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AN ANNOTATED BIBLIOGRAPHY ON INTERPLANETARY DUST

by Paul W. Hodge, Frances W. Wright, and Dorrit Hoffleit

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An Annotated Bibliography on Interplanetary Dust

By Paul W. Hodge,[1] Frances W. Wright,[1] and Dorrit Hoffleit[2]

This annotated bibliography presents a compilation of references to significant papers relating to the study of interplanetary dust. Some references have been included from *Bibliography on Meteoritic Dust with Brief Abstracts* compiled by Hoffleit (Harvard College Observatory Reprint Series II–43, 45 pp., 1952), and now out of print.

In the selection of references from the Hoffleit bibliography, we have attempted to include all important papers as well as representative samples that are of special interest for historical reasons.

In the selection of references published since the appearance of the Hoffleit bibliography, we have been guided by the main principles that Hoffleit adopted for her compilation:

> Three types of dust have been considered as meteoritic dust in the search for material: particles that enter the upper atmosphere as minute dust particles (the zodiacal light may be a source of such); dust products of the disintegration of larger meteoroidal masses during their passage through the atmosphere; and possible pulverized remnants of meteorite-impacts.

In addition, we include some papers relating to interplanetary dust outside the earth's atmosphere.

As far as practicable, the titles of journals appear in the original language of publication. For maximum usefulness to the reader, however, titles of papers are given in English. Papers written in a language other than English are usually indicated by a parenthetical note.

[1] Harvard College Observatory and Smithsonian Astrophysical Observatory, Cambridge, Mass.

[2] Maria Mitchell Observatory, Nantucket, Mass., and Yale University Observatory, New Haven, Conn.

Ahnert, E.

1954. Preliminary report on attempts to detect meteoritic dust. Die Sterne, vol. 30, pp. 36–38. (In German.)

The lack of nickel in the spherules collected by Thomsen (1953) casts doubt on their interplanetary origin. Hoffmeister has collected dust in the neighborhood of factories and has found spherules (45 to 135μ in diameter) similar, at first glance, to Thomsen's spherules, but nonmagnetic. Collections from more isolated regions contained no spherules. Collections from snow showed no spherules but did show irregular particles, 15 percent of which were magnetic, with diameters of 100 to 200μ.

Allen, C. W.

1956. Influence of solar atomic emission on the orbits of interplanetary particles. Observatory, vol. 76, pp. 101–103.

The author discusses the magnitude of the collision effect and shows that the rate at which particles approach the sun may be greater than that indicated by calculations based on the Poynting-Robertson effect. He does not consider the influence of large-scale solar magnetic fields.

Ångström, A.

1929. On the atmospheric transmission of sun radiation and on dust in the air. Geografiska Annaler, vol. 11, p. 156ff.

The author studies the effect of dust on measurements of the solar constant; he be-

lieves that dust of cosmic origin may be characterized by particles of smaller size than those of volcanic origin or of dust brought by convection from the earth to the atmosphere.

ANONYMOUS
1885. Meteoric dust. Sci. American, vol. 52, p. 83ff.

The complete article reads: "A metallic substance in powder or small granules has been sent to the *Science News* laboratory for examination. It proves to be meteoric dust, largely composed of iron, nickel, and silica. Dr. Batchelder, of Pelham, N.H., who sent the specimen, states that he collected the dust on the walk in front of his house after a smart thunder shower. It is probable that large quantities of this material fall upon the earth, but remain unnoticed. Much of the iron found in soils is due to precipitation from interstellar spaces, the particles becoming entangled in our atmosphere."

ANYZESKI, V.
1947. A conjecture on the nature of some meteoritic matter. Pop. Astron., vol. 55, pp. 169–171.

The author suggests that some meteors may be solid hydrogen or ice with inclusions of ordinary meteoritic material. Some bolides on entering the atmosphere may have a thick coating of hydrogen that might account for some trains and might explain the "nebulous meteors."

ARAGO, D. F. J.
1857. A list of the principal recorded showers of cosmic dust. Astron. Populaire, vol. 4, p. 208ff.

ASTAPOVICH, I. S.
1958. Bolides and their dust trains. *In* Meteoric phenomena in the earth's atmosphere. State Publishing House of Phys.-Math. Literature, Moscow. (In Russian.)

In Chapter 29 the author discusses bolides and their dust trains, and gives lists of bolides observed in the U.S.S.R. Chapters 34 and 35 deal with meteoric and cosmic dust in the earth's atmosphere, and meteoric material on the earth's surface. The author gives a review of work done by others on meteoric and cosmic dust in the earth's atmosphere and on meteoric material on the earth's surface. He concludes that more than 16,000 tons of meteoric material fall on the earth each year.

BARBIER, D.
1955. Variations in intensity of the zodiacal light. Mém. Soc. Roy. Sci. Liège, ser. 4., vol. 15, pp. 55–71. (In French.)

The author describes his photoelectric measurements in three colors of the intensity of the zodiacal light, and discusses the variations of intensity and color with time.

BARRINGER, D. B.
1909. Meteor crater in Northern Central Arizona. Pamphlet, National Academy of Sciences, 24 pp.

The author discusses small specks of meteoritic material admixed with rock fragments.

BEACH, A.
1942. The zodiacal light. Astron. Soc. Pacific, Leaflet No. 155, 8 pp.

This is a historical note in popular style.

BEARD, D. B.
1959. Interplanetary dust distribution. Astrophys. Journ., vol. 129, pp. 496–506.

The author maintains that the most reliable estimates of the concentration of of interplanetary dust depend upon our interpretations of measurements of scattered light observed in the solar corona and in the night sky. On this basis, and also from a theoretical discussion, he concludes that interplanetary dust is probably distributed as $r^{-3/2}$, where r is the distance from the sun, and certainly the variation

of the dust concentration with solar distance has this rate as an upper limit. He gives a few microns as the minimum radius of the dust particles, and deduces that near the minimum particle radius, the particle number varies as $a^{-3.5}$, where a is the particle radius. The mass of all the planets causes the dust to move towards the ecliptic, and the distance from the ecliptic is proportional to the solar distance of the dust. The dust concentration at the earth's orbit is approximately 10^{-14} to 10^{-15} particles per cm^3, but at the earth's surface it is 10^{-10} to 10^{-11} particles per cm^3.

Behr, A., and Siedentopf, H.

1953a. Investigations of the zodiacal light and the gegenschein from photoelectric measures on the Jungfraujoch. Zeitschr. Astrophys., vol. 32, pp. 19–50. (In German.)

The authors observed the brightness and the polarization of the evening zodiacal light by using a photoelectric photometer in two colors. They also observed the night sky in the region of the gegenschein. They interpreted the observations on the working hypothesis that the zodiacal light material consists partly of free electrons, which cause the observed polarization, and partly of dust particles with radii greater than 10^{-4} cm, which cause no noticeable polarization. For the space density of the electrons near the earth the authors give the value $600/cm^3$. The density rises in the ecliptic to around $1000/cm^3$ at 0.6 a.u. from the sun, and falls to about $120/cm^3$ at 1.3 a.u. from the sun. The space density of dust particles in the ecliptic outside Venus' orbit is constant, but inside Venus' orbit falls off somewhat towards the sun. The gegenschein has a simple explanation if we accept the hypothesis that a cloud of particles exists in the neighborhood of the libration point of the sun-earth system. Here the particle density exceeds by 10 or 10^2 the general particle density in the ecliptic.

