful. Another is that the efforts to secure a suitable instrument for conducting another survey such as the Yerkes-McDonald survey of 1950–52 have not been successful as yet.

The number of MPC's issued during this three-year period is more than double that of the previous one. From 1961–63 the Cincinnati Observatory computed 154 sets of improved elements of numbered planets. During 1964–66, the Institute of Theoretical Astronomy at Leningrad computed 415 sets (1, 2, 3, 4, 5), and the Cincinnati Observatory computed 242 sets (6), as well as 129 sets for unnumbered planets (7). In passing, we should inscribe a special tribute to the NORC, the Naval Ordnance Research Calculator at Dahlgren, Va. It is estimated that during the 12-year lifetime of this electronic calculator it calculated 10^{10} individual arithmetic operations for the benefit of minor planet research and more than 15 000 extended opposition ephemerides.

Contributions to this draft report have been received from S. Arend, L. Boyer, J. Bruwer, F. K. Edmondson, T. Gehrels, A. Gutierrez-Moreno, S. Herrick, P. Jackson, T. Kiang, J. Kovalevsky, L. Krésak, S. G. Makover, B. G. Marsden, V. V. Michkovitch, B. Milet, L. Oterma, E. Rabe, E. Roemer, G. Schrutka-Rechtenstamm, J. Schubart, C. J. Van Houten, G. A. Wilkins, and H. Wood. In the area of comets, the draft report has been prepared separately by Dr Elizabeth Roemer.

OBSERVATIONS

Observations with the 10-inch Cooke triplet at the Goethe Link Observatory have been at a gradually declining rate (426 plates in 1963, 313 in 1964, and 216 in 1965) but the rate has

https://doi.org/10.1017/S0251107X00030492 Published online by Cambridge University Press

fallen off even more in recent months, due to the lack of personnel who are interested in this program. The number of accurate positions which have been requisitioned in support of the improvement of elements has increased sharply (more than 300), and such requests may be expected to continue for some time to come. Mrs B. Potter retired in June 1966, and this will adversely affect the program because she has blinked and measured all the plates during the last 17 years.

Somewhat in compensation, an observing program with a 40 cm *f*/4, astrographic camera (100 square degrees) was initiated in 1964 at the Crimean Astrophysical Observatory. In 1965, 92 plates were obtained, with a total of 449 minor planet positions. The plate reductions are computed on the BESM-2 electronic computer by the Institute of Theoretical Astronomy, mainly based on reference stars from the Yale Zone Catalogues. This rate of activity may well be doubled in future years. Observations also continue at Abastumani, Alma-Ata, Tartu, Tashkent and other places (**50** to **69**, incl.). The program of observations of ten selected minor planets for determination of the systematic errors of fundamental catalogues continues successfully. Pulkova, Moscow, Kiev, Tashkent, Nikolajev and several observatories outside the U.S.S.R. all contribute their observations to ITA (**70, 71, 72, 73, 74**). To date about 5000 observations have been collected and the $(O - C)$'s and normal places have been formed. Pulkova has measured and reduced the plates from the Cape Observatory (**75, 76**). This program will be carried through three complete revolutions of each planet, and it will be completed by 1969.

