

COMMISSION No. 15

PHYSICAL STUDY OF COMETS, MINOR PLANETS AND METEORITES

(ETUDE PHYSIQUE DES COMETES, DES PETITES PLANETES ET DES METEORITES)

Report of Meetings 4, 6, and 9 August 1988

PRESIDENT: L. KRESAK

VICE PRESIDENT: J. RAHE

Prof. L. Kresak was unable to attend the IAU General Assembly due to a sudden illness and had asked J. Rahe to be Acting President for the duration of the General Assembly. M.F. A'Hearn agreed to serve as secretary.

Tribute is paid to those members of Commission 15 who have passed away since the last General Assembly: Dr. Ludwig BIERMANN, Dr. Nicholas BOBROVNIKOFF, Dr. Richard Heinrich GIESE, Dr. Marie-Therese MARTEL, Dr. Reginald WATERFIELD.

The Commission had one Business Session, two Science Sessions on "News in Cometary Research" (organized by C. Arpigny), one Science Session on "News in Minor Planet Research" (organized by A.W. Harris), a Joint Discussion with Commission 20 on "Major Observing Programs and Data Bases" (organized by Y. Kozai and L. Kresak), and a Joint Discussion with Commission 22 on "Interrelation of Meteor Streams, Comets and Asteroids" (organized by P. Babadzhanyov and L. Kresak)

I. BUSINESS SESSION

The triennial report, previously distributed to all members of the commission, was outlined by Rahe and accepted by the Commission.

Publication of the Atlas of Comet Halley 1910 II, sponsored by the Commission and published by NASA as SP-488, was noted, as was the availability of copies from B. Donn.

Following long tradition, members of the Organizing Committee who have served two terms will step down; these include C. Chapman, H. Fechtig, and L. Shul'man. Although J. Wasson has served two terms, he has only served one term as chairman of the Working Group on Meteorites and will continue as chairman and thus on the Organizing Committee for one more term. L. Kresak, as past President, will automatically be a member of the Organizing Committee.

The following new officers, members of the Organizing Committee, members of Working Groups, new Commission members and consultants were elected:

PRESIDENT: J. Rahe (FRG) VICE PRESIDENT: A.W. Harris (USA)
SECRETARY: M.F. A'Hearn (USA)

ORGANIZING COMMITTEE: C. Arpigny (Belgium), J. C. Brandt (USA), M. J. S. Belton (USA), O. V. Dobrovolskiy (USSR), E. Gruen (FRG), H. F. Haupt (Austria), D. Hughes (UK), L. Kresak (Czechoslovakia), D. F. Lupishko (USSR), H. Rickman (Sweden), E. Tedesco (USA), J. T. Wasson (USA), S. Wyckoff (USA), V. Zappala (Italy)

A list of proposed new members and consultants of Commission 15 was presented and additional nominations were solicited. The list was approved by the Organizing Committee and subsequently by the IAU.

