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FORMATION OF IONS AND RADICALS FROM ICY GRAINS IN COMETS; William
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Ion and radical formation in comets are thought to occur primarily by
photodissociation of gas phase molecules. In this paper experimental evidence and
theoretical calculations will be presented that show that some of the radical and ions can
come directly from ice grains. The experimental evidence suggest that if the frozen
molecules on the surface of grains undergo direct dissociation then they may be able to
release radicals directly in the gas phase. If the molecules undergo predissociation it is
unlikely that they will release radicals in the gas phase since they should be quenched.
Calculations of this direct photodissociation mechanism further indicate that even if the
parent molecule undergoes direct dissociation the yield will not be high not to explain
the rays structure in comets unless the radicals are stored in the grains and then released
when the grain evaporates.

Calculations were also preformed to determine the maximum number of ions that
can be stored in an icy grain it's radius. This number is compared with the ratio of the
ion to neutral molecular density. From the comparison, it is suggested that some of the
ions observed near the nucleus of the comet could have originally been present in the
cometary nucleus. It is also pointed out that the presence of these ions in icy grains
could lead to radical formation via electron recombination. Finally an avalanche process
has been evaluated as another means of producing ions in comets.

Interstellar origin of CHON particles

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The organic component of cometary dust, known as CHON particles, is of interstellar origin. The organics are nitrogen poor and contain saturated and unsaturated compounds with no, one or two oxygen atoms (Korth et al., 1989). The particles that were detected, have sizes from 0.05 μm radius up to 0.5 μm, with a trend for an increase in mean density with size (Maas et al., 1989).

Unsaturated organic matter is found in space as the product of carbon rich outflows of red giant stars, or as the product of the UV photolysis of small gas phase molecules frozen on dust grains. The lifetime of organic grains is very short due to the sensitivity to errosion by chemical sputtering and shock destruction. The in–situ formation mechanism by UV photolysis is therefore a potentially important mechanism and is studied in laboratory analogue experiments (i.e. De Groot et al. 1988).

We have found that the UV photolysis of second generation molecules on a cold substrate in vacuum leads to the formation of small complex polymeric materials, that have in common that they show a more or less linear increase in extinction between $\lambda^{-1} = 2\mu\text{m}^{-1}$ and $\lambda^{-1} = 5\mu\text{m}^{-1}$. Such a linear increase is a feature of the interstellar extinction curve (Fitzpatrick and Massa, 1988). In order to absorb efficiently in the UV, part of the organic mantles of grains should be shattered by grain–grain collisions into small (a< 0.02μm) pieces.

In spite of early hopes, it is not possible to form the tiny graphitic grains thought to be responsible for the bump absorption at 220 nm, in this way in the laboratory. In space the necessary carbonisation may occur by pyrolysis of the smallest of the fragments, which obtain high temperatures after absorption of a single photon. In order not to evaporate, the third generation organic material should still contain a significant amount of oxygen. This generic picture qualitatively agrees with the correlations found between big grain size and both linear rise and bump absorption.

The generic picture implies that the pre–solar system dust exists as of core–mantle grains and pieces of mantle material. Both kinds grow due to accretion in the dense pre–solar cloud. Coaggulation of the small (a~0.01 μm) organic grains leads to small (a= 0.05 μm) low density fluffy CHON particles and accretion on larger pieces to large (a = 0.5 μm) higher density CHONs. The core–mantle particles and large CHONs grow into the fluffy Greenberg–Hage particles, needed to explain the infrared emission bands of cometary dust (Greenberg and Hage, 1990).

Fitzpatrick E.L., Massa D.: 1988, *Astroph. J.*, **328**, 734

Greenberg J.M., Hage J.I.: 1990, *Astroph. J.*, **361**, 260

de Groot M.S., van der Zwet G.P., Jenniskens P.M.M., Bauer R., Baas F., Greenberg J.M.: 1988 in *Dust in the Universe*, 265

Korth A., Krueger F.R., Mendis D.A., Mitchell D.L.: 1989 *Asteroids Comets Meteors III*, 373

Maas D., Krueger F.R., Kissel J.: 1989 in *Asteroids Comets Meteors III*, 389

New Geminid meteor orbits

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The most likely candidate for an extinct cometary nucleus is the asteroidal object 3200 Phaeton. The object is associated with the Geminid meteor stream. From a numerical integration back in time of a number of Geminid meteoroids, Gustafson (1989) found that the meteoroids had been ejected at perihelium, not at aphelium, which favours a cometary origin.

For further research, he expressed the wish for data on meteoroids with both well determined orbits and an estimate of the surface to mass ratio. Between 1990, december 11–15, we obtained over 100 geminid meteoroid orbits from a small camera network campaign, conducted under ideal circumstances in the south of France. At least part of the data are expected to provide also estimates of surface to mass ratios, needed to improve the quality and statistics of the numerical calculations.

Gustafson B.A.S.: 1989, *Astron. Astrophys.*, **225**, 533

THE EVOLUTION OF THE QUADRANTID METEOR STREAM; J. Jones, Physics Dept. University of Western Ontario, London, Ontario, Canada, N6A 3K7 and W. Jones, Physics Dept., University of Sheffield, S3 7RH, U.K.

