COMMISSION 20: POSITIONS AND MOTIONS OF MINOR PLANETS, COMETS, AND SATELLITES (POSITIONS ET MOUVEMENTS DES PETITES PLANETES, DES COMETES ET DES SATELLITES)

Report of Meetings, 14, 16, and 21 August 1979

PRESIDENT: B. G. Marsden. SECRETARY: E. Roemer.

14 August 1979

SESSION 1: ADMINISTRATION

Remarking upon the unprecedented 40-minute delay in the opening of the first session of Commission 20, the President opened the meeting and welcomed those in attendance. C. Froeschlé was appointed to serve as interpreter and E. Roemer as secretary. All present stood in silent respect as the names of members and former members who had died during the triennium were read: M. Itzigsohn, V. V. Michkovitch, K. Reinmuth, and A. Schmitt.

The report of Commission 20 for the triennium 1976-78 had been circulated to members of the Commission shortly after its submission for publication in IAU Trans. XVIIA. Several corrections were given in the Commission Circular No. 9.

The list of proposed new members of the Commission, some contingent on election of the individuals to membership in the IAU, as well as the list of consultants for the triennium 1979-82, were introduced by the President. The proposals for new officers of the Commission, G. Sitarski, President, and E. Roemer, Vice-President, and for members of the Organizing Committee, Yu. V. Batrakov, M. P. Candy, F. K. Edmondson (who replaces P. Herget at Herget's request), Y. Kozai, L. Kresák, B. G. Marsden, J. Schubart, G. E. Taylor, and P. Wild, were accepted unanimously. (Kozai, Kresák, and Taylor were confirmed in their capacities as chairmen for the triennium 1979-82 of the Working Groups on satellites, comets, and occultations, respectively.)

Noting that the membership of the Commission now numbers well over a hundred, the President wondered whether mailings to so large a number might become a problem for future presidents. He suggested that some who were no longer active participants in Commission affairs might prefer to retire. It was proposed that three names be dropped because of lack of response to two mailings, and one person resigned because of membership in too many commissions. It was emphasized, in response to a comment, that membership in commissions was a separate matter from membership in the IAU.

The President next reported on the status of several resolutions and proposals that were under active review: (1) Financial support for the Minor Planet Center. A slight increase over the amount for the triennium 1976-79 had been requested. (2) Pursuant to the recommendation approved in 1976, the President was particularly pleased to note that the 1980 volume of Minor Planet Ephemerides, just received from the Institute of Theoretical Astronomy, Leningrad, includes high-precision current osculating elements for all but the lost minor planets through (2095). (3) Separate proposals have been made by T. Gehrels and by M. B. Protitch concerning magnitude data in the opposition ephemerides of minor planets. (4) A request was made by F. K. Edmondson for endorsement of proposals for continuing financial support of the Indiana minor planet program. (5) A proposed restatement of the policy governing naming of minor planets has been submitted by B. G. Marsden in his capacity as Director of the Minor Planet Center. (6) Related proposals concerning the reference system of ephemerides have been made by S. Ferraz-Mello (satellites) and D. K. Yeomans (comets). (7) A question was raised and a proposal made by J. Kovalevsky regarding the matter of requirements and priorities for astrometric observation of minor planets. (8) A resolution concerning space missions to comets, already submitted to the General Assembly by Commission 22, was brought to the attention of Commission 20 by P. R. Weissman. Following considerable discussion of the several proposals, particularly of that concerning space missions to comets, it was agreed that consultations on the matters involved would continue and that refined versions of proposed resolutions would be considered at the second administrative session of the Commission. A straw vote on whether a less desirable alternate mission should be mentioned in the resolution on space missions to comets showed members of the Commission to be equally divided on the question.

SESSION 1 (CONTINUED): MINOR PLANETS

With the President continuing in the chair, scientific reports were then presented as follows:

(1a) T. Gehrels: Magnitude Predictions for Minor Planets — Observational Data. Gehrels first reported briefly on the status of the book on asteroids, which was based on papers presented at the conference in Tucson in March 1979, and also on the current status of the Pioneer flyby of Saturn, which was in progress at the time of the General Assembly. Using as an example observations of *V* vs. phase angle, *B-V* vs. phase angle, and *U-B* vs. phase angle for (6) Hebe, he then explained that the current definition of absolute magnitude involves linear extrapolation to zero phase, without allowance for the opposition effect. Because there are considerable differences among minor planets in the dependence of magnitude on phase, it is proposed to extrapolate the actual magnitude vs. phase relation, including the opposition effect, whenever it is known for individual objects, and otherwise to use a mean phase relation. The net effect of the proposal would be a redefinition of absolute magnitudes such that in 1982 "all asteroids would suddenly become 0.3 mag brighter." In fact, the proposed new definition of absolute magnitudes is already being used in the TRIAD file of data on asteroids and in the book from the Tucson conference.

