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 on 24th, 25th, 26th, 30th and 31st of July, 1991

PRESIDENT: R.M. West VICE-PRESIDENT: A. Carusi SECRETARY: H. Rickman

1. ADMINISTRATION AND SCIENTIFIC SESSION ON OCCULTATIONS AND MINOR PLANETS (July 24)

The President welcomed members of the Commission to Buenos Aires and opened the administrative session by reporting on the Commission activities during the past triennium and on some problems to be dealt with in the future. The progress was highlighted by the recent recoveries at the Minor Planet Center of (724) Hapag by S. Nakano and (878) Mildred by G.V. Williams; only (719) Albert is still lost. The work on the transition from the FK4/B1950.0 to the FK5/J2000.0 coordinate system has been completed, and the J2000.0 system will be used in the Ephemerides of Minor Planets (EMP) from the 1992 edition. The recommended procedures are described in detail in the report of the System Transition Committee delivered by its chairman, D.K. Yeomans, in August 1990.

The recent problem of duplication of minor planet names for some of the newly discovered Neptunian satellites was meantioned as the topic of a proposed commission resolution (see below). Of some concern is the question about which planets should be included into orbital calculations involving planetary perturbations. A standard is desirable, but the current one of including Pluto seems inappropriate. Furthermore, recent years have seen an increasing number of discoveries indicating a transitional nature of many objects with respect to the asteroid/comet classification. Thus problems arise regarding the naming of objects, and the question whether any change of current practice is warranted was foreseen as a topic of debate during the joint session with Comm. 15 on Comet-Minor Planet Interrelations. Finally, the President called attention to the lack of coordination between the many meetings of interest to Comm. 20 members that have recently been held in different countries and continents.

All present stood in silence for a short while in remembrance of the Commission members who had died during the past triennium: Willi Strobel, Maciej Bielicki, Leland E. Cunningham, Edgar Everhart III, Jack Bennett, Minoru Honda and Peter Millman.

The current membership of the Commission and its committees and working groups was then reviewed, and suggestions for new members and consultants as well as regarding the composition of the committees and working groups were invited. The nomination by the OC of A. Carusi as President and D.K. Yeomans as Vice-President of Commission 20 for the coming triennium had in the meantime been agreed to by the IAU Executive Committee and was confirmed by acclamation. Likewise, H. Rickman was unanimously appointed as Secretary of Commission 20 (1991 - 1994). Yeomans' place in the OC, was left vacant until further notice. In the WG on Comets, R.M. West stepped back as a member, and it was noted that N.A. Belyaev's membership is no longer appropriate since he does not work in astronomy any more. The future replacement by another member of the ITA staff was considered desirable. L.K. Kristensen wanted to step back as a member of the WG on Occultations. D.K. Yeomans was proposed to replace R.M. West in the Satellite Nomenclature Liaison Committee and the Minor Planet Names Committee, while in the Comet Nomenclature Committee as well as in the

Standing Committee to Oversee the Publication of Photometric Data for Minor Planets, West will be automatically replaced by the new President, A. Carusi. The Chairman of the Satellite Nomenclature Liaison Committee, K. Aksnes, raised the question of the continued usefulness of this committee, but no action was proposed. L.D. Schmadel, having replaced E. Bowell, was confirmed as the Chairman of the Study Group on Minor Planet Names. L.K. Kristensen wished to withdraw from this study group.

A number of resolutions were presented for possible endorsement by the Commission. It was proposed to submit to the General Assembly a joint commission resolution concerned with the assessment of the perceived need for better knowledge and surveillance of the population of Near-Earth Objects (NEO's) and better understanding of the hazard they present to mankind. The attitude to this proposal was generally positive and since the wording was recognized as a matter of importance, it was decided to call a common meeting among all concerned commissions on 25 July (see below). The opinion of Comm. 20 on two further resolutions before the GA was asked, one of them prepared by the IAU WG on Reference Systems and the other recommending the avoidance of interplanetary pollution. Several internal Commission resolutions were also proposed. Two of them concerned the activities of the ITA in S:t Petersburg, dealing with the observational programme for selected minor planets and special software packages to be used with the Ephemerides of Minor Planets. One resolution concerned the establishment of a Data Centre on Satellites at the Bureau des Longitudes in Paris. Two resolutions dealt with nomenclature business. One of them suggested the future amalgamation of the Commission's committees (currently at least four) dealing with the naming of solar system objects. The other recommended an expansion of the Minor Planet Names Committee to deal more actively and efficiently with selection of names and citations and to secure a closer liaison with the IAU WGPSN, thus hopefully avoiding further undue duplication of names.