According to the orbital calculations of Babjahnov and Obrubov (1987) the last close approach of the Quadrantid stream with Jupiter occurred about 3200 years ago which may have been the occasion when the parent comet of the Quadrantid stream was captured into its "present" orbit. If this is the case the stream may be only a few thousand years old. We have modelled the evolution of the stream to determine if the observed features of the Quadrantid/Arietid/δ-Aquarid complex are consistent with such a short time scale. Two starting dates were chosen 4000 years and 2400 years ago for a detailed modelling of the stream with 500 test particles including the gravitational perturbations of 6 planets as well as the likely spread in initial orbits elements resulting from the ejection process of the grains from the comet. The calculations show that although gravitational perturbations alone are unable to account for the observed features of the complex much better agreement is possible when the effects of the differential ejection velocities are included.

FORWARD-SCATTER RADIO-METEOR STUDIES; J. Jones, Physics Dept. University of Western Ontario, London, Ontario, Canada, N6A 3K7 and A.R. Webster, Department of Electrical Engineering, University of Western Ontario, London, Ontario, Canada. N6A 5B9.

Forward-scatter systems have been much neglected for the study of meteors and meteor streams. Much of this neglect stems from the complicated geometry which has made the interpretation of results difficult in the past. This no longer presents a problem because the of the computer power now available. There are practical advantages in using forward-scatter in that low-power transmitters are much easier to handle than the high-power ones used in pulsed back-scatter radars. The data reduction of the CW signals is significantly simpler than the pulsed signals usually associated with back-scatter meteor radars. Also the reflection geometry causes the duration of the echoes to the somewhat longer than for back-scatter geometry which partially alleviates the problem of the under-dense echo ceiling.

We have built a "short hop" forward-scatter system between Ottawa and London (Ont) for which the transmitter and receivers are separated by about 500 km. With it we are able to measure unambiguously the directions of arrival of the echoes using a 5-antenna interferometer of novel design. The directional errors are of the order of 0.5 degree. We describe this system and discuss its performance.

Jones (1977, BAC, 28, 272) and Morton & Jones (1982, MN, 198, 737) have shown how the echo direction distribution can be deconvolved to yield the meteor radiant distribution for back-scatter data. We extend that technique here to the forward-scatter case and present some preliminary meteor radiant distribution maps.

EFFECT OF THE GEOMAGNETIC FIELD ON THE DIFFUSION OF METEOR TRAINS;

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The solution to the problem of the diffusion of a meteor train in the geomagnetic field from an initial line density may be written in closed form in terms of effective diffusion coefficients depending on direction. The solution is essentially exact within the quasi-neutrality approximation, and enables detailed calculations across the entire range of angle of train to field and relevant heights.

For heights of 95km and above the diffusion is severely inhibited by the field if θ, the angle between train axis and the field lines, is close to zero. This effect diminishes very rapidly as θ is increased to about 2°, in accordance with previous suggestions based on considerations of a planar plasma irregularity. The completely new element of our results is that while the effective diffusion coefficient in the plane of train and field then remains close to the zero field ambipolar value right up to 90° the effective coefficient in the direction of the normal to plane of train and field drops steadily to its $\theta = 0$ value at $\theta = 90°$. Even for a height as low as 95km the magnetic field can reduce the diffusion in the normal direction by a factor of two below the zero field value. This corresponds to a change of almost 5km in "diffusion height", that is, the height of an underdense meteor calculated on the basis of the exponential decay of its radar echo. We estimate the consequent changes in the expected distribution of diffusion heights for various orientations of radar antenna.

OBSERVATION OF METEORS BY MST RADAR:

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The vast majority of meteors give appreciable back scatter radar echoes only from a region near the "reflection point" on the perpendicular from the train to the receiver. This implies trains observed with the vertical beam of an MST radar to be horizontal; thus relatively few meteors will be observed, the majority having burned up before reaching the reflection point. There are advantages to using an MST radar in the observation of meteors, nevertheless, in particular that the height resolution is very good and that the zenith angle is known.

We have used the Aberystwyth MST radar to observe the Geminid meteor shower of December 1990, recording heights and the rate of decay of the echo.

The heights of underdense meteors are commonly estimated on the basis of diffusion theory. This theory predicts that the exponential decay time of the radar echo will be inversely proportional to the diffusion coefficient D and thus directly proportional to the air density. However, because of the difficulty of estimating the meteor height by other means, confirmation of this procedure has in the past been largely statistical and not completely satisfactory. The MST radar provides us with accurate heights for individual meteors, and in the range for which the echoes occur shows the average of the "diffusion heights" to be in fair agreement with the true height, but also that the diffusion height of an individual meteor can differ from the true height by to 4 km.

Since the zenith angle is known, we can use the true heights to estimate the size of the individual particles from the usual ablation theory, suitably modified to take account of the curvature of the Earth. The true heights are almost entirely confined to the range 86.5 - 91km, and are interesting in indicating a fairly sharp cutoff in the size distribution at the upper end. However, the absence of echoes above 91km, is to be attributed to the fact that the radar returns data every 1/12th of a second, so that if a signal decays in less time we are unable to determine it as a meteor.

THE CORRELATION BETWEEN WATER PRODUCTION RATES AND VISUAL MAGNITUDES IN COMETS;

L. Jorda (Observatoire de Paris-Meudon and European Southern Observatory), J. Crovisier (Observatoire de Paris-Meudon), and D.W.E. Green (Smithsonian Astrophysical Observatory).