(1b) E. Bowell: Magnitude Predictions for Minor Planets — Theory. Work by K. Lumme (Helsinki) on the theory of multiple scattering in various surfaces was described. A general theory has been developed through which the magnitude vs. phase angle behavior of objects as diverse as (1) Ceres, (4) Vesta, and the ice-covered Jovian satellite Europa can be represented. A multiple-scattering factor Q_V represents the fraction of multiply-scattered light compared with the total scattered light. A good correlation of Q_V with p_V (0°) indicates that all asteroid surfaces are similar in texture. Bowell stated that he would like to see the adoption of new absolute magnitudes based on the Lumme theory. It was agreed at the Tucson meeting in March to defer a change from the present conventional mag/phase relation of 0.023 mag/degree until 1982, but in fact the conventional relation gives a poor representation of asteroid magnitudes in general.

Because of the divergent points of view being expressed, and particularly because of actions already being taken, the President indicated that he thought it desirable for the Commission to take a position to clarify what was desired with respect to magnitude ephemerides of minor planets in the near term. On a motion by E. Roemer, the statement developed by a committee consisting of T. Gehrels, K. Lumme, B. G. Marsden, E. Roemer, E. Tedesco, and J. G. Williams at the time of the Tucson conference was adopted unanimously: "We recommend that the T. Gehrels and N. Gehrels (*Astron. J.* 83, 1660-1674, 1978) list of asteroid B(1,0), with a phase coefficient of 0.023 mag/degree be used until 1982. Probably, at that time, a change will be made that should be durable."

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(2) Y. Kozai: Asteroids with Large Secular Orbital Variations. Secular perturbations of asteroids for which $(1 - e^2)^{\frac{1}{2}} \cos i < 0.86$ have been computed as functions of the arguments of perihelion. For most asteroids the eccentricities are much changed, so that also the perihelion and aphelion distances are strongly affected. However, for a few of them, including the Apollo-type asteroids, the eccentricities are little affected. These objects resemble short-period comets in their dynamical characteristics.

(3) J. Kovalevsky: What Minor Planets to Observe and How? (Presented by B. G. Marsden.) New objectives, such as the use of minor-planet positions for improvement of star catalogues, observation of occultations to improve diameters and search for companions, physical observations of any kind, and spacecraft rendezvous, have been added to such classical goals in minor-planet studies as structure of the asteroid belt, celestial mechanics, and definition of the reference system. It is necessary to track asteroids so that they can be recovered when specifically needed, but is it necessary to follow them all to high precision? Some of the new programs compete for time on major instruments that are expensive to run. It would be helpful to have priorities stated by the IAU so that those observations may be made that would yield the largest scientific return. Commission 20 might provide a list of objects for which precise positions are needed, for improvement of catalogues, for prediction of occultations, or at risk of loss.

It was agreed that the challenging questions raised by Kovalevsky should be considered at the meeting of the Commission on 21 August.

(4) P. Hemenway: Fundamental Studies of Minor Planets. Minor planets make ideal "test particles" with which to test the global uniformity of existing reference frames. Crossing-point observations were defined as referring to astrometric observation against the same reference star frames but at different times of two minor planets whose apparent paths intersect. Such observations were shown to provide powerful constraints on the solution for orbital elements and system parameters. Reduction of such observations was outlined, and the applicability of crossing-point observations to ongoing observational programs was stressed. Finally, a proposed study of fainter minor planets was described. (See also Hemenway, Herget Symposium, to be published in Celestial Mechanics.)

(5) R. L. Branham: Use of Minor Planets for Determining Equator-Equinox Corrections. Theoretical observations of minor planets 1, 2, 3, 4, 6, 7, 8, 9, and 15 were used to determine mean errors for the equinox and equator of a celestial coordinate system. The observations were calculated for a ten-year period commencing 2 Jan. 1980 under the assumptions that: (1) the minor planets could be observed from quadrature through opposition to quadrature; (2) a planet could be observed only if $m_V \leq 10.0$; (3) the mean error of unit weight was $0\overset{''}{.}350$; and (4) the distribution of clear nights was determined by a random number generator. The conclusions of the study are: (1) the best site from which to determine the equinox and equator from minor planet observations is one with a minimum of 60% clear nights well distributed throughout the year; (2) an observing program should last a minimum of two years, but little is gained by observing over ten years; (3) minor planets should be observed out to quadrature, but it is not essential to observe them over their entire orbits; and (4) the best minor planets to use are numbers 1, 2, 4, 7, and 15.

(6) V. I. Orel'skaya: Preliminary Values of Corrections to the Equator and Equinox of the FK4 Obtained from Observations of Ten Selected Minor Planets. (A brief summary was given by A. S. Sochilina.) About 25 000 observations made over a time span of 25 years have been analyzed to find corrections to the equinox, corresponding to $\Delta\alpha_o = -0\overset{s}{.}052 \pm 0\overset{s}{.}009$, and to the equator, corresponding to $\Delta\delta_o = 0\overset{''}{.}00 \pm 0\overset{''}{.}02$. These values are in good agreement with the results found by

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Fricke: $\Delta\alpha_o = -0^s.050 - 0^s.083$ T, where T is in centuries counted from 1960; $\Delta\delta_o \sim 0$.