A plea from the European Space Agency to obtain astrometric observations of comet P/Grigg-Skjellerup in preparation for the July 1992 Giotto encounter was noted. Another matter for discussion at the following administrative session was brought up by the President. In 1969 L. Kohoutek had discovered a minor planet which he had wished to name "Palach" in memory of the Czech student who died early that year in protest against the occupation of Czechoslovakia in 1968. For personal reasons, he had at that time hesitated to make a formal claim for the name Palach, but his wish was known at the Minor Planet Centre. Since the resolution of Comm. 20 not to name minor planets after political persons unless they have been dead for 100 years was passed only in 1985, the Commission was asked on Kohoutek's behalf whether the asteroid (1834) could now receive the name Palach since it had been conceived long before the resolution entered into force.

The President read the report by L. Wasserman on results obtained from occultations by minor planets and satellites during the past triennium. Special attention was given to the 3 July 1989 occultation of 28 Sgr by Titan. In general, few events of good quality had been predictable – among them occultations by (529) Brixia, (9) Metis and (4) Vesta. The preliminary report by D.W. Dunham *et al.* on additional occultations by (216) Kleopatra and (381) Myrrha at the ACM-91 meeting in Flagstaff was also highlighted. In view of L.K. Kristensen's wish to withdraw from the WG on occultations, the need for a replacing person from Northern Europe was stressed and suggestions were solicited.

B.G. Marsden then took the chair for the first scientific session on minor planets. He himself gave the first report about the plans of the Minor Planet Center for the J2000.0 transition. A time-table including actions both taken and foreseen was shown. Due to the mass conversion of observations, orbits and computer programmes to be effectuated during the period Nov. 1991 to

Jan. 1992, possible closure of the MPC for part of that period was foreseen, although genuine emergencies would be handled by the Central Bureau for Astronomical Telegrams. As future standard for planetary perturbations, Mercury-Neptune plus Ceres was proposed. A review of mass determinations for Ceres was given, leading to a recommended value of $5.0 \cdot 10^{-10}$ solar masses. Special attention was also given to the choice of the best system of J2000.0 solar coordinates, as well as the availability of J2000.0 star catalogues.

A.G. Sokolsky then presented ITA proposals on the programme of Selected Minor Planets (SMP) and related issues. About 30,000 observations of SMP made since 1949 at 35 observatories around the world have been collected and checked at ITA. Sokolsky surveyed the purposes of the programme both for checking and comparing astrometric catalogues and for doing various important asteroid research. To improve on the programme, several recommendations were made. Only the brightest 15 objects, of mean opposition magnitude < 13, should be considered, allowing to extend the observational arcs to near quadrature. Modern reference catalogues, and telescopes with focal lengths $\gtrsim 2 - 3$ m and image scales $\gtrsim 70 - 100$ arcsec/mm, should be used to reach high precision. Observing minor planets near the crossing-points of their sky tracks serves the same purpose. The software packages STAMP and CERES developed in the USSR for minor planet work on IBM-PC compatible machines in MS DOS environment were introduced and their benefits described. The EMP are already available on diskettes for easy use with STAMP and CERES, and this is the preferred means of distribution in the future. B.G. Marsden asked the audience how many would still like to have printed ephemerides, and the answer came out as roughly one person out of four.

