22. METEORS AND INTERPLANETARY DUST (METEORES ET LA POUSSIERE INTERPLANETAIRE)

PRESIDENT: O.I. Belkovich
VICE-PRESIDENT: D.E. Brownless
ORGANIZING COMMITTEE: P.B. Babadzhanov, W.J. Baggaley, W.J. Elford, H. Fechtig, M.S. Hanner, J.A.M. McDonnell, J. Stohl, K. Tomita

I. INTRODUCTION

Following past practice, a number of authors have contributed reviews of their own field. The contributions have been edited by the President in order to avoid some overlaps, to reduce the length of the reviews an to add some publications. When possible reference numbers in the Astronomy and Astrophysics Abstracts are used. As editor, the President accepts responsibility for any shortcamings in the report.

The next Proceedings of a major meetings and books were published during the review period:

" Meteor Matter in the Interplanetary Space". Proc. of Symp. held at the Kazan University, Sept. 9-II, I980, ed. O.I.Belkovich, P.B.Babadzhanov, V.A.Bronshten, N.I.Suleymanov, Moskva, I982 (Russian).

"Asteroids, Comets, Meteors". Proc. of a meeting held at the Astron. Obs. of Uppsala University, June 20-22, I983, ed. C.-I.Lagerkvist and H.Riekman, Uppsala, Sweden, I984, (34.0I2.042).

"Aerosol in the Upper Atmosphere and Interplanetary Dust". V.N.Lebedinets, Gidrometeoizdat, Leningrad, I98I (Russian).

"Distribution of Meteor Bodies near the Earth's Orbit". Yu.I.Voloshchuk, B.L.Kashcheev, Nauka, Moskva, I98I (Russian), (30.003.I56).

"Results of Photographic Observations of Meteors on the Programms of the International Geophysikal Year, International Quiet Sun Year and International Active Sun Year. Catalogue". Materials of the World Data Center B. E.N.Kramer, I.S.Shestaka, Moskva, I982.

"Radio Meteor Investigations in Obninsk. Catalogue of orbits. Sept-Dec. I967". Materials of the World Data Center B. V.N.Lebedinets, V.N.Korpusov, A.V.Manokhina. Moskva, I98I.

"Radio Meteor Investigations in Obninsk. Catalogue of orbits. Jan.-Aug. I968". Materials of the World Data Center B. V.N.Lebedinets, V.N.Korpusov, A.V.Manokhina, Moskva, I982.

"Meteor Matter in the Earth's Atmosphere and the Circumsolar Cosmic Space". E.N.Kramer, I.S.Shestaka, Nauka, Moskva I983 (Russian).

" Physics of Meteoric Phenomena". V.A.Bronsten, Reidel, Holland, I983, (34.003.040).

"BMS Meteor Observer's Handbook. Vol.I. Naked Eye Work". R.A.Mackenzie, Dover, England, I983, (32.003.079).

It is with sorrow that we record the deth of members of the Commission 22, C.L.Hemenway, L.A.Katasev, A.Kizilirmak, E.L.Krinov, A.N.Simonenko.

II. PHOTOGRAPHIC AND TV METEORS

P.B.Babadzhanov.

The Canadian MORP and Europian EN camera networks continue in operation during the review period. Systematic photographic observations are carrying out in the USSR by small cameras in Dushanbe, Kiev and Odessa. Geometric, dynamic, photometric and orbital data on all 29 fireballs photographed within the European Network in the year I977 have been published by Ceplecha et al (34.I04.006). In two cases meteorite impact points and areas are given.

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

Similar data on the Traunstein Fireball photographed at two Czech station of EN are given by Cplecha et al (33.I04.050). Multiple meteorite fall of 3 to 4 bodies of comparable mass close to I kg was predicted. Indirect data on fragmentation of the type-II-fireball body were presented and carbonaceous chondrite fall proposed. The determination of reliable orbits for meteors from extende camera networks have been reviewed by Halliday et al (33.I04.0I8). It appears that typical orbits of earth-crossing objects that deposed meteorites are direct orbits of low inclinations with perihelia between Venus and the Earth and with aphelia in the asteroid belt. In August I982 the bright fireball $-I3^m.8$ of the Upsilon Pegasid meteor shower was observed at five Czech stations of EN. The velocity of the meteor body near the earth is 5I.5 km s^{-1}, the perihelion distance 0.2 AU, and the inclination of the orbit 85^o (Povenmire and Ceplecha, I983). Another bright fireball $-I9^m$ accompanied with sound phenomena was observed by the cameras of EN Oct 2, I98I (Rentdel, I982).

Orbits, trajectories and light curves of 44 meteors obtained in Dushanbe in I968-I977 have been published by Babadzhanov et al (33.I04.036). There are 33 Perseids, I Geminid, I Alpha Capricornid and 9 sporadic meteors. The instantaneous photographs with exposures 5.6 x IO^{-4}s permit to investigate the disruption process of meteoroids in the atmosphere, particularly, the disruption of a body into plenty of fragments. It was shown that in most cases the short meteor trails ($L < 200$ m) are caused by fragments with masses of IO^{-5} to IO^{-7}g while the long tails are caused relatively large fragments with masses of IO^{-3}g and more (Babadzhanov and Konovalova, I983, Babadzhanov et al , 33.I04.033, Babadzhanov, 34.I04.023). Results of photographic observations of meteors on programms IGY, IQSY, IASY are given in the book of Kramer and Shestaka (I982) in form of catalogue trajectories, light curves, geometric and physical characteristics of meteor flares, radiants and orbital elements of Perseids.

Photographic and visual observations of meteor showers have been carried out by amateur astronomers in Great Brittain. 24 photographs of Geminids were obtained in I980 (Spalding, 32.I04.002). A comparison of simultaneous photographic, radar and visual observations have realized by Czech amateur astronomers. Selections of the methods and real differences in distributions of the orbit elements for different masses of meteoroids have been found (Novakova, 32.0I3.076).

Kramer and Shestaka (30.I04.03I, 30.I04.040), Kramer et al (I983) have obtained new values of masses of meteor bodies from the photographic observations in Odessa and Kiév using the new luminous efficiency coefficient that led to increase masses of faint meteors (nearly by the order) and decrease masses of bright meteors. Estimations of terrestrial influx of the large meteoric bodies have been made by Halliday et al (I984), Baggaley (34.I04.003) and Kovshun (3I.I04.0I5). Seven doubly photographed meteors are shown by Drummond (32.I04.02I) to be members of the Delta Aurigids wich now appear to extend from Sept. 29 to Oct. I8. The mean orbital elements of the stream point to an unknown short period (II5 years) retrograd comet as parent. Andreev et al (I983) have derived the formulae for the accounting selectivity of photographic observations of meteors on the basis of geometrical conditions of observations and the physical theory.

The problem of automatisation of TV meteor observations have been discussed by Meleev et al (33.I04.026). Hapgood and Rothwell (3I.I04.023) have presented a study of meteor trails, which were imaged with low light level TV cameras simultaneously from two stations. They determined the characteristics of 98 meteor trails, 39 recorded in the South of England during the Perseid meteor showers of I977 and I978, and 59 recorded in

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

Northen Norway in Oct./Nov. I977.

III. RADAR METEORS

O.I.Belkovich, C.S.Keay.

Analyses of physical processes in ionized meteor trails were given by Levitskij and Abdrakhmanov (30.I04.002), Levitskji (I983) and Kolomiets (I983). Kolmakov (33.I04.004)have proposed a new theory of the initial radius of a meteor trail. A method of determination of the initial radius in the characteristic height from forward scattering radio observations was given by Gajdaev et al (30.I04.0II). Baggaley has found from the measurements of line densities of non-shower meteors that there is a difference in ablation characteristics according to height, indicating the presence two distinct meteoroid components. The component consisting of meteoroids which ablate at height above I05 km appears to be associated with retrograde orbits. Baggaley (32.I04.007) has also found that reported diurnal variations in observed meteor mass distribution indices may be explained as a consequence of the characteristics of the height-magnitude distribution which is in turn dependent on meteoroidal structure and ablation characteristics. He also analysed irregularities in meteor trails (33.I04.0I0). The dependance of average height on meteor velocity from radar observations was found by Olejnikov (30.I04.027). A catalogue of ionization curves, masses and densities of 276 meteor bodies according to radar obsevations from 5 points is presented by Gartman and Chebotarev (33.I04.002).A comparison with results of meteor TV observations was given. Some parameters of meteor trails wre obtained by Chumak and Mojsja (I984) from two-frequency radar observations. Descriptions of meteor radar systems and methods of observations were given by Baggaley (34.I04.026), Malynyak (I982), Kashcheev and Nechitajlenko (I983), Nechitajlenko and Voloshchuk (I983) and Sakhibgareev (I983).