We have studied the correlation between the water production rate and the visual magnitude in a dozen of recent comets with heliocentric distances ranging from 0.32 to 2.8 AU. The visual magnitudes are taken from the International Comet Quarterly data base. The water production rates are evaluated in a consistent way from the OH 18-cm lines measured with the Nançay radio telescope, following the method of Bockelée-Morvan *et al* (1990, *Astron. Astrophys.* **238**, 382). There is a strong correlation between the heliocentric magnitude m_h and the water production $Q[H_2O]$. The empirical law deduced from the whole set of data is:

$$\log Q[H_2O] = 30.76 - 0.25\ m_h.$$

Surprisingly, there is no strong deviations from this law for individual comets. In a first inspection, dusty and non-dusty comets behave in the same way. This law may be used for gas production rate estimations when no spectroscopic observations are available.

Inversion Methods for the Interpretation of Asteroid Lightcurves

M. Kaasalainen, L. Lamberg, and K. Lumme (University of Helsinki)

We have developed methods of inversion that can be used in determining the three-dimensional shape or the albedo distribution of the surface of an asteroid from lightcurve observations, assuming the shape to be strictly convex (*Bull. Amer. Astron. Soc.* **22**, 1113, 1990; *Asteroids, Comets, Meteors III*, pp. 115-118, 1990). Although in theory it is sometimes possible to obtain separate solutions describing both the shape and the albedo distribution of an object, the present quantity and quality of observational data of asteroids are not sufficient for this in practice. Thus one must decide in each case whether the result obtained in the inversion is taken to describe shape rather than albedo features, or if the surface is not convex on a global scale; fortunately, there are some indicators for this. A solution ascribed to shape is less sensitive to errors in lightcurve data than one ascribed to albedo variegation.

Since small errors in the data may have large effects on the results, we discuss the influence of various observational factors on the inversion. Of these factors, the most important ones are the number and range of the observing geometries (primarily concerning the solar phase angle and the aspect angle) and the accuracies of the lightcurve measurements and the pole position used for the asteroid. We also present results obtained using real asteroid lightcurve data and discuss the possible interpretations.

CYCLOTRON IRRADIATION SIMULATION OF COSMIC RAY MODIFICATION OF ORGANIC MATTER

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Frozen CH_4 and CH_4/Ar mixtures are irradiated at 15 K with 10 to 20 MeV p and $^3He^{2+}$ ions from the Jülich compact cyclotron CV28 in order to simulate the effect of cosmic rays on solid organic matter in comets. The products both gaseous and solid, in particular non volatile residues, were analyzed by a multiplicity of analytical methods including MS, REM, RBS, ERDA, ^{1}H-NMR, HPLC, GC/FID, GC/MS, FTIR und RAMAN. It could be shown that non volatile residues consisted of a mixture of long chained aliphatic and olefinic compounds and polycyclic aromatic substances (PAH and related). The formation of cyclic compounds is due to a multicenter reaction within the collision cascades induced by the cyclotron (cosmic ray) ions and their secondaries and depends in particular on energy density. Critical L_T values for the formation of PAHs for solid CH_4 are between $2 \cdot 10^3$ and 10^4 eV/μm. He-ions and heavier components of solar or cosmic rays are very effective in processing organic matter. There is a distinct difference between solids closed into cuvettes compared to those condensed in μm layers onto cold fingers in vacuum. The first are representative for reactions in the interior of comets or icy planets and yield more PAHs. The latter are representative for thin layers on dust grains, ring material or cometary, planetary or asteroidal surfaces and yield preferentially aliphatic compounds, and solid carbon. Carbon formation is a consequence of stronger H-elimination in the open targets.

METEOR FIREBALL SOUNDS IDENTIFIED

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Sounds heard simultaneously with the flight of large meteor
fireballs are electrical in origin. Confirmation that Extra/Very
Low Frequency (ELF/VLF) electromagnetic radiation is generated by
the fireball has been obtained by Japanese researchers. Although
the generation mechanism is not fully understood, studies of MORP
and other fireball data indicate that interaction with the
atmosphere is definitely responsible and the cut-off magnitude of
-9 found by Astapovich for sustained electrophonic sounds is
supported by theory. Brief brief bursts of ELF/VLF radiation may
accompany flares or explosions of smaller fireballs, producing
transient sounds near favourably placed observers.
Laboratory studies show that mundane physical objects can respond
to electrical excitation and produce audible sounds.
Reports of electrophonic sounds should no longer be discarded. A
catalog of over 300 reports relating to electrophonic phenomena
associated with meteor fireballs, aurorae and lightning has been
assembled. Many other reports have been catalogued in Russian by
Bronshten. These may assist the full solution of the similar
long-standing and contentious mystery of audible auroral displays.

HIGH RESOLUTION SPECTRA OF CH, CO_2^+, C_3 AND NH_2 IN COMET AUSTIN;

S.J. Kim and M.F. A'Hearn (University of Maryland, College Park), M. Brown and H. Spinrad (University of California, Berkeley)

We analyzed high resolution (~ 0.05 A) spectra of the nuclear regions of comet Austin
(1989c1) in the 3800 - 8000 A range, which were obtained at the Lick Observatory on May
13, 1990 (UT) (Brown and Spinrad, BAAS, 22, 1100, 1990). The purpose of this
analysis is to construct molecular band models of CH, CO_2^+, C_3, NH_2 and S_2 in order to
compare the models with observed emission lines and to identify molecular lines in the
spectra. The constructed models of the CH, CO_2^+, C_3, and NH_2 bands are preliminary.
We could, however, indentify numerous lines of the CO_2^+, C_3, and NH_2 bands, and of the
0-0 band of CH. In particular, some of the individual lines of the CH band are clearly
resolved, which have not been previously resolved with relatively low resolution
spectroscopy (Arpigny, C. et al., Symposium on the Diversity and Similarity of Comets,
pp. 607-612, April 1987, Brussels, Belgium, ESA SP-278). We could not find any S_2
lines in the Austin spectra. We will present rotational temperatures derived from the
molecular band structures of these molecules, and discuss their implications on the
collisional and fluorescence processes in the coma of comet Austin.