R.M. West read a report, on behalf of L.D. Schmadel, on the progress of the Study Group on Minor Planet Names. Statistics of the current situation were summarized. As of 27 June 1991, there were 3858 named asteroids. 65% of these can be regarded as secure in the sense of complete knowledge of the meaning of the name, and a further 28% are secure but incomplete. The rest ($\sim 7\%$) are uncertain, or have questionable or unknown meanings. It is hoped that this number can still be halved. A Dictionary of Minor Planet Names is to be issued by Springer Verlag in the spring of 1992. Finally, the counting of votes given for the naming of minor planet nr. 5000 (foreseen in late 1991) was performed by R.M. West and O. Hainaut. Out of ten suggestions, the winning one was *IAU* with 6 votes out of a total of 20.

2. JOINT COMMISSION MEETING ON THE PROPOSED SEARCH FOR NEAR-EARTH OBJECTS (July 25)

At short notice a Joint Commission Meeting (involving members from Commissions 4, 7, 9, 15, 16, 20, 21 and 22) was convened in order to discuss the proposed resolution to the IAU GA on the hazard posed to the Earth's biosphere by Near-Earth Objects (NEO's: minor planets, comets, and fragments thereof). A wide-ranging discussion ensued in which the scope and wording of the resolution was debated. Some of those present wanted the resolution expanded and to include various other possible aims of the search beyond the hazard aspect: especially follow-up and physical observations for purely scientific goals, but also to identify future spacecraft targets, and assess mineral resources deriveable from NEO's. The fact that an international effort is essential was clear, which makes the adoption of the resolution by the IAU of paramount importance.

The views of the Presidents of each of the commissions involved were canvassed. They were all principally in favour. Plans for the membership of the Working Group to be set up should the resolution be carried by the GA (as actually occurred on 1st August) were discussed. The final wording of the draft resolution to be submitted to the IAU Executive Committee was as

follows:

The XXIst General Assembly of the International Astronomical Union,
Considering that various studies have shown that the Earth is subject to occasional impacts by minor bodies in the solar system, sometimes with catastrophic results, and
Noting that there is well-founded evidence that only a very small fraction of NEO's (natural Near-Earth Objects: minor planets, comets and fragments thereof) has actually been discovered and have well-determined orbits,
Affirms the importance of expanding and sustaining scientific programmes for the discovery, continued surveillance and in-depth physical and theoretical study of potentially hazardous objects, and
Resolves to establish an *ad hoc* Joint Working Group on NEO's, with the participation of Commissions 4, 7, 9, 15, 16, 20, 21 and 22, to:
1. Assess and quantify the potential threat, in close interaction with other specialists in these fields;
2. Stimulate the pooling of all appropriate resources in support of relevant national and international programmes;
3. Act as an international focal point and contribute to the scientific evaluation; and
4. Report back to the XXIInd General Assembly of the IAU in 1994 for possible further action.

Upon decision that each of the commissions involved select two members of the Working Group, the following were eventually proposed:

A. Carusi (Italy; Convenor), A.T. Basilevsky (USSR), B.Å.S. Gustafson (Sweden/USA), A.W. Harris (USA), Y. Kozai (Japan), G. Lelièvre (France), A.C. Levasseur-Regourd (France), B.G. Marsden (USA), A. Milani (Italy), D. Morrison (USA), K. Seidelman (USA), E.M. Shoemaker (USA), A.G. Sokolsky (USSR), D. Steel (Australia/UK), J. Štohl (Czechoslovakia), Tong Fu (P.R. China).

3. SCIENTIFIC SESSION ON MINOR PLANETS (July 26)

B.G. Marsden chaired the second session on minor planets spanning a wide range of topics with five scientific presentations and one short communication.

D.K. Yeomans started the session by reviewing the situation regarding acquisition of radar astrometric data (line-of-sight velocity and range) for minor planets and comets, and the benefits of their incorporation into orbit determinations. Such data currently exist for four comets, more than 30 NEO's and more than 20 main-belt asteroids. Moreover, after upgrading of the Arecibo and Goldstone antennas, the detection limits will soon be further improved. Radar data are complementary to, and more precise than, optical observations. In combination with the latter, they can dramatically improve the recovery ephemerides of NEO's after their first passage near the Earth. This was exemplified by the case of the Earth-approacher 1989 PB.