Other observatories which have observing programs for minor planets report as follows. At Uccle, observations with the 40 cm double astrograph continue as in former years, at a rate of about 250 accurate positions per year (**77** to **82**, incl.). It is planned to transfer this instrument to a better observing site. The IBM-1620 has been programmed by H. Debehogne and G. Roland to compute accurate plate reductions and checks by Arend's method (**8**), preliminary orbits by the Gauss-Encke method, orbit improvements by variation of geocentric distances, parabolic orbits by the method of Olbers-Banachiewicz, and ephemerides and residuals. At the Republic Observatory, Johannesburg, about 200 accurate positions per year are obtained, and 64 positions were accurately reduced from older plates. The program is aimed at objects brighter than 15·8 magnitude and south of $-20°$. Comets brighter than 14th magnitude are observed in the southern hemisphere (a total of 24 positions). At Santiago, Chile, a Gauthier astrograph was newly mounted in March 1965, and thus far 140 plates have been taken for the planets of the Pulkova program, and (1), (2), (3), (4), and (51). Skalnaté Pleso initiated a program in 1966 with a new 30/150 cm Zeiss Vierlinser. At Turku the 500/1031 mm Anastigmat has been removed because of site deterioration and it is expected to be remounted 27 km to the east. At Tuorla (12 km east of Turku, long. $1^h 29^m 46^s$E, lat. $+60° 24' 57''.5$) an anastigmatic reflector 380/380/1031 mm has been mounted, and test plates reached 16·7–17·0 phot. magn. Another reflector (700/700/1719 mm, with full correcting plate) is not yet finished. A list of 1000 accurate positions from Turku plates during 1938, 39 has been prepared by Mrs Rantaseppa. Miss Roemer's observing program at Flagstaff has been concluded and published (**83, 84, 85**). Her new prospects at Tucson include the use of the 61-inch, *f*/13·5 reflector in the Catalina Mts., a 7-inch, *f*/7 Bailey astrograph, and other instruments in the area and at Kitt Peak. At Sydney, Australia, Wood, Robertson, and Sims continue a program of observing all even-numbered minor planets in the southern hemisphere within their magnitude capability, as well as special observing of selected objects for use in fundamental astronomy (**86** to **91**, incl.). It was presumed that the odd-numbered minor planets would be observed at La Plata, but their contributions have greatly diminished in recent years. At Wein, Paul Jackson has undertaken to measure accurately about 500 old plates which are on file, and the reductions will be carried out in cooperation with the Cincinnati Observatory. At Nice, the Zeiss double astrograph has been used by B. Milet since July 1965 to obtain 247 plates with 1071 positions of 200 numbered minor planets, and 38 positions of two comets. He has established a least

https://doi.org/10.1017/S0251107X00030492 Published online by Cambridge University Press

squares reduction program using Cracovians which permits the determination of the constants to the 6th order.

The Palomar-Leiden survey of faint minor planets has reached the stage where ambiguities of identification have been settled for the vast majority of objects and the elements have been computed. One comet was discovered (9). Some plates were re-examined with the help of search ephemerides, and 38 additional objects were found. The remaining objects which afforded only indeterminate orbits will be examined with the view to determining an approximate distance, for photometric purposes. In 1965 six plates were taken by Dr T. Gehrels on the 48-inch Palomar Schmidt, covering two fields in the neighborhood of one of the Trojan libration points. These will be examined at Leiden in the same manner as were the previous plates.

Dr T. Gehrels determined a photoelectric light-curve for the Trojan (624) with the Kitt Peak 84-inch during February 1964. The amplitude of the light-curve is 0·2 magnitude, which is to be compared with the amplitude of 0·8 magnitude found, at the Radcliffe 74-inch, in April 1957. The Trojan apparently has a large obliquity, similar to an effect found for the common asteroids (10). During 1965, C. J. Van Houten and I. Van Houten-Groeneveld determined photoelectric light-curves with the 36-inch at Broederstroom, South Africa, for (2), (19), (22), (23), (24), (28), (29), (43), and (54). Also (349) and (354) were observed for the determination of their phase function. Using an additional 1500 magnitude determinations made at Indiana by Mrs D. Owings, Gehrels has prepared an improved list of minor planet absolute magnitudes for approval and adoption, to replace the list adopted in Moscow in 1958. An additional intercomparison of 400 Indiana magnitudes with the Yerkes-McDonald survey of 1950–52 substantiates that the variation of brightness is inversely as the square of the heliocentric distance over the range from 2·2 to 3·1 A.U. (exponent is 2·00 ± 0·02).

ORBITS, EPHEMERIDES

The ITA continues to publish the annual ephemeris volume in the same satsifactory format as in previous years (11, 12, 13). All ephemerides are based upon special perturbations unless the elements are designated by A (for absolute or general perturbations) or E (for elliptic orbit or no perturbations). Some planets, marked L, are considered to be lost and no ephemerides are given. In 1967, those not computed at the ITA or the Latvian State University are credited as follows: Cincinnati 230, Tokyo, 60, Shanghai 60, Purple Mt. 5, Herrick 4, J. Schubart 1, P. Naur 1. At ITA the computations are mostly by Cowell's method, including Jupiter and Saturn. All computations on the NORC are by the variation of vectorial constants at a 20-day interval, including all major planets from Venus to Neptune.