MEMBERS OF COMMISSION 15

M.F. A'Hearn, C. Allegre, E. Anders, D.A. Andrienko, J. Arnold, C. Arpigny, W.I. Axford, P.B. Babadzhanyan, G.S.D. Babu, M.E. Bailey, E.S. Barker, D.B. Beard, M.J.S. Belton, P. Birch, J.E. Blamont, D. Bockelee-Morvan, H. Bohnhardt, E. B. Boswell, J. Bouska, E.L.G. Bowell, J.C. Brandt, A. Brecher, R.H. Brown, D.E. Brownlee, W.E. Brunk, B. Buratti, L.F. Burlaga, J.A. Burns, M.P. Candy, A. Carusi, G.R. Carruthers, A. Cellino, Z. Ceplecha, P. Cerroni, T. Chandrasekhar, C.R. Chapman, R.D. Chapman, D.-H. Chen, V.I. Cherednichenko, J. Clairemedi, G.C. Clayton, R.N. Clayton, S.V.M. Clube, A. Cochran, W.D. Cochran, M. Combi, B.C. Cosmovici, C.G. Cristescu, J. Crovisier, D.P. Cruikshank, J. Cuyppers, P.A. Daniels, A.C. Danks, H. Debehogne, J. Degewij, A.H. Delsemme, I. DePater, S.F. Dermott, D. De Sanctis, W.A. Deutschman, M. Di Martino, O.V. Dobrovolsky, B.D. Donn, F. Dossin, A.V. Douglas, M.J. Drake, M. Dryer, V.P. Dzhaspiashvili, T. Encrenaz, A. Ershkovich, E. Everhart, A. Eviatar, P. Farinella, H. Fechtig, P.D. Feldman, J.A. Fernandez, J.C. Fernandez, I. Ferrin, M. Festou, C. Froeschle, A. Fujiwara, M. Fulchignoni, T. Gehrels, J. Geiss, E. Gerard, D.M. Gibson, J. Gibson, F. Giovane, J.C. Gradie, S. Green, J.M. Greenberg, R. Greenberg, L. Grossman, S. Grudzinska, E. Grun, B.A.S. Gustafson, G. Hahn, I. Halliday, M.S. Hanner, A.W. Harris, B.W. Hapke, W.K. Hartmann, M. Harwit, I. Hasegawa, L.N.K. Haser, H.F. Haupt, E.F. Helin, G. Herzberg, Z.W. Hu, W.F. Huebner, D.W. Hughes, K. Ibadinov, W.H. Ip, W.M. Irvine, S. Isobe, V. Ivanova, W.M. Jackson, K. Jockers, T.V. Johnson, K. Keil, H.U. Keller, R.F. Knacke, Z. Knezevic, Ch. Koeberl, L. Kohoutek, V.P. Konopleva, C.T. Kowal, L. Kresak, K.S. Krishna Swamy, L.K. Kristensen, C.I. Lagerkvist, P. Lamy, P. Lancaster Brown, H.P. Larson, S.M. Larson, L.A. Lebofsky, A.C. Lefevre-Regourd, B.Yu. Levin, W. Liller, C.F. Lillie, C.A. Lindsey, J.J. Lissauer, L.Z. Liu, R. Luest, M.E. Lipschutz, K.A. Lumme, D.F. Lupishko, B.A. Lutz, R.A. Lyttleton, D.J. Malaise, S.P. Maran, B.G. Marsden, D.L. Matson, O.T. Matsuura, T.B. McCord, R.E. McCrosky, J.A.M. McDonnell, S. McKenna-Lawlor, D.D. Meisel, D.A. Mendis, B.L. Milet, F.D. Miller, R.L. Millis, P.M. Millman, D. Moehlmann, E.P. Moore, V.I. Moroz, D. Morrison, A. Mrkos, T. Mukai, M.J. Mumma, T. Nakamura, W.M. Napier, G. Nazarchuk, J.S. Neff, G. Neukum, R.L. Newburn Jr., C.R. O'Dell, J.A. O'Keefe, D. Olsson-Steel,

P. Paolicchi, J.P. Parisot, P. Pellas, H.A. Perez de Tejada, C.B. Pilcher, E.M. Pittich, P.E. Proisy, D. Prialnik-Kovetz, J. Rahe, H.J. Reitsema, L.G.A. Remy-Battiau, D.O. ReVelle, H. Rickman, E. Roemer, R.Z. Sagdeev, F. Scaltriti, D.G. Schleicher, F.P. Schloerb, H.U. Schmidt, M. Schmidt, H.J. Schober, C. Sharp, Z. Sekanina, M. Shimizu, V.G. Shkodrov, E.M. Shoemaker, L.M. Shul'man, K.R. Sivaraman, B.A. Smith, R. Smoluchowski, L.E. Snyder, M. Solc, H. Spinrad, J. Stohl, J.M.G. Surdej, J. Svoren, K. Szego, H. Takeda, H. Tanabe, J. Tatum, E.F. Tedesco, A.K. Terentjeva, D. Tholen, K. Tomita, L. Typhoon, G.B. Valsecchi, V. Vanysek, G.J. Veeder, J. Veverka, M.K. Wallis, S.Ch. Wang, J.T. Wasson, T. Wdowiak, H. Weaver, P.A. Wehinger, S. Weidenschilling, P.R. Weissman, G.W. Wetherill, F.L. Whipple, L.L. Wilkening, I. Williams, W.Z. Wisniewski, J.A. Wood, M.M. Woolfson, A. Woszczyk, S. Wyckoff, S. Yabushita, A.A. Yavnel, D.K. Yeomans, V. Zappala, J.C. Zarnecki, B.H. Zellner.