SIMILARITY AND DIFFERENCE OF POLARIMETRIC CHARACTERISTICS
OF DUST PARTICLES OF COMETARY ATMOSPHERES AND THE SURFACE
LAYERS OF ASTEROIDS. N.N.Kiselev, G.P.Chernova, Institute of
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Phase dependences of polarization of dust particles of co-
mets and asteroids are being compared. The "asteroid like" ne-
gative branch of polarization of comets is a good evidence of
aggregate structure of particles of cometary atmospheres and
the identity of scattering processes of sun light on the grains
of comets and asteroids. The phase dependence of polarization
of comets are similar to C-type asteroids in the region of
small angles ($\alpha < 25°$). It is shown that comets with a conside-
rable continuum have more stable parameters P(min), α(inv),
h(slope) in comparison with asteroids of any types. Their con-
stancy is interpreted as the result of homogeneous composition
of dust particles in atmospheres of different comets. Parame-
ters of the positive polarization P(max), α(max) of comets and
asteroids are badly known. The few observations of comets and
near-Earth asteroids of S-type permit us to state their consi-
derable differences: for comets - P(max)$\approx 25\%$, α(max)=90°; for
asteroids - P(max)$\approx 8.5\%$ and α(max)$\approx 110°$. The parameters of
the positive polarization of comets are explained by the consi-
derable contribution of the quasi-Rayleigh polarization compo-
nent arising from the effective scattering of light on small
particles of cometary atmospheres.

POLARIMETRY OF ASTEROIDS IN THE USSR. N.N.Kiselev[1], D.F. Lupishko[2], G.P.Chernova[1]

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2) Astronomical Observatory of Kharkov University, Kharkov, 310022, USSR

The review is given of the results of the polarimetric observations of asteroids obtaining according to the following programmes: the polarimetry of the CMEU-asteroids with the aim of classifying them to types, distinguishing and studying the M-type asteroids; the investigation of spectral dependence of polarization; the polarimetry of near-Earth asteroids; the polarimetry of individual asteroids (4 Vesta, 16 Psyche and others).

The results show the polarimetry is an effective method of investigation and should be used more widely, especially combined with photometry.

The following perspective directions of investigations are noted:
a) determining the parameters of phase curves of polarization of asteroids of all types, groups and sizes;
b) studying the spectral dependences of P(min), inversion angle α(inv) and slope h and determining their diagnostic significance for the study of structural and mineralogical properties of asteroid surfaces;
c) the polarimetry of near-Earth asteroids with the aim of obtaining the maximum complete phase dependence, the study of regoliths of several kilometer bodies, the distinction of minor planets - probable extinct cometary nuclei;
d) the polarimetry of individual asteroids for studying the photometric heterogeneous of their surfaces.

ASTEROID FAMILIES AND DIFFERENTIAL MASS INDEX; J. Klačka,
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The basic results and consequences of the existence of
asteroid groups with differential mass index $k > 2$ are reviewed.
This result is practically independent on various classifications
of asteroid families. The only groups with such value of k are
situated in the inner and outer part of the asteroid belt. The
total mass is dominated by the small-particle end of the range
of masses. So, the total mass of such groups could have been
much higher than it is at present and also much higher as to be
initially concentrated in one body and disrupted by collision
(generally accepted explanation of the origin of asteroid fami-
lies). Since the collision mean-life $\propto D^{3k-5}$, we do not have
$\propto D^{1/2}$ as it is generally accepted but $\propto D^2$ (approximately).
This explains why the present total mass of investigated groups
of asteroids corresponds to values generally accepted. The grea-
ter part of asteroids with $D \lesssim 1$ km is depleted from given groups
due to collisions. This conclusion about the critical point whe-
re the size-frequency curve of small objects departs from that
extrapolated from known asteroids should be verified in future.
Some other consequences (histogram distributions of rotation ra-
tes for the Koronis and Eos families and a set of nonfamily aste-
roids; the presence of dust bands in Themis, Eos, Koronis families
and not in Flora family) can be also explained by this interpre-
tation.

ASTEROIDAL JET-STREAM FLORA A; J. Klačka, Department of
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Problem of the existence of the most significant jet-stream
Flora A is analysed. On the basis of the data analysis it is
shown that Flora A consists mostly of very faint asteroids with
oppositions falling on the autumn months and with very low incli-
nations. Due to the favourable observing conditions just during
September, the concentration of proper perihelion longitudes is
explained as a consequence of the observational selection effects.
The low inclinations explain the concentration in proper longitu-
des of nodes just in the area corresponding to that of the jet-
-stream Flora A. Thus the most important asteroidal jet-stream
Flora A is fully explained as a consequence of observational se-
lection effects.

