Meteoroid breakup with radiative transfer and ablation

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In order to describe the meteoroid impact flashes in the atmosphere a 1D piston model, amplified by some assumptions concerning the body size and shape changes is usually used. The ablation coefficient and luminous efficiency of the debris cloud in this model are considered to be identical to those of a single cloud sized meteoroid.

We have elaborated a more sofisticated 3D model for radiation-gasdynamic numerical simulations of the fragment cloud dispersion due to aerodynamical loading. At the stationary regime the forces exerted on the body are calculated in the form of drag and lift coefficients. Radiative transfer and ablation are taken into account.

Multimaterial numerical hydrocode is used to calculate hydrodynamic flow of two different substances around the solid fragments with accurate definition of the boundaries. Radiation transfer equations for 4 spectral groups are solved along 6 rays crossing the center of each cell and parallel to the coordinate axis. The value of radiative flux at the fragment surface determines the evaporation rate. Initial temperature of the vapor equals the phase-transition temperature.

In the first set of simulations we consider two identical fragments of radius R moving side by side along parallel trajectories at some distance d. This distance varies in the interval of $(0.05-2)R$. It may be concluded that, first, ablation and vapor cloud formation causes a pulsing regime of the flow around the fragments just after disruption ($d < 0.2R$). Second, the unified vapor cloud in the case of two fragments does not arise, and each fragment moves within its own vapor cloud. Third, the evaporation mass rate has its maximum at some intermediate distance between the fragments $d \simeq 0.4R$. The fragments repel each other at the distancies $d < R$. Over this interval the lift coefficient is 3–4 times smaller than the drag. Thereafter the pieces move within separated shock waves and show little to no interaction, but debris cloud continues to expand with constant lateral velocity

Numerical simulations using the 3D model with radiative transfer and ablation for a large number of fragments (up to 10–20) are also conducted to obtain a more deep insight into the influence of fragmentation on the ablation rates and luminosity. Most likely in this case the fragments are surrounded by the cloud consisting of an air-vapor mixture. Interaction of the fragments is more complex and includes repulsion and collimation at the same time.

Statistical results on discovered Near-Earth Asteroids

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This paper gives a recent overview (until 1st of May 1998) of the Near-Earth Asteroids (NEAs) database stored at Minor Planet Center. Some statistical analyses point out strong observational biases in the population of discovered NEAs, due to the preferential discoveries, according to the objects' distances and sizes. I represented here the relative motions of these objects respect to that of the Earth in a simpler manner, using the bidimensional polar space of corresponding mutual distances between bodies versus Earth's mean anomaly. In this space I introduced *the curve of minimum distances* between the Earth's orbit and those of the asteroids, which describes the degree and the modality of approach between them. This parameter refines the definition of Potentially Hazardous Asteroids (PHAs) and introduces several subclasses, describing their modality of approach and its repeatability in time. A connection with the sideral periods of these asteroids was also found. After this analysis, I integrated numerically the PHAs' motions around the Earth's orbits within one hundred years, funding that the population of PHAs is continuously renewed from the entire population of NEAs and the lifetime of an orbit that is inside of the Moon's orbit is about of order of ten years, due to the gravitational perturbations. Some peculiar samples from PHAs are detailed discussed, accentuating on the most dangerous objects for us.

Some results of meteor spectroscopy

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Meteor spectra have been observed for more than one hundred years. The aim has been to determine the chemical composition of meteoroids and to study the physics of meteor radiation. At the Ondřejov Observatory, the spectra of bright fireball are photographed in connection with the European Fireball Network. The interpretation of the spectra yielded several new results in the recent years.

It was found that the spectral line intensities can be in the first approximation well fitted by a simple model assuming local thermal equilibrium. However, two spectral components with different temperatures are present: the main component with $T \sim 4500$ K and the second component with $T \sim 10\,000$ K. The intensity of the second component increases with meteor velocity and brightness.

The composition in the radiating meteoroid vapors does not always directly reflect the composition of the meteoroid. The refractory elements are incompletely vaporized under some condition and are then depleted in the radiating gas. This complicates the determination of meteoroid chemical composition. Nevertheless, the chemical composition of meteoroids does not show large diversity. The composition of most asteroidal and cometary meteoroids is consistent with the chondritic composition, at least for the observable elements. Only few percent of meteoroids differ substantially and their composition corresponds to iron meteorites or achondrites.

Meteor spectra also evidence differences in the ablation process and in the hydrodynamic configuration around the meteoroid. These conditions influence the completeness of the evaporation, the formation of the two temperature configuration and thermal equilibrium conditions. However, the relationships are not well understood yet and more observational and theoretical work is needed.