E. Helin gave a summary of the international conference held in San Juan Capistrano 30 June – 3 July 1991 on Near-Earth Asteroids. The meeting had an attendance of about 150 people: scientists, engineers and general public. Many of the contributions were briefly reviewed, in particular those dealing with search programmes and follow-up observations for securing reliable orbits, and related papers dealing with statistical and evolutionary aspects of the NEO population.

K. Muinonen then presented a paper, co-authored by E. Bowell, on orbital error analysis as a criterion for numbering asteroids in an objective and automated way. The principle should

be to compute a reference orbit omitting bad observations. If necessary, single-night apparitions and single-night observations with a large individual influence on the ephemeris uncertainty should be excluded. The maximum ephemeris uncertainty arising from the exclusion of single observations from the material over, e.g., 10 years should then be less than, say, 10 arcsec in order for the asteroid to be numbered. B.G. Marsden pointed out a problem in dealing with systematic trends in the residuals, to which the proposed method is not sensitive.

The current situation regarding absolute magnitudes of asteroids was reviewed by E.F. Tedesco. Reasons for modifying the H,G system used in the Sep. 1986 listing were given, in particular concerning the non-uniqueness problems of selecting a default value of G among several alternatives. The new procedure is to take G = 0.15 as an average over all albedo groups unless G can be derived from least-squares fits to phase data. The current data base contains 113 asteroids with H,G values thus derived – less than before since solutions are no longer attempted when the material spans a wide range of aspects. L.K. Kristensen proposed G derived as a function of albedo when infrared magnitudes are available. For other cases and new objects there is a selection effect in favour of high albedos, so the default value should be larger than the mean for low-numbered planets. In response to this, Tedesco mentioned that the mean value of G is based on the observed distribution for well-observed asteroids – a sample that is highly biased toward close, large and high-albedo objects. While the mean for this sample is 0.17-0.18, corresponding to a high-albedo and a low-albedo half with values near 0.25 and 0.1 respectively, correction for the fact that the total observed sample has about 3/4 low-albedo objects leads to a mean value near 0.15.

The status of the PPM catalogue was summarized by S. Röser. Its northern part (authors: S. Röser and U. Bastian) is available since 1991 in printed form (two volumes; Spektrum Akad. Verlag). The southern part already has a preliminary version published in *Astron. Astrophys.* **187**, 159 (1991) by Bastian *et al.* and will be available in final form in Dec. 1991 aiming at a book to appear in early 1992. Both parts are also available on magnetic tape (from CDS at Strasbourg and NSSDC at NASA-Goddard SFC) and on 3.5-inch diskettes (15 per hemisphere). PPM North has 181731 stars with a mean error of 0.27 arcsec in R.A. and Decl. at epoch 1990 and a mean proper motion error of somewhat more than 0.4 arcsec/century in both coordinates. In PPM South, about 180000 stars are expected with positional mean errors of 0.12 arcsec and proper motion errors of 0.3 arcsec/century.

Some problems of naming minor planets were finally discussed by S. Isobe. Since the number of Japanese discoveries is already rising rapidly and the number of efficient telescopes ($>$ 60 cm aperture) in Japan will soon be doubled, the expected discovery rate is $\sim$ 1000 per decade. Isobe suggested that measures might be taken to facilitate the work spent on naming so many objects, like stopping the naming of minor planets after nr. 5000, or having an IAU naming committee instead of soliciting proposals from the discoverers.