Comet Levy Images at 3.36μm

James Jay Klavetter (UMD) and Susan Hoban (GSFC)

We observed comet Levy (1990c) with the ProtoCAM through a 1.4% CVF centered at 3.36μm at the IRTF on 1990 August 8 and 10. After subtracting the continuum, we find the spatial profile of the unidentified 3.36μm emission feature to be indistinguishable from the continuum out to 1225 km from the optocenter. Our measurements of the ratio of the flux at 3.36μm to that of the continuum in comet Levy is consistent with values reported by Brooke *et al.* (1991) of P/Halley at comparable heliocentric distance. Since the average value of the dust-to-gas ratio in P/Halley (25.4, by Brooke *et al.*(1990)) is similar to that of comet Levy measured on 1990 August 25-27 (25.6, D. Schleicher, private communication), our measurements of the feature-to-continuum ratio in comet Levy strengthen the conclusions of Brooke *et al.* (1990) that the abundance of the progenitor of the 3.36μm feature relative to water is comparable for all comets observed to date. For the August 10 data, we find the integrated band flux at 3.36 ± 0.014 μm in a 2.7" aperture to be 1.45×10^{-17} W/m^2 (±10%).

THE CARBON ISOTOPE ABUNDANCE RATIO IN COMETS HALLEY AND LEVY

M. Kleine, S. Wyckoff, P. A. Wehinger, *Department of Physics and Astronomy, Arizona State University*, and B. A. Peterson, *Mount Stromlo and Siding Spring Observatories*.

High resolution spectra of the R-Branch (0-0) band of the CN $B^2\Sigma^+ - X^2\Sigma^+$ transitions have been observed using the Mount Stromlo Observatory 1.9 m telescope and coudé echelle spectrograph of comets Halley(1986 III) and Levy(1990c). The observed rotational spectra is very sensitive to the comet's heliocentric velocity. New fluorescence calculations to model the Swings effect have been developed so that the $^{12}C/^{13}C$ abundance ratio could be determined from the observed line intensities. The abundance ratio for P/Halley is a reanalysis of the data (cf. Wyckoff *et al.* 1989, *Ap. J.*, **339**, 488) utilizing these new fluorescence efficiencies. The carbon isotope abundance ratios for comets Halley and Levy will be presented.

IMPROVED ASTEROID PROPER ELEMENTS AND THEIR ACCURACY

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We have computed a new set of proper elements for 4537 numbered asteroids by a fully analytical iterative theory extending the one described in Milani and Knežević, 1990, *Cel. Mech.*, in press. The main improvements with respect to the previous version are: (i) a more accurate computation of the Laplace coefficients; (ii) the effects of all four outer planets being accounted for at the level of the linear theory; (iii) the effects of Saturn being included up to degree four in eccentricity/inclination and to order two in the mass of Saturn; (iv) a correction to the secular frequency due to the inner planets is applied; (v) possible secular resonance cases are identified and separately reported.

The advantages of this type of proper elements are that they can be computed efficiently; this allows not only to process large catalogues of orbits, but also to test their accuracy and long term stability by a conceptually simple procedure. We have performed an extensive set of numerical integrations of representative asteroid orbits (by chosing one example for almost each family identified by Zappalà et al., 1990, *Astron. J.*); then proper elements have been computed and their changes with time used as an estimate of the accuracy. The results show a significantly better accuracy with respect to the previously distributed version; apart from some dynamically peculiar regions (e.g. near the Kirkwood gaps, near the main secular resonances, and the ω-libration region), for most of the asteroid main belt and for an overwhelming majority of asteroids, the accuracy is more than enough for the identification of fragments of catastrophic disruptions. The error estimate can be used for statistical tests of the reliability of family identifications.

Laboratory Studies Of The Gas-Particle-Interaction On Comets; H. Kochan [1) and Markiewicz, W.J. [2).1) Institut für Raumsimulation, DLR-Köln, P.O.Box 906058, D-5000 Köln 90, FRG., 2) Max-Planck-Institut für Aeronomie, P.O.Box 20, D-3411 Katlenburg-Lindau, FRG.

The in situ observation of insolated ice/mineral mixtures in the DLR Space-Simulator opened some insights e.g. in the emission processes of ice-/dust-particles from the surface [1,2,3]. The cited results may be shortly reviewed by the statements: 1)The particles are bonded to their neighbors. Before the individual particles can be emitted at first their interlinking bonds have to be "eroded" by the outstreaming gas, originating from the sublimation of volatiles. 2) The extricated particles are entrained into the gas flow, rather than ejected from the surface. In the last experiments KOSI (= Kometen-Simulation) 5, 6, and 7 dating from 1989 to 1991 the ice-/dust-particle emission was monitored with three high-speed shutter CCD-video-cameras. In the experiments KOSI 5 and KOSI 6 the same cylindrical sample container 15 cm high and 30 cm in diameter was used. The gas-particle interaction investigated and published so far is based on the experiments that used this sample container. KOSI 7 (Jan.`91) was performed with the new larger sample container 30 cm high and 60 cm in diameter, requiring 80 litres of the icy material.

The gas-particle-interaction, i.e. the exchange of momentum depends on the gas flux (velocity, density) and on the nature (density, structure, cross section) of the ice-/dust-particles. The particle collectors developed and operated by KOSI team members [4], define the portion of volatiles in the emitted particles. At the beginning of the experiment when a fresh sample surface is insolated, particles with a high amount of volatiles are emitted. The "ice-load"-factor of the emitted ice-/dust-particles decreases with increasing insolation time. To get a better understanding of the drag-coefficient, during KOSI 7 cryogenized collectors were introduced, to preserve the emitted particles for a later inspection. At the end of the same experiment glass-spheres (drag-coefficient known) of different diameters, all in the micron area, were dropped down on the sample surface. The glass spheres also were entrained into the gas flow. Emission angle and -velocity were defined via the video observation.