The Kuiper Belt objects: Accuracy of their positional observations, fast orbit determination and ephemeris service

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Near 1400 astrometric positions obtained during 1992–1997 yrs by world observatories for the all Kuiper Belt objects (now near 60) were analysed with the help of CERES software package created at the Institute of Theoretical Astronomy (Russia).

The accuracy of observations was estimated by studing the dispersion of the average (O-C) for each type of observation obtained by each great telescope. A representative sample of the considered observations was statistically reliable. The star catalogs GSC and USNO-A1.0 were used by practically all the observers for the astrometric reduction of their CCD-scans. Results of internal and external accuracies of observations will be given for each observatory and eash telescope. Usually an accuracy of a single observation may be characterized the next values: near ±0.20" in position obtained during single night and more ±0.40" in position obtained by statistical treatment of several night observations.

It is shown that a circular preliminary orbit calculated with the the new Pulkovo Apparent Motion Parameters Method is more correct for an identification of the KB-object during 6–12 month period than an its ellipical orbit with an assumed resonance eccentricity diven by the International Minor Planet Center.

Peculiarities of the high resolution spectrum of comet Hale-Bopp (C/1995 O1) April 17, 1997

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We present some results of the study of the comet Hale-Bopp spectrum obtained April 17, 1997 by K. Churyumov and F. Mussayev with the help of the 1-meter Zeiss reflector and the echelle spectrometer (spectral resolution $\Delta\lambda/\lambda \approx 50000$), CCD and the long slit, oriented along the radius-vector ("Sun-comet direction"). Energy distributions for four selected regions including the C_3, C_2(0-0), CN($\Delta\nu = 0$) molecules and Na emissions of the comet Hale-Bopp spectrum were built. The rotational lines of the CN($\Delta\nu = 0$) band were identified. The CCD spectrum was processed with the help of the computer programs allowing reductions of the CCD bias level, cosmic particles, flatfielding, night sky contribution. Four selected regions of the spectrum of comet Hale-Bopp with C_3, C_2, CN emission bands and Na are presented. The spectral regions near vibrational transitions C_3, C_2 (0-0) and CN ($\Delta\nu = 0$) with the well-developed rotational structures are clearly seen. The unusual high emission peak near λ 4020Å band was detected. The lines of the C_3, CO^+ and O_2 molecules might be in this region (Greenstein, 1962). We do not think that it is possible to explain the presence of the emission feature R_2 (3-0) at 4020 Å by radiation of the band CO^+. It follows from the fact that the CO^+ band has peculiar dublet structures with approximately equal intensities of the dublet lines because in the given spectrum the emission R_1 (3-0) at 4000 Å is absent. Besides other intensive lines of the CO^+ bands (2-0) and (4-0) are absent. We have also verified the hypothesis about a posibility of identification of the emission feature at 4020 Å with radiation of molecule O_2 which has strong emission at 4020.6 Å (Schumann-Runge system). Besides thhe absence of other emissions of the Schumann-Runge system (at 4095.4, 4172.7, 4291.8 et al.) this hypothesis has not been confirmed. We think that the line at λ 4020 Å belongs to the C_3 molecule because this molecule is observed in the spectrum and the emission feature wavelength is close to the wavelength of one line of the C_3 band $\tilde{A}^1\Pi_u - \tilde{X}^1\Sigma_g^+$. We received the best approximation of the cometary continuum in the form two components of the solar reflected continuum and the fluorescent comet one. Parts of the solar spectrum and the fluorescent cometary continuum were determinated as 77 and 23 per cent respectively for the spectral range 4370 - 4390 ÅÅ of the cometary spectrum. We have investigated other spectral ranges for the presence of the fluorescent continuum. We find parts of the fluorescent continuum for 3960-3980 ÅÅ as 32%, for 4920-4940 ÅÅ as 0%, for 5490-5510 ÅÅ as 0%. We assume that the cometary continuum of the nonsolar origin for the spectral ranges 4370 - 4390 ÅÅ and 3960-3980 ÅÅ was detected. This phenomenon can be explained by luminescence of cometary organic particles (Nazarchuk, 1987).