CONSULTANTS:

M.A. Barucci, R.P. Binzel, H.C. Brinton, H. Campins, P.A. Daniels, R. Decher, M.J. Drake, T.I. Gombosi, D.W.E. Green, G. Hahn, H.L.F. Houppis, D. Jewitt, J. Klinger, V. Krasnopolskij, Y. Langevin, P. Magnusson, E.P. Mazets, R.P. McCoy, L.A. McFadden, G. Nazarchuk,

M. Neugebauer, M. Niedner, S. Ostro, R.O. Pepin, X.Y. Yang.

WORKING GROUP ON COMETS: C. Arpigny (Belgium) - chairman, M. F. A'Hearn (USA), J. C. Brandt (USA), O. V. Dobrovol'skij (USSR), P. D. Feldman (USA), E. Gerard (France), W.-H. Ip (FRG), A. C. Lvasseur-Regourd (France), T. Mukai (Japan), H. Rickman (Sweden), Z. Sekanina (USA), L. M. Shul'man (USSR)

WORKING GROUP ON MINOR PLANETS: V. Zappala (Italy) - chairman, P. V. Birch (Australia), S. F. Dermott (USA), P. Farrinella (Italy), J. C. Gradie (USA), H. F. Haupt (Austria), D. F. Lupishko (USSR), K.-I. Lagerkvist (Sweden), X.-H. Zhou (PRC)

WORKING GROUP ON METEORITES: J. T. Wasson (USA) - chairman, M. Fulchignoni (Italy), A. Yavnel (USSR)

It is expected that these Working Groups coordinate the corresponding Commission related activities and assist the Commission President in submitting his report to the IAU General Assembly.

WORKING GROUP REPORTS

1. Comets - C. Arpigny: The principal activity of this committee was writing the triennial report which was much longer than usual because of the wealth of new results from comet P/Halley.

2. Minor Planets - A. Harris: The largest activity was writing the triennial report. Additional activities included preparing a list of

rotational characteristics of minor planets, as directed at the Delhi General Assembly, for inclusion in the Ephemeridi Malikh Planet.

3. Meteorites: no report.

Joint Working Group on Fluffy Structures: J. M. Greenberg reported on the establishment of this working group by Commission 21 and the hope for co-sponsorship by other commissions. B. Donn was nominated for membership and accepted.

RESOLUTIONS

1. A proposal by M. Belton for an observational campaign to determine the rotational state of P/Halley's nucleus after the coma has faded was endorsed by the Commission.

2. The following proposal to endorse the maintenance of data bases on asteroids and comets by A.W. Harris was adopted by the Commission and subsequently by the IAU.:

"Commission 15 endorses the continued maintenance of a database on minor planets, and recommends the establishment of a comparable database on comets. The Working Groups on Minor Planets and on Comets are charged with the responsibility of defining the contents of the respective databases and of monitoring their compilation, updating, and dissemination."

"La Commission 15 recommande le maintien d'une banque de donnees relative aux petites planetes et preconise l'etablissement d'une telle banque de donnees pour les cometes. Les groupes de travail "Petites Planetes" et "Cometes" sont charges de definir le contenu de leurs banques de donnees respectives et d'en surveiller la compilation, la mise a jour et la diffusion."