1953b. The structure of the zodiacal light. Experimentia, vol. 9, pp. 134–135. (In German.)

At the Jungfraujoch the authors made photoelectric observations of the intensity and polarization of the zodiacal light. On the assumption that the polarization arises from free electrons, the authors calculate a space density of dust particles of $10^{-15}/cm^3$, which is nearly constant through the ecliptic.

Bowen, E. G.

1953. The influence of meteoric dust on rainfall. Australian Journ. Phys., vol. 6, pp. 490–497.

Data on worldwide rainfall suggest a correlation between rainfall and meteor showers. In some localities heavy rainfalls tend to occur on certain days in a pattern repeated yearly. The author suggests that meteoritic dust provides rain-forming nuclei when it enters cloud systems in the lower atmosphere. Particles with diameters of 1 to 4μ require 30 to 50 days to fall to about 45,000 feet above the earth. This rate of fall explains the 30-day lag between the occurrence of the Geminid, Ursid, and Quadrantid meteor showers, and the recorded maximum rainfalls. It is suggested that noctilucent clouds originate from meteoritic dust.

Bracewell, R. N.

1953. Meteors and rain. Observatory, vol. 73, pp. 249–250.

The author reports Bowen's findings on meteors and rainfall.

Brier, G. W. (see under Kline and Brier)

Bullrich, K.

1949. Scattering of light on vapor and ice particles. Zeitschr. f. Met., vol. 3, p. 335ff. (In German.)

The author discusses Link's attempt to determine the extinction coefficient of the air from measurements of light intensity at the zenith. One difficulty is the uncertainty of the scattering function, which varies with the composition of aerosols in the atmosphere. The theoretical scatter functions for water, dust, and ice, and for various angles, are set up and compared with various experimental determinations.

Burger, J.
1949. Problems of cosmical aerodynamics. Proceedings of symposium on the motion of gaseous masses of cosmical dimensions, Int. Union Theoretical and Applied Mechanics and Int. Astron. Union, edited by J. Burger, 237 pp.

While meteoritic dust as such is not discussed, several of the papers on interstellar matter have theoretical bearing, especially papers by Spitzer, van de Hulst, and von Weissacker.

Chladni, E. F. F.
1819. On fireballs and dust-falls. Vienna, 434 pp. (In German.)

Chapter 6 contains reports in chronological order of falls of dust or fine material in dry or moist form. Also, pages 20–23 give a chronological table of supposed meteoritic dust-falls between the years 472 and 1816. Most of these are described as falls of red rain, red snow, or dust falls. More than 50 examples are given.

Cialdea, R.
1950. The spectral distribution of polarization in skylight. Ann. Geofis., vol. 3, pp. 357–370. (In Italian.)

From observations of the degree of polarization of light from the sky, three typical conditions are indicated in which the polarization increases, remains constant, or decreases with wave length. Theory shows that this relationship depends upon the ratio of scatter from particles of molecular size to diffuse scatter from layers of large particles, the thickness of these layers determining the type of spectral distribution.

Cosari, D. L.
1834. Account of some remarkable hailstones which fell at Padua on the 26th of August, 1834. Ann. delle Scienze del Regno Lomb. Veneto (in Italian). See also Edinburgh New Philosophical Journ., vol. 19, p. 83ff. (in English).

Among the large and very numerous hailstones found, a great number contained sandy matter. The author himself obtained only two such. In one there was only a minute quantity at the center. In the other, the nucleus of ash-grey color was about ⅛ inch in diameter and surrounded by pure ice. The minute amount of dust gained from this sample was insufficient for chemical analysis. Some of the grains were easily attracted by a magnet. It seemed probable that the dust was a combination of iron or nickel with some other unidentified substance.

Crozier, W. D.
1956. Rate of deposit in New Mexico of magnetic spherules from the atmosphere (Abstract). Bull. Amer. Meteorol. Soc., vol. 37, p. 308.

This paper gives a condensed report of the collections of magnetic spherules found in New Mexico. The rate of deposit varies only slowly, and may be correlated with meteor showers. There are no rapid changes in the rate of deposit which might be correlated with short-period meteorological effects.

—— and Seely, B. K.
1949. Some techniques for sampling and identifying particulate matter in the air. Technical Report No. 3–NR, Research and Development Division, New Mexico School of Mines, Socorro; Proceedings of the First National Air Pollution Symposium, Pasadena. Abstracts: Pop. Astron., vol. 57, p. 459, 1949; Sky and Tel., vol. 9, p. 54, 1950.

Means have been developed for collection of air-borne particles of sizes down to well below one micron. Methods are given for combined microscopic and chemical analysis. As a by-product of studies of mass movements in the atmosphere, cosmic dust in the air is being investigated. If tests show iron, nickel, and cobalt, the dust particles are probably of meteoric origin.

DAUBRÉE, A.

1893. Deep-sea deposits. Smithsonian annual report for year ending June 30, 1893, p. 545ff.

The paper includes a section on mineral substances of extraterrestrial origin (pp. 557–560), gives general discussion on the plausibility of finding meteoritic dust on the sea-bottom, and cites examples of meteoritic dust accretion. In regard to the friable chondritic meteorites that fell at Orgueil on May 14, 1864, the author comments that if, instead of perfectly clear weather, it had been rainy or the sky had been only covered with clouds through which the stones would have had to pass, nothing could have been gathered up but a viscous mud.

DAVIDSON, D. T. (see under Handy and Davidson).

DURST, C. S.

1935. Dust in the atmosphere. Journ. Roy. Meteorol. Soc., vol. 61, pp. 81–87; Discovery, vol. 16, pp. 87–88.

The paper gives a theoretical picture of a dusty atmosphere in which each particle of dust is surrounded by a pocket of air having temperature and humidity different from that of the general air mass. This picture is corroborated by the rising of haze tops, the air temperature above the Arabian Sea during the S.W. monsoon, and the diurnal variation of wind in that region. Some consequences are pointed out; one is that there may be a layer of dust high up in the atmosphere.

EHRENBERG, C. G.

1858. Meteoric dust from the *Joshua Bates*. Monatsber. K. Akad. Wiss. Berlin, pp. 1–10. (In German.)

The author discusses the great flame explosion near Baku, Feb. 7, 1839, and a fall of black, polished, hollow kernels similar to atmospheric iron dust found at the sea-bottom of the Pacific.

ELBERTY, W. T. (see under Stoiber, Lyons, Elberty, and McCrehan).

FESENKOV, V. G.

1938a. On the origin of the zodiacal light. Comptes Rendus, Moscow, new ser., vol. 19, p. 677ff. (In French.)