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Polarimetry of the near nuclear region of comet Hale-Bopp (C/1995 O1)

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We present the results of the polarimetric study of comet Hale-Bopp. Images of the near nuclear region of the comet were received through polaroid and narrow band interference IHW filter with the effective wave length $\lambda = 684nm$ with the help of the AZT-8 (F=28 000 mm, D=700 mm) telescope and the image-convertor tube "Filin-3" during April 1-29, 1997 at Lisnyky station of the Astronomical Observatory of Taras Shevchenko Kyiv University by O.M. Evtushevsky, K.I.Churyumov, F.I. Kravtsov. The near nuclear region of the comet with some helix structures was detected. Orientation of the polaroid axis changed after each exposition on 60 degrees. 14 series of the cometary images during 14 nights (3 images in each series) were received . All negatives were scanned with the scanner "ScanJet" and as the result the PCX files were received. With the help of the computer program written by V. Ya. Choliy these PCX files were transformed in the files of the following data: the coordinates of pixels and their densities. All the necessary reductions were made. The relative intensities of each pixel were determined on the basis of the characteristic curves for photographic films. Using Fesenkov's formula (Fessenkov, 1935) the polarisation degrees and the position angles of polarisation plane vectors were calculated. The detailed maps of distribution of the polarisation degrees and plane polarisation vectors in the near nuclear region of comet Hale-Bopp for 14 dates were built. We determined that the comet polarisation degrees are 30 - 60 per cent for helix structures (shells) and 5 - 20 per cent for the regions between amd out of shells. The position angles of polarisation plane vectors are directed mainly along the radius-vector of the comet and opposite the Sun, but in the shells their directions change in the limits of 50 - 70 degrees. The obtained high values of the degrees of polarisation show that the near nuclear region of comet Hale-Bopp is very dusty, may be it is the most dusty near nuclear region among other famous bright comets.

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On isotopic composition of carbon in comets

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The up-to-date carbon isotopic composition was determined for 7 comets. The C^{12}/C^{13} ratio in comets varies in a wide range: from 65 to 115. Before the discovery of comets Hyakutake (C/1996 B2) and Hale-Bopp (C/1995 O1) we found that comets with retrograde orbital motion ($i \simeq 144^o - 180^o$) have the smallest values of the C^{12}/C^{13} ratio (Churyumov and Stepanov, 1995). These are comets 1P/Halley (ratio = 65, $i \simeq 162^o$) and Ikeya C/1963 A1 (70, $\simeq 160^o$). Comets with i within the interval $i \simeq 90^o \pm 52^o$ have the C^{12}/C^{13} ratio approximately 100. These are comets Kobayashi-Berger-Milon, C/1975 N1 ($i \simeq 80^o$) and Tago-Sato-Kosaka, C/1969 T1 ($i \simeq 75^o$). Comets with direct orbital motion (i within the interval $0^o - 36^o$) are characterized by the most high the C^{12}/C^{13} ratio which is equal to approximately $\simeq 115$, for example, comet Kohoutek, C/1973 E1 ($i \simeq 14^o$). This law is confirmed for comets Hyakutake, C/1996 B2 ($i \simeq 56^o$, the C^{12}/C^{13} ratio $\simeq 98$) and Hale-Bopp, C/1995 O1 ($i \simeq 90^o$, the C^{12}/C^{13} ratio $\simeq 100$) (Jewitt et al.,1997). We develope Vsekhsvyatsky's eruptive conception of the origin of the Solar system (Vsekhsvyatsky, 1972) to explain the shown peculiarities of the carbon isotope composition in comets.

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Helix structures in the near nuclear region of comet Hale-Bopp (C/1995 O1) and rotation of its nucleus

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Some results of the study of the helix structures in the near nuclear region of comet Hale-Bopp are presented. More than 300 images of the helix structures (shells or dust arcs) in the near nuclear region of comet Hale-Bopp were received with the AZT-8 reflector (F=28 m, D=0.7 m) and the image-convertor tube "Filin-3" during March 24-May 10, 1997 (23 nights) at Lisnyky station of the Astronomical Observatory of Taras Shevchenko Kyiv University by K.I.Churyumov, O.M. Evtushevsky, F.I. Kravtsov. Images of the near nuclear region of comet HB were obtained both in integral light (without filters) and using the narrow band interference IHW filters CO^+ λ_{eff} = 426 nm, C_3 λ_{eff} = 496 nm, C_2 λ = 514 nm, RC (red continuun) λ_{eff} = 684 nm. Velocities of expansion of the helix structures (arcs) are in the limits of 0.8-1.6 km/s. From our measurements of the expanding shells (arcs) we received the period of rotation of the comet nucleus equal to $\simeq 11.4^h$, and the period of possible precession of the nucleus equal to $\simeq$ 10 days. Our value of the period of the nucleus rotation of comet HB is in the good agrement with the nucleus rotation period , obtained by J.Licandro et al. (1998) (P=11.35^h) and by Tony L.Farnham et al. (1998) (P=11.33^h) .