4. *ADMINISTRATIVE SESSION* (July 26)

The President chaired this session and started by asking the Commission's approval of seven resolutions. Following a brief, clarifying discussion, all of them were unanimously agreed upon. The first resolution, on Reference Frames, was still being discussed within the Working Group on Reference Frames, but the members present expressed their confidence that the final text would be acceptable for Comm. 20 and its representative to this WG, D.K. Yeomans. The second resolution concerned the search for Near-Earth Objects (see above). The following five Commission resolutions were then passed:

Commission 20,
Noting the recent disagreement between it and the Working Group on Planetary System Nomenclature (WGPSN) concerning the proposed names for the recently discovered satellites of Neptune,
Drawing attention to its 1985 resolution to minimize the duplication between the names of minor planets and natural satellites, and
Considering the vast potential for drawing on a number of different cultures for the selection of names,
Recommends that its Minor Planet Names Committee, currently consisting of the President, the Vice-President and the Director of the Minor Planet Center, be expanded to include more effective liaison with the WGPSN, and
Charges the expanded Committee to take a more active role in both choosing names and writing completed, concise citations.

Commission 20,
Considering that it currently has at least four committees that deal with some aspect of the naming of solar system objects,
Suggests that they be at some time amalgamated into a single Nomenclature Committee.

Commission 20,
Welcoming the proposal of the Institute of Theoretical Astronomy to prolong the observational programme for 15 selected minor planets (nos. 1, 2, 3, 4, 6, 7, 11, 18, 25, 39, 40, 148, 389, 532 and 704) for the period 1991-2000,
Encourages all observatories which have astrographs of focal length > 2 m to take part in this programme, and
Recommends that the most precise reference catalogues, PPM (Positions and Proper Motions), Fokat (Fotograficheskij Katalog, Pulkovo) and ACRS (Astrographic Catalog Reference System), are used for the determination of the spherical coordinates of the planets.

Commission 20
Supports the activities of the Institute of Theoretical Astronomy (ITA) on the elaboration of PC software packages for the provision of ephemerides of minor planets, and
Suggests that systems like "STAMP" may be used together with the printed, annual volumes "Ephemerides of Minor Planets".

Commission 20,
Having heard the report of the Chairman of the Working Group on Satellites in which is proposed the creation of a Data Centre at the Bureau des Longitudes (France),
Supports this proposal, and
Recommends that this Centre develops into an International Data Centre, as defined in Internal Resolution of Commission 20, adopted on August 8, 1988, during the XX IAU General Assembly.

The president projected the lists of the Commission's proposed new members and consultants and of the members and chairmen of the various Working Groups and Committees. The names were reviewed and then approved by the Commission members, as listed below:

New members: C. Blanco (Italy), C. Edelman (France), E. Elst (Belgium), G. Hahn (UK/Sweden), S. Isobe (Japan), R. Jacobson (USA), H. Kosai (Japan), A. Manara (Italy), R. McNaught (Australia), A.K. Pandey (India), V. Protitch-Benishek (Yugoslavia), R. Rajamohan

(India), S. Röser (Germany), K. Russell (Australia), M. Sato (Brazil), A.G. Sokolsky (USSR), D. Steel (Australia), J.B. Tatum (Canada), M. Tsuchida (Brazil).

Consultants for 1991-94: C.M. Bardwell (USA), S.J. Bus (USA), K.I. Churyumov (USSR), R.W. Farquhar (USA), E. Kazimirchak-Polonskaya (USSR), S.M. Milbourn (UK), K. Muinonen (USA), Z.M. Pereyra (Argentina), H. Oishi (Japan), J.G. Sanguin (Argentina), N. Samojlova-Yakhontova (USSR), T. Seki (Japan), C.S. Shoemaker (USA), G. Tancredi (Uruguay), G.V. Williams (USA).

Organizing Committee: K. Aksnes, J.-E. Arlot, L. Kresák, B.G. Marsden, T. Nakamura, H. Rickman, V. Shor, L. Wasserman, R.M. West, J.X. Zhang.

Working Group on Comets: M.E. Bailey, M.P. Candy, A. Carusi, A. Gilmore, L. Kresák, B.G. Marsden, S. Nakano, H. Rickman (ch.), E. Roemer, G. Sitarski, P. Wild, D.K. Yeomans.