1938b. On the role of galactic matter in the phenomenon of the zodiacal light. Comptes Rendus, Moscow, new ser., vol. 19, p. 451ff. (In French.)

1938c. Some considerations of the origin of the zodiacal light. Russian Astron. Journ., vol. 15, p. 368ff. (In French.)

1940. The problems of the zodiacal light. Russian Astron. Journ., vol. 17, p. 25ff. (In Russian.)

1941. Investigation of the zodiacal light based on observations in the tropics. Russian Astron. Journ., vol. 18, p. 31ff. (In Russian.)

1942a. The dynamic theory of the zodiacal light. Russian Astron. Journ., vol. 19, pp. 28–49. (In Russian.)

1942b. Minor planets and cosmic dust. Doklady Acad. Sci. Report, vol. 34, pp. 163–167. (In Russian.)

1943. On the origin of the zodiacal light. Doklady Acad. Sci. Report, vol. 39. p. 377ff. (In Russian.)

1945. Cosmic material and the zodiacal light. Meteoritika, vol. 2, p. 3ff. (In Russian.)

1946. On the motion of meteoric dust in interplanetary space. Russian Astron. Journ., vol. 23, pp. 353–366. (In Russian with English abstract.)

The author discusses the influence of gravity and radiation pressure.

1947. On the stability of the material of the zodiacal light. Russian Astron. Journ., vol. 24, pp. 39–43. (In Russian.)

1949a. Atmospheric turbidity produced by the fall of the Tunguska meteorite on June 30, 1908. Meteoritika, vol. 6, pp. 8–12. (In Russian.)

Unusual atmospheric phenomena that occurred after the fall of the Tunguska meteorite must have been caused by a large mass of thinly scattered material in the atmosphere. For shorter wavelengths (4000 to 7000 angstroms) the atmospheric transmission coefficients, determined at the Mt. Wilson Station by the Smithsonian Astrophysical Observatory, showed a noticeable decrease in atmospheric transparency from mid-July to mid-August, 1908, and some variation continued to occur during the succeeding months. The author estimates the particles from the Tunguska meteorite to be of the order of 1μ in size, and the total mass to be at least a few million tons.

1949b. The zodiacal light and the outer atmosphere of the earth. Russian Astron. Journ., vol. 26, p. 344. Abstract in Astron. News Letter (Harvard), No. 54, p. 3, 1951.

The author found an unsymmetrical distribution of the zodiacal light, which he believes is not of cosmic origin but originates in an unsymmetric extension of the earth's atmosphere illuminated by the sun.

1950. On the gaseous tail of the earth. Russian Astron. Journ., vol. 27, p. 89. Abstract in Astron. News Letter (Harvard), No. 51, p. 8.

The author announces the discovery of "false zodiacal light" seen in the western sky two or two and a half hours before sunrise, and probably related to the gegenschien. He discusses and rejects Glydèn and Moulton's meteoric hypothesis. The density of "tail" decreases by a factor of two at intervals of 4.67 radii of the earth.

1958. Zodiacal light as the product of disintegration of asteroids. Russian Astron. Journ., vol. 35, pp. 327–334 (in Russian). An English translation appears in Soviet Astron. Journ., vol. 2, pp. 303–309, 1958.

The disintegration of asteroids produces a considerable amount of fine dust that spreads into space. To explain the observed brightness of the zodiacal light, the density of this dust in the neighborhood of the earth must be 10^{-23} to 10^{-24} grams per cm^3, as a lower limit. Good agreement exists between the observed form of the zodiacal light and the theoretical isophotes calculated (with the scattering function of Piaskovskaia-Fesenkova) from the known distribution of inclination angles of asteroid orbits. This fact constitutes the strongest argument in support of a meteoritic or asteroidal origin for the zodiacal light.

1959. On the nature of zodiacal light and its probable connection with asteroids and periodic comets. Annales d'Astrophys., vol. 22, pp. 820–838.

The author gives a mathematical discussion of the nature of the zodiacal light and its probable relation to asteroids and periodic comets. He shows that the observed characteristics of the zodiacal light, including its polarization, can be accounted for by the scattering of solar light by fine interplanetary particles, if their properties are similar to those of aerosols always present in the upper atmosphere. No observations support the hypothesis that light is scattered by free electrons. It is possible to obtain the theoretical isophotes of the zodiacal light from the distribution of the inclinations of the orbits of periodic comets or asteroids. Periodic comets can account for the observations, but an asteroidal origin for the dust of the zodiacal light would require velocities of several kilometers per second for the dust, with respect to the parent asteroids.

Fessenkoff, B.
1914. The zodiacal light. Gauthier-Villars, Paris, 174 pp. (In French.)

Fonton, S. S. (see under Krinov and Fonton)

FREDERIKSSON, K.

1956. Cosmic spherules in deep-sea sediments. Nature, vol. 177, pp. 32–33.

Cores taken from the ocean bottom by the Swedish Deep-Sea Expedition yielded several hundred black spherules greater than 35μ in diameter, composed of metallic iron nuclei surrounded by magnetite. The depth of the sedimentary layers in which the spherules were found indicates a cosmic origin. The estimated age of several million years for the sedimentary layers indicates that the spherules were probably deposited in the Tertiary Period. Spherules obtained from atmospheric dust collected in Göteborg were found to be industrial in origin.

FREE, E. E.

1911. The movement of soil material by the wind. U.S. Dept. Agriculture, Bureau Soils, Bull. 68, pp. 1–272.

This paper includes a bibliography of Eolian geology, a discussion of extraterrestrial dust, numerous references to the literature of cosmic dust, and a discussion of volcanic dust.

GOODY, R. M. (see under Volz and Goody)

GOSSNER, J. L. (see under Whipple and Gossner)

GÖTZ, F. W. P.

1948. Some investigations at the Arosa Light-Climatic Observatory touching solar-terrestrial relationships. Sixth Report of the Commission for the Study of Relations between Solar and Terrestrial Phenomena, Orleans, p. 166.

"Bright nights" are probably associated with an abnormal E-layer caused by invasion of cosmic dust particles.

GRIMMINGER, G.

1948. Probability that a meteorite will hit or penetrate a body situated in the vicinity of the earth. Journ. Applied Phys., vol. 19, pp. 947–956.

The author considers particles down to magnitude 30 (fine dust) and presents formulas for penetration if the particle speed is high relative to the propagation of plastic deformation in the target.

GUTH, V.

1955a. Meteoric astronomy. Bull. Astron. Inst. Czechoslovakia, vol. 6, pp. 65–70 (in Russian); pp. 70–76 (in English); the abstract covers pp. 75–76.

The author reviews Czechoslovakian work on meteoritic dust during the period 1949 to 1955.

1955b. Meteoritic dust. Transactions of the Int. Astron. Union, vol. 9, pp. 303–304.