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The analytical model of the cometary outburst – application to P/Halley

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The cometary outbursts have been noted by astronomers for many comets. It is generally accepted that the activity of cometary nuclei is driven by the heliocentric distances. Observations show that most of the comets at distances greater than 4 AU do not show outburst activity. But for a few comets outbursts at large heliocentric distances have been observed. P/Halley flared up of ~ 5 mag on February 12, 1991 at 14.3 AU heliocentric distance! The model explaining these outburst is proposed. It has been assumed on the basis of the previous author's model, that the comet outburst is initiated by accidental polymerization of HCN. The energy released by the polymerization of HCN is sufficient in a some part of nucleus to initiate the phase transition of the amorphous water ice to the cubic ice. These phenomena induce the nucleus to throw off the surface layer of the nucleus. In this way, ejected surface layer in the form of dust-ice particles increases the total area reflected the sunlight, and finally it increases brightness of comet. The obtained results for the change of the comet brightness and the final expansion velocity of the dust halo are in a good agreement with observations for P/Halley.

In situ measurements in the comae of comets

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The in situ measurements are effective approach for studying such actual problems in the physics of comets as the problem of anomaly distribution of emissions of metal atoms in the inner coma, the paradox of ions of refractory elements like FeII-coma in comet Halley 1986 III, the origin of the soft X-ray emission from comets. Perspectives of the in situ measurements for the future missions like Rosetta are indicated.

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Long period particle motions in the ring problem

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The increased interest on the dynamics of the gravitational N body problem ($N > 3$), has led many scientists, during the last decades, to propose various models in order to approach the basic characteristics of the general case. Moving on this direction, we have created a simple but efficient model consisting of many coplanar primaries, which we have called "the ring problem" because of its geometrical shape. In the proposed configuration, $\nu = N - 2$ equidistant spherical and homogeneous primaries P_i, $,\imath = 1, ..., \nu$, with equal masses $m_1 = m_2 = .. = m_\nu = m$ are located at the vertices of a canonical polygon of side α which may be inscribed in a circle of radius d. Another primary P_0 of mass m_0 is located at the centre of the polygon. The peripheral primaries revolve on their plane around their common centre of mass in circular orbits under their mutual gravitational attraction with the same constant angular velocity. The Nth body is a particle of negligible mass which is assumed to move on the same plane under the gravitational attraction of the primaries. The zone of asteroids consists of hundreds of small bodies in orbit about the central attracting body, while many other similar stellar formations exist in the universe. It is hoped that the proposed model will highlight the dynamics of a small body in the presence of many other celestial bodies. In two previous articles we have given the general equations of the particle motion, the stationary solutions and the areas where the particle motion is permitted, for various values of the parameters β and ν . We have also investigated the symmetric periodic motions and their fundamental aspects. Many families of orbits have been found for the two cases examined, that is for systems with 4 and 5 peripheral primaries. During the numerical exploration, we have found near the zero-velocity curves, some symmetric orbits which are characterized by long periods and relatively high energies, some of them with extremely complicated shapes, curling and twisting around some or all the primaries. In a few cases these orbits seem to evolve very rapidly into collision orbits. In this work we present these orbits and we list in tables their principal characteristics.

Identification of the celestial bodies in a real time of their CCD-observations

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The CERES software package developed at the Institute of Theoretical Astronomy and LAPLACE software created at the Pulkovo Observatory were used to test and identify the asteroids observed by Tom Gehrels' group with the Spacewatch Telescope during February 1995 – March 1995 at Kitt Peak (1027 objects in all).

Method to solve the identification problem was elaborated. It requares an one date asteroid's normal place and the first order Apparent Motion Parameters: the first derivatives of asteroid spherical coordinates or the value and direction of its topocentric angular velocity. It was shown that these new parameters have a great ephemeris importance and allow to identify the registered object only on the base of the station's own observations within an interval up to a few weeks.

The results obtained were compared with the same identification of the International Minor Planet Center. Our method gave near twenty new identifications in the considered data.

Photographic fireballs observations in Tajikistan

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The results of double-station photographic fireballs observations and their spectra on mountain astronomical observatory Sangloh and Hissar astronomical observatory in the period 1990-97 years are presented. The observations were made by using the fireball's cameras "All-sky", equipped with objectives "Hasselblad" and "Rollei" (F:D=3.5:30) and rotating sharps (speed of rotation 25 per sec.); the spectra are received by using the objective diffraction grating (200 lines on mm).

As a result of the reduction of the double-station fireballs photographs the data about the fireball's orbits, their velocities, heights, pre-atmospheric masses are received. The light curves of the fireballs in abs.mag. and results of fireballs spectrograms reduction are presented. The data of the meteor substance composition for the investigated fireballs are received on the basis of the analysis of their light curves, which made with account of the fireballs fragmentation in the Earth's atmosphere.