Two different methods for the improvement of orbits are used at the ITA (14). In the first method only accurate observations are used. This provides improved orbits with a precision comparable to that of the observations. The second simplified method deals with approximate observations, and is convenient for a preliminary improvement of orbits having large $(O - C)$'s, either not observed for many years, or having an insufficient number of accurate observations. Systematic work on the improvement of orbits of such planets is now in progress. Unfortunately the number of planets not observed in the last 10 years has not only not decreased but has actually increased. In the 1967 volume, 170 such planets have been listed. The increase in the number of such planets is probably the result of a general diminuation of observations throughout the world.

At the Cincinnati Observatory there is only one orbit improvement method, which is programmed for the IBM-1620. It allows the operator complete flexibility to reject unsatisfactory observations. Approximate positions are not used if it is possible to have the position remeasured accurately, and sometimes approximate positions are excluded simply because they increase the probable error of the solution. Herget has also programmed the IBM-1410

https://doi.org/10.1017/S0251107X00030492 Published online by Cambridge University Press

to compute perturbations at intervals of 4-, 10-, 20-, or 40-days, with any selection of major planets from Mercury to Pluto. The Minor Planet Center has a quick-response capability for computing preliminary orbits on the IBM-1620, using as many observations as may be available (**15**). Orbits for newly discovered objects are also computed at various other places (**16** to **21**, incl.).

At the Latvian State University at Riga, M. A. Dirikis has programmed the BESM-2 for accurate numerical integrations, including perturbations by seven major planets, and also programs for comparison of observations and orbit improvements. Orbits for about 40 planets have been improved and the ephemerides are calculated until 1975. At Heidelberg, J. Schubart has used his program on the Siemens 2002 to compute the orbit of (1221) Amor, using all the observations in five apparitions since 1932. The mass of the Earth had to be introduced as a seventh unknown. It turned out that Amor offers a reliable way to determine the mass of the Earth. The value obtained agrees closely with the result found from radar observations.

This work is one of three examples which have recently required the introduction of a new concept into orbit correction processes, namely the integration of the variational orbit. Schubart found that the successive differential corrections did not converge, simply because the usual method of computing the partial differential coefficients is inadequate. A similar condition was experienced by Cohen and Hubbard when they undertook to improve the orbit of Pluto. The resulting residuals showed a systematic trend with the period of Jupiter, and a satisfactory result was impossible until the variational orbit was integrated. At Cincinnati, Herget has completed a large portion of the work on the orbits of the outer satellites of Jupiter, where the integration of the variational orbit was included as a principal part of the main program. The differential corrections proceeded in a highly satisfactory manner. This problem and other related ones have also been studied by V. A. Izvekov (**22**, **23**, **24**).

Herrick has provided all the appropriate ephemerides for the close-approach planets, (1566), (1580), (1620), and (1685). Special observations of Icarus were secured at Pretoria in 1966 June and July, and this will strengthen the prediction for the passage in 1968. L. Boyer is engaged in searching for identifications, especially utilizing the circular elements published by the late A. Patry (**25**). Michkovitch reports: (1) The list of the mean periods of quasi-identical oppositions has been completed with the new numbered asteroids; (2) Card catalogues have been completed for the elements Ω, i, a, Φ, ω, ordered according to their ascending values; (3) Studies have been continued of the peculiarities and interesting proximities of quasi-coplanar orbits. Bardwell has recomputed the preliminary orbits of many minor planets with a view to providing reliable ephemerides, both for the past and the immediate future, to aid in identifications and recoveries.

At the Bureau des Longitudes, Paris, Kovalevsky has resumed work on a general theory of Jupiter VIII, aided by a recent series of observations by Miss Roemer. He has also started a general analytical theory of Nereid, for which observations are urgently needed. A. Bec is engaged in a discussion of all the observations of Jupiter's outer satellites VI to XII, which is expected to yield a new determination of the mass of Jupiter. Theoretical work on the motion of the Galilean satellites has been started under S. Ferraz Mello (**26**). A program of photographic observations is being developed, and G. Billaud has made photoelectric observations of eclipses. B. Morando (**27**) has derived a numerical general theory of the motion of Vesta without any secular or mixed terms. A comparison of the theory with observations is to be started soon.