The author gives a short account of research on meteoritic dust. He states that L. Kresák has disproved the observation of F. Link (1953) and Z. Linková that the intensity of the earth's shadow observed during lunar eclipses depends upon the amount of meteoritic dust in the atmosphere; Kresák has shown that only very big meteor showers could have any influence on the intensity of the shadow. Guth states that the question could be settled by optical measurements of the brightness and polarization of the twilight sky.

HANDY, R. L., AND DAVIDSON, D. T.

1953. On the curious resemblance between fly ash and meteoritic dust. Iowa Acad. Sci., vol. 60, pp. 373–379.

The authors identify Thomsen's (1953) spherules as fly ash from coal-dust furnaces.

HARTLEY, W. N., AND RAMAGE, H.

1901. The mineral constituents of dust and soot from various sources. Proc. Roy. Soc., London, vol. 68, pp. 97–109. See also abstract in Nature, vol. 63, p. 552, 1901.

The dust that fell November 16, 17, 1897, showed a regularity in composition and a similarity to meteorites in being

magnetic and in having comparative freedom from extraneous matter. These properties are in favor of its cosmic origin.

HASEGAWA, I.
1956. Collecting and theories of meteoric dust. Tenkai (The heavens), Oriental Astron. Assoc. Memoir No. 175, p. 226ff. (In Japanese.) Translation of some sections into English, Reference Manual No. 1, Smithsonian Astrophys. Obs., pp. 1–46, 1959.

The author describes methods of collecting meteoric dust, gives details of various collecting projects in Japan, and reviews previous work by others. He is interested primarily in magnetic spherules.

HAWKINS, G. S. (see under Whipple and Hawkins)

HEARD, J. F.
1955. Meteorites large and small. Journ. Roy. Astron. Soc., Canada, vol. 49, pp. 49–63.

An investigation was made of dust collected by a filtering device operated in an aircraft flying at an altitude of 6,000 feet in the Arctic. About 300,000 cubic feet of air were filtered, producing 1950 particles. Examination under a microscope of 100-power detected only two black spheres, in contrast to 36 collected by the same method above Windsor, Ontario, from air subject to industrial pollution. This work supports the conclusion of Hogg and Norris in 1949 that such spherules have a terrestrial origin. No bright metallic splinters were found, and the black spheres are probably not meteoritic. Assuming for the particles a mean density of 3 gm/cm^3, the author computes that at 6,000 feet the Arctic air contained about 7 x 10^{-8} gm/ft^3 of solid material at the time of the collections. The magnetic fraction was 10 to 100 times greater than the amount expected from van de Hulst's calculations, and probably only a small fraction was extraterrestrial. The author favors the theory that interplanetary dust is primordial rather than debris from larger bodies, and thinks that the study of micrometeorites can hardly fail to add to our knowledge of the origin and history of the solar system.

HEIS, E.
1859. The meteorite spherules of Captain Callum. Wochenschr. Astron. Meteor. Geogr., new ser., vol. 2, p. 319ff. (In German.)

A shower of small black spherules like very fine shot fell on the American ship *Joshua Bates*, Nov. 14, 1856, about 60 miles southeast of Java. A small quantity was collected by Captain Callum for Lieutenant Maury, who sent a sample to Ehrenberg for microscopic study. Reported by Ehrenberg (1858). However, von Reichenbach (1859) regards these spherules as evidence of a fireball.

HIRST, W. P.
1951. Some astronomical effects of radiation. Monthly Notes, Astron. Soc. South Africa, vol. 10, pp. 44–46.

The author discusses the effect of the sun's radiation on small bodies, comets, and the zodiacal light.

HODGE, P.
1956. Opaque spherules in dust collected at isolated sites. Nature, vol. 178, pp. 1251–1252.

A preliminary report on dust collected simultaneously at three widely separated stations: in California, in central Alaska, and in the Arctic. A detailed report appears in Hodge and Wildt (1958).

—— AND RINEHART, J. S.
1958. High-altitude collection of extraterrestrial particulate matter. Astron. Journ., vol. 63, p. 306. (Abstract.)

The authors describe dust collected by millipore filters on jet aircraft flying at heights ranging from 20,000 to 55,000 feet. The filters were examined with a high-power microscope. About 10,000 particles were measured. Some dark shiny metallic particles may be extraterrestrial, since their abundance does not change rapidly with altitude, as with particles of terrestrial origin.

—— AND WILDT, R.

1958. A search for airborne particles of meteoritic origin. Geochim. et Cosmochim. Acta, vol. 14, pp. 126–133.

The authors report on results of a year-long program involving daily collections of atmospheric dust at several widely separated, isolated sites. The particles are opaque shiny spherules with diameters less than 15μ, entirely different from the larger spheres commonly found in densely populated areas. Their meteoritic origin is suggested by recent evidence regarding ablation of meteorites, and by the fact that the rate of fall and the frequency distribution with size are the same at the several stations. The average rate of fall at each station was 1.1 spherules per cm^2 per day for particles greater than 3μ in diameter. The rate of fall over the entire earth is 5×10^8 kg per year.

HOFFLEIT, D.

1949. Medal for meteor study awarded. Sky and Tel., vol. 9, p. 32.

Note on F. L. Whipple's work on micrometeorites.

1951. The *Josiah* and the *Joshua Bates* and the meteoritic dust shower of November 14, 1856. Pop. Astron., vol. 59, pp. 319–322.

The author clarifies the misconception leading to the belief that there had been two showers of dust, when in fact there had been only one.

HOFFMEISTER, C.

1930. Contribution to the photometry of the southern Milky Way and the zodiacal light. Veröff. Berlin-Babelsberg, vol. 8, pt. 2, 60 pp. (In German.)

The author gives photographically determined isophotes for the zodiacal light.

1932. Investigation of the zodiacal light. Veröff. Berlin-Babelsberg, vol. 10, pt. 1, 141 pp. (In German.)

The author associates the zodiacal light with the concept of very small minor planets.

1934a. On the cometary disturbances of the upper layers of the atmosphere. Sitzungsber. Bayer. Akad. Wiss., Math-Nat. Abteil., pp. 129–144.

1934b. A hitherto unknown cosmic disturbance in the upper atmosphere. Naturwissenschaften, vol. 22, pp. 458–460.

1934c. Luminous bands, ionization of the upper atmospheric layers and propagation of electromagnetic waves. Forsch. u. Forschr., vol. 10, pp. 322–323.

In the above three papers the author asserts that ionospheric disturbances as well as luminous night-sky phenomena can with a certain degree of assurance be attributed to cosmic disturbances or to intrusions of dust into the upper layers of the atmosphere.

1934d. On the nature of the zodiacal light. Pop. Astron., vol. 42, pp. 426–430.

1937. Meteors. Akademische Verlagsgesellschaft, Leipzig, chapters 2, and 3. (In German.)

This book contains material on interstellar absorption, smoke trails, dust and ionization, ionization from dust-clouds of supposed cometary origin, the possibility that meteors and cosmic dust clouds might have influence on climate or weather, and related topics.

1941. Remarks on the problem of the zodiacal light. Astron. Nachr., vol. 271, p. 204ff. (In German.)

The author attempts to clarify the reasons for the differences between the terrestrial theory of F. Schmid and other theories.