Effects of the resonance, polarisation and physical processes in meteor trails on characteristics of radio-echoes were discussed by Chumak and Moysja (I983), Soljanik and Tkachuk (I983), Gorovenko (I984), Novikov and Zygankov (I982) and Abdrakhmanov and Bajrachenko (33.I04.0I5). A study of diffractions of radio waves on meteor trails has been carried out by Kostylev and Kostylev (30.I04.007), Kostylev (3I.I04.009, I983). A number of authors have used the diffraction pictures for the determination of some characteristics of meteor trails (Kostylev, 32.I04.0II, I982, Andrianov, 3I.I04.0I0, Kolmakov, 33.I04.003). The problem of the meteoroid velocity measurement was discussed by Tkachuk (33.I04.006) and Andrianov and Sidorov (I983). The selektivity of meteor radars have been considered by Voloshchuk (I982) and Voloshchuk et al (32.I04.009).

Morton and Jones (3I.03I.502) have presented an entirely new method for obtaining maps of meteor radiant distributions obtained from a new microprocessor-based radar system. Another method of statistical analysis of density variations of radiants of sporadic meteors over the celestial sphere using an ordinary radar with a rotating aerial have been proposed by Pupyshev (30.I04.008). The maps of the radiant density over the whole celestial sphere obtained by the method have been published (Pupyshev et al, 30.I04.009). Pecina (3I.I04.002 and 003, I984) developed his method of the flux density determination from radar observations. He shows that the usual method of finding the mass distribution index from log N vs log T curve for overdence echoes can give incorrect results. On the contrary, Belkovich et al (I982a) show that the values of the mass exponent S obtained for the Geminid meteor shower by different methods are nearly the same. The problem also discussed by Bibarsov (I982), Kostylev and Svetashkova (I982), Sviridov and Kshcheev (33.I04.0I6), Voloshchuk and Kashcheev (I982) and Šimek (I984).

A number of papers have analysed results of radar meteor observations:

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

Malynyak (30.I04.026), Voloshchuk and Malynyak (30.I04.025), Voloshchuk and Nazarenko (34.I04.025), Bibarsov and Kolmakov (I984), Lebedinets and Manokhina (3I.I04.0I3).

Meteor wind determinations continue from several groups. Results of radar observations of meteor showers are given in the next section.

IV. METEOR SHOWERS B.A.Lindblad.

Observations of the major meteor showers have been carried out by visual, photographic, radar and television techniques. Data from long series of radar observations are being used to determine the cross-sections of meteor streams and the distributions of particles along a stream. Many of these studies are listed under the individual showers heading below. For a general discussion of meteor stream structure see Tkachuk (33.I04.0I7). For a historical account of meteor shower observations see Hughes (34.I04.036). Several studies of the dynamical effects associated with planetary perturbations on the orbits of meteor streams and associations have appeared in the period I982-84. See papers by Kramer and Timchenko-Ostroverkhova (29.I04.022), Sherbaum and Kazantsev (29.I04.0II), Babadzhanov and Obrubov (3I.I04.029 , 33.I04.020, 34.I04.0I5), Andreev and Babadzhanov (32.I04.0I2, I982), Zausaev and Galimova (33.I04.035), Williams and Fox (34.I04.0I8), Emelyanenko (I984), Kruchinenko (I984) and Kramer and Shestaka (I984). The secular perturbations of meteor orbits over very long time intervals have been studied by Galibina and Terentjeva (33.I04.007). The investigation details the mechanism producing North- South branches of meteor showers.

The theoretical radiant distribution expected for ecliptical meteor orbits is discussed by Štohl and Hajdukova (34.I04.037 and 049). the determination of telescopic meteor radiants from one station is investigated by Porubčan and Hajdukova (34.I04.046). A theoretical discussion of the zenith attraction correction for meteor radiants is presented by Andreev (33.I04.040). The dependance of shower hourly rates on zenith distance of the radiant is studied by Zvolankova (33.I04.0I3). Various geometrical factors affecting the detection probability of radiants in photographic and radar surveys are discussed by Tkacuk and Matsenko (30.I04.029). A comparison of some methods of the meteor flux density determination from radar observations of meteor showers have been carried out by Andreev et al (I984). Sidorov and Karpov (I984) and Andreev et al (3I.I04.0II) have used statistical methods for investigations of some flux structures. Lebedinets (I984) has discussed a possibility of meteor shower observations at the background of the zodiacal light. Statistical analisis of catalogues of orbits of the main meteor streams was carried out by Lebedinets and Manokhina (I982a). They show that the accuracy of the best of them is unsufficient for the investigation of the structure of streams.

The relation between comets and specific meteor streams - in particular the association of Comet Halley with Eta Aquarids and Orionids - is the subject of numerous studies. Predicted meteor radiants from earth-orbit approaching comets are listed by Drummond (30.I04.022, 3I.098.037, 3I.I04.0I7) and comparison is made with published lists of photographic and radar determined stream radiants. Predicted radiants from earth-orbit approaching asteroids are listed by Drummond (3I.098.037) and Babadzhanov and Obrubov (33.098.092, 34.098.063).

The detection of new meteor streams and/or unexpected recurrences of old streams depends almost exclusively on the efforts of amateur meteor observers. For references on amateur groups and observations see the previous report of Commission 22 and Sky and Telescope (I983, 66, 63). Visual observations by

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

large supervised teams of amateur astronomers have been carried out in Czechoslovakia (32.104.006, 33.104.032), USSR (33.104.023, 34.104.008) and elsewhere. Observer's handbooks for visual and telescopic work have been published by Mackenzie (32.003.079, 34.104.029).

The relation of the visual magnitude scale to the color index of meteors is discussed by Hajdukova and Štohl (34.104.045). The observational errors in magnitude estimates of meteors by experienced visual observers have been discussed by Lindblad and Stohl (34.104.025).

Quadrantids. Mathematical models for the formation of the Quadrantid stream and studies of the nodal regression have been presented by Hughes et al (29.104.010), Murray (31.104.016), Fox (34.104.010) and Zausaev and Pushkarev (1984). Porubchan and Hajdukova (34.104.048) have studied the cross-section of the Quadrantid stream using Ottava radar observations 1963-68. McIntosh and Šimek (1984) have combined radar data from Ottava and Ondrejov to obtain a continuous twenty five year sequence. This study indicates that the activity curve of the shower is asimmetric with a very fast decay after shower maximum which occurs at solar longitude 282°.6 (1950.0). Variations of the flux density and the mass exponent S for the Quadrantid stream are obtained by Belkovich et al (1982b, 1984) from radar observations at the Engelhardt Astronomical Observatory for the eight year period. The stability of the shower from year to year is found out. The standard of random variations of the maximum flux density do not exceed 10%. The activity curve of the Quadrantid stream is also discussed by Tkachuk (1983a), Svetashkova (1982), Andreev et al (1982), Isamutdinov (1983), Zausaev and Pushkarev (1984). Quadrantid observations are discussed in (31.104.022) and by Schippke (32.104.015). Visual Quadrantid recordings in 1971-80 are analyzed by Levina and Martynenko (33.104.008).

Lyrids. Visual recordings of Lyrids in 1945-52 from Skalnate Pleco observatory have been analysed by Porubčhan and Stohl (1983). The magnitude distribution of Lyrid meteors is studied and mean activity curve of the shower is derived. Maximum activity occurs at solar Longitude 31°.5. Lyrid observations are also discussed in references (31.104.021) and (31.104.038). An exceptional Lyrid display was reported by visual observers in 1982 (Meteor News, No.58).

Eta Aquarids. The orbital evolution of Comet Halley and Eta Aquarid and Orionid streams under the influence of planetary perturbations is discussed in several papers. For references see Orionid stream.