Low-light meteor mass distribution from TV observations in Kyiv

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For correct determination of the meteor flow matter to the Earth is necessary to take into account the selection of a meteor registration method of used observational equipment. At the present moment it is known the estimations for efficiency of visual, photographic and radio-locating observational methods. In this work it is given an analogical model for the calculation of the efficiency of TV meteor registration method. It is shown the estimation of the meteor flow matter in mass range 0.0001-0.1 g from of many years double-station TV meteor observations, carried out at the Astronomical observatory of Kyiv Taras Shevchenko university. Except the integral estimation it is demonstrated a distribution of the observed meteors upon their masses. The comparison of such distributions for sporadic and shower meteors is presented.

Computer experiment of the small bodies dynamics. Stochastic method.

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The development stochastic model of eruptive ejection is used in the framework of a spatial disturbed two-body problem for object 3200 (Phaeton). The computer experiment allowed to estimate the stochastic measure from a great number of Keplerian orbital elements of fragments ejected from the Phaeton surface and from the range of D-criterion variations calculated for these orbits relative to the Phaeton orbit and the average orbit of a possible meteor stream (Geminids?). Two models of a ejection – isotropic and exponential are described. The ejection rates range within 200–300 m s^{-1}; 1–1.2 km s^{-1}. The ejection was simulated in the perihelion and aphelion of the Phaeton's orbit. The probability functions are obtained for semimajor axis, eccentricities, perihelion distances as well as of inclination angles and perihelion argument for a great nimber of Keplerian orbits of ejected fragments. The analysis of calculated probability functions of the D-criterion allowed to conclude that new formations will be more compact relative to the average orbit of the Geminids and less compact relative to the Phaeton's orbit. This formations will also have a rather layered structure on depth and rather inhomogeneous density in the longitudal direction. The obtained simulation results correlate well with observational data for the Geminids and in our optinion permit the more full analysis of a given meteor stream.

Observations of Kuiper Belt objects with BTA-6m telescope: A photometrical approach to protoplanet disc chemistry

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Three Kuiper Belt objects (KBO) of 23–24 V-magnitudes were observed with BTA-6m Telescope of the Special Astrophysical Observatory, Russia. CCD-photometry in BVRI bands was performed and the spectral curves of the KBOs normalized reflectivity were obtained. By occasion, an unknown Main Belt asteroid passed within 20" next to one of the KBOs in the same frame, which made it possible to compare the colors of the two bodies directly. The normalized reflectivity curves contain information about chemical composition of KBO surfaces that can be revealed by comparison with some laboratory spectra. The results of recent observations (February–March, 1998) are to be added.

Interplanetary dust in circumterrestrial space from twilight scattered light photometry

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The existence of the circumsolar dust ring near the Earth's orbit have been derived from IRAS and COBE measurements (Dermott et al.,1993). According to this model Earth nears a denser part of the ring once a year, in the autumn months. This should have an effect on the annual variation of atmospheric influx of the sporadic meteor dust. We have analysed our long term photometric data obtained in Abastumani astrophysical observatory by means of the twilight sounding method. The resulting annual curves of air turbidity at different altitudes of the meteoric zone of the upper atmosphere show clear autumn maximum with the turbidities 2 to 3 times higher than that of the other seasons. The typical height distributions of the air turbidities of different seasons are also obtained. The dust particles responsible for light scattering within 0.3 to 1 μm spectral region where our observations had been carried out should be mainly of < 1 μm diameter.

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Numerical simulation of Encke meteoroids orbital elements

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Dispersions of orbital elements for dust particles released from comet Encke are calculated. Gravitational perturbations of planets and non-gravitational effects acting on these meteoroid particles are taken into account. Numerical simulations are compared with the present observational data.

Particles are released from perihelia of comet Encke at its various returns in the past. Ejection velocities of 20 and 40 m/s are considered for the meteoroids.

The orbits of the model meteoroids do not cover the interval of the perihelion longitudes, of the perihelion distances and the inclinations, which are common for observations. This discrepancy can be explained by the existence of another mother body of the observed meteoroids.

Impacts of the 1–10 m – in – diameter meteoroids into the Martian atmosphere

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A disruption of meteoroids in the planetary atmosphere leads to deficiency of the number of small impact craters on the planetary surface compared with the airless Moon. Tenuous atmosphere of Mars influences only relatively small meteoroids, as differentiated from Earth and Venus. The atmospheric entry for the of 1-10 m – in diameter meteoroids is mainly governed by fragmentation, while ablation becomes less essential factor. The meteoroid strength is falling with the increased mass according to the statistical theory and inversly proportional to radius according to the dynamical approach. It is impossible to predict exactly beforehand the breakup pressure. The meteoroid entry are scarcely affected by the chemical composition of the atmosphere. Thus for similar bodies one may use the statistical data for the case of the Earth and only the altitude of the flight would be changed.