(7) L. K. Kristensen: Equator and Equinox of FK4 from Observations of (51) Nemausa. Concluding a program initiated in 1939 by Strömgren, some 2240 observations of (51) Nemausa have been used to find corrections to the equator and equinox of the FK4. The correction to the declinations of the FK4 in the equatorial zone is $\Delta\alpha_o = +0''.03 \pm 0''.03$, and the correction affecting all right ascensions of the FK4 is $E = +0^s.044 \pm 0^s.005$ (1956). The last result relies on the corrections to Ephemeris Time given in the Astronomical Ephemeris. It may be asked whether a repeat of the campaign of 1949-1961, in which long series of accurate observations were obtained by a few observatories, would still be useful in these days of space astrometry. If the answer is in the affirmative, Kristensen offered to support those who may wish to make the necessary observations.

It was emphasized in discussion of the several preceding papers that, since minor planets are not observed from the Sun, the orbital elements of the Earth also must enter as unknowns into the solutions for corrections to the coordinate system.

SESSION 2: COMETS AND MINOR PLANETS

E. Roemer, Chairman of the Working Group on Orbits and Ephemerides of Comets, then took the chair and introduced the session with some brief remarks about the functions of the Working Group. She expressed her appreciation to those who contributed information for the section on comets of the triennial report of the Commission. Special thanks were due to E. I. Kazimirchak-Polonskaya, who had provided carefully done summaries of the work of astronomers in the U.S.S.R. for several triennial reports. Reliable predictions for the returns of periodic comets are now regularly available. And, thanks in particular to efficient work at the IAU Central Bureau for Astronomical Telegrams, ephemerides for newly-discovered comets are distributed soon after sufficient observations have been reported. A number of amateurs regularly provide for the brighter comets precise positions that are nearly as good as those measured by professional astronomers from wide-field plates. The situation with observations of the fainter comets is less secure, but, thanks in particular to the group at the Center for Astrophysics led by R. E. McCrosky, it seems that very few expected comets get through a perihelion passage totally unobserved. Good progress is being made in theoretical studies of the diffusion of comets into the inner solar system from the Oort cloud and of the subsequent dynamical evolution of some of them into short-period orbits. Puzzles remain, however, as with respect to the fate of comets that seem to drop from sight after making a first passage from the Oort cloud through the inner planetary system.

Scientific papers were then presented as follows:

(1) P. R. Weissman: Evolution of the Oort Cloud. The existence of the cloud of comets surrounding the solar system is firmly established by the distribution of the original inverse semimajor axes of the observed long-period comets. Very little is known, however, of how the cloud was formed or of its subsequent evolution. Recent dynamical studies by Weissman and B. Schreur using Monte-Carlo simulations have shed light on the means by which comets are introduced into the planetary region from the Oort cloud, and on the subsequent evolution of the comets under planetary perturbations. The application of Monte-Carlo techniques to the problems of Oort-cloud formation and evolution should be similarly illuminating. This work must also be tied to general theories of solar-system formation.

(2) L. Kresák: Instrumental Effects on the Apparent Brightness Changes of Comets. There is a broad variety of magnitude scales in use for comets, ranging from the visual integrated brightness to the photographic brightness of the nuclear condensation. In determining the photometric parameters of individual

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objects, these utterly inhomogenous data (with systematic differences up to 5-7 magnitudes!) are often put together, and the results are quite spurious. Improvement of instrumentation with time, and preferential use of different scales at different heliocentric distances, result in: (1) systematic underestimates of the intrinsic brightness and their correlation with perihelion distance; and (2) systematic overestimates of the photometric exponent, especially for recent and short-period comets. The impact on statistical analysis of the available data involves, e.g., apparent dying-off of absolutely bright comets, and a complete failure of the predicted death dates for short-period comets. Some photometric peculiarities claimed for the new comets are simply due to the fact that these are normally observed in a broad range of heliocentric distances — otherwise they are not recognized as new. Since it is essentially impossible to determine the integrated brightness when the comet is very faint, regular comet observers are urged to pay more attention to the magnitude determination of the nuclear condensations of bright comets. Existing astrometric plates can well be used for this purpose, provided that appropriate rough calibration is possible. Some unification of such observations would be highly desirable.