From Ottava radar observations in 1958-67 Hajduk (30.104.014) has derived the activity curve of the Eta Aquarid shower. Hajduk and Buhagiar (32.104.008) have combined northern hemisphere radar observations and southern hemisphere visual observations to derive Eta Aquarid activity vs solar longitude.

Arietids. Radio observations in Tomsk in 1965-66 of the Perseids, Orionids, Ursids and daytime Arietids are analyzed by Svetashkova (33.104.029).

Delta Aquarids. This major southern hemisphere meteor shower has largely been neglected by visual and radar observers. It deserves detailes study. Observations of the Delta Aquarid shower by television technique are described by Sarna and Jones (28.104.038).

Perseids. Computer studies of the dynamics of the Perseid stream are presented by Fox (34.104.010). The stability of the node of the stream is discussed by Hughes and Emerson (31.104.008). A study of the Perseid stream structure and radiant motion based on a compilation of photographic data is presented in the monograph by Kramer and Shestaka (34.003.093). Onsala radar recording of the Perseid shower in I956-78 are analyzed by Lindblad and Šimek (34.I04.02I). The activity curve of the shower is studied. Peak shower activity for long duration radar echoes occurred at solar longitude I39°2I (I950.0). Doublestation TV observations of Perseids in I978 are discussed by Hapgood and Rothwell (29.I04.002, 3I.I04.023) and by Hapgood et al (32.I04.0I3). Perseid beginning and end heights were obtained and the results were compared with dustball ablation theory.

The expected perihelion passage in I980-84 of Comet I862 III and its association with the Perseid stream is discussed in (34.I03.26I). Although no reports of the return of the parent comet have appeared(as of September I984) high Perseid activity in I980-82 has been reported. See Russel (3I.I04.024), Martynenko and Levina (32.I04.005), Savrukhin (32.I04.0I9) and Sky and Telescope (I98I, 62, 624). A detailed analysis of the I980 Perseid shower by visual, photographic and radar techniques is presented by Mason and Sharp (29.I04.02I). Observations in I980 have been described by Eltry and Stomeo (3I.I04.007). Large scale visual observations in I980 and I982 have been reported by Martynenko et al (33.I04.023, 34.I04.008). Teams of visual observers spread out over I00° in geographical longitude were employed in I982 to obtain I6 hrs of continuous recordings of Perseid activity around shower maximum.

Draconids. The orbit of this stream has been considerably perturbed by the major planets. Numerical modelling of the stream has been performed by Reznikov (30.I04.0I8). The geometrical conditions for observing the strong showers of I926, I933, I946 and I952 are analyzed.

Taurids. The association between Comet Encke and the Taurids is studied by Katasev and Kulikova (33.I04.022). Detailed computations of comet and stream orbits are reformed and the results are compared with original investigation by Whipple and Hamid. A similarity between the orbits of Comet Encke, the Taurids and certain asteroids is discussed by Napier (33.I02.080). See also Galibina and Kastel' (33.098.004).

Orionids. The relation of the orbital parameters of the Orionid stream (and Eta Aquarid stream) to those of Comet Halley have been discussed by a number of authors. See papers by Babadzhanov and Obrubov (33.I04.034), Kramer and Shestaka (33.I04.054), Simonenko (33.I04.009) and Hajduk (33.I04.044, 34.I04.020). McIntosh and Hajduk (34.I04.030) present a new model of the stream based on the orbital history of the parent comet and historical accounts of Orionid showers. The total mass of the combined Eta Aquarid-Orionid stream is estimated by Hajduk (34.I04.027) to be 5×10^{14} kg. Radar observations of the I978 and I979 returns of the Orionids have been reported by Hajduk and Cevolani (30.I04.006) and Hajduk et al (I984). Radar observations in I980 and I98I are discussed by Jones (34.I04.002). The activity curve and magnitude distribution of the Orionid stream is investigated by Stohl and Porubchan (30.I04.0I3). The data base for this study is an extensive series of visual observations carried out at the Skalnate Pleso observatory in I944-50. Observations of the Orionids also reported in (3I.I04.036).

Leonids. A detailed study of Comet Temple-Tuttle and the evolution of the Leonid meteor stream is presented by Yeomans (30.I04.02I). Geometrical conditions for observing an intence Leonid shower are discussed. The orbit of the stream is studied by Kondrat'eva (33.I04.039) and Kondrat'eva and Reznikov (34.I04.040). Prediction for future encounters of the Leonid stream with the Earth are given. Leonid radar observations in I966-68 are reported by Andreev et al (29.I04.026).

Geminids. Model calculations of stream evolution are presented by Kazantsev and Sherbaum (3I.I04.0I8, I982) and Fox et al (3I.I04.03I, 34.I04.03I). The evolution of the Geminid radiant under the influence of secular perturbations is investigated by Terent'eva and Galibina (34.I04.037). The spatial structure of the shower is analyzed by Pupyshev et al (30.I04.039). See also a review by Tkachuk (I983b). The activity of the stream is discussed by Jones (3i.I04.00I) and model calculations are compared with observational results.

The newly discovered asteroid I983 TB moves in an orbit resembling that of the Geminid meteor stream (34.I04.033).A genetic assosiation between the asteroid and the Geminid stream has been proposed (34.098.065, 34.098.089), Fox et al (I984).

Radar observations of the Geminid stream have been reported by Andreev et al (30.I04.032, 33.I04.028, I982a) and Jones and Morton (3I.I04.030), Isamutdinov and Chebotarev (I984). Variations of the meteor flux density and mass exponent S vs the solar longitude were obtained from radar observations by Belkovich et al (I982a). A stability of the flux curve for different years of observation is confirmed. The good agreement with the results of photographic and visual observations was ascertained. Radar observations at the stations in Ottava, Ondrejov and Dushanbe have been compiled and analysed by Šimek et al (32.I04.0I8). Visual, photographic and radar Geminid observations in I980 are summarized by Spalding (32.I04.002, I984).

Minor streams and possible new streams. Radar studies of a minor shower observed on I7-20 Nov. I967 are presented by Andreev et al (29.I04.027). Newly detected minor meteor showers are reported by Korpikiewicz (30.I04.038), Nesterov(32.I04.0I7), Macek (34.I04.043) and in reference (30.I04.04I). A moderately strong visual display in I982 of meteors associated with Comet Grigg-Skjellerup has been reported by Simmons (I982). In an analysis of visual and telescopic meteors observed in August Znojil (32.I04.006) identified a large number of minor meteor streams. Most of these occur in previous photographic and radio lists and they should therefore be considered as significant.

A possible new minor meteor shower the Upsilon Pegasids is discussed by Povenmire (3I.I04.005), Povenmire and Ceplecha (I983), McRobert (I984) and McLeod (I984). Possible meteor stream associated with Comet Lexell are discussed by Carusi et al (32.I03.83I, 34.I04.0II).

V. METEOR ORBITS

P.B.Babadzhanov.

A Meteor Data Centre had been set up by Dr. B.A.Lindblad at Lund observatory in Sweeden. The purpose of the Centre is to collect and store data obtained by photographic and radar methods on atmospheric trajectories and heliocentric orbits of meteors and fireballs. The Executive Committee of the IAU had allocated SwFr I800 per annum for the three calendar years I983-85 forvards the cost of maintaining the Centre.

Two catalogues of radar meteor orbits (Lebedinets et al, I98I,I982) and two catalogues of orbital elements of bright meteors (Kramer and Shestaka, I982, Babadzhanov et al, 33.I04.036) were published during the review period. The problem of the reliability of orbital catalogues was discussed by Lebedinets and Manokhina (I982b).

A number of papers were devoted to the problem of the "cosmic weight". Kramer and Shestaka (I983) have found the probability of the detection of meteor streams that have the certain values of the orbital elements. Modifications of the Öpik's formula were done by Bronshten (I983a, I983b). Belkovich (34.I04.0I3) has presented an exact solution of the problem both for the set of orbital elements and for the transformation of the flux of sporadic meteors in the gravitation field of a moving body. The influence of the form of the cosmic weight formula on the distributions of the orbital elements of the sporadic meteors has been treated by Lebedinets and Manokhina (1982c, 31.104.025). Andreev V.V. et al (1982) and Stohl (34.104.019) have analysed the distribution of sporadic meteor orbits in the solar system.