1942. Remarks on the problem of the zodiacal light. Astron. Nachr., vol. 273, p. 131ff. (In German.)

1951a. Interplanetary matter. Naturwiss., vol. 38, p. 227ff. (In French.)

A semipopular article.

1951b. Specific luminous phenomena in the center of the ionosphere. Ergebnisse der exakten Naturwiss., vol. 24, p. 1ff. (In German.)

The author describes observed phenomena and interprets them in terms of micrometeorites.

1955. On some peculiar aspects of the zodiacal light. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 72–79.

The author discusses some peculiar aspects of the zodiacal light and the gegenschein. He emphasizes that the zodiacal light is a topological or astrometric problem, as well as a physical one.

Hogg, F. S.

1949. Meteoritic dust. Astron. Journ., vol. 54, p. 205. (Abstract.)

The author outlines a program for collecting atmospheric dust and for extending the work to the Arctic.

1950. Graduate work in meteoritic astronomy and work on meteoritic dust in Canada. Letter to Professor Leonard, Pop. Astron., vol. 58, pp. 357–358.

The author discusses the search for meteoritic matter in atmospheric dust, and dust collecting in the Arctic.

Hoppe, J., and Zimmermann, H.

1954. Separation of interplanetary from industrial particles. Die Sterne, vol. 30, pp. 33–36. (In German.)

The authors give a critical analysis of Thomsen's (1953) work. They show pictures of spherules obtained from iron filings that had been passed through the flame of a Bunsen burner, of steel chips, and of spherules produced by welding. Collections made at various distances from the center of Jena suggest that Thomsen's spherules were industrial in origin. The authors believe that some extraterrestrial particles reach the earth's surface but that identification would be difficult.

Hulburt, E. O.

1930a. A theory of zodiacal light. Phys. Rev., ser. 2, vol. 35, p. 663. (Abstract.)

The paper presents a theory that assumes that the zodiacal light originates in the uppermost layer of the earth's atmosphere.

1930b. The zodiacal light and the gegenschein as phenomena of the earth's atmosphere. Phys. Rev., ser. 2, vol. 35, pp. 1098–1118.

Hulst, H. C. van de

1949. Scattering in the atmospheres of the earth and the planets. *In* Kuiper, ed., The atmospheres of the earth and planets, pp. 49–111.

1955. On the polarization of the zodiacal light. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 89–95.

The author discusses the polarization of the zodiacal light. He explains that, contrary to some claims, the polarization of the dust component may be appreciable and that an uncertainty in the electron density arises from this fact.

Jager, C. de

1955. The capture of zodiacal dust by the earth. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 174–182.

The author discusses the capture of zodiacal dust by the earth. The amount of extraterrestrial dust observed on the earth is about 10^3 times greater than the amount computed from meteor frequencies. The author suggests that for the zodiacal dust the capture diameter of the earth is approximately 8×10^6 km. The daily deposit of dust was computed on the basis of two different density distributions of the zodiacal light. From van de Hulst's figures the author found 1.6×10^3 kg per day, and from Elsässer's he found 9.0×10^3 kg per day.

JUNG, B.
1939. Investigations of the zodiacal light. I: Gas and solid matter in the solar system. Mitt. Univ. Sternwarte Breslau, vol. 5, p. 50ff. (In German.)

The author discusses the motion of dust particles in interplanetary space.

KAISER, T. R., AND SEATON, M. J.
1955. Interplanetary dust and physical processes in the earth's upper atmosphere. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 48–54.

The authors conclude that the density of interplanetary particles is too low for them to have much effect on the physical processes in the terrestrial upper atmosphere, but that the particles probably account for certain kinds of ionospheric abnormalities.

KALLMAN, H. K.
1955. Quantitative estimate of frequency and mass distribution of dust particles causing the zodiacal light effect. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 100–113.

The author gives a quantitative estimate of frequency and mass distribution for dust particles that cause the zodiacal light. She concludes that interstellar space has two classes of dust particles, with different origins but similar densities: fast-moving meteor particles and a quiescent interplanetary dust cloud.

KAMMERMAN, A.
1886. Meteor shower of Nov. 27, 1885. Astron. Nachr., vol. 113, pp. 138–140. (In German.)

This paper deals with Yung's analysis of the dust that fell on and after November 27 at Gent. A considerable number of meteoritic particles were found.

KARANDIKAR, R. V.
1948. Effect of dust and haze on the spectral distribution of zenith-scattered radiation. Proc. Indian Acad. Sciences, "A," vol. 28, pp. 46–53.

Spectrophotometric observations on zenith-scattered light showed anomalous behavior, which is attributed to scattering by large particles present in the atmosphere.

KIZILIRMAK, A.
1954. Preliminary report on the amounts of iron dust which daily fall on the surface of the earth. Communications de la Faculté des Sciences de l'Université d'Ankara, vol. 6, ser. A, Fasc. 2, pp. 186–192.

The author describes his collection of irregular magnetic dust particles 1 to 100μ in length, found in and around Ankara. Chemical analysis showed iron, but no nickel, cobalt, nor magnesium. The number of iron particles that fell daily was recorded with the daily meteorological data. The iron dust may be terrestrial, the result of erosion; or it may be extraterrestrial, from meteors. Some evidence indicates that maximum particle counts occur on or near the days of meteor showers.

KLINE, B., AND BRIER, G. W.
1958. A note on freezing nuclei anomalies. Monthly Weather Review, vol. 86, pp. 329–333.

The authors made daily observations of freezing nuclei in the Washington, D.C., area during the first three months of 1958. In spite of the probable observational uncertainties, the fluctuations in the number of freezing nuclei were highly significant. Near the January dates for which maxima were predicted by a meteoric dust hypothesis the values were abnormally high, but later peaks do not seem to be associated with any known major meteor streams. An analysis of the dates of marked peaks shown by similar observations made since 1954 at other places tends to confirm the presence of singularities in January which are statistically significant.

Kolomensky, V. D., and Yudin, I. A.
1958. The mineral composition of the fusion crust of the Sikhote-Alin meteorite, and meteoritic and meteoric dust. Meteoritika, vol. 16, pp. 59–66. (In Russian.)

Sharp-edged particles from the dust contain nickel-iron, magnetite, and iron hydroxides (limonite and goethite). A few spherical and rounded particles, both solid and hollow, and from 0.2 to 0.04 mm in size, resemble in mineral composition the external zone of the fusion crust of the larger meteorites, which consists mainly of oxymagnetite. The latter has a microgranular structure with nodules of isometric form, 3 to 8μ in diameter.

Krasovsky, V. I.
1946. Cosmic rays and the optical concentration of scattered matter. Comptes Rendus, Acad. Sci., U.S.S.R., new ser., vol. 51, p. 183ff. (In Russian.)

Accepting as fact that iron and other metals in interstellar space have positive charges while stony particles have negative charges, the author computes that a cloud of iron meteoritic particles of 10 a.u. radius would have a potential of 3 x 10^{11} volts. He then considers the charges that would occur if the meteoritic cloud penetrated a gas cloud. Charged particles with velocities greater than 45 km per sec would release kinetic energy, possibly giving rise to the emission of cosmic rays.