Herget's program for the numerical integration of the orbits of the outer satellites of Jupiter has yielded excellent agreement with observations for Jupiter VIII, Jupiter IX, Jupiter XI, and Jupiter XII, and all the ephemerides have been computed until 2000 A.D. The orbit of Jupiter XII is weakly determined because of the paucity of observations since its discovery in 1951. There is still some problem with the determination of the mass of Jupiter and this must be

https://doi.org/10.1017/S0251107X00030492 Published online by Cambridge University Press

examined further. J. D. Mulholland has developed a program for deriving a general numerical theory for Jupiter VI, based on rigorous differential equations and successive iterations. Several iterations have been completed, and the results continue to improve, but the agreement with observations is not yet satisfactory.

GENERAL

G. A. Wilkins (**28**) has continued his studies of the orbits of the satellites of Mars. He has obtained orbital elements for Phobos and Deimos by an analysis of all suitable observations from 1877–1928 and has obtained revised estimates of the mass and dynamical flattening of Mars; the values do not differ significantly from those obtained in earlier discussions of such orbital data. He also found that the new orbital elements give a satisfactory fit to observations made in 1941 and 1956 without the postulation of a secular acceleration in the motion of Phobos.

T. Kiang (**29**) has examined the problem of observational selection in the statistics of the orbital elements of asteroids. Reasons are given for believing that the discovery of asteroids, unsystematic as it has been, is nevertheless practically complete down to magnitude 14–15; beyond this we have to reckon with three selection factors (brightness, latitude and seasonal) and their interactions. A technique of 'discovery sequence' is found effective. It is then inferred that selection has caused (A) an overabundance of small inclinations and a spurious second harmonic in the frequency distribution of nodes among asteroids fainter than magnitude 15, and (B) an overabundance of large eccentricities among those fainter than magnitude 16. Inference (A) fully resolves the age-long controversy, initiated by Kleiber in 1886 (**30**) and Bauschinger in 1901 (**31**), over the question whether or not the distribution of nodes agrees with the predictions of the perturbation theory. The well-known discrepancy between observation and theory in the case of the distribution of perihelia is shown to be largely an indirect effect of (B), rather than due to seasonal factors as first conjectured by Brunn in 1906 (**32**); but part of discrepancy remains in the sense that the displacements in the (e,π) plane of the centers of revolution should be some 30% greater than hitherto calculated. There is also a significant, positive correlation between proper eccentricities and inclinations, which suggests the former existence of a resisting medium.

L. Krésak has investigated asymmetries in the asteroid belt, and determined its inner boundary and the elliptic elements of the center. The non-uniformities in the distribution of asteroids in heliocentric latitude and longitude, found by Narin, are explained by observational selection and alignment of the lines of apses to that of Jupiter. This alignment governs the radial asymmetry of the belt in that it produces differences in the asteroid density at the same heliocentric distance but different heliocentric longitude by as much as one order of magnitude. Some implications of this phenomenon are briefly discussed: the region of maximum probability of collisions able to yield Earth-crossing orbits, the seasonal variation of meteor impact on Mars and space probes launched to Mars, and seasonal variation of the discovery conditions of faint asteroids moving in eccentric orbits.

Rabe's work is reported, in part, in Commission 7. In collaboration with Mrs M. P. Francis, he is extending the former work on Eros, including many additional observations up to 1966 and a new integration program for the motion, including the relativity effect on the perihelion.

Herrick has examined and summarized the problem of universal variables for two body motion, differential correction formulas, and the variation of parameters (**33**). He has also discussed two problems associated with the Gaussian constant as it applies to heliocentric and geocentric orbits (**34**, **35**). Annual reviews of minor planet problems have been prepared by N. S. Yakhontova (**36** to **40**, incl.).

Other general works which deal with problems concerning minor planets will be found in the following references (**41** to **49**, incl.).

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PROPOSALS

Gehrels proposes the adoption of a new list of absolute magnitudes of the numbered minor planets, to supplant the one adopted in 1958, since the new list will be based on more observations and include recently numbered planets. Presumably the material will be fully prepared by the time of the meeting in Prague.

The question of how to activate effective observing programs reaching to one or two magnitudes fainter than has routinely been achieved in the past will be an important subject of discussion. Chebotarev proposes an annual subsidy for a special program with the 40 cm astrograph of the Crimean Astrophysical Observatory. More details will be available at the time of the meeting.

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REPORT OF THE WORKING COMMITTEE ON ORBITS AND EPHEMERIDES OF COMETS

CHAIRMAN: E. Roemer.

MEMBERS: Candy, Kępiński†, Kresák, Makover, Porter.