(3) D. K. Yeomans: The Intermediate-Period Comets — Orbital Problems. The nongravitational-force model that has been so successful for short-period comets has not been completely successful for the intermediate-period comets ($20 < P < 200$ years). In order of increasingly peculiar behavior, we have, first, intermediate-period comets Crommelin and Herschel-Rigollet, both of which are well behaved and show no obvious evidence of nongravitational forces. Comets Halley and Olbers have obvious nongravitational forces that are consistent with the rocket effect of an outgassing water-ice nucleus. The orbital motion of both comets has been successfully modeled. Orbits for comets Tempel-Tuttle and Pons-Brooks were not entirely successful even when the present model of the nongravitational forces was employed. Although large residual trends remained, the situation was improved for comet Pons-Brooks when the nongravitational-force model was adjusted to include in the nucleus ices more volatile than water. The orbital motions of comets Westphal and Brorsen-Metcalf are erratic; the two apparitions of each comet could not be satisfactorily linked with one orbit even when the nongravitational force model was employed. These two erratic comets are probably small objects easily perturbed by nongravitational forces and perhaps near the end of their lifetimes. Comet Westphal disappeared during its 1913 return to perihelion and was not recovered in 1975-76. The 1989 return of comet Brorsen-Metcalf is therefore uncertain.

Referring to experiences of radio astronomers trying to observe Comet Kohoutek in 1973-74, Yeomans made two suggestions for consideration by the Commission: (1) that it be stated periodically exactly what is in the published ephemerides of comets, and (2) that light-time corrections should be included, i.e., that in the future, ephemerides should be astrometric rather than geometric. With ephemerides now published to accuracy $0\overset{s}{.}01$ and $0\overset{''}{.}1$, the difference can be significant, particularly for fast-moving comets close to the Earth.

(4) A. C. Gilmore: The Observing Program in New Zealand. A regular program of astrometric observation of moving objects was established at the Carter Observatory, Wellington, in mid-1973. In six years the program produced some 660 positions, equally divided between comets and unnumbered minor planets in the southern sky. Until June 1978 most plates were obtained with the 41-cm cassegrain reflector at the Carter Observatory. A 10/100-cm astrograph on the same mounting provided plates for field transfers. These telescopes have now been relocated in the Black Birch Range of the South Island. Additional plates were obtained with the 61-cm reflector at Mount John Observatory, Lake Tekapo. Limiting magnitudes of the two reflectors are about 18 and 19 respectively. With the removal from Wellington of the 41-cm cassegrain, routine work will rely upon a recently completed 23/91-cm astrograph at a site south of Wellington city. It is expected

that the different field size and brighter magnitude limit of the new instrument will alter the character of the program from that established in the past six years.

(5a) G. Sitarski: The Orbit of (2101) Adonis. Two apparitions of the minor planet, discovered in 1936 and observed again in 1977, were linked. However, the iterative process of orbit improvement, assuming a linear approximation for computation of numerical values of partial derivatives, appeared to be divergent. A simple way was found to take into account the second-order terms so as to obtain the correct values of partial derivatives. A method that gives the exact solution also was developed. This second method was applied successfully also to improvement of the orbit of the minor planet Apollo from the observations in 1932 and since the 1973 recovery. In both cases the analysis was made more difficult because of close approaches of the minor planet to Venus and to the Earth between the observed apparitions.

(5b) R. Dvorak: The Orbit of (2101) Adonis. In work done in collaboration with G. Schrutka, Vienna, the definitive elements of (2101) Adonis were derived and compared with Sitarski's results. The method used was a classical differential correction in which it was not necessary to take into account the second-order terms. The method converged after six iterations (mean error $0''.97$), when the orbits for 1936 and 1977 were corrected separately and then integrated.

(6) C. Froeschlé and H. Scholl: New Numerical Experiments to Deplete the Outer Part of the Asteroidal Belt. Numerical integrations over 10^5 yr of fictitious asteroidal orbits in the region $3.6 < a < 3.9$ AU show a partial depletion of an initially uniform distribution of asteroids caused by close encounters with Jupiter. Two models were used: the three-dimensional restricted Sun-Jupiter-Saturn model and the same without Saturn. Several protection mechanisms which avoid close approaches to Jupiter were found. In particular, e-ω coupling is an effective protection mechanism if there is a significant inclination to the orbit of Jupiter. A systematic search for minor planets at high ecliptic latitude is suggested.

16 August 1979

SESSIONS 3 and 4: SPACE ASTROMETRY

Commission 20 joined with several other commissions in co-sponsoring two joint sessions on Space Astrometry. These joint sessions were organized by G. Westerhout at the requests of Commissions 24 and 33. The proceedings will appear in *Highlights of Astronomy*.