Krinov, E. L.
1955. Basic meteoritics. State Publishing House of Technical-Theoretical Literature, Moscow. (In Russian.) Translated by Irene Vidziunas and edited by Harrison Brown as Principles of meteoritics, Pergamon Press, 535 pp., 1960.

The author describes dust found at the site of fall of the Sikhote-Alin iron meteorite. He favors the following classification for extraterrestrial material: meteoric, meteoritic, cosmic. (1) Meteoric dust results from the disintegration of meteoric bodies in the atmosphere and comprises spheroidal particles with diameters from a few microns up to 100μ. (2) Meteoritic dust is the product of the crushing of meteorites that have fallen to the earth. The particles are small, acute-angled, irregular, and have a composition and microstructure identical to those of meteorites. (3) Cosmic dust includes the smallest particles that invade the earth's atmosphere from interplanetary space; because of their small mass they reach the earth's surface practically unaltered. They are Whipple's "micrometeorites." From examination of particles at the site of the Sikhote-Alin fall, the author concludes that particles of the dust trains of bolides are solidified globules that are blown away from the melting surfaces of meteoric bodies. He shows photographs of magnetic particles collected from the site. They comprise primarily meteoritic dust, plus a small number of globules with diameters of 3μ to 800μ, as well as small hollow flasks with open necks, and drop-shaped particles.

—— and Fonton, S. S.
1952. Detection of meteoric dust at the place of fall of the Sikhote-Alin iron meteorite shower. Doklady Acad. Sci. Report, vol. 85, pp. 1227–1230. (In Russian.)

The particles of dust trains of bolides seem to represent solidified droplet-globules that are blown away from the melting surfaces of meteoric bodies as they move with cosmic speeds and are spattered in the earth's atmosphere. Traces of the melted matter were found on the surfaces of the Sikhote-Alin meteorites. Particles subjected to fusion or those formed by the condensation of gasses may be spherules and particles that are not affected by high temperatures may be acute-angled.

1954. Meteoric dust from the place of fall of the Sikhote-Alin iron meteorite shower. Meteoritika, vol. 11, pp. 122–131. (In Russian.)

The authors present a table of the frequency of spherules and meteoritic particles

from samples of the soil at the Sikhote-Alin site. For another presentation of the work, see Krinov (1952).

KULIK, L. A.
1926. On the question of the relation between meteorites and comets. Mirovédénié, vol. 15, p. 173ff. (In German.)

The author discusses luminous night clouds associated with the great Siberian meteorite fall.

LAEVASTU, T., AND MELLIS, O.
1955. Extraterrestrial material in deep-sea deposits. Trans. Amer. Geophys. Union, vol. 36, pp. 385–389.

The authors examined black spherules from a Pacific Ocean core obtained by the Swedish Deep-Sea Expedition of 1947–1948. They estimate that about 125 tons of black cosmic spherules fall on the earth each year and suggest that Pettersson and Rotschi's (1952) chemical analysis gave too large averages of NiO and Fe_2O_3 for the minute quantities of spherules present. The authors conclude that nickel and iron seem to be derived partly from coprecipitation from sea water.

LANDSBERG, H. E.
1947. A report on dust collections made at Mount Weather and Arlington, Virginia, 1 October to 20 November, 1946. Pop. Astron., vol. 55, pp. 322–325. (Abstract.)

Certain of the dust particles are thought to be of cosmic origin.

LANE, A. C.
1913. Meteor dust as a measure of geologic time. Science, vol. 37, pp. 673–674.

LARMOR, J.
1938. Origins of the zodiacal light. Nature, vol. 141, p. 201ff.

As origin, the author suggests a nebula surrounding the sun.

LEONARD, F. C.
1941. Small aërolites recovered from the site of the Holbrook, Arizona, fall of 1912. Pop. Astron., vol. 49, pp. 384–386.

Aërolitic particles have been found in ant-hills; they weigh from 0.0074 to 0.0628 gm.

LEVI-CIVITA, T.
1930. Maxwellian distribution of cosmic dust. Pont. Acc. Sci., N. Lincei, Atti, vol. 83, p. 176ff.

Cosmic dust includes particles of all sizes, even meteorites. If the distribution is Maxwellian, the result of an encounter with a planet is always directly opposed to the planet's motion.

LEVIN, B. J.
1943. The nature of gas and dust trains of various types. Russian Astron. Journ., vol. 20, p. 49ff. (In Russian.) See also, Doklady Acad. Sci. Report, vol. 38, p. 304ff.
1955. Spatial density of interplanetary particles and their distribution according to size. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 114–124. (In French.)

The author discusses the space density of interplanetary particles and their distribution in size. He concludes that at present the astronomy of meteors and studies of the zodiacal light and corona give only uncertain data on the solid matter in interplanetary space. However, the study of interplanetary matter is important both for astronomy and for the physical constitution of the earth. Hence, theoretical and observational studies should be carried out by all means at our disposal.

1956. Physical theory of meteors and meteoric material in the solar system. Publishing House of the Academy of Sciences, Moscow, pp. 266–281. (In Russian.)

The author discusses the results obtained by other investigators, and summarizes in

a table some values obtained by various workers for the space density of meteoric material in the vicinity of the earth's orbit. He believes that a considerable amount of meteoric material reaches the earth's atmosphere not in the form of cosmic dust, but in the form of large porous bodies that disintegrate and evaporate in the atmosphere.

LIBEDINSKY, B.

1933. Cosmic dust and noctilucent clouds. Himmelswelt, vol. 43, p. 226ff. (In German.)

This paper gives a general review and reaches a good many forced conclusions. It summarizes knowledge of noctilucent clouds, the bright night clouds of June 30, 1908, and the Tunguska meteorite fall, and attempts to show that the cosmic dust cloud which produces the bright nights and the noctilucent clouds has a period of about 6 years and is associated with the Pons-Winnecke comet. It discusses Nordenskiöld's description of meteoritic dust-fall.

LINK, F.

1950. Optical soundings of the upper atmosphere with the help of lunar eclipses. Internat. Assoc. Terr. Magn. Elect. Bull., no. 13, pp. 502–503. (In French.)

Observations of the optical density of the earth's shadow show it to be a function of the distance from the center; and from photometric theory the density of the shadow can be calculated. The difference between the observed and the computed values increases rapidly from 24 km to the top of the O_3 layer. A further layer is indicated at 100 km; it may be meteoric dust.

1953. Meteoric dust in the earth's atmosphere. Bull. Astron. Inst. Czechoslovakia, vol. 4, pp. 158–161. (In French.)

The author considers the possibility that a high altitude layer of meteoritic dust would cause absorption of light that could be observed during lunar eclipses. For the effective diameter of particles that produce the greatest absorption he obtains values of the order of one μ. A systematic, extensive collection of meteoric dust could provide data on the nature of the particles and their total mass. However, particles that enter the earth's atmosphere simultaneously are not collected simultaneously on the surface of the earth, since the time required to fall depends on their diameters. During a long time of fall, fine iron particles may be oxidized and therefore would not be found in magnetic material collected.