GENERAL

With the widespread availability of electronic computing facilities, a decreasing proportion of the efforts of those engaged in study of the dynamical properties of comets is required to be devoted to routine calculations of perturbations and ephemerides. Almost all current predictions for returns of periodic comets are based on improved starting orbits and allowance is made for perturbations due to most of the major planets. Two or more independent predictions are available for a gratifying number of returning comets. In an increasing number of cases, several returns have been linked, leading to a greater reliability of the predicted positions.

Especially noteworthy have been the recoveries of three 'long-lost' periodic comets, two of them (P/Holmes, P/de Vico-Swift) as a direct consequence of studies by Marsden (**1**). Investigations by Schubart contributed to the recovery of P/de Vico-Swift and were basic to the recovery of P/Tempel-Tuttle, associated with the Leonid meteors (**3**). Adequate searches should be made for several other objects at appropriate times.

Satisfactory progress is being made toward computation of general orbits of adequately observed nearly parabolic comets. These general orbits have in turn been used in several investigations of original and future orbits. A word of caution may be in order, however, in interpretation of general orbits based on only a short observed arc, from which the eccentricity often is only very poorly, or not at all significantly determined.

A Supplement to the Catalogue of Cometary Orbits, 1960, has been published (2) under the sponsorship of the British Astronomical Association, aided by a subvention from the IAU.

ASTROMETRIC OBSERVATIONS

A useful adjunct of transfer of the Telegram Bureau to the Smithsonian Astrophysical Observatory has been the availability of the Baker-Nunn cameras of the SAO satellite tracking stations in obtaining rapid confirmation of newly discovered brighter comets and early approximate positions of useful accuracy. The value of this network has been repeatedly demonstrated.

Important series of observations of brighter comets have been obtained during the triennium at the following observatories:

Abastumani
Alma-Ata
Armagh
Ascot
Ashkhabad
Athens
Barcelona (Fabra)
Bloemfontein (Boyden Sta.)
Bordeaux (Floirac)
Bucharest
Burakan
Canberra (Mt. Stromlo)
Cleveland (Case Inst.)
Mayaki (near Odessa)
Meudon
Nanking
Nice
Prague
Pulkovo
San Juan (Yale-Columbia Sta.)
Saratov
Simeis
Córdoba
Cracow
Dresden
Dushanbe
Flagstaff (Lowell Obs.)
Flagstaff (U.S. Naval Obs. Sta.)
Goloseyevo
Johannesburg (Hartbeespoort Annexe)
Heidelberg-Königstuhl
Kazan
Khabarovsk
Kiev
Leiden
Skalnaté Pleso
Sonneberg
Tartu
Tashkent
Tautenberg
Tucson (Catalina Sta.)
Tokyo (Mitaka, Dodaira, Okayama)
Uccle
Vienna
Washington (U.S. Naval Obs.)

In several cases valuable assistance with plate measurements and reductions is provided by one observatory to another. The Boyden Observatory acknowledges important help from Uccle, while the Cincinnati Observatory regularly assists several observatories with dependence plate reductions.

The amount of time available with major instruments for long-focus astrometric work, especially on fainter comets, minor planets, and satellites, leaves much to be desired. The observed orbital arcs of comets often can be extended by many months, minor planets can be followed longer and at less favorable oppositions, and the faint satellites of major planets can be recorded only with those large telescopes already under great pressure from observing-time demands of other programs. The importance of the longest possible accurately observed arcs to improvement of orbital elements, both of periodic and of nearly parabolic comets, can hardly be overemphasized.

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So far as is known, important regular assignments of time for long-focus astrometric observations of the fainter comets are being made currently at only two centers:

Tokyo–Dodaira 36-inch, *f*/5 reflector (Hirose, Tomita, Kozai)
Okayama 74-inch, *f*/4·8 reflector (Hirose, Tomita, Kozai)

Tucson–Catalina Station 61-inch, *f*/13·5 reflector (Van Biesbroeck, Roemer)

The skilful use of the 24-inch *f*/5 reflector at Skalnaté Pleso, an appreciably smaller telescope than those mentioned above, in following comets over the longest possible arc, deserves special mention.

Several important lists of position have been published (**4–10**) in addition to those reported to the IAU Central Bureau.