In the Earth atmosphere a large number of bright flashes of energies in light impulse of about 0.1-1 kt TNT have been registered by satellites. Light impulses are created by impacts of meteoroids disrupted in the atmosphere (mainly at altitudes of about 30-45 km). Analysis of the light curves provide valuable information on a frequency of impacts and characteristics of impacting bodies. In the Martian atmosphere similar impactors will disintegrate lower 15 km or reach the planet surface, partially in disrupted form. The brightest sattelite event 1 February 1994 with light energy of about 4.5 kt TNT was caused by meteoroid with the inital energy E$\sim$30-40 kt and velocity V$\sim$24 km/s, which disintegrated at altitudes of about 34 km and 21 km. Similar impactor would reach the Martian surface as a tense swarm of fragments. It may be assumed that a number of impacts on Mars is smaller by a factor of 2-3 in comparison with that of Earth, that is about once in 4-10 years. The body similar to that caused the Sikhote-Alin event (E$\sim$10-15 kt TNT, V$\sim$12-15 km/s) would hit the surface in form of large fragments or even as a whole body due to low velocity.

Many smaller bolides are registered by groundbased photographic European Network. One of the well documented bolides is the Benešov bolide (V$\sim$21 km/s, M$\sim$2-4 t, E$\sim$0.1-0.2 kt). Detailed analysis of this event showed the substantial influence of breakup on the radiation and motion of meteoroid. Such a body fragments in the Martian atmosphere at low heights causing bright flashes and hitting the surface as a swarm of fragments. About 10-20 similar bodies hit the Martian surface per year.

The process of atmospheric entry can substantially influence the crater formation. Number of bodies with 1-10 m in – size reaching the Martian surface is lower than it follows from the simple meteor theory due to low strength of large bodies and fragmentation, which increases brightness of the flashes. The bolide registration would help to estimate the meteoroid flux onto Mars and to search fresh craters.

From points in the sky to real objects: Binary asteroids and monolithic bodies among NEAs

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We will present some recent results of the Ondřejov NEO Photometric Programme. Three asteroids with two-period lightcurves (1991 VH, 1994 AW_1 and (3671) Dionysus) have been revealed from observations obtained within this programme and from ESO. We interpret the data as being a strong evidence for binary nature of the three NEAs; the binary asteroid model interprets the detected two-period lightcurves as being produced by occultation/eclipse events combined with rotations of the bodies. It suggests that binary objects are relatively common among near-Earth asteroids. The three detected binary asteroids are so similar one to each other in some of their characteristics that we tentatively derive some typical characteristics of the population of binary objects among NEAs. In addition to this, we will present also the results of our observations of 1998 KY_{26}. The rotation period (10.702 ± 0.003) min was detected for it. This is by far the shortest period detected for an asteroid up to now; all other known asteroid periods are greater by about one order or more. This suggests that 1998 KY_{26} is, unlike most of the other studied asteroids, a monolith rotating under tension, rather than a "rubble pile" held together by self-gravitation only, like most of the larger asteroids are.

Variation of physical conditions in the new plasma tail of comet 1P/Halley during the disconnection event 6–8 January, 1986

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The estimates of the acceleration, the life time of fluorescent particles, longitudinal and cross diffusion coefficients in the new plasma tail of comet 1P/Halley were obtained. Estimation of the magnetic field induction in 1P/Halley plasma tail was received. The analysis of the obtained calculations shows that the magnetic field induction increase in the plasma tail can be determined by the formula:

$$B = B_m(1 - e^{-t/\tau})$$

where B_m is possible maximum of the magnetic field induction of the plasma tail, t is the interval of time after the disconnection event, τ is the interval of time when the solar wind carries away the cometary ions. Perhaps, the value B_m depends on both physical characteristics of the comet and conditions in the interplanetary medium. According to the formula the disconnection event of 1P Halley plasma tail can be Jan. 6.8 UT. This is the time of the passage of 1P Halley comet through the sector boundary of the interplanetary magnetic field $(+/-)$. Calculations were made with the help of the diffusion model. Observed photometry longitudinal and cross profiles of plasma tail were built. These photometry profiles were compared with theoretical profiles of diffusion model.