Working Group on Satellites: K. Aksnes, J.-E. Arlot (ch.), S. Ferraz-Mello, P.A. Ianna, R.A. Jacobson, J.H. Lieske, B. Morando, J.D. Mulholland, T. Nakamura, D. Pascu, M. Rapaport, P.K. Seidelman, V. Shor, D.B. Taylor, R. Vieira-Martins.

Working Group on Occultations: J.C. Bhattacharyya, C. Blanco, G.L. Blow, D.W. Dunham, M.-F. He, A.R. Klemola, R.L. Millis, M.D. Overbeek, V. Shor, M. Soma, G.E. Taylor, L. Wasserman (ch.).

Satellite Nomenclature Liaison Committee: K. Aksnes (ch. & delegate to WGPSN), J.-E. Arlot, A. Carusi, P.K. Seidelman (vice-ch. & alternate delegate to WGPSN), D.K. Yeomans.

Standing Committee to Oversee Publication of Photometric Data for Minor Planets: E. Bowell, A. Carusi, A.W. Harris, B.G. Marsden.

Minor Planet Names Committee: K. Aksnes, A. Carusi, Y. Kozai, B.G. Marsden, L.D. Schmadel, V.A. Shor, D.K. Yeomans.

Comet Nomenclature Committee: A. Carusi, B.G. Marsden, H. Rickman.

Study Group on the Origins of Minor Planet Names: V.K. Abalakin, E. Bowell, F. Edmondson, H. Haupt, B.G. Marsden, J.D. Mulholland, E. Roemer, L.D. Schmadel (ch.), K. Tomita, I. Van Houten-Groeneveld, J.X. Zhang.

The Commission finally discussed whether minor planet (1834) should be named "Palach", as suggested by B.G. Marsden on L. Kohoutek's behalf. Different opinions were voiced and a secret vote was called for. A majority was in favour of accepting the name (1834) Palach (16 votes against 6) and the naming has since been made official on MPC 18643.

SCIENTIFIC SESSION ON COMETS (July 30)

H. Rickman chaired this session, mainly devoted to recent advances in cometary dynamics but with other important progress being covered as well.

M.E. Bailey reviewed the problem of the capture of short-period (SP) comets. The flux of comets in near-parabolic orbits and their average capture probability was discussed, and it was concluded that there is a shortage in the steady-state number of SP comets thus predicted. Additional sources hence appear required, and a trans-Neptunian belt and an inner core of the Oort cloud were discussed from the point of view of comet formation scenarios as well as of their ability to explain the characteristics of the Jupiter family. The approximate dynamical techniques hitherto used for elucidating the latter aspect were reviewed and criticized. Several

additional problems that merit further attention were mentioned, and as a general conclusion the source of SP comets was deemed still unresolved.

The problems of modelling cometary dynamics and the essential properties of cometary chaos were then further highlighted by C. Froeschlé. As a word of caution, he remarked that these are still largely open issues: if he knew how to model cometary chaos, he would have done it! He then went on to review the various mapping techniques, either deterministic (Keplerian map for near-parabolic comets; planetary conjunction "kicks" for near-circular orbits in the giant planet region; synthetic map for interpolation on a phase-space grid) or stochastic (Monte Carlo simulations; Markov chain modelling). Particular attention was paid to the problem of injections from the trans-Neptunian "Kuiper belt" into Neptune-crossing orbits.

A. Carusi, in collaboration with L. Kresák and G.B. Valsecchi, talked about the complementary aspect of accurately representing the motions of real SP comets. He thus focussed on results obtained when preparing the 2nd edition of the atlas of long-term evolutions of short-period comets, for which the integrations are now finished. The new atlas will contain 155 comets, of which 93 have been observed at several apparitions. Statistics on the number of planetary encounters and temporary librations were given, and examples of remarkable behaviour were shown (e.g., the temporary Jovian satellite capture of P/Helin-Roman-Crockett around the year 2075).