ORBITS OF SHORT-PERIOD COMETS

With the widespread application of electronic computers to the work of prediction, it has become possible to devote more attention to improvement of starting orbits and to accounting more precisely for perturbations, with resulting greater accuracy of current ephemerides. Orbits of several short-period comets have been improved by linking accurately observations

Table 1

Short-period comets—current predictions

Encke	Makover 1963, *Comet Circ.* (*Kiev*) 4.
	Kastel 1967, *Handbook, Brit. astr. Assoc.*
Grigg-Skjellerup	Sitarski 1966, *Acta astr.*, **16**, 209.
Tempel 2	Marsden 1967, *Handbook, Brit. astr. Assoc.*
Neujmin 2	Marsden (**1**).
Brorsen	Marsden (**1**).
Tuttle-Giacobini-Kresák	Lea and Milbourn 1967, *Handbook, Brit. astr. Assoc.*; Kresák MS.
Tempel-Swift	Marsden (**1**).
Tempel 1	Marsden (**1**); Schrutka-Rechtenstamm MS.
Forbes	Marsden 1967, *Handbook, Brit. astr. Assoc.*
Perrine-Mrkos	Hirose
Schwassmann-Wachmann 2	Rasmusen ?; Marsden MS.
Biela	Marsden (**1**).
Wirtanen	Julian, Marsden 1967, *Handbook, Brit. astr. Assoc.*
Reinmuth 2	E. Rabe, Ainslie and Christison and Delo 1967, *Handbook, Brit. astr. Assoc.*
Brooks 2	Wilson and Freeman, Buckley 1966, *Handbook, Brit. astr. Assoc.*
	Vorobjev 1966, *Bull. Engelhardt Obs.*, Kasan; 1966, *Comet Circ.* (*Kiev*) 39.
Harrington 2	Wilson, Marsden 1967, *Handbook, Brit. astr. Assoc.*
Finlay	Porter and Candy 1967, *Handbook, Brit. astr. Assoc.*
Borrelly	Christison and Delo 1966, *Handbook, Brit. astr. Assoc.*
Harrington-Abell	Hasegawa
Arend	Lea and Milbourn 1966, *Handbook, Brit. astr. Assoc.*
Wolf 1	Kamienski and Sitarski 1967, *Acta astr.*, **17**; Harbour, Egerton 1967, *Handbook, Brit. astr. Assoc.*
Tuttle	Abalakin and Belyayev 1966, *Comet Circ.* (*Kiev*) 38; Cundall and Marsden 1966, *Handbook, Brit. astr. Assoc.*; F. Narin 1953, *IAU Circ.*
Neujmin 1	Raudsaar 1966, *Comet Circ.* (*Kiev*) 37.
Halley	Zadunaisky 1966, *Astr. J.* **71**, 20; Brady MS.

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at several perihelion passages (**13, 15, 24, 33, 34**). Further studies of P/Halley have been made by Kamieński (**16**), and special studies of P/Brooks 2 by Kastel (**17**), of P/Wolf 1 by Kazimirčak-Polonskaya (**21, 22**), P/Kopff by Kępiński (**23**), of P/Tempel 1 by Schrutka-Rechtenstamm (**31**). Significant basic work on the orbits of certain comets of interest as possible targets of space probes has been done under contract with the U.S. National Aeronautics and Space Administration (**14, 28, 29, 30**), or for the European Space Research Organization (**32**).

Marsden reports that a preliminary study has been made of the past histories of the short-period comets of more than one apparition, using the *n*-body integration program written by J. Schubart and P. Stumpff; it has been established that the comet observed by La Hire in 1678 was not P/de Vico-Swift, as Leverrier supposed. Marsden also proposes to study further the past histories of the short-period comets for data of statistical use in trying to understand their orbital evolution. A careful study of certain comets, especially P/Encke and P/Pons-Winnecke, is to be made, independent of previous or intended work by other investigators, to examine further the question of non-gravitational effects.

Sitarski reports that programs to carry out almost all the orbital computations by digital computer have been prepared. It is intended to investigate non-gravitational anomalies in motions of periodic comets by a linkage of several appearances of the comet. Detailed investigations of the motion of P/Wolf 1, Kopff, and Grigg-Skjellerup are to be undertaken.

An extensive study of the effects of the outer planets on the evolution of the orbits of well-studied short-period comets over an interval of 400 years is being made by Belyayev (**11, 12**) and by Kazimirčak-Polonskaya (**18, 19, 20**).