II. SUMMARY OF SCIENTIFIC SESSIONS

1. JOINT SESSION OF COMMISSIONS 15 AND 20 ON DATABASES AND LARGE PROJECTS (ORGANIZED BY L. KRESAK AND Y. KOZAI)

INTERNATIONAL HALLEY WATCH (IHW): R. Newburn emphasized the archival work of the IHW. Noting the submission of nearly all data on Giacobini-Zinner, he discussed the progress with the data on Halley. Data are due at the JPL IHW Lead Center (after having been processed by the Discipline Specialists) by 1 May 1989. He estimated that 40% of known data was at the Lead Center with another 30% in the hands of the Discipline Specialists. The primary archive will consist of 22 Gbytes of data on Halley and 220 Mbytes of data on Giacobini-Zinner. It will be published on approximately 21 compact discs; the question whether a printed archive will also be produced, will be decided by the IHW Steering Group in mid-1990.

ASTEROIDAL DATABASE: E. Tedesco described the implementation of the two parameter (H,G) asteroidal magnitude system adopted at the 1985 IAU GA. The system is in place and values of the magnitude parameters are given in the Ephemeridi Malikh Planet beginning with the 1988 volume. Formal solutions for (H,G) which yield $G < 0$ or $G > 0.5$ are replaced with $G = 0.15$ and 0.25 , respectively with H derived from the forced fit.

ASTEROIDAL TAXONOMY: D. Tholen described the currently widely accepted taxonomic system which is defined in terms of the 8-color asteroidal photometric system. The taxonomic classes were defined by a cluster analysis of the data, cutting the longest branches of the minimal tree in color-color plots. Albedos derived outside the 8-color survey are used to subdivide some classes yielding a total of 14 classes. Many of the classes are similar to those defined earlier on more subjective grounds but several new classes are now recognized. A fifteenth class may be justified distinguishing members of the Eos family from other S-class asteroids.

2. JOINT SESSION OF COMMISSIONS 15 AND 22 ON METEOR STREAMS, COMETS, AND ASTEROIDS (ORGANIZED BY P. BABADZHANOV AND L. KRESAK)

D. Olsson-Steel reported on a radar search for streams associated with Apollo-type asteroids. Convincing evidence exists for streams associated with 3200 Phaethon (previously known), 1566 Icarus, 5025 P-L, 1982 TA, 984 KB, 2201 Oljato, and several others. It is impossible to determine whether they come from extinct cometary nuclei or collisional debris.

D. Olsson-Steel reported also recent observations aimed at deriving the height distribution at frequencies of 2, 6, and 54 MHz. The data show that previous measurements using VHF radars have detected only a few percent of the total influx of microgram-milligram particles.

P. Stohl and V. Porubcan discussed the Taurid meteor complex and its cometary and asteroidal associations. The analysis of all precise photographic orbits and radiants of meteors and FN-fireballs of the Taurid meteor complex associated with P/Encke has enabled them to conclude that: (1) the activity of the complex extends over 4 months (170-300 degree of solar longitude); (2) both, the continuous variations of the mean orbital elements and of the mean position of the radiant of the complex confirm that several minor showers are in fact regular berths of the complex. Their names are derived from the position of the radiant at the corresponding period of observations: Arietids, Piscids, CH-Orionids, Ro-Geminids; (3) Asteroids 2201 Oljato, 1982 TA and very probably also 5025 P-L and 984 KB are closely associated with the southern branch of the Taurid meteor complex if the derived varied mean orbit is taken into account.

Otsukha studied Monocerotids in photographic meteor catalogues and compared the radiant of 15 meteors with that expected from Comet Mellish; good agreement is found, except that the peak occurred two days earlier than expected.

Hasegawa summarized recent Japanese studies of meteors. In addition to an extensive program of visual observations there are photographic programs which have given roughly 600 double-station observations over about 10 years and an FM radar program that has shown, e.g., that the hourly rate of eta Aquarids is constant from year to year.

Taguchi showed 4-color photographs of a persistent train from a bright Orionid meteor with strong emission in the 6000-7000 Angstrom region.