Physical processes affecting the motions of the meteor bodies in the solar system have been discussed by Mendis (30.091.066), Tokhtasjev (1982a), Mukai and Yamamoto (31.106.009), Grimshaw (32.106.026), Kapisinsky (33.106.057) and Williams (34.104.009).

Work related to the modelling of the orbital evolution of meteor streams has been carried out by Andreev and Sukhotin (1982), Babadzhanov et al (1982), Kulikova (1982), Kazantsev and Sherbaum (30.104.005), Zausaev and Galimova (33.104.035). Babadzhanov and Obrubov have shown that a number of features of meteor showers is explaned by joint influence of planetary perturbations, the Pointing-Robertson effect and its corpuscular analogue, light pressure and ejection velocities of different mass meteoroids from cometary nuclei. The dynamical evolution of meteor particles ejected from Comet Lexell was computed by Carusi et al (34.104.011) to investigate the propeties of that part of the swarm wich remained in earth-crossing orbits.

The problem of hyperbolic orbits was discussed by Matsenko and Tkachuk (1982), Kazantsev and Sherbaum (32.104.003) and Tkachuk et al (33.104.014). Studies interrelations among asteroids, comets and meteors by Levin (1982), Simonenko and Levin (34.098.036) have shown that most promising to regard the asteroid belt as the primary supplier of Apollo and Amor type objects. Their numerous fragments of all sizes can produce meteorites. It is possible that the asteroid belt is the supplier of short period meteor streams. The method of search of objects geneticaly related to Apollo, Aten and Amor asteroids was proposed by Simonenko and Terentjeva (1984). It was based on the principle of the spatial comparison of the orbits with taking into account a similarity of physical or chemical parameters of objects.

VI. PHYSICAL THEORY OF METEORS AND FIREBALLS D.O.ReVelle.

In this section both recent advances in physical modelling and related observations of effects produced by meteors and fireballs are considered.

A major contribution to the literature of meteors, fireballs and meteorites is the publication in English of "The Physics of Meteoric Phenomena" by Bronshten (34.003.040). This treatment of the subject is an attempt to meaningfully present the current state of the art and its evolution using the latest scientific advancements in the fields of radiation gas dynamics and plasma physic especially. All things considered, Bronshten has written an exellent monograph for the training of the next generation of researchers in this field.

Work related to meteor modelling has been carried out by Bronshten (29.104.028, 34.104.039), Kalenichenko (32.104.010, 33.104.021, 1982), Apshtein, Pilyugin and Vartanyan (32.104.014), Hapgood, Rothwell and Royrvik (32.io@.013), Hawkes, Jones and Ceplecha (1984), Kovshun (33.104.025, 1984), Smirnov and Kovshun (1982), Blokhin and Novikov (1982), Benyukh (32.104.004) and Smirnov (34.104.038).

Bronshten's paper used elastic interaction theory combined with fireball observations to deduce the tangential momentum accomodation factor. The range of values determined compare well with values obtained by other methods. The

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

method used can also be applied to meteor data, but for both type of data, the theory is only suitable near the beginning of the trajectory, i.e., for conditions of weak shielding (near-free molecular flow). In a series of papers Kalenichenko considered a quasicontinuous fragmentation process of meteoroid destruction during entry to the atmosphere. Using this model he identified the modes of ablation of meteors using both light curve and velocity data. Apshtein et al applied their earlier model which includes shape change to calculate the mass removal rate, body temperature, light curve and electron line density in meteor trail. These results have been compared with the simple physical theory of meteors and important differences were found under certain conditions. Hapgood et al compared the dust-ball meteor model of Hawkes and Jones with two-station TV observations of Perseid meteors. From their results the observed Perseids were deduced to be even weaker structurally than that predicted using the model Hawkes and Jones. In the paper by Hawkes, Jones and Ceplecha theoretical beginning heights are calculated considering simultaneously the effects of thermal conduction into the meteoroid, thermal radiation emitted by the body and deceleration. It should be noted that as far back as I974 the physical model of the ablation of meteor bodies in mass range of IO^{-6} - I g was developed by Tokhtasjev (Belkovich and Tokhtasjev, I2.I04.05I) taking into account the same effects. The model have been successfully applied for decade for the interpretation of meteor shower observations (Belkovich et al, I982a, I982b) and for the study of densities of meteoroids in meteor showers (Tokhtasjev, I982b). The results obtained by Hapgood et al (32.I04.0I3) confirm this model completely. Finally, Kovshun demonstrated that his model B of the light curve produced better agreement with the observations for the portion of the trail at altitudes above the maximum magnitude altitude than did the earlier predictions using Model A. The problem of fragmentation of meteor bodies was discussed by Babadzhanov et al (I982), Novikov et al (I984). Obrubov and Konovalova (33.I05.229) considered the effect of the rotation of a meteor body in the Earth's atmosphere.

Work related to fireball modelling has been carried out by Wetherill and ReVelle (30.I04.042, 32.I02.0I9), Lebedinets (29.I04.024), Korobeinikov, Chushkin and Shurshalov (33.I05.238), Zelenin, Konstantinov, Mikheev and Salimov (33.I05.I66), Sekanina (34.I05.0I0), Pecina and Ceplecha (33.I04.0I2, I984), Halliday, Griffin and Blackwell (33.I04.0I8), Ceplecha (33.I04.043, I983), Babadzhanov (33.I04.042), ReVelle (33.I04.047, I983), Padavet (34.I04.032), Bronshten (29.I04.025, 34.I04.0I6, 34.I04.039), Kalenichenko (I984). Work related to fireball modelling has also been carried out by Tiwari and Subramanyan (I980).

The papers by Wetherill and ReVelle adress the problem of identifying meteoritic and "cometary" types of fireballs respectively. The theoretical single-body approach is used to estebilish four relative criteria which are applied to the US Prairie Network fireball observations using data from the Lost City and Innisfree Meteorite falls as a calibration. It is deduced up to one third of the fireballs are of the meteoritic type. Also, "cometary" fireballs have a much wider range of structural properties than the meteoritic material studied. These results are very similar to those deduced earlier by Ceplecha and McCrosky methods. Lebedinets considered a model of quasi-continuous fragmentation of meteorites during atmospheric entry. Unlike the work of Kalenichenko (see above), Lebedinets considered a constant value of coefficient of heat transfer, etc. On the other hand, Lebedinets developed his theory using the classical approach as modified by Jaccia in the I950's, using the progressive fragmentation parameter. Both workers reached similar conclusions, however, namely that the low density friable meteoroid hypothesis is not necessary to explain the behavior of photographic meteors and that many observed meteors can be modelled assuming ablation occured predominantly in

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

the solid phase, i.e. as a quasicontinuous fragmentation process.

Two papers have appeared in an attempt to better understand the Tunguska (1908) event. Korobeinikov et al considered the effects of a nonzero lift to drag ratio on the trajectory of the fireball. Also the visible and infrared radiation energy losses were computed as a function of the horisontal range of the shock wave from the explosion center. Sekanina in a comprehensive review of all reliable "data" through 1983 concluded that Tunguska could not have been composed of low density material typical of a comet. Insted he concluded that Tunguska was probably a small Apollo-type asteroid. Its behavior in the atmosphere consistent with that of a type II fireball using the notation of Ceplecha and McCrosky.