Preliminary orbit determination of of the celestial bodies from their positional short arc CCD-observations

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The classical Laplacian and new Apparent Motion Parameters method (the AMP-method) developed by Drs. A.Kiselev and O.Bykov at Pulkovo observatory can be used for a fast orbit determination of any celestial body having several (3 or more) accurate topocentric positions along a supershort angular arc. One can obtain these crowded positions with a modern astronomical CCD-technique during several minutes or hours of observations depending on angular velocities of moving objects. The statistical treatment of such information allows to calculate the apparent motion parameters of object for a middle moment of observations: position, topocentric angular velocity, positional angle, angular acceleration and a curvature of the trajectory. This is very important for an identification of all Near Earth and other objects fixed during their observations with CCD-telescope in interactive mode.

Pulkovo observatory has a large experience of applying the AMP-method at the epoch of Photographic observations of celestial bodies and we hope a success of their utilization during the new CCD epoch.

The algorythms and examples of applying the Laplacian and AMP-method for orbit determinations of Space Debris, Near Earth Objects and Asteroids will be given.

S-L9 Comet impact: influence of fragments' structure on the penetration process

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The qualitative picture of the S-L9 Comet impact against Jupiter was described by many authors. Simple estimates and detailed numerical simulations correlate rather well with the observational data of Galileo instruments, Habble and Earth based telescopes. Nevertheless this unique event continues to attract considerable interest from the viewpoint of impact, impactors and impact consequences study.

The purpose of the present investigation is to consider impact process for fragments with different structure and the influence of the structure on the energy deposition in the atmosphere. Three types of fragments were treated: a uniform fragment with a density of 0.22 g/cm^3, a heavy (1 g/cm^3) kernel surrounded by low density (0.1 g/cm^3) envelope and a low density ball with heavy grains. All the fragments have the same radius of 0.5 km, the same mass of $1.22 \cdot 10^{11}$ kg and the same kinetic energy of $2 \cdot 10^{20}$ J. The SOVA multimaterial numerical hydrocode was used to simulate the impact process. Radiation transfer was taken into account in the thermal conductivity approximation. Gruneizen-like equation of state was applied to describe thermodynamic properties of the comet material.

It has been shown that the process of fragment evolution may be divided into two clearly defined stages. At the first stage a strengthless body is flattened and converses to a debris jet with practically the same velocity as the initial one. The jet parameters depend strongly on the fragment structure. At the later stage the jet decelerates and releases its energy in the atmosphere. Comparison of the results with those obtained using semianalitical models shows that only the first stage of the impact (flattening) may be described by these simplified models. The energy release was found to depend considerably on the fragment structure. Nonuniform fragments penetrate deeper. In all cases the energy release curves have two peaks connected with the two stages of impactor evolution. Radiation transfer and ablation do not considerably influence the penetration process and atmosphere-fragment energy exchange.

Some peculiarities of meteor radiation

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Discussing meteor plasma peculiarities of radiation based on the study of meteors spectrograms: the comparison between the radiation of a longwave and shortwave ranges of a meteor spectrum; the radiation of a meteor flare; the meteor's spectrum change thrughout a flight.The estimation of cosmic matter influx to the Earth present. The examples of such calculation are used from Smirnov's book (Spectra of transient atmospheric light phenomena: meteors. Moscow, Fizmatlit Publishing Company).

Secular perturbations in motion of the pericentron in the three body problem

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The paper presents the investigation of motion of the pericentron of the inner orbit in the nonrestricted problem of three bodies with comparable masses, in which the distance between two of the bodies is much smaller than the distance of either from the third.

The general solution of the simplified canonical system of differential equations of motion, in which in the Hamiltonian contains terms to the second order only, are considered to be unperturbed. The analytical formulae of the secular motion of the pericentron are obtained. The terms of the third order in the Hamiltonian, transformed by the Zeipel's method, are considered as the perturbing function. It contains the secular part and must be discounted in large time interval.

Introducing the secular parts of angular variables as new variables we received the secular perturbations in motion of the pericentron by the method of variation of constants. Obtained formulae may be applied on a real triple stellar system, e. g. on the Epsilon Lyrae, and after some modification on far satellites in the solar system too.