The next talk was given by A. Smette and R.M. West, with O. Hainaut as co-author, on observations of distant comets – P/Halley and others. The emphasis was naturally placed on the recent outburst of P/Halley, first observed on 12 Feb. 1991 using the Danish telescope at ESO, La Silla, but apparently dating back to late December 1990. Images were presented showing the time-evolution of this event. Such observations strengthen the case for obtaining images of other distant comets – for accurate astrometry and also to learn whether outbursts are a common feature beyond Saturn's orbit. Recommendations for observing techniques were made, and problems such as the large number of background galaxies at $m > 25$ were discussed. P/Halley will probably be followed all the way to aphelion.

Finally G.B. Valsecchi presented the recent calculations, performed together with A. Carusi, L. Kresák and M. Kresáková, on the orbit of comet P/d'Arrest linking it to La Hire's comet of 1678. This one actually topped the authors' preliminary list of ancient comets that might prove identical to known SP comets discovered at later dates, although they were not aware of Valz' (1851) suggestion. The linkage is remarkable in one particular regard, i.e., that four encounters to within 0.5 AU of Jupiter occurred between 1678 and 1851. Several integrations using different dynamical models were shown, and it was demonstrated that a nongravitational effect similar to the present one must exist over the entire interval in order to fit the observations satisfactorily. In the discussion, D.K. Yeomans drew attention to the fact that the nongravitational effect of P/d'Arrest correlates very well with the comet's strongly asymmetric light curve, indicating a constancy of its outgassing behaviour.

5. *SCIENTIFIC SESSION ON SATELLITES* (July 30)

This session was chaired by J.-E. Arlot who also gave the first paper on the activities and goals of the Working Group on Satellites. In particular, he gave an account of the plans to set up a Data Centre for astrometric data on natural satellites that had been initiated at the previous IAU GA in Baltimore 1988. Among the tasks of the Data Centre, he listed the classification and documentation of both raw and reduced data, the publication of catalogues with evaluation of the accurary, and the availability of these data by circulars or by log-in through electronic

networks. In addition, the search for old observations and conversion of these into a standard reference frame, the collection of bibliographic information on both theoretical dynamics and physical studies, and the provision of ephemerides available through electronic networks, were mentioned as important goals.

D. Pascu then reviewed CCD observations of satellites, as performed ground-based by seven groups around the world. These had been preceded by observations with electronographic cameras, for instance during the 1980 Saturn ring plane crossing leading to several discoveries of new satellites. The obvious strengths of CCD's are their speed and their linear response, facilitating background subtraction. Their small fields of view so far make them best suited for work on faint inner satellites. Problems arising in doing CCD astrometry of satellites were then described.

L. Duriez reviewed theoretical work on Saturnian satellites (except rings and shepherds) and concluded that first, a great deal of work has been done to improve both observations and theories of motion. Thus for the major satellites there is hope of new theories soon representing even the best observations to the level of their accuracy (< 350 km). However, in spite of this progress, large improvements are still needed in order to be ready for the CASSINI mission with its extraordinary requirements (precision $<$ a few km). Duriez nonetheless expressed the feeling that recent works on major satellites are already on the right tracks to succeed in this goal.

Finally, J.-E. Arlot presented a paper on the influence of surface effects on the astrometry of Galilean satellites on behalf of W. Thuillot and P. Descamps. These involve various limb darkening effects and asymmetries of the albedo distributions, and the astrometry is mainly affected by a displacement of the photocenter relative to the true disk center amounting to a maximum of 0.10 arcsec for Ganymede. In the observations of mutual events, which reach accuracies of 0.02 arcsec, surface effects become noticeable and have been known for some time to cause the systematic residuals occurring in such observations. Progress in the photometric modelling of the satellites and in the relevant astrometric observations was reviewed.

SPECIAL SCIENTIFIC SESSION ON NONGRAVITATIONAL EFFECTS

This session was affected by the fire in the San Martin Centre so that all presentations had to be drastically shortened. H. Rickman was the chairman, but D.K. Yeomans agreed to act as substitute chairman for most of the talks given by Rickman on behalf of himself or absent friends.