Pecina and Ceplecha have shown the impotance of atmospheric variables in deducing meteoroid parameters in two impotant papers. Their work has shown that the form of deceleration assumed previousli in deducing values from observations is not a good approximation for fireballs. Using single-body theory they have deduced an expression for distance along the meteor trajectory as a function of time which can be used to reliably retrieve ablation coefficients, etc, if the instantaneous atmospheric density profile is used. Halliday et al have used the results of Wetherill and ReVelle and data from the MORP and EN networks to identify meteoritic fireballs from data from all three fireball networks. They considered the orbital parameters of the fireballs and concluded that typical meteoritic orbits are direct and of low inclination with perihelia between Venus and the Earth and with aphelia in the asteroid belt. Ceplecha recomputed bulk density, ablation parameter, etc, for group I and II fireballs after correcting for the effects of using a seasonal air density profile rather than simply using a standard atmosphere profile. Ablation coefficients (mean values) of Group I fireballs now agree quite well with the ablation modelling of ReVelle. Ceplecha also presented a review paper summarizing the connections that are currently recognized between meteoroids and meteorites. Babadzhanov analysed fireball data taken using the method of instantaneous exposures in order to study fireball fragmentation processes. This technique is one that has great potential for developing a better understanding of both the fragmentation process and of reliably determining fireball compositions from photographic data. ReVelle considered the modelling of the light production of fireballs in paper that has yet to appear. Modifications of the classical theory are needed at both very high and very low altitudes in order to obtain reasonable agreement between theori and observations. In a separate paper ReVelle formulated a model of porous meteoroid completing a model developed earlier by Liu. Application of the model to the US Prairie Network observations revealed very similar mean ablation coefficients and bulk densities as compared to those obtained previously by Ceplecha and McCrosky for the three fireball groups. Padavet developed a theory for fireballs in the continuum flow regime but relied on perfect gas relations among the atmospheric variables behind the bow shock wave. The author also hypothesizes that the fireball groups identified by Ceplecha and McCrosky correspond only to the known meteorite types. Bronshten has considered the problem relating the green atomic oxigen line emission in meteor spectra and the meteoric head echo phenomena observed using radar. This topic is also briefly considered in his recent monograph. He has also considered the problem of explaining electrophonic noises from very bright fireballs in a separate paper. A theoretical mechanism is proposed and tested which relies on the action of magnetohydrodynamic processes along the trail as suggested qualitatively in 1980 by Keay. The first communication on the instrumental detection of electromagnetic waves from meteors has come from Epifanova (32.082.080). She has observed radiopulses produced by faint meteors at the wavelength 3 cm. Classification of meteor acustics was given by Clarence (31.105.014).

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

Finally the work of Tivary and Subramanian considered the effects of shape change on the continuum flow field during Jovian entry conditions. Parameters such as shock-standoff distance, radiative heating rate, etc can be significatly changed by the shape change of the body.

Consistent with the previous report we now consider new areas research which rely heavily on the results from improved physical modelling of meteors, fireballs and meteorites:

a) The problem of understanding the Moon and Mars as source regions for meteorites found on the Earth. Specifically the case for the SNC meteorites being from Mars is considered in detail by Wetherill (I984);

b) Entry of meteors into the atmosphere of a comet. This is considered for example in Dobrovolskij and Ibadov (33.I04.005);

c) Entry of meteors into the atmospheres of Mars and Venus and the inverse problem of remotely sensing these planetary atmospheres using meteors as in situ probes. The latter is considered in the works of Levin and Simonenko (I982) and Apshtein, Pilugin and Vartanyan (32.I04.0I4); and

d) Entry of Sun grazing comets into the solar atmosphere. Weissman (I983) has considered the early stages of the latter problem. The question of the nature of the cometary nucleus and the relation of comets to carbonaceous chondrites and the various fireball groups has a direct bearing on the solution of the problem.

VII. METEORS AND AERONOMY W.J.Baggaley.

Work has continued on the relationship of meteor products to noctilucent clouds, nacreous clouds and stratospheric aerosols.

A comprehensive review (30.082.025) of the meteoritic influence on clouds and aerosols included reviews of observations, models of the various channels followed by meteoric species - micrometeorites, smoke particles (2 - I0 Å size) and vapours (considering gas phase reactions and absorption into meteoric dust). Scenarious were presented of the nucleation growth to the particle sizes observed in mesopause (83 km) noctilucent clouds. Particle orientation, ice crystal form, and sedimentation times were considered. The interaction of meteoric products with stratospheric aerosols was also reviewed. A model of ice crystal nucleation growth in noctilucent clouds and the role of metal ion products has also been given (30.082.046).

In an account of the current status of noctilucent cloud theories (32.082.067) the authors presented the first numerical scheme to couple together particle nucleation, condensation, evaporation, coagulation, gravitational coalescence, sedimentation and diffusion with ion-electron processes. The comprehensive study considered ice crystals of various shapes and concluded that meteoric dust acts as effective nucleation centres with large water cluster ions (with cores of meteoric species) being effective for mesopause less than I30 K.

A later report (33.093.0I6) compared the role of meteoric debris as a nucleation agent in the Venus and Earth atmospheres, while mass spectrometer measurements of condensation nuclei have been made by Björn and Arnold (I98I).

For a more definitive model of meteoric species in noctilucent clouds, work is needed on rocket sampling of the particles size distribution and composition during different stages of cloud formation.

Several studies (for example Kirchhof, Clemeska and Simonich, 30.082.0I3, Kirchhof and Clemeska, I983a, Kurbanmuradov and Mukhamednazarov, I982) have

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

been devoted to the aeronomy of meteoric sodium in the lower thermosphere. Models (Kirchhof and Clemeska, 1983b) of time variations in the 90 km sodium layers calculated the dinamical and chemical lifetimes of Na atoms and response to changes in the meteor influx rate.

Using the two dimentional model employing mass spectrometer measurements of Si^+ and $SiOH^+$, H_2O mixing ratios have been inferred (Soloman, Fergusson, Fahey and Crutzen, 1982). The authors find that Si^+ loss is dominated by O_2 association rather than as a result of H_2O reaction and also discuss the question of the extraterrestrial H_2O sourse in meteoric dust. A series of positive ion mass spectrometer measurements (Kopp and Herman, 1984) detailed the height distributions of proton hydrates, NO^+ cluster ions, meteoric metals Fe^+, Mg^+, Al^+, Na^+, as well as the usual thermospheric components O_2^+ and NO^+. The authors consider the role of atomic oxygen in controlling the transition layer and the chemistry of meteoric metals. Comparisons between mass spectrometer measurements of meteoric ions with lidar Na observations and resonance line estimates of Fe and Mg atoms concentrations have been used by Swider (1984) to model the variations of meteoric ion layer during aurorae in terms of charge transfer from auroral produced O_2^+ and NO^+. Measurement of phase path changes and absorption using 16 kHz and 60 kHz one hop links have been used by Rumi (1982) to determine the influence of increased meteor activity on the nocturnal D region. Enhanced meteoric ionization deposited during the Geminid shower yield changes in the LF radio path which permitted the determination of the electron density and collision frequency and height of the ionization ledge at about 83 km. The results were compared with models of ionic processes affecting deposited meteoric ionization.

Although rocket measurements reveal that sporadic-E ionization irregularities (90 - 115 km) are composed mainly of positive ions of meteoric origin, inconsistent conclusions have been found in attempts to associate E_s events and enhanced meteor influx. Using nearly four decades of E_s data and four years of radio-meteor rates for two southern hemisphere stations the seasonal characteristics of both phenomena were examined at different diurnal intervals. No significant changes in medium intensity E_s occurence were found to result from major meteor shower ionization influx (Baggaley, 1984a, 1984b).

The influence of height variations of atmospheric density scaleheights on the interpretation of fireball trajectories has been considered by Pecina and Ceplecha (1984). Radar meteor rate have been found to vary with solar activity (Prikryl, 33.104.011), while meteor heights have been found to depend on atmospheric changes near sunrise (Porubčan and Cevolany, 34.104.007, Porubčan et al, 34.104.024). The relationship between visual meteor magnitude and meteor trail ionization emploing aeronomical models has been determined in a simultaneous visual-radio programme by Znojil et al (1982).

The dependence of the ambipolar diffusion coefficient of a meteor trail on the geomagnetic field has been studied theoretically and experimentally by Abdrakhmanov (33.104.027) and Levitskij et al (1982).

VIII. TEKTITES

B.P.Glass.

Stauffer (33.105.192) has researched tektite localities in Indonesian Borneo and he concluded that the only authentic localities are at Martapura Pelaihari and the Sungei (river) Riam Kanan which are all within 40 km of each other in the southeastern corner of the island. O'Keefe (1983a) discussed new tektite localities in the Czechoslovakian strewn field and finds that the strewn field trends SSE to NNW. Han-chang et al (1982) reported three new deep-sea microtektite locations in the western equatorial Pacific Ocean which

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

they suggested may be from a previously unidentified strewn field (or strewn fields). However, the locations are all within or very close to the boundary of the Australasian strewn field as defined by Glass (I982), and the composition they give is similar to the composition of Australasian microtektites.