The video records of the ice-/dust-particle trajectories crossing the new, large sample container are under evaluation. These trajectories are controlled by the momentum transfer from the gas flow to the particles. The region of decoupling is determined for the different experimental conditions, large and smaller sample. The particle trajectories markedly differ from the ballistic parabolas calculated with the first observable values of emission angle and velocity. The gas-particle-interaction derived from the different experiments will be discussed.

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INTEGRATED   SOFTWARE PACKAGE   "STAMP" FOR   MINOR PLANETS;
O. M. Kochetova, V. A. Shor, Institute of Theoretical Astronomy, USSR
Academy of Sciences.

The package STAMP is designed for rapid and precise
reproducing the tables of the annual "Ephemerides of Minor
Planets" with the help of PC XT/AT. STAMP makes it possible to
reproduce any table from the current volume of the EMP, to print
it or to write it in a file. Then, the package enables to select
the data from the tables complying with a condition or
combination of some conditions. Finally, it provides a means for
calculation of some often used functions of the orbital elements,
for sorting the results of selection and/or calculations, for
drawing the histograms and for interpolating the tabular data. In
addition, STAMP makes it possible to solve the routine problems
such as the comparison of the observed positions with
ephemerides, the identification of minor planets, the
determination of the planets which can be seen at a given moment
within the limited sky region.
Thus, STAMP is of great utility in solution of varied
problems related to minor planets. Dealing with the package is
accomplished through the multistage menu. It is useful tool for
professional astronomers and amateurs.

Laser Characterization of Small Particles Ejected from Cometary Analogue Samples

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Particle ejection is one of the basic physical processes which occur at the surfaces of cometary nuclei. This has already been confirmed by different laboratory simulation experiments of the KOSI project. They proofed that even in the terrestrial gravitational environment dust and ice particles may be lifted from the surface of sublimating ice-dust-samples. However, there had been no possibility to characterize even small particle ($<100\mu$m).

For this reason we developed, calibrated and applicated a laser particle detector for the large space simulator in the KOSI experiments. The beam of a 7 mW He-Ne-laser has been chopped by a high frequency crystal deflector in order to open a few cm wide detection area. Reflected light signals of the passing particles are observed by a optical photomultiplier system. Main experimental problem was the background light suppression within the space simulator. Calibration measurements and results of the instrument are presented.

We present the results from the KOSI 7 experiment. It has been shown that size distribution of the emitted particles changes with duration of irradiation time significantly. While a large number of the smaller particles have been emitted during the first hours of irradiation the distribution shows a significant lack of the small ones in later phases. A simple model for this behaviour will be presented.

The emission activity decreases in the free sublimation experiment down to about fifty percent. Single particle evaluation by analyzing the light scattering signals shows a distinct correlation between speed and size. The results are discussed taking calibration measurements into account. They are compared with results of other diagnostic instruments of KOSI.

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During KOSI (comet simulation) experiments mineral-/ice mixtures are observed in laboratory simulated space conditions. Here we refer to the KOSI 5 experiment where the sample consisted of 70 weight % H_2O-, 17 weight % CO_2- and 4 weight % CH_3OH-ices and 9 weight % minerals (olivine:montmorillonite = 9:1). This mixture was insolated with xenon lamps to simulate solar radiation. The intensity of insolation was nearly 1.2 solar constants for about 12 hours. The pressure in the space simulation chamber was about 10^{-4} Pa.

Emission of ice-/dust particles from the sample surface is observed by different devices. The particles trajectories are recorded with a video system. The recorded tapes are evaluated with an image processing system. The two parameters that were extracted are the elevation angle and the particle velocity near the sample surface. To study the time dependence of the emission process we looked at definite time intervals covering the total insolation period. Time dependent measurements are also possible by rotating particle collectors. The dust residues of the particles in a selected collector are investigated by optical microscopy in transmitted light. Then the sizes of the particles are measured via an image processing system. So the size distributions can be determined as a function of time. The volatile component of the collected particles is measured by a particle detector with ionization gauge. All these detectors are mounted on a frame in front of the sample together with 264 passive dust collectors. By these collectors a spatial distribution of dust particles is determined. In a distance of about 1 m several piezo acoustic impact detectors are arranged azimuthally on this frame. The signals from the particles hitting the detectors give the size and the velocity of the individual particles.

The particle emission activity decays exponentially with time. The emission rate of ice particles reaches its maximum immediately after the sun is switched on and levels off within less than one hour. Mineral type particles with slowly sublimating volatiles reach their maximum emission rate about 30 minutes after the beginning of insolation. At this time the maximum emission rate of particles is also observed on the video tapes. The particle velocities near the sample surface range from 0.4 to 2.4 m/s, with a mean around 1.1 m/s. The mean elevation angle of the velocity vector decreases with time. The size distributions of particles measured by piezo detectors (≥ 200 μm) and collected in rotating collectors (≥ 40 μm) are nearly constant with time.

These results are correlated to the gas flux density and the temperature on the sample surface during the insolation period. The data are interpreted in terms of phenomena on the sample surface, e. g. formation of a dust mantle and mechanisms of particle emission and are related to processes on real comet surfaces.

ENERGY BALANCE OF COMETARY SURFACE LAYERS

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Abstract

It is likely that large parts of a typical cometary surface consist of porous ice which is covered by a thin layer of non–volatile material. In order to study the thermal behavior of such a system we have performed both systematic laboratory experiments and theoretical investigations. The energy balance of such a crust/ice system, the ice temperature as a function of the flow resistance of the overlying crust, and the gas pressure in the interior of the porous ice is discussed in detail. It is found that a non-volatile porous crust has a strong influence both on the ice temperature and on the gas loss rate of a comet.