The first speaker was D.K. Yeomans who gave a review of recent advances in nongravitational force modelling. Different lines of approach were surveyed, such as Sitarski's long-term extrapolation of P/Halley's motion fitting the observed times of perihelion passage to a model variation of the semimajor axis, Rickman's mass estimates for P/Halley and, in general, attempts of modelling a force that is asymmetric w.r.t. perihelion. The standard, symmetric force model was deemed to be fine for ephemeris predictions but inappropriate for physical studies. Asymmetric models should fit the water production curves but remain simple as regards extra parameters to solve for. Examples of asymmetric models were given with emphasis on P/d'Arrest and P/Halley. Last but not least, improved modelling must depend upon improved astrometry, thus highlighting the need to work with improved star catalogues, long-focus telescopes and the best available detectors and measuring equipment. The inclusion of radar data was shown to be important in some cases, exemplified by the detection of slight nongravitational effects in the motion of (1566) Icarus.

H. Rickman then reviewed his own work, mostly in collaboration with M.C. Festou and L.

Kamél, on prediction and physical interpretation of nongravitational effects. After a background to the idea that the easily measurable perihelion delays ΔP of SP comets should correlate with the light curve asymmetries both in sign and modulus, the introduction of an asymmetry parameter E was described and the correlation between E and ΔP was demonstrated. It was shown how this statistical regression had been used to predict P/Brorsen-Metcalf's ΔP just before it was recovered in 1989. B.G. Marsden pointed out that P/Swift-Tuttle may possibly be expected back at perihelion in late 1992 and suggested that light curve data from the 1862 apparition could help constraining the time of perihelion passage.

On behalf of G. Sitarski, H. Rickman presented recent progress by Sitarski and co-workers in solving directly for physical properties of the nucleus in multi-apparition linkages involving non-gravitational forces. Results concerning comets P/Honda-Mrkos-Pajdušáková, P/Kearns-Kwee, P/Grigg-Skjellerup and P/Kopff were shown. Usually the parameters solved for in addition to the six osculating elements are A (the modulus of the jet acceleration at heliocentric distance 1 AU), η (the lag angle = deviation of the jet acceleration vector from the antisolar direction), I (the equatorial obliquity) and Φ (the cometocentric solar longitude at perihelion), and the two time derivatives dI/dt and $d\Phi/dt$ modelled as constants. The linkage intervals thus obtained range from 4 to 16 apparitions, and the mean residuals are around 2 arcsec or less for $\gtrsim 100$ observations.

H. Rickman then gave a report on recent developments in nongravitational force modelling at ITA on behalf of Yu.V. Batrakov, Yu.D. Medvedev and Yu.A. Chernetenko. One investigation, performed by Chernetenko, concerns P/Encke, and observations from 1901-1987 are used. The physical model to link all these apparitions is similar to that of Whipple and Sekanina (1979: *Astron. J.* **84**, 1894), but light shifts (offsets of the photocenter from the nucleus) are introduced for the different apparitions individually. The other project, led by Medvedev, involves a detailed representation of P/Halley's motion during the 1985-86 apparition. A thermal model of the nuclear surface layers is used in order to compute the jet force and torque as functions of the parameters used. These are the spin parameters and up to 13 coefficients describing the shape of the nucleus in terms of 3rd-order spherical harmonics. Reduced solutions limiting the number of unknowns have yielded shape coefficients consistent with other knowledge based on close-up imaging.

P. Colom was the last speaker, reporting on the work of the Meudon group on radio-astronomical measurements of the outgassing asymmetries and jet forces affecting the cometary nuclei. Analysis of the OH emission lines yields the geocentric radial velocity of the centroid of the OH cloud and thus also of the parent H_2O cloud. The difference w.r.t. the geocentric ephemeris velocity of the nucleus then yields the line-of-sight component of the mean outflow velocity with good accuracy. Results for P/Halley (already published) and a few more recent comets were presented and compared.

The final joint session on Comet-Minor Planet Interrelations is dealt with in the report of Comm. 15. At the end of that session, the Comm. 20 members present thanked the President, R.M. West, for his contributions to the running of the Commission during the past triennium.