The question of the origin of tektites has long been a subject of debate. Although most researches support a terrestrial impact origin for tektites, there are some who favor a lunar volcanic origin. O'Keefe (I983b) is the major proponent of a lunar volcanic origin. Yuan (I98I) also feels that tektites must have a volcanic rather than impact origin; and since the tektites do not have compositions similar to local volcanic matarial, he supports the lunar volcanic origin for tektites. Rost (I98I) pointed out that the irghizites were formed by accretion of numerous fibres, rags and tiny spherules. Heide et al (3I.I05.I63) compared the surface structures of irghizites with volcanic ejecta (pyroclastic material). Bouška et al (30.I05.028) concluded that the irghizites were formed by melting of sedimentary rocks at the Zhamanshin area and that they were enriched in less mobile elements of the impacting meteorite. According to Florensky and Dikov (I98I) the conditions necessary for tektite formation include: very high temperature, low pressure and short time. They state that only impact can produce those conditions and they propose that tektites are formed by the fall of a giant meteorite into silica-rich rocks. Additional evidence for the impact origin of tektites comes from the discovery of an iridium anomaly associated with the North American microtektite layer (Asaro et al, I982, Ganapathy, I982, 3I.I05.2I6, Alvarez et al, I982a, I982b). A study by Glass et al (I982) shows that the late Eocene iridium anomaly is actualy associated with a layer of crystal-bearing glass spherules that occurs below the normal North American microtektites. However, the authors argued that the crystal-bearing spherules were formed at the same time.

An earlier suggestion that Elgygytgyn crater in northern Siberia might be the sourse for the Australasian strewn field appears to be ruled out because of its old age (Komarov et al, I983). Shaw and Wasserburg (I982) found that their Sm-Nd and Rb-Sr isotopic data are consistent with the Ivory Coast tektites being derived from the Bosumtwi crater in Ghana. They also found that the Sm-Nd and Rb-Sr systematic support the hypothesis that the Czechoslovakian tektites were derived from the Ries crater in Germany. Hörz (i982) argued that the Czechoslovakian tektites were derived from Tertiary freshwater sediments that capped the Ries area prior to the impact that formed the crater. The source crater for the North American tektites has still not been found.

Some attempts have been made to identify the impacting body that produced the tektites. Bouska et al (30.I05.028) belive that the impacting body that produced the Zhamanshin crater and associated irghizites was probably a chondrite. Glass et al (I983) concurred with that conclusion. Based on ratios of siderophile elements, Koeberl and Kiesl (I983) concluded that Czechoslovakian tektites (moldavites), like the Ries crater, were contaminated by an achondrite and that the Australasian tektites were contaminated by a chondrite projectile. The North American tektites may have been formed by the impact of an undifferentiated meteorite (Ganapathy, I982, 3I.I05.2I6).

One of the most interesting aspects of tektite studies is the possibility that the impact events that produced the tektites may have also been responsible for climatic and biological changes as well (Glass, I982). The North American microtektite layer appears to be associated with the extinction of several species of one-celled marine organisms (Glass, I982). Alvarez et al (I982a) pointed out that the North American tektite event is also within 4 m.y. of the mass extinction of terrestrial mammals. Ganapathy

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

(I982, 3I.I05.2I6) suggested that a massive (> 3 km, >50 billion tons), chemically undifferentiated meteorite collided with the Earth ~34 m.y. ago producing the North American tektites and microtektites and causing worldwide extinctions.

IX. INTERPLANETARY DUST - DISTRIBUTION AND DYNAMICS H.Fechtig.

Grün et al (I984) have complited a study of the dynamics of dust grains within I AU sun distance. It has been shown that the collisions of small dust particles ($< 10^{-6}$g) with larger ones ($> 10^{-6}$g) play a major role. The question now to maintain the spatial distribution of interplanetari dust has been investigated by Leinert et al (33.I06.004). The authors come to the conclusion that from the primary sourse of solid particles a reservoir of radio meteors is preserved. A continuous input of $\geqslant$ 200 kg/s to the interplanetary dust cloud is created by catastrophic collisions.

Bishop and Searl (33.I04.022) and Haranyi and Kecskemety (34.I02.030) have considered analytically the possibiliry of power-law mass distributions of meteoroids as asymptotic solutions to the rate equations govering both accretion and fragmentation of particles that interact only on collision. The influence of the Lorentz force on the spatial distribution of the interplanetary dust grains has been investigated by Mukai and Giese (I984). Particularly the orbital inclinations are influenced by electromagnetic perturbation. As a result, the authors could explain the dependance of heliocentric distance r as $n(r) \propto r^{-1.3}$ on the basis of the influence of the Pointing-Robertson effect and the Lorentz force.

Zook et al (I984) have showed that impacts at low impact angles (I5°) produce up to 2 orders of magnitudes more ejecta than normal impacts. As a result one has to expect many secondary impact craters in the submicron-sized crater range on lunar samples which can not be differentiated from primary impact craters. The estimations of the flux density of interplanetary bodies of different masses were made by Kresak (30.098.I05), Zacharov et al (30.I04.003) and Lebedinets (I98I). The nature, origin and evolution of interplanetary dust grains have been discussed by Lamy (33.I06.029).

Progress has been made in another aspect: the structural and dynamical change of interplanetary dust grains with time. The Helios Dust Experiment (Grün et al, 27.I06.0I6) has registered two types of dust grains: compact dust grains orbiting the sun on ellipses with low eccentricities $e < 0.6$ and fluffy ones orbiting the sun on ellipses with high eccentricities $e > 0.6$. One has to consider the comets as the only significant source. According to Greenberg (I983, I984) the cometary particles are conglomerates of core/mantle particles. The cores are believed to be silicates as were directly observed from infrared observations by Ney (32.I02.020). The mantles consist of the light elements H, C, N, O and, after being photoprocessed, from more or less complex organic molecules as shown by laboratory simulation experiments. Just after release from a comet nuclei the organic mantles may be coated by ices. Conglomerates of these building blocks are the cometary particles and one would like to call them "Greenberg-particles". Particles larger than I μm in diameter orbit the sun first on the comet's trajectory. That means, however, that they warm up - as the comet nucleus itself - during the perihelium passages and they cool down during aphelium. The corpuscular irradiation sputters the mantle material and above a certain temperature limit the organic mantles may slowly sublime. Mukai and Fechtig (33.022.II4) have calculated the situation for a Comet Halley dust grains and found that with the mass loss of approximately 10^{-13}g/cm^2 s all mantle material is lost in a time comparable to the time needed to change the high eccentric (cometary) orbit into a quasicircular orbit due to the Pointing-Robertson effect. By the loss of the

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

mantle material the Greenberg-particles of rathe low density (< 1 g/cm^3) change into Brownlee-particles of higher densities (~ 1 g/cm^3) and, possibly, by rearranging the naked cores into compact grains of normal densities (~ 3 g/cm^3). And this is exactly what was observed by the Helios Dust Experyment. The very similar result was obtained independently by Tokhtasjev (I982b, I984) from radar and photographic observations of meteor streams. He has found the dependence of meteoroid densities on their orbital elements.

Considering the existance of these Greenberg-particles leads us to anothe interesting consequence: organic mantles become black when exposed to high energetic corpuscular irradiation (Johnson, I984). This means the albedos ofthe Greenberg-particles are considerably lower than the albedos of silicates. This could possibly explain the discripancy of the results of the Pioner IO and II dust experiment: the penetration experiment sees constant fluxes between I and 20 AU (Humes, 28 I06.079) while the zodiacal light experiment registers a decreasing dust frequency between I and 3.3 AU sun distance but no scattering sun light beyond 3.3 AU (Hanner et al, I7.I06.056). If the albedos of the Greenberg-particles are sufficiently low, the optical experiment may only see the Brownlee-particles and all compact particles. In the picture given above, the Greenberg-particles are the youngest ones if one counts the time after release from comet nuclei. These young particles orbit on highly eccentric ellipses, as analyzed by Humes (22.I06.079). Most of the time they stay outside the inner solar system. Only during the fast perihelium passages they are within I AU sun distance. The older the particles, the higher their albedos: first as Greenberg-particles, later as Brownlee-particles and finally as compact grains. The eccentricities of their orbits become smaller and smaller, meaning that the old particles finally always stay within the inner solar system (Fechtig,I984).