Kresák (**25, 26**) discusses effects of commensurability in the system of short-period comets, while Makover (**27**) speculates that the hypothesis of capture of comets may not be sufficient to explain the origin of all comets of short period.

ORBITS OF NEARLY PARABOLIC COMETS

An improved orbit of Comet Everhart (1964 b) has been published by Sekanina (**45**). Sitarski (**48**) has studied the circumstances of the close approach of Comet 1759 III to Jupiter.

Definitive orbits have been computed for nearly parabolic comets by Belous (**36, 37**), Galibina and Barteneva (**41**), Grabner (for Comet Peltier, 1952 VI, MS), Hasegawa (**42**), Mamedov (**44**), and Van Biesbroeck (**50**).

Original and future orbits of additional comets have been investigated by Barteneva (**35**), Galibina (**39, 40**) and Sekanina (**46**). Sekanina also has studied the apparently slightly hyperbolic orbits of comets as related to Oort's hypothesis of a cloud of comets at great distance from the Sun (**47**).

Steins and Kronkalne (**49**) examined changes in orbital elements for a complete passage of a comet through the planetary system.

Loss of long-period comets from the solar system has been the subject of investigations by Lyttleton and Hammersley (**43**) and by Brady (**38**). Brady reports that additional nearly parabolic orbits have been integrated subsequent to his published report, to total 100 comets now investigated. It appears that 80% of comets with an osculating eccentricity greater than a critical value of about 1·0003 pick up energy and escape from the solar system.

Marsden reports that it was found from an investigation of the sungrazing comet group that the differences among the orbits of the various members cannot be explained in a simple fashion by planetary perturbations. The family of sungrazers has also been of interest to Harwit (Abstract, Amer. Astr. Soc., Ithaca, N.Y., 1966).

Orbits of long-period comets have been reported under further investigation as follows: 1955 V (Honda) by Hasegawa; 1957 III (Arend-Roland) independently by Hasegawa and by

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Candy; 1957 VI (Wirtanen) by Hasegawa; 1962 VIII (Humason) by Marsden; 1963 III (Alcock) by Sekanina; 1963 V (Pereyra) by Sekanina; and 1963 VIII (Kearns-Kwee) by Marsden.

THEORETICAL INVESTIGATIONS

Mrs Samoilova-Jakhontova has reviewed the orbit work on comets conducted at the Institute of Theoretical Astronomy, Leningrad (**51**).

Dynamical problems of the origin of the comet cloud and of the capture of some objects into orbits of shorter period have been the subjects of papers by Harwit (**52**), Kresák (**53**), Laucenieks (**54**), Makover (**55**), Öpik (**56**), Steins (**57**), Vsekhsviatsky (**58**), Whipple (**59**), and Witkowski (**60**).

COMPUTING TECHNIQUES

Mamedov has modified Olbers' method for determination of a parabolic orbit from three observations by use of the electronic computer BESM-2 (**61**) and applied a method for the determination of a nearly parabolic orbit to Comet Borrelly-Daniel, 1909 I (**62**).

Perlin describes a method for the calculation of perturbations of a comet moving in a very eccentric orbit (**64**) and describes auxiliary tables used in calculations by her method (**63**).

Sitarski reports papers by himself (**65, 66**) and by Ziołkowski (**67, 68, 69**) which are concerned with problems associated with computations of disturbed motion by use of the electronic computer.

PROPOSALS

Probably the most serious and immediate problem is that of assuring adequate observation of intrinsically faint comets and of comets remote from the Sun. It is proposed to discuss the steps that may be taken to encourage astrometric observations of comets with large telescopes. Two questions are involved: (1) telescope time for interested observers, and (2) arrangement for measurement and reduction of plates. Because the only suitable source of reference star positions for long-focus observations is the *Astrographic Catalogue*, often unavailable at newer observatories, endorsement of the efforts of Commission 23 toward reprinting of the Catalogue volumes now out of print and toward calculation of plate constants on a reliable standard catalogue system for all zones could prove helpful.

Marsden has called attention to the potential usefulness of a more complete account of all comets ever observed, including those for which orbits could not be calculated. Pre- and post-discovery ephemerides from improved orbits for at least some objects could prove useful, as, for example, in analysis of photometric data. It may be discussed at Prague whether the large effort required by such a compilation would be justified, and if so, what steps could be taken toward its realization.

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