3. SCIENTIFIC SESSIONS ON "NEWS IN COMETARY RESEARCH" (ORGANIZED BY C. ARPIGNY)

B. Donn summarized our understanding of cometary nuclei separating facts that are definitely known (the nucleus is a single body, that activity occurs in isolated areas, the low albedo, the predominance of water among the volatiles, etc.) from phenomena that are still not well understood (scale of surface irregularities, whether the mantle is intrinsic or evolutionary, the composition-thickness-structure of the mantle, the cause of outbursts and active areas, and the nature of the interior). He also reviewed models of Donn, Yamamoto and others, which demonstrate the the nucleus is formed by accretion of grains.

H. Rickman summarized his techniques for modelling the non-gravitational forces and how these techniques lead to estimates of the density of cometary nuclei. He stressed that if P/Halley precesses as much as implied by Sekanina's studies, then the average insolation is peaked at the subsolar latitude thus simplifying an otherwise intractable problem. He concludes that the $0.1 < \text{density} < 0.5 \text{ g/cc}$.

U. Keller discussed the outgassing as observed from Giotto. The principal results include the observations that most outgassing occurs from three main sources covering perhaps 10-20% of the surface, the dust in the jets is reddish (9% per 1000 Angstroms redder than Sun), the strongest jets can be correlated with ground-based observations, filaments of width 0.5-1.0 km are common and criss-cross each other, the fact that a breeze must carry dust past the terminator, and the significance of the absence of activity on the dark side of the nucleus. He stressed that our present picture of cometary nuclei is different than that previously held by many investigators.

Z. Sekanina described his model of active vents and noted that the floor of the vents on P/Halley and P/Encke must recede by of order 10 meters per revolution. Thus individual vents can not remain active over millennia. Encke apparently has gone through two different phases of activity, one current and one producing the Taurid meteor stream, with a long inert period between these events.

R. West showed recent (April 1988) photographs of P/Halley taken with a cod system at the Danish 1.5-m telescope at La Silla. Combination of images for an effective 12-hour exposure and subtraction of the circularly symmetric component allows one to see a definite tail with a surface brightness near 29 mag per square arcsec. The nucleus varies with an amplitude near 1 magnitude.

M. Hanner surveyed infrared results obtained from the ground which characterize the dust. Although some emission peaks are associated with specific species, others are not. The structure in the feature at 3.36 microns is still not definitively understood whereas the structure in the 10-micron silicate feature has been associated with crystalline olivine. The similarity between infrared spectra of Halley and those of IDPs was noted.

A.-C. Levasseur-Regourd described the in-situ results on the dust, noting that differences were found in the size distributions of 'new' and 'old' dust. She also summarized the important results on the composition of the dust, particularly the discovery of the three types of particles - chondritic, CHON, and mixed. She discussed tentative results suggesting that the CHON material might come from mantles on silicate particles and the fact that the CH particles were seen further from the nucleus than most other types suggesting that either they are break-down or longer-lived products. She concluded with a brief discussion of possible polymers.

D. G. Schleicher summarized results from Earth-based observations of the neutral gas. He stressed the importance of the new species detected from Earth and the relatively high abundance of CO. He noted also that for the first time there were numerous determinations of the velocities of several species from Doppler shifts using radio and infrared FTS techniques. These results agree with measurements using traditional techniques (expansion of features) and in situ results. He also discussed relative abundances noting that P/Giacobini-Zinner was highly anomalous while P/Halley was very 'normal'. Finally he noted the extreme variability.

W.-H. Ip surveyed the in situ studies of gas, particularly ions, in P/Halley. He pointed out particularly the outstanding questions - the high abundance of sulfur ions at large distances, the discrepancy between the spherical symmetry of H₂O as seen by the NMS on Giotto and the jet of H₂O seen spectroscopically from Vega. He noted the direct measurement of the contact surface and the dramatic change in the ionic kinetic temperature across this surface. He also

noted the controversy on the nature of the polymers and the question of the source of S and C ions.