21 August 1979

SESSION 5: SATELLITES

The session was opened by S. Ferraz-Mello, Chairman of the Working Group on Satellites, who called attention to forms that had been prepared to facilitate the collection of information from everyone who was working on satellites. Three different questionnaires were addressed to (1) Observers, (2) Ephemeris Users, and (3) Ephemeris Producers and Theoreticians. Chairman Ferraz-Mello then reviewed the highlights of work on satellites during the triennium, with particular emphasis on those areas in need of attention: (1) discovery of three new satellites, 1978 P 1, 1966 S 2, and 1975 J 1 was reported, but they have not yet been confirmed; (2) work has been done during the triennium on the motion of the Martian and Galilean satellites, on some of the outer satellites of Jupiter, and on some of the satellites of Uranus and Neptune, but no recent work has been reported concerning J V, J X, J XI, J XII, U III, U IV, and N I; some effort on these objects during the next triennium would be welcome; (3) the observational effort in the triennium shows an important increase with respect to the recent past, but

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special efforts are still necessary to increase the amount of data concerning the outer satellites of Jupiter, J V, and the satellites of Neptune. The first introductory treatise on the theory of the Galilean satellites was published as a monograph by Ferraz-Mello. Also, L. E. Rose has recently published a new determination of the mass of Saturn based on a study of the motion of S IX (Astron. J. 84, 1067-1071, 1979).

Scientific papers were then presented as follows:

(1) V. A. Shor: Report on Studies on Natural Satellites Carried Out in the U.S.S.R. (1976-1978). (Brief summary given by Ferraz-Mello.) Observational work has been summarized in the report of Commission 20 in IAU Trans. XVIIA. Theoretical researches concerned the satellites of Mars and Jupiter and non-Keplerian intermediate orbits.

(2) D. Pascu: Summary of the Observational Program at the U.S. Naval Observatory. The long-focus photographic observations made of the planetary satellites at the U.S. Naval Observatory since 1967 were inventoried. Filter techniques were used in all cases to reduce the light of the primary. While the observations are largely unpublished and incomplete, they are being used in several programs of orbital corrections, such as that at JPL in support of the navigation of the Voyager spacecrafts. Mars' satellites have been observed at every opposition since 1967, and observations of the Galilean moons of Jupiter were obtained in 1968 and at each opposition since 1973. About 1000 exposures have been made for each of these systems. Since 1973, about 500 exposures have been made of Saturn's satellites I-VIII. Observations of the Uranian moons and of Triton made in 1975 and 1977 by Walker have been published.

(3) J. Lieske: Improved Ephemerides of the Galilean Satellites. Over 4800 Earth-based observations of Jupiter's Galilean satellites have been analyzed in order to develop improved ephemerides of the satellites for the Voyager mission, using the new theory of motion of the Galilean satellites. Included are over 1700 eclipses of the satellites by Jupiter spanning the interval 1878-1974, 85 mutual events (eclipses and occultations) observed in 1973, and over 2900 exposures on photographic plates from 1967 through 1978. The resulting ephemerides (labeled E2) were employed for the Voyager I encounter and are in error by less than 200 km at the time of Jupiter close approach. A very small ($0\overset{\circ}{.}066$) amplitude of the Laplacian free libration is indicated by the data.

(4) J.-E. Arlot and W. Thuillot: The Galilean Satellites. A report was given by Thuillot concerning recent work at the Bureau des Longitudes, Paris. (1) A campaign for the observation of the mutual phenomena in 1979 has been organized by astronomers at the Bureau des Longitudes and French observers. Four phenomena have already been observed under satisfactory conditions, and new observations are expected in October and November 1979. (2) A few photographic plates showing the Galilean satellites have been analyzed by Arlot with a PDS microdensitometer controlled by a PDP 11/40 computer at Nice. A new method that uses the light gradient from the primary for the determination of the center of the planet has been devised. This has proved to be the best of all the methods tested, giving significantly better residuals than the methods currently in use. (3) An analysis of available observations of the Galilean satellites has been made by Thuillot, who used for this purpose a numerical-integration program.

In discussion, T. Kiang mentioned that mutual phenomena of the Galilean satellites had been observed at Nanking in 1974 and a lengthy paper was published in Acta Astron. Sinica. An English translation appears in Chinese Astronomy 2, 13-39, 1978.

(5) K. Aksnes: Need for Observations of Mutual Phenomena of the Jovian and Saturnian satellites in 1979-80. Around 100 photometric observations of the

Galilean satellites in 1973 provided very accurate radii and relative positions of the satellites. In 1979 and 1980 some 75 mutual phenomena involving Jupiter I-V, and some 300 involving Saturn I-VII, are expected to occur (Aksnes and Franklin, Icarus 34, 188-207, 1978). Photometric observations of these phenomena with small and medium-sized instruments are encouraged: such observations can lead to a considerable improvement in the long-term accuracy of the theory of motion for the Galilean satellites and can provide astrometric data of unprecedented accuracy on the Saturnian satellites.

(6) R. S. Harrington: The Satellite of Pluto. Plates of Pluto taken in 1979, in addition to old plates taken for special purposes, show image elongations consistent with predictions based on the hypothesis that Pluto has a satellite with a revolution synchronous with Pluto's rotation. Analysis of one electronographic plate confirms the existence of two point light sources. The very small mass of Pluto is confirmed. (The orbital inclination to the plane of the sky, currently 105°, decreases 2°/yr because of the motion of Pluto. The 90° epoch comes in 1985; photometric phenomena may be expected in the interval 1983-1988.)