The current dust experiments, using space shuttle techniques and particularly the Long Duration Exposure Facility of NASA are primarily of interest for the chemical analysis of dust. Dynamical aspects can only play a minor role since the experiments are passive. However, impact craters, as recently recorded on a shuttle experiment (McDonnell et al, I984) and similar experiments of LDEF may give detailed insight into the near Earth dust inviroment. In particular, the space debris dynamics is of interest because artifical dust is expected to stay in Earth orbit. As recently discussed on a COSPAR Workshop on Space Debris (Graz,I984) collisional fragments are continuously produced and build up an Earth's dust belt in the future. The natural dust belts around the Earth were found from the new processing of the meteor experiment data carried out on the space probes "Electron -I" and "Electron-3" (Barsukov and Nazarova, I983). The theory of the dust belt formation have been developed by Gulak (34.I04.004, I983).

X. INTERPLANETARY DUST - PHYSICAL CHARACTERISTICS AND SOURSES

Hughes (34.I02.028) has presented a brief review of our knowledge of the source and characteristics of cometary dust. He has considered that all particles responsible for meteor showers, Brownlee-particles in the stratosphere etc originate in the cometary nucleus. Singer and Stanley (33.I04.024) have thought that submicron particles observed with Explorer 46 in I974-75 and affilated with meteor streams to be produced by comets during perihelion passage. On the other hand Parkin et al (34.I05.057) have argued that rarely occuring white stony cosmic spherules in deep-sea sediments together with ordinary black spherules originate in asteroidal collisions. Evidence was adduced by Greenberg (34.I02.029) to show that comets and carbonaceous meteorites have a common origin via aggregation of interstellar dust. A possible relation of the interplanetary dust with comets and presolar interstellar particles discussed by Brownlee (I982).

Samples of interplanetary dust have been succesfully collected for laboratory study from the stratosphere and from the sea floor. Elemental and isotopic abundances of He, Ne and Ar suggest a space exposure of small particles in the inner solar system for at least tens of years (Fraundorf et al, 32.106.017). Unique crystal morphologies and microstructures of enstatite whiskers and platelets observed in dust particles strongly suggest that they are primary vapor phase condensates which could have formed either in the solar nebula or in prosolar inviroment (Bradley et al, 33.106.013). Dust agregates are black, fine grained material and exhibit significant differences in composition, morphology and mineralogy (Fraundorf, 29.106.022, Brownlee, 30.106.053, Papanastassion et al, 34.106.026).

XI. METEOR SPECTROSCOPY

A summary of the major results of the meteor spectroscopy in the recent years was given in the review papers by Millman (33.104.019) and Bronshten (1982). Other results on the topic see Russel (29.104.005), Babadzhanov and Getman (1982) and Smirnov (31.104.014).

References

Alvarez, W., Asaro, F., Michel, H.V. and Alvarez, L.W.: 1982a, Science, 216, p.886.
Alvarez, W., Asaro, F., Michel, H.V. and Alvarez, L.W.: 1982b, Geol. Soc. Am. Abstracts, 14, p.431.
Andreev, G.V. and Babadzhanov, P.B.: 1982, MMIS, p.261.
Andreev, G.V. and Ryabova, G.O.: 1982, MMIS, p.129.
Andreev, G.V. and Sukhotin, A.A.: 1982, MMIS, p.175.
Andreev, G.V., Lazarev, R.G., Rubtsov, L.N. and Ryabova, G.O.: 1982, MMIS, p.1l3.
Andreev, G.V., Belkovich, O.I., Ryabova, G.O. and Svetashkova, N.T.: 1984, Astron. Vestn. 18, p.74.
Andreev, V.V., Belkovich, O.I. and Zabolotnikov, V.S.: 1982, MMIS, p.8.
Andreev, V.V., Belkovich, O.I. and Tokhtasjev, V.S.: 1983, Astron. Vestn. 17, p.244.
Andrianov, N.S. and Sidorov, V.V.: 1983, Meteorn. Rasprostr. Radiovoln, 18, p.25.
Asaro, F., Alvarez, L.W., Alvarez, W. and Michel, H.V.: 1982, Geol. Soc. Am. Spec. Paper, 190, p.517.
Babadzhanov, P.B., Bibarsov, R.Sh., Narziev, M. and Chebotarev, R.P.: 1982, MMIS, p.190.
Babadzhanov, P.B. and Getman, V.S.: 1982, MMIS, p.225.
Babadzhanov, P.B., Zausaev, A.F. and Obrubov, Yu.V.: 1982, MMIS, p.131.
Babadzhanov, P.B. and Konovalova, N.A.: 1983, Doklady Akad. Nauk Tadzh. SSR, 26, p.494.
Baggaley, W.J.: 1984a, Bull. Astron. Inst. Czech. in press.
Baggaley, W.J.: 1984b, Planet. Space Sci. in press.
Barsukov, V.L. and Nazarova, T.N.: 1983, Astron. Vestn. 17, p.238.
Belkovich, O.I., Sulejmanov, N.I., and Tokhtasjev, V.S.: 1982a, MMIS, p.88.
Belkovich, O.I., Sulejmanov, N.I. and Tokhtasjev, V.S.: 1982b, MMIS, p.121.
Belkovich, O.I., Sulejmanov, N.I. and Tokhtasjev, V.S.: 1984, Bull. Astron. Inst. Czech. 35, p.123.
Bibarsov, R.Sh., and Chebotarev, R.P.: 1982, MMIS, p.63.
Bibarsov, R.Sh. and Kolmakov, V.M.: 1984, Astron. Vestn. 18, p.71.
Björn, L.G. and Arnold, F.: 1981, Geophys. Res. Lett. 8, p.1167.
Blokhin, V.A. and Novikov, G.G.: 1982, MMIS, p.236.
Bronshten, V.A.: 1982, MMIS, p.208.
Bronshten, V.A.: 1983a, Astron. Vestn. 17, p.175.
Bronshten, V.A.: 1983b, Astron. Tsirkular, No. 1266, p.5.
Ceplecha, Z.: 1983, Meteoritics, 18, p.278.
Chumak, Yu.V. and Mojsya, R.I.: 1983, Vestn. Kiev. Univ., Phys. 24, p.23.