Disturbances of Both Cometary and Earth's Magnetospheres Excited by Single Solar Flares

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Comets P/Brorsen-Matcalf and C/Okazaki-Levy-Rudenko appeared successively in 1989 and displayed marvellous disturbances of the magnetospheres. A comet is generally like a windvane moving three-dimensionally in the heliomagnetosphere. The recent period of the sunspot maximum phase is important for the study of comets, because the neutral sheet of the heliosphere is nearly perpendicular to the ecliptic plane and intense solar flares occur very frequently.

We found two cases of a phenomenon in which outstanding disconnection event of the cometary plasma tail (on August 13 and November 16, 1989) was followed by geomagnetic storms (on August 14 and November 17). A survey of solar flares clarified that the identical solar flare excited successively the earth's magnetosphere and the cometary magnetosphere.

The velocities of the shock front in the interplanetary space were calculated by using the onset times of the disturbances of both the comets and the earth. The results suggest that the propagation of the shock front associated with the flare is not symmetric around the radial axis from the flare region of the sun.

A NEW MEASUREMENT OF THERMAL CONDUCTIVITY OF AMORPHOUS ICE: RELEVANCE TO COMET EVOLUTION

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Although the importance of knowing the thermal conductivity of amorphous ice (a-H_2O) for predicting the thermal evolution of comets has been widely realized. There has been no previous direct measurement available. Until now, all the discussions on comet evolution have been based on a theoretical estimation of the thermal conductivity by Klinger[1]. On the basis of our new experimental results, we have arrived at a new estimate of the thermal conductivity of a-H_2O.

A thin film of H_2O ice was prepared at 125-135 K by the condensation of water vapor onto a metal substrate in a vacuum chamber (5 x 10^{-7} Pa). The structural change of thin ice film was examined in-situ by reflection electron diffraction. When the ice film is thin the deposited ice is amorphous. On the other hand, when the thickness of the ice exceeds the critical value, Xc, the diffraction pattern has been changed to ice Ic. This observation shows that the surface temperature of an a-H_2O film exceed the transition temperature (Tx=140 K) at the critical thickness, Xc.

To calculate the thermal conductivity using above data we have solved the equation of thermal conduction in the ice film. We also considered the net rate of radiation input from the external radiation field and heat of condensation as a boundary condition. We have found that the thermal conductivity of a-H_2O ranges from at least one to four or more orders of magnitude smaller than that estimated by Klinger[1] and depends strongly on its formation conditions.

Our results have very important implications for the thermal evolution of comets. Since the cometary nucleus itself is very porous, the thermal conductivity of the comet nucleus may be an additional four orders of magnitude smaller than that of the constituent icy grains. This suggests that the net thermal conductivity of the comet nucleus is smaller than 10^{-8} W m^{-1} K^{-1} ! The major mechanism of heat transfer in the comet nucleus can not be by conduction. Although we considered the heat transfer either by radiation or by diffusion of water molecules, both effects are negligible. Consequently, it appears unlikely taht the heating of a comet at depths larger than 10 cm (conservatively) has ever occurred.

Reference
[1] Klinger J. (1980) Science 209, 271-272.

The Solar Wind Structure that Caused a Large-scale Disturbance of the Plasma Tail of Comet Austin

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The study of disturbances of cometary plasma tails or cometary magnetospheres provides us very valuable information on the solar wind and the solar magnetosphere. From the last half of 1989, five bright comets appeared within a year and many disturbance phenomena of the plasma tails were observed. Since it was a period of the active sun, more disturbances were observed in these comets than in comet Halley which appeared at the solar minimum. From the analyses of these phenomena, various results have been obtained. In this study we report the results of the analysis and the fact obtained from the very distinct phenomenon observed in comet Austin on April 29, 1990.

A series of photographs shows the movement and variation of two kinds of very peculiar structures. One structure is of many arcades with a scale of $\sim 10^6$ km. The other is a large wave structure of the order of 10^7 km. A multi-arcade structure is interpreted as the structure of the magnetic field lines which passed through the cometary plasmapause around the nucleus. The travel speeds of these structures are found to increase with the distance from the nucleus. It is proposed that the large wave structure was caused by a change of the non-radial component of the solar wind flow. A computer simulation of the deformation of the plasma tail was performed by changing the speed and the direction of the solar wind flow. The result agrees quite well with the observation. It is concluded that this non-radial flow was caused by an interaction between a high-speed flow from a coronal hole and a low-speed flow from the western region of the sun.

Early and unidentified apparitions of short-period comets

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Comets listed in Marsden's Catalogue (1989) with parabolic orbits were examined to find how many, and which of them, had in fact revolution periods shorter than 20 years. Two statistical approaches were applied to estimate their number : evaluation of the relative distributions of extreme apparent magnitudes of long- and short-period comets, and of the distributions of their orbital inclinations. The conclusion was that there are about 15 unrecognized short-period comets observed before 1759, but only very few observed later.