(7) T. C. Van Flandern: Satellites of Minor Planets. Observations by experienced lunar-occultation visual observer J. H. McMahon of an occultation of a star by (532) Herculina on 7 June 1978 showed six secondary events in addition to the occultation by the 230-km primary. The largest of these secondaries corresponded to a 50-km body, and was apparently confirmed in a photoelectric trace taken at Lowell Observatory. The combined observations indicate that this particular secondary event was caused by a body co-moving through space with Herculina, presumably therefore a satellite. Some 28 additional secondary events observed in conjunction with occultations of stars by nine minor planets have also been interpreted as possible satellites. Calculations indicate that such satellites would be gravitationally stable out to about 100 times the diameter of the parent, and collisionally stable over the lifetime of the solar system.

It was noted by L. H. Wasserman, Lowell Observatory, in response to a question, that the altitude of Herculina at the time of the visual observations of secondary events was 8-9°, while the Lowell photoelectric observations were made at an altitude of 2-3°.

(8) J. D. Mulholland: Solar-System Astrometry at McDonald Observatory. During the interval 1974-79, the satellite systems of the Jovian planets have been observed regularly with the 2.1-m Otto Struve reflector. A total of 113 observations were made of Jupiter's satellites V-XIII, of which about 80% are measured, reduced and published. The Saturn-satellite plates (about 50 of the system I-VIII, 30 of Phoebe) are only 25% measured and 10% reduced, but reduction priority has recently been shifted to these data, due to NASA Voyager mission requirements. About 40% of the 36 Uranus system plates are measured, and 10% of the 49 Neptune exposures. This is a continuing program whose purpose is to assure that observational coverage of the faint satellites will be maintained at an adequate level of continuity for the requirements of future dynamical studies. This work is supported by NASA, under grant NGR 44-012-282.

SESSION 6: OCCULTATIONS

The Chairman of the Working Group on the Prediction of Occultations, G. E. Taylor, reviewed the current state of work on predictions of occultations of stars by minor planets, noting that nearly 100 objects are now on the list of minor planets being monitored for occultations, and that the lead time for predictions of likely events has been increased to about 18 months. Many data are available far beyond that. Searches have been made to 1989 or 1990 for occultations by the largest minor planets and by (51) Nemausa. Predictions are also being made for occultations of non-catalogue stars by (1) Ceres, and for events involving the rings of Saturn and Uranus. Plates are being taken to search for possible occultations by Pluto to around 1985. Some 18 predictions have been issued over the past 36 months. Occultations by (6) Hebe (5 Mar. 1977), (2) Pallas (29 May 1978), (532) Herculina (7 June 1978), and (18) Melpomene (11 Dec. 1978) have been successfully observed. More photoelectric chords across Pallas have been obtained than for any other solar-system object including the Moon. The observations of Herculina led to possible detection of a satellite. Prospects are excellent for successful observation in North America of an occultation by (3) Juno on 11 Dec. 1979, when Juno is very close to its stationary point. The track for an occultation by (48) Doris on 4 Jan. 1980 is very long, and again presents a good possibility of successful observations. The possible occultation by Pluto on 6 Apr. 1980 presents a very difficult problem, and is the subject of a special meeting of the Working Group.

Scientific papers were then presented as follows:

(1) B. H. Zellner: Plans for the April 1980 Occultation by Pluto. Four occultation photometers were specially constructed by the group at the University of Arizona for the 1977 Uranus-occultation event. One of the photometers was sold to the Perth Observatory, but the Arizona group still has three and is prepared to travel anywhere for observations of occultations. With respect to the Pluto event, there are various predictions, some of which indicate that no event will be observable anywhere on the Earth. Long-focus astrometry should resolve the matter about two weeks before the event. Various observing sites in Africa and South America are being considered, the cost of manning a site being between \$3000 and \$4000 per station. No extra money is available for observation of the Pluto event; costs will have to be covered within the present budget.

(2) J. L. Elliot: Occultations by Ring Systems. The main advantage of using stellar occultations to study planetary ring systems is their high spatial resolution of the ring structures — about 1 km for Jupiter, Saturn and Uranus. Continued observations of Uranian-ring occultations are needed to establish for the nine rings the precession rates, which can be used to determine the higher-order terms in the Uranian gravitational potential. It may be noted that the reference system of the Uranian rings has been used to obtain the radius and oblateness of the planet. These led to a rotation period of $12^{h}.8 \pm 1^{h}.7$ as an unexpected byproduct that is of some importance because of the disagreement of even modern values measured spectroscopically. No photoelectric observations of occultations by the ring systems of Saturn and Jupiter have yet been made; such data would tell us whether or not these systems contain narrow components of the type found in the Uranian system. To carry on further with this work, a systematic search for future occultations by ring systems is badly needed.