1955. The role of meteoric dust in the earth's atmosphere. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 35–47. (In French.)

The author summarizes previous observational and theoretical research on meteoric dust in the earth's atmosphere.

1956. On the amount of meteoric dust in the earth's atmosphere. Bull. Astron. Inst. Czechoslovakia, vol. 7, pp. 69–75. (In French.)

A difference of the order of 10 exists between values for the amount of meteoritic accretion deduced by direct determinations (Pettersson 1955) and by indirect measures (Link 1953). To explain the difference Svestka thought it necessary to postulate meteoric particles with radii one tenth of a micron or less, while the author suggested a radius of one micron. Link believes Svestka's arguments to be incorrect, and that it is preferable to retain the value of one micron and to look elsewhere for an explanation of the difference, if it is not simply the result of the inevitable errors in the methods employed.

LINKE, F.

1909–1910. Lectures: 2. Twilight phenomena, their regularities and disturbances. 3. Geophysical occurrences during the earth's passage through a comet's tail. 4. Preliminary geophysical results of observations of the passage of the comet from May 18–19 in Frankfort on the Main.

Jahresbericht des Physikalischen Vereins zu Frankfurt am Main, pp. 55–60. (In German.)

This paper discusses normal effects at twilight of dust in the atmosphere, the additional effects that might be anticipated from the passage of Halley's comet, and very briefly the effects actually observed.

1910. Aeronautical Meteorology, 126 pp.

The author mentions Halley's comet as a source of atmospheric dust, May 1910 (pp. 40–45), and discusses the effect of sunlight on the diurnal variation of heights of dust-layers in the atmosphere, and optical phenomena from dust.

—— AND OTT, J.

1909–1910. Geophysical observations on the Feldberg i.T. during the passage of Halley's comet. Jahresbericht des Physikalischen Vereins zu Frankfurt am Main, pp. 98–126. (In German.)

Observations of Bishop's ring indicate that dust penetrated deep into the atmosphere but settled into the lower regions only gradually (a matter of days).

LOCK, C. (see under Packer and Lock)

LYONS, J. B. (see under Stoiber, Lyons, Elberty, and McCrehan)

LYTTLETON, R. A.

1948. On the origin of comets. Monthly Notices Roy. Astron. Soc. London, vol. 108, pp. 465–475.

During the passage of the sun through a cloud of interstellar dust the particles converge to the accretion-axis where their transverse velocities are destroyed by collisions. A stream of dust forms at the axis, and for low relative speed of the sun and cloud, that part of the stream within several hundred astronomical units is captured and flows toward the sun.

1951. On the structure of comets and the formation of tails. Monthly Notices Roy. Astron. Soc. London, vol. 111, pp. 268–277. See also abstract in Observatory, vol. 71, p. 179.

The author considers comets as consisting of widely separated solid particles, some of which collide with one another at relative velocities sufficient to pulverize them. The resulting particles of diameter of the order 10^{-5} cm are repulsed by solar radiation pressure to form the tails.

MAPPER, D. (see under Smales, Mapper, and Wood)

MAYNE, K. I.

1956. Terrestrial helium. Geochim. et Cosmochim. Acta, vol. 9, pp. 174–182.

The amount of He^4 released to the atmosphere from the earth's crust is 60 times greater than had previously been estimated. Because of the isotopic abundance ratio of atmospheric helium ($He^3/He^4 \sim 1.2 \times 10^{-6}$), the production of He^3 in the atmosphere must be greater than the amount calculated from (n, H^3) reactions induced by cosmic rays on nitrogen. Extraterrestrial dust, continuously received by the earth at the rate of 5,000 tons per day, is considered as a source of He^3. The author favors the theory that this is the interplanetary dust associated with the zodiacal light. He stresses the desirability of cosmic dust collection, particularly in Antarctica where one cubic meter of snow should contain one milligram of cosmic dust.

MCCREHAN, R. H. (see under Stoiber, Lyons, Elberty, and McCrehan)

MELLIS, O. (see under Laevastu and Mellis)

MEUNIER, S.

1884. Dust, liquids, and gas of meteoritic origin. Chemistry Encyclopedia, II, Metalloids, pp. 307–318. (In French.)

Treats various sources: earliest, Saloman, Hanover, Dec. 3, 1586; latest, Yung, Switzerland, 1876. Also states, "Le navier *Josiah-Bates* naviguant, dans la nuit du 24 au 25 janvier 1859." Cf. E. Heis (1859), who gives different dates; 1859 is wrong.

1903. Shower of dust recently observed in Iceland. Comptes Rendus, Paris, vol. 136, p. 1713ff. (In French.)

Red snow was observed the evening of May 27 at latitude 64°54′ N, longitude 13°40′ E, and opaque black granules, some rounded, glassy, "des filaments et des globules." Similar dust fell in Norway and Sweden in 1875, and was like Batavian tears. No polarization was observed. Such material is probably produced suddenly at temperatures below −100°.

——— AND TISSANDIER, G.

1878. The presence of magnetic spherules, similar to those of atmospheric dust, in rocks of ancient geological periods. Comptes Rendus, Paris, vol. 86, p. 450ff. (In French.)

Magnetic spherules collected from the air and the sea-bottom are compared with certain similar ones found in sands from deep wells.

MILLMAN, P. M.

1954. Meteor showers and rainfall. Journ. Roy. Astron. Soc. Canada, vol. 48, pp. 226–227.

The theory that rainfall and meteor showers are related confronts astronomical and geophysical difficulties that have not been fully considered. Rainfall data for the southern hemisphere (Bowen, 1953) cannot be correlated with meteor showers in the northern hemisphere. The rate of settling from the 100-km level will vary greatly with the size of the meteoritic particles, and relatively sharp rainfall peaks are difficult to explain.

MINNAERT, M.

1955. Dust in the interplanetary space. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 15–34.

The author introduces a series of papers on dust in interplanetary space, presented at an international conference on Astrophysics, held at Liège in July 1954.

MURRAY, J., AND RENARD, A. V.

1884. On the microscopic characters of volcanic ashes and cosmic dust, and their distribution in the deep-sea deposits. Proc. Roy. Soc. Edinburgh, vol. 12, p. 490ff.

NEWKIRK, G.

1959. Measuring variations in sky brightness. Naval Research Reviews, October, pp. 20–22.

Preliminary measurements show that at an altitude of 38,000 feet the daytime sky is five times brighter than it would be if the earth's atmosphere were free of contaminating dust. Measures were made by means of a coronograph flown in a high-altitude balloon.

NININGER, H. H.

1941. Collecting small meteoritic particles. Pop. Astron., vol. 49, pp. 159–162.

The author discusses the recovery of gravel-size meteorites and the importance of studying even finer dust.

NORDENSKIÖLD, N. A. E.