For the identification of these comets, a combination of 7 criteria was developed, basing on the compatibility of the positional data with a short-period orbit, the orbital inclination, perihelion latitude, perihelion distance, absolute magnitude, apparent magnitudes, angular tail lengths, and observing geometry. 25 candidates selected in this way were divided into five groups according to the probability P' that they were actually of short period :

P' = 99% : comets 1678, 1702, 1743 I, 1949 III and 1963 IX
P' = 95% : comets 1230, 1345, 1351, 1457 I, 1491 II, 1499, 1539, 1577 II, 1585 and 1833. P' = 80% : comets 568, 1080 and 1457 II. P' = 50% : comets 1245, 1293, 1618 I and 1618 III. P' = 20% : comets 390, 1757 and 1860 IV. The sum of these objects weighted by P' - 16 before 1759 and 3 thereafter - agrees very well with the statistical estimates.

Comet 1678 was already identified with certainty with periodic comet d'Arrest by Carusi et al. (1991). Other identities with the known short-period comets appear possible. Pairs of similar orbits include comet 1457 II and P/Finlay or P/Denning-Fujikawa, comet 1230 and P/Biela, comet 568 and P/d'Arrest, comet 1618 III and P/Barnard 3, comet 1491 II and P/Denning. Unambiguous identifications are difficult mainly due to the unknown operation of nongravitational effects over long time spans, with many planetary encounters. However, as illustrated by the linkage of comet 1678 with P/d'Arrest, they could provide important information on the active lifetimes, progressive fading, behaviour of nongravitational forces, and orbital evolutions over periods much longer than those for which observations are available at present.

On the ecliptical concentration of long-period comets

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The distribution of comets in orbital inclination as a function of their revolution periods (or aphelion distances) provides the principal distinction between their subsystems of different dynamical evolution, and perhaps also of different origin. While the separation of the Jupiter family from the comets of Halley type is sharp, the transition between the latter group and the old long-period comets is rather smooth. The question at which aphelion distance the prevalence of direct orbits disappears entirely, is relevant both to their sources and evolutionary mechanisms : the possible flattening of the inner Oort cloud, the dependence of planetary perturbations on the encounter geometry, and the active lifetimes of comets.

While the present database on cometary orbits is extensive enough for statistical studies, it is strongly affected by observational biases. Even the answer to the question whether prograde or retrograde orbits prevail, depends on the limiting accuracy of the orbit determination adopted for the investigated sample. This reflects the dependence of the discovery probability and of the duration of observability on the orbital geometry. A simple illustration : the median duration of the observation of long-period and parabolic comets is 65 days for $i > 150°$, but 90 days for $i < 30°$. When those parabolic comets which were in fact of short period are discarded, the latter figure even increases to 120 days. At the same time, the number of comets observed longer is essentially the same in both samples : 21 and 23 for $D > 120$ days, and 7 and 6 for $D > 1$ year. In the present paper we attempt to evaluate the impact of the various selection effects involved, and to determine the limits within which direct orbits actually prevail.

The result is a limiting aphelion distance of about 120 AU corresponding to revolution periods between 450 and 500 years for the comets which can be detected Beyond this limit, the excess of retrograde motions among all orbits, the excess of prograde orbits among those of higher accuracy, and the lack of orbital planes perpendicular to the ecliptic, are produced by the interaction of a number of selection effects.

E. Kuehrt, B. Giese, and H. U. Keller

"Interpretation of Infrared Measurements of Small Solar System Bodies"

Atmosphereless bodies like asteroids, comets, and small moons show strong small-scale temperature inhomogeneities due to their surface roughness. This effect has to be taken into account in interpretations of any infrared measurements. A model for thermal radiation from rough surfaces is described and some results of the analysis of spacecraft based measurements of Phobos and ground based measurements of Deimos are given.

SPIN VECTOR AND SHAPE OF 532 HERCULINA; T.Kwiatkowski, and T.Michałowski, Astronomical Observatory, Adam Mickiewicz University, ul. Słoneczna 36, 60-286 Poznań, Poland

Some oppositions of 532 Herculina show two maxima and two minima per rotational cycle, while the others only one maximum and one minimum. Thermal lightcurves lead to conclusion that the light variations of this asteroid are due primarily to shape rather than to surface albedo variegation.

We have obtained the spin vector of Herculina, and try to explain both the reflected and thermal lightcurves by non-ellipsoidal shape of this asteroid.

Second Update of the Asteroid Photometric Catalogue

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A new update of the Asteroid Photometric Catalogue is now beeing prepared. It contains asteroid lightcurve observations published during the period 1988-90. All observations have been reduced to unit distance and corrected for light-time, if applicable. For easy comparison, they are plotted in diagrams with the same scale for all curves of the same asteroid. Information on the observing site, photometric system and aspect data are also provided.

In addition, a digital version containing the same information is available. It also includes the data in the original catalogue and its first update, making a total of about 4000 lightcurves for more than 560 different asteroids.

An order form for both versions will be available at the poster.

CHANGING PROPERTIES OF THE DUST COMA OF P/HALLEY:

IMPLICATIONS FOR AN INHOMOGENEOUS NUCLEUS

P. LAMY, C. COSMOVICI, G. SCHWARZ

High-resolution maps of the color and polarization of the coma of comet Halley derived from CCD images obtained during the first half of March 1986 reveal considerable temporal as well as spatial variations. They remain however restricted to the inner coma and are well correlated with the activity of the comet. The varying reddening and polarization are best explained by a population of organic grains which do not survive beyond a few 10000 km. Color and polarization do not exhibit a unique correspondance. Taking into account the rotation of the nucleus, this implies an inhomogeneous nucleus. The maps of the color, the polarization and the jet structures as revealed by unsharp masking are correlated to delineate the physical properties of the dust grains in the jets and in the background coma.