(3) E. Bowell: The (non)Occultation by Ceres. The track of the occultation by Ceres on 31 July 1979 that had been predicted by Bowell and Wasserman (*Astron. J.* 84, 661-667, 1979) to cross Europe had in fact lain substantially farther south than the prediction. The level of interest aroused among astronomers whose main interests are in other fields makes it clear that a large number of competent observers are willing to help observe occultations. But some of those astronomers were badly disappointed when the event did not occur as predicted. It is clear that we have not yet succeeded in establishing adequate channels of communication for the updated predictions that can be made only on the basis of last-minute astrometry.

It was emphasized in discussion that the key point in successful predictions of occultations of stars by minor planets remains the relative position of the star and minor planet, which generally must be refined within the few days immediately preceding the event. G. E. Taylor noted that more help with the astrometry would be exceedingly useful.

SESSION 6 (CONTINUED): ADMINISTRATION

Commission President B. G. Marsden then took the chair and introduced Y. C. Chang, Director of the Purple Mountain Observatory, Nanking, China. Professor Chang gave a brief overview of the astrometric program on minor planets at the Purple Mountain Observatory. He also referred to his discovery of the minor planet originally catalogued as (1125) China during his work with G. Van Biesbroeck at the Yerkes Observatory in the 1920's.

Following several announcements, the following proposals were put to votes, all passing unanimously:

(1) Y. C. Chang should become a member of the Organizing Committee of Commission 20 as soon as negotiations for entrance of the People's Republic of China to the IAU are successful.

(2) Membership of the Commission and Consultants. The following new members were admitted: J. C. Bennett, E. L. G. Bowell, N. S. Chernykh, F. L. Garcia, R. J. Greenberg, A. W. Harris, I. Hasegawa, K. Hurukawa, P. A. Ianna, C. T. Kowal, L. K. Kristensen, M. Lovas, R. Millis, T. Nakamura, D. A. Pierce, L. Quijano, M. Rapaport, H. Rickman, H.-E. Schuster, P. K. Seidelmann, V. A. Shor, C. Torres, S. Vaghi, D. T. Vu, L. H. Wasserman, V. Zappalà, and K. Ziolkowski. The following members retired or resigned: W. J. Klepczynski, A. A. Orlov, H. Q. Rasmusen, and J. M. Torroja. Consultants for 1979-82: C. M. Bardwell, N. A. Belyaev, R. L. Branham, A. Carusi, K. I. Churyumov, E. Helin, P. D. Hemenway, V. A. Izvekov, C.-I. Lagerkvist, Z. M. Pereyra, C. F. Peters, V. Protitch-Benishek, H. J. Reitsema, and P. R. Weissman.

(3) Composition of Working Groups:

Orbits and Ephemerides of Comets: J. C. Bennett, M. P. Candy, A. C. Gilmore, E. I. Kazimirchak-Polonskaya, L. Kresák (chm), B. G. Marsden, E. Roemer, G. Sitarski, Ko. Tomita, R. M. West, P. Wild and D. K. Yeomans.

Satellites: K. Aksnes, Yu. V. Batrakov, A. Borsenberger-Bec, O. Calame, C. Cristescu, S. Ferraz-Mello, R. Greenberg, P. Ianna, Y. Kozai (chm), J. H. Lieske, R. Millis, B. Morando, J. D. Mulholland, D. Pascu, M. Rapaport, E. Roemer, J. L. Sagnier, V. A. Shor, A. T. Sinclair, and D. T. Vu.

Prediction of Occultations: D. W. Dunham, J. L. Elliot, A. C. Gilmore, A. R. Klemola, Y. Kozai, B. Morando, W. H. Robertson, V. A. Shor, G. E. Taylor (chm), L. H. Wasserman, and R. M. West; H. Reitsema (consultant).

Introducing the consideration of proposed resolutions, the President noted that the requested slight increase of the subvention for the Minor Planet Center had been approved by the Finance Committee.

A slightly modified version of the resolution on comet missions discussed in Commission 20 earlier had been approved in the interim by Commissions 15 and 22; Commission 21 also was considering the same resolution. The modified version was voted upon and carried, with none opposed and one abstention.

The resolution concerning Space Astrometry, sponsored by Commission 24 and supported by a number of other commissions, was next voted upon favorably, with none opposed and one abstention.

Consideration next turned to internal resolutions of Commission 20.