V. Vanysek summarized recent measurements of isotopic ratios in comets noting the decreasing error bars as measurement techniques improve. He briefly discussed the implications of isotopic ratios similar to those on Earth and of a reduced $^{12}\text{C}/^{13}\text{C}$ ratio.

P. Wehinger described their determination of the $^{12}\text{C}/^{13}\text{C}$ ratio in P/Halley with the result 65 ± 9 .

D. Bockelee-Morvan summarized recent work by the group at Meudon. She compared the detection of HCN in P/Halley with the upper limits for comets Wilson and P/Giacobini-Zinner noting that the results are consistent with constant fractional abundance. She also summarized their studies of OH which show the 7.4-day periodicity and yield good estimates of the lifetimes and velocities for both H_2O and OH. The magnetic field in P/Halley was determined as 50mT .

M. Niedner surveyed results from the study of photographs of plasma tails and their correlation with variations in the solar wind. In P/Halley, the first tail seems to have formed between Nov. 10 and Nov. 13, a time which may be correlated with a high speed stream in the solar wind but which may also be associated with an increase in outgassing, thus leaving the mechanism for onset indeterminate. The outstanding questions are the initial velocity of the ions, whether DEs are due to front-side or tail-side reconnection, and the nature of tail rays.

A. H. Delsemme led a brief discussion about the question which properties of P/Halley were typical of all comets and which were unique to P/Halley. A consensus was not reached on most of these questions. He also discussed some of his own work on the chemical contents of cometary nuclei and on distinguishing Oort-cloud comets from Kuiper-belt comets based on their somewhat different temperatures of formation. He concluded that P/Halley came from the Kuiper belt.

4. SCIENTIFIC SESSION ON "NEWS IN MINOR PLANET RESEARCH" (ORGANIZED BY A.W. HARRIS)

S. Ostro summarized the properties of asteroids as seen with radar. He noted that some classes such as M, seem distinguishable from others while many other classes show similar properties at radar wavelengths. He pointed out numerous unusual asteroids such as Kleopatra, noting the forthcoming occultation of this asteroid which may answer questions about its shape. He discussed recent work modelling the shape of asteroids showing the distinctly different shapes of Ivar (significantly elongated) and Apollo (more nearly circular).

V. Zappala summarized the distribution of rotational properties. He described the variation of the rotation rate with size (minimum at sizes near 125 km) and the variation of the amplitude (axial ratio) with size (decreasing from about 25 km to 125 km, with possibly a minimum there or possibly a flat distribution). He also showed that the statistical properties could be described by a bi-modal distribution of velocity-size relations. He noted the need for binary asteroids to explain the longest periods in the light curves.

Z. Knezevich described several approaches to integrating the proper elements of asteroids over very long intervals. He has used a 6-body model and compared it with a 3-body model. For some cases it gives a significant improvement, but not for all. He concluded that no single approach will work well for all asteroids.

C. Chapman presented a new bias analysis of the distribution of asteroidal taxonomic types. He noted that in a simple plot of U-B vs. B-V, more than 50% of the space defines unique types. The size distributions differ dramatically from type to type with the distribution for type C deviating most drastically from a classical collisional distribution. The subdivisions of the S type seem to be at least weakly correlated with size and albedo. The question of whether S-types correspond to stony-iron or to chondritic meteorites is still open. Other questions include: why do families not have a sensible set of taxonomic types? How can Vesta have a thin crust on a metal core when Psyche has been stripped of its crust? Where did the olivine from mantles go?

A. W. Harris discussed the comparison of observed light curves near opposition with current scattering theories. Surprisingly, some asteroids with very steep phase curves, such as Aurelia, show virtually no opposition effect whereas other asteroids such as Nysa show a strong opposition spike inside 2 degrees even though theory predicts that they should not. In general, the dark asteroids show less opposition effects than expected from current theories.

M. Fulchignoni described very briefly VIEW (Vesta International Earth Watch), a proposed effort to support the Vesta mission.

M. A'Hearn
L. Kresak
J. Rahe