Photographic monitoring of fireballs in Central Europe

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Atmospheric entries of large meteoroids (fireballs) are spectacular celestial events. Their photographic recordings provide excellent means to examine physical and spectral properties, as well as the temporal and spatial distribution of extraterrestrial matter in a near-Earth space. Unfortunately, these events are very scarce. Therefore to obtain photographic records of bright fireballs, many stations over a large territory each with cameras covering the whole sky are needed. Beginning in the 60's three networks of cameras for fireball observations had been in operation, initially, in Central Europe, the United States, and Canada. While the Canadian as well as the US Network have shut down, the European fireball network is the only that has remained in full operation. The European Network (EN) consists of four operational parts: Czech, Slovak, German and Dutch. The funding and service of the stations are performed in each of these three parts independently. All records are measured and computed at the Ondřejov Observatory except the Dutch part. The number of stations operating in Central Europe nowadays oscillates around 40, and the average spacing between them is approximately 100 km. The whole system covers an area of about one million square kilometers. The most developed observational system of the EN is in the Czech part where each station is equipped with one fixed fish-eye camera. The extremely good optical quality of Zeiss Distagon objectives (f/3.5, f = 30 mm) used in these cameras enables us to derive positions from one photograph of the whole sky hemisphere with a precision better than one minute of arc. The German part is mostly equipped with less precise all-sky mirror cameras. The average efficiency of the Czech part of the EN is about 30 at least double-station fireballs per year brighter than magnitude -5. The capabilities of this observational system are demonstrated on some recent exceptional cases.

The polygonal Schwarzschild problem in the solar system

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The Schwarzschild problem (associated to a potential $A/r + B/r^3$) constitutes a good model for the dynamics of small bodies in the solar system: orbits of asteroids and comets in the Sun's relativistic field, motion of satellites and rings around oblate planets, etc. The polygonal problem applies especially to planetary rings.

Consider the Schwarzschild $(n+1)$-body problem with a mass M and n equal masses m. Using two lemmas, the following theorem can be proved:

If the masses m are initially situated at the vertices of a regular polygon centered in M, and if the initial velocities form a vector field symmetric with respect to M, then all along the motion the equal masses will form a regular polygon centered in M, homothetic with the initial polygon, and rotating around M with variable angular velocity. The motion of every m with respect to M is given by the solution of the Schwarzschild-type two-body problem.

The qualitative behaviour of every mass within this framework being known, all possible evolutions of the polygon are known, too. There are collision and escape trajectories, quasiperiodic and periodic motions, relative equilibria, homoclinic orbits, etc.

α Monocerotid TV Spectra

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An outburst of α Monocerotid meteors was widely observed on November 22, 1995. Jenniskens et al. found that α Monocerotids penetrate deeper into the atmosphere than meteoroids of the Orionid stream or Perseid stream (meteoroids with similar velocity) and that their light curves do not show flares [2]. The Jenniskens' results imply that α Monocerotids are more compact than other showers meteoroids and can therefore contain lower amount of volatile elements. We obtained four α Monocerotid spectra with our television system on the Ondřejov observatory [1,3]. The spectra allowed us to test the above mentioned hypothesis. We found that the sodium line Na-I (589 nm) is very faint in all α Monocerotid spectra. The velocity of the meteoroids is 64 km/s but the spectra have a specific appearance different from both Perseids (61 km/s) and Orionids (67 km/s). The hypothesis concerning low amount of volatile elements could be confirmed, at least for sodium. The α Monocerotid TV spectra will be presented together with a comparative statistical analysis with other showers. The dependence of meteor spectra on velocity will be also discussed.

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Follow-up astrometry of Near Earth Objects at Kleť Observatory – present and future

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The reliable orbit determination of newly discovered Near Earth Objects (NEOs) is impossible without precise follow-up astrometry in sufficient arc of observations. This paper describes the follow-up astrometry NEO programme at the Kleť Observatory. Since 1994 we use 0.57-m reflector equipped with CCD camera for confirmations of newly discovered NEO candidates, early follow-up astrometry of NEOs in discovery opposition, recovery of NEOs in second opposition and also follow-up astrometry of poorly observed NEOs in further oppositions. In this field Kleť Observatory belongs to the most productive sites in the world. This programme will be extended to fainter objects with new 1.02-m reflector – start of operation is planned at the end of 1998.

Kleť photographic search programme for minor planets (overview)

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Long-term photographic search programme for minor planets was begun at the Kleť Observatory at the end of seventies using 0.63-m Maksutov telescope, but with insufficient respect to long-arc follow-up astrometry. More than two thousands of provisore designations were given to new Kleť discoveries. Since 1993 targeted follow-up astrometry of Kleť candidates has been performed with 0.57-m reflector equipped with CCD camera and reliable orbits for many previous Kleť discoveries were determined. The photographic programme results in more than 330 numbered minor planets credited to the Kleť as one of the most prolific world discovery sites, nearly 60 per cent of them were numbered in consequence of CCD follow-up observations since 1994.

This brief summary describes results of this Kleť photographic minor planet survey between 1977 and 1996. The majority of Kleť photographic discoveries belong to the main belt asteroids, but two Amor type asteroids and one Trojan have been found.