The updated policy statement concerning the naming of minor planets had been refined, in part on the basis of discussion at the first administrative meeting

https://doi.org/10.1017/S0251107X00025712 Published online by Cambridge University Press

of the Commission. The refined version was put to a vote and adopted, with none opposed and two abstentions:

"Commission 20 affirms the tradition that the discoverer of a numbered minor planet be permitted to propose a name for the object. A proposal would normally be accepted, provided that it is consistent with the broad policy of the Working Group on Planetary System Nomenclature. The name would become official following the publication in the MPCs of a brief citation explaining its significance. The Commission defines the discovery as the earliest apparition at which an orbit useful in the establishment of identifications was calculated; in the case of double designations during the same apparition, priority will be given in order of announcement of discovery, unless the double designation follows from an orbit computation using the observations made according to the second announcement. Further, the Commission proposes that, if the discoverer is deceased, or if a minor planet remains unnamed ten years after it has been numbered, a name could appropriately be suggested by identifiers of the various apparitions of the object, by discoverers at apparitions other than the official one, by those whose observations contributed extensively to the orbit determination, or by representatives of the observatory at which the official discovery was made. In such a case, the selection of a name shall be judged by a committee of three, consisting normally of the President and Vice President of Commission 20 and the Director of the Minor Planet Center, and the final decision shall be made not less than six months following the announcement of the numbering of the minor planet."

The next matter was the proposal to include correction for the light time in ephemerides for minor planets and comets, so that ephemerides should be astrometric rather than geometric. Some careful explanations were given of the meaning of the different kinds of ephemerides, and a question was raised as to what should be done about ephemerides of satellites, the relative ephemerides usually being apparent. Should the resolution apply to ephemerides of faint satellites, such as the outer satellites of Jupiter? After some discussion, it was clear that a consensus had not been reached on exactly what should be done, but there was a consensus that the matter could not be put off until the next General Assembly. It was therefore proposed that a vote be taken on the principle that ephemerides of minor planets and comets should be astrometric rather than geometric, such matters as the date of introduction of the change and the question of what should be done about ephemerides of satellites being left to an ad hoc committee to work out. This proposal passed, with none opposed, and one abstention. The President then appointed a committee consisting of himself, K. Aksnes, Yu. V. Batrakov, B. Morando, J. D. Mulholland, P. K. Seidelmann (chm), and G. E. Taylor to compose the specific recommendation. This is now available as follows:

"Commission 20 proposes that, as soon as practicable, the published ephemerides of minor planets, comets and satellites be astrometric or apparent, rather than geometric. An astrometric position means that the light-time correction has been applied and that the ephemeris is directly comparable with star positions given in a catalogue referred to a mean equinox such as that of 1950.0, except for the application of observer-dependent effects, such as parallax, refraction and diurnal aberration; an astrometric position differs from an apparent position by the effects of precession, nutation and annual aberration. The Commission further proposes that explanations of the meaning of the ephemerides be published from time to time in the standard sources."

The resolution regarding the absolute magnitude to be used in ephemerides of minor planets until 1982 was next formally voted upon; a recommendation based on

https://doi.org/10.1017/S0251107X00025712 Published online by Cambridge University Press

that developed at the asteroid conference in Tucson was adopted, with none opposed, and three abstentions:

> "Commission 20 recommends that the T. Gehrels and N. Gehrels (Astron. J. 83, 1660-1674, 1978) list of asteroid B(1,0), with a phase coefficient of 0.023 mag/deg, be used until 1982. Probably, at that time, a change will be made that should be durable."

The President appointed an ad hoc committee, with membership consisting of Yu. V. Batrakov, E. Bowell (chm), T. Gehrels, L. Kresák, B. G. Marsden, E. Roemer, and L. D. Schmadel, to look into the matter of magnitude ephemerides for minor planets and to make a recommendation for consideration at the next General Assembly.

With respect to the questions raised by Kovalevsky regarding priorities for observational programs on minor planets, it was noted that there is need for a substantially larger number than now available of minor planets with well determined orbits for use in such studies as that of J. G. Williams on asteroid families. It was proposed that an ad hoc committee be appointed to sharpen the goals and observational requirements of astrometric programs on minor planets. The President asked the following to be members of the committee: E. Bowell, J. Kovalevsky (chm), L. K. Kristensen, B. G. Marsden, J. Schubart, V. A. Shor, G. E. Taylor, C. J. van Houten, and J. G. Williams.

Announcements were made regarding future meetings of interest to members of Commission 20: (1) Satellites of Jupiter, 13-16 May 1980, Kailua-Kona, Hawaii; (2) Comets: Gas, Grains, and Plasma, 11-14 March 1981, Tucson, Arizona. The latter meeting is being organized by L. Wilkening in the pattern of earlier Tucson conferences directed by T. Gehrels and will be followed by publication of a book by the University of Arizona Press.

J. D. Mulholland inquired about the value of such programs as the ongoing long-focus observational program on faint satellites at the McDonald Observatory, noting the tight situations with respect to both telescope time and funding. Y. Kozai spoke in support of the program. With time running out, F. K. Edmondson proposed a vote of thanks to President Marsden for his distinguished service as the ninth president of the Commission. This was adopted by acclamation, and the meeting adjourned.