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press

Chumak, Yu.V. and Mojsya, R.I.: I984, Meteornye Issledovaniya, Kiev, 9, p.69.
Emeljanenko, V.V.: I984, Pis'ma v Astron. Zhurnal, IO, p.3I5.
Fechtig, H.: I984, XXV COSPAR Meeting Graz.
Florensky, P.V. and Dikov, Yu.P.: I98I, Geochemistry International, I8, p.92.
Fox, K., Williams, I.P. and Hughes, D.W.: I984, MNRAS, 208, p.II55.
Ganapathy, R.: I982, Geol. Soc. Am. Spec. Paper, I90, p.5I3.
Glass, B.P.: I982, Geol. Soc. Am. Spec. Paper, I90, p.25I.
Glass, B.P., Dubois, D.L. and Ganapathy, R.: I982, J. Geophys. Res. 87, p.A425.
Glass, B.P., Fredriksson,K. and Florensky,P.V.: I983. J.Geophys.Res.88, p.B3I9.
Gorovenko, A.P.: I984, Komety i Meteory, 35, p.47.
Greenberg, J.M.: I984, Scientific American, June I984, p.96.
Grün, E., Zook, H.A. and Giese, R.H.: I984, Icarus, in press.
Gulak Yu.K.: I982, Astron. Tsirk. No.I273, p.2.
Gulak, Yu.K.: I983, Astron. Vestn. I7, p.232.
Hajduk, A., Cevolani, G.,Formiggini, C., Babadzhanov, P.B. and Chebotarev, R.P.: I984, Bull. Astron. Inst. Czech. 35, p.I.
Halliday, I., Blackwell, A.T. and Griffin, A.A.:I984, Science, 223, p.I405.
Han-chang, P., Kui-huan, Z. and Sui-tian, C.: I982, J.Geophys.Res. 87,p.5563.
Hawkes, R.L., Jones, J. and Ceplecha, Z.: I984, Bull.Astron.Inst.Czech.35,p.46.
Hörz, F.: I982, Geol. Soc. Am. Spec. Paper, I90, p.39.
Isamutdinov, Sh.O.: I983, Bull.Astrophys.Inst.Akad.Nauk Tdzh.SSR, 74, p.20.
Isamutdinov, Sh.O. and Chebotarev, R.P.: I984, Komety i Meteory, 35, p.35.
Johnson, R.E.: I984, XXV COSPAR Meeting Graz.
Kalenichenko, V.V.: I982, MMIS, p.I99.
Kalenichenko, V.V.: I984, Astron. Vestn. I8. p.I5I.
Karpov, A.V., Sidorov, V.V.and Stepanov, A.M.: I984, Astron. Vestn. I8, p.44.
Kashcheev, B.L. and Nechitajlenko, V.A.: I983, Meteor Res. 8, p.5.
Kazantsev, A.M. and Sherbaum, L.M.: I982, MMIS, p.III.
Kirchhoff, V.W.J.H. and Clemeska, B.R.: I983a, J. Geophys. Res. 88, p.442.
Kirchhoff, V.W.J.H. and Clemeska, B.R.: I983b, Planet. Space Sci. 3I, p.369.
Koeberl, C. and Kiesl, W.: I983, Meteoritics, I8, p.326.
Kolomiets, A.R.: I983, Probl. Kosm. Phys. I8, p.65.
Kopp, E. and Herrmann, V.: I984, Annales Geophys. 2, p.83.
Kostylev, K.K.: I982, MMIS, p.252.
Kostylev, K.V.: I983, Meteorn. Rasprostranenie Radiovoln, I8, p.I5.
Kostylev, K.V. and Svetashkova, N.T.: I982, MMIS, p.6I.
Kovshun, I.N.: I983, Astron. Vestn. I7, p.I83.
Kramer, E.N. and Shestaka, I.S.: I982, Materials World Data Center B, Moskow.
Kramer, E.N. and Shestaka, I.S.: I983, Problemy Kosm. Phys. I8, p.48.
Kramer, E.N. and Shestaka, I.S.: I984, Astron. Vestn. I8.p.I47.
Kramer, E.N., Shestaka, I.S., Kruchinenko, V.G.,.Markina, A.K. and Musij, V.I.: I983, Vestn. Kiev. Univ., Astron. 25,p.53.
Kruchinenko, V.G.: I982, MMIS, p.I93.
Kruchinenko, V.G.: I984, Vestn. Kiev. Univ., Astron. 26, p.98.
Kulikova, N.V.: I982, MMIS, p.I77.
Kurbanmuradov, K. and Mukhamednazarov, S.: I982, MMIS, p.23I.
Lebedinets, V.N.: I984, Astron. Vestn. I8, p.35.
Lebedinets, V.N. and Manokhina, A.V.: I982a, MMIS, p.I04.
Lebedinets, V.N. and Manokhina, A.V.: I982b, Trudy Inst. Exp. Meteorologii, No. I2/96, p.49.
Lebedinets, V.N. and Manokhina, A.V.: I982c, Trudy Inst. Exp. Meteorologii, No. I2/96, p.55.
Levin, B.Yu.: I982, Izvestiya Akad. Nauk USSR, 6, p.25.
Levin, B.Yu. and Simonenko, A.N.: I982, MMIS, p.257.
Levitskij, S.M.: I983, Problemy Kosm. Phys. I8, p.67.
Levitskij, S.M., Abdrakhmanov, N. and Timchenko, V.P.: Izvestiya Vuzov, Radiophysika, 25, p.I240.
Malynjak, M.I.: I982, MMIS, p.248.
Matsenko, S.V. and Tkachuk, A.A: I982, MMIS,p.36.

McDonnell, J.A.M., Carey, W.C. and Dixon, D.G.: I984, Nature, 309, p.237.
McIntosh, B.A. and Šimek, M.: I984, Bull. Astron. Inst.Czech. 35, p.I4.
McLeod, N.: I984, Sky and Telescope, 67, p.I08.
McRobert, A.: I984, Sky and Telescope, 68, p.I48.
Mukai, T. and Giese, R.H.: I984, Astron. and Astrophys. I3I, p.355.
Nechitajlenko, V.A. and Voloshchuk, Yu.I.: I983, Meteor Researches, 8, p.77.
Novikov, G.G., Lebedinets, V.N. and Blokhin, A.V.: I984, Pis'ma v Astron. J. I0, p.7I.
Novikov, G.G. and Tsygankov, S.F.: I982, Izvestiya Vuzov, Radiophys. 25, p.239.
O'Keefe, J.A.: I983a, Trans. Am. Geophys. Union, 64, p.257.
O'Keefe, J.A.: I983b, Plenary Lecture Intern. Conf. on Glass in Planet. and Geol. Phenomena, New-York.
Pecina, P.: I984a, Bull. Astron. Inst. Czech. 35, p.5.
Pecina, P.: I984b, Bull. Astron. Inst. Czech. 35, p.I20.
Porubčan, V.and Štohl, J.: I983, Contrs Astron. Obs. Skalnate Pleso II, p.I69.
Povenmire, H. and Ceplecha, Z.: I983, Sky and Teleskope, 66, p.I74.
Rentdel, J.: I982, Astron. und Raumfahrt, 20, p.I50.
ReVelle, D.O.: I983, Meteorites, I8, p.386.
Rost, R.: I98I, Chem. Erde, 40, p.265.
Rumi, G.C.: I982, J. Atmos. Terr. Phys. 44, p.773.
Sakhibgareev, D.G.: I983, Trudy Inst. Exper. Meteorologii, No. 6/I07, p.84.
Show, H.F. and Wasserburg, G.J.: I982, Earth Planet. Sci. Lett. 60, p.I55.
Šimek, M.: I984, Bull. Astron. Inst. Czech. 35, p.I26.
Simmons, K.: I982, Meteor News, 58,p.7.
Simonenko, A.N. and Terentjeva, A.K.: I984, Astron. Vestn. I8, p.2I5.
Smirnov, V.A. and Kovshun, I.N.: I982, MMIS, p.235.
Solyanik, O.A. and Tkachuk, A.A.: I983, Meteor Researches, 8, p.67.
Solomon, S., Fergusson, E.E., Fahey, D.V. and Crutzen, P.J.: I982, Planet. Space Sci. 30, p.III7.
Spalding, G.H.: I984, J. Brit. Astron. Assoc. 94, p.I09.
Svetashkova, N.T.: I982, MMIS, p.I02.
Swider, W.: I984, Planet. Space Sci. 32, p.307.
Terentjeva, A.K.: I983, Astron. Tsirk. No.I256, p.5.
Tiwari, S.N. and Subramanjan, S.V.: I980, Acta Astronaut. 7, p.583.
Tkachuk, A.A.: I982, MMIS, p.67.
Tkachuk, A.A.: I983a, Meteor Researches, 8, p.5I.
Tkachuk, A.A.: I983b, Probl. Kosm. Phys. I8, p.53.
Tokhtasjev, V.S.: I982a, MMIS, p.I62.
Tokhtasjev, V.S.: I982b, MMIS, p.I84.
Tokhtasjev, V.S.: I984, "Meteor Bodies in Interplanet. Space and Earth's Atmosphere, Theses of the Conf., Dushanbe, p.53.
Voloshchuk, Yu.I.: I982, MMIS, p.32.
Voloshchuk, Yu.I. and Kashcheev, L.B.: I982, MMIS, p.45.
Weissman, P.R.: I983, Icarus, 55, p.448.
Wetherill, G.W.: I984, Meteorites, I9, p.I.
Yuan, B.: I98I, Scientia Geologica Sinica, 4, p.329.
Znojil, V., Simek, M., Grygar, J. and Hollan, J.: I98I, Bull. Astron. Inst. Czech. 32, p.I.
Zook, H.A., Lange, G., Grün, E. and Fechtig, H.: I984, Lunar Planet. Sci. Conf. XV, p.9652.

Note: MMIS = "Meteor Matter in the Interplanetary Space". Proc. of Symp. held at the Kazan University, Sept. 9 - II, I980. Moskva,I982.

https://doi.org/10.1017/S0251107X00006349 Published online by Cambridge University Press