1874a. On the cosmic dust which falls on the surface of the earth with the atmospheric precipitation. Philos. Mag., ser. 4, vol. 48, p. 546ff.

1874b. On cosmic dust which falls with atmospheric precipitation on to the earth's surface. Poggendorf, Annalen der Physik und Chemie, vol. 151, pp. 154–165. (In German.)

The author believes he has proved the presence of cosmic dust by comparison with analyses of other dusts collected from air.

1883. Program for the expedition to Greenland. Nature, vol. 28, p. 37ff.

From the collection of new data on cosmic dust, the author believes there is greater variation in dust falls than is generally assumed. The polar regions especially are suited to a search for such material.

1885. Studies and research instigated during my travel in the High North. Leipzig, Brockhaus. (In German.)

This paper is mostly devoted to the author's theory of the vast importance of cosmic dust and contains much about meteors and meteorites as well as a list of dust falls (p. 157). Pages 121–127 cover the geological importance of the fall of cosmic dust on the earth's surface with special consideration of the theory of Kant and Laplace.

1894. On the great dust fall in Sweden and adjacent lands on May 3, 1892. Met. Zeitschr., vol. 11, p. 212ff. (In German.)

The subsections present older observations of dust-showers, the various types, dust of unquestionable cosmic origin, lists of falls, and analyses.

Oleak, H.

1956–1957. The behavior of small meteoritic particles in the earth's atmosphere. Wiss. Zeitschr. Friedrich-Schiller Universität, Jena, vol. 6, pp. 133–143. (In German.)

The author presents a mathematical discussion of the behavior of small meteoritic particles (10^{-2} to 10^{-7} cm) in the atmosphere, and discusses their velocities as a function of height, the height at which they begin free fall, the time of fall, and problems of ablation.

Öpik, E. J.

1955. Cosmic sources of deep-sea deposits. Nature, vol. 176, pp. 926–927.

The author gives a table (with references) for various abundance ratios obtained for iron, nickel, cobalt, and copper. He suggests that the nickel of the deep sea may be of cosmic origin, even though other abundances in sea material differ from those of meteorites. There is no good reason to assume that abundances of elements in cosmic dust would be identical with those in meteorites. Attention is called to the larger ratio of nickel to iron in cores from the Pacific, as compared with that in the earth's crust. Although the terrestrial abundances agree best with those of the deep-sea deposits, this does not necessarily imply a terrestrial origin for the latter. The earth's outer crust itself, being the last addition to our planet from cosmic sources, may be built of a material whose remnants are still falling on the earth from the zodiacal-light cloud.

1956. Interplanetary dust and terrestrial accretion of meteoric matter. Irish Astron. Journ., vol. 4, pp. 84–135.

In a long and detailed discussion the author considers a number of processes of accretion and evaluates limits for particle sizes and amounts. The radius for metallic particles in interplanetary space has a lower limit of 7.2×10^{-6} cm because of radiation pressure. For compact stone fragments the lower limit is 1.9×10^{-5} cm. Zodiacal dust is the main source of terrestrial accretion, and direct collision is the most important process. With a space-density of zodiacal dust of 2×10^{-21} gm/cm^3, the total accretion is most probably 0.051 grams in 10^6 years per horizontal square centimeter of earth's surface, or 250,000 tons of meteoric dust per year over the entire surface of the earth. A table is included of the relative abundances of nickel, cobalt, and copper.

Ott, J. (see under Linke and Ott)

Ovenden, M. W.

1951. Meteors and space travel. Journ. British Interplanetary Soc., vol. 10, p. 176ff.

Present observations indicate a negligible danger to an interstellar rocket of collision with interstellar dust particles.

Packer, D. M., and Lock, C.

1950. The brightness and polarization of the daylight sky at altitudes of 18,000 to 38,000 feet above sea level. Naval Res. Lab. Report 3713, July 31.

The data indicated the presence of large scattering particles in the atmosphere above

the observers at all altitudes. Observations were made from a B–29 over Arizona, over southern California, and over western Canada, flying at 27,500 feet over snow fields and at 3,400 feet over cloud layer.

PALMIERI, P.

1879. Studies of dust collected on February 25, 1879 in Portici. Rend. R. Acc. Sci. Fis. Naples, vol. 18, p. 112ff. (In Italian.)

The author found Fe_3O_4 by use of a magnet, but did not find Fe or effervescence with acids.

1901. On terrestrial and cosmic dust, and the African sands. Analysis and discussion. Rend. R. Acc. Sci. Fis. Naples, ser. 3, vol. 7, pp. 156, 163, 172. (In Italian.)

The author gives the history of the fall of March 10, 1901, and states that particles of Fe_3O_4 were found.

PATON, J.

1951. Auroras and luminous night clouds. Nature, vol. 168, pp. 487–488.

The nature and origin of the clouds are still uncertain. Meteoric dust would tend to drift to and remain below the base of the temperature inversion at 80 km. The presence of the clouds at this level is in itself evidence for the existence there of a temperature minimum.

PENNISTON, J. B.

1931. Note on the origin of loess. Pop. Astron., vol. 39, pp. 429–430.

The author proposes meteoric dust as the origin.

1942. Detailed description of the zodiacal light. Pop. Astron., vol. 50, pp. 547–552.

This paper, based largely on observations by G. Jones during Perry's expedition to Japan, 1853–1856, favors the theory that zodiacal light is a ring or disc around the sun.

PETTERSSON, H.

1949. Exploring the bed of the ocean. Nature, vol. 164, pp. 468–470.

This general article mentions tiny meteoritic pellets as part of the deposit.

1955. Magnetic spherules and meteors. Naturwiss., vol. 42, pp. 387–388. (In German.)

The paper summarizes the results of research on iron spherules collected by the Swedish Deep-sea Expedition of 1947–1948. The number of magnetic spherules collected from Pacific Ocean sediments (nearly 1,000 per kilogram of sediment) is 20 to 40 times greater than the number previously found. The spherules occur to a depth of at least 3 meters under the sediment area, indicating a deposit age of from 1.5 to 3 million years.

1960. Cosmic spherules and meteoritic dust. Sci. American, vol. 202, no. 2, pp. 123–132.

A plausible figure for the amount of meteoritic dust landing on the earth is 5 million tons per year. The figure is based on the author's measures of deep-sea cores and of samples obtained in Hawaii, and on values given by other scientists.

—— AND ROTSCHI, H.

1950. Nickel-content of deep-sea deposits. Nature, vol. 166, p. 308.

Preliminary results from the Swedish Deep-Sea Expedition of the Oceanografiska Inst., Göteborg. If the nickel found is of meteoritic origin the apparent rate of accretion is estimated at several thousand tons a day, which is considerably more than astronomers get on the basis of visual and telescopic counts of meteors entering the atmosphere.

1952. The nickel content of deep-sea deposits. Geochim. et Cosmochim. Acta, vol. 2, pp. 81–90.

Determinations of the amounts of nickel, manganese and iron present in sediment cores from the central Pacific Ocean have been made by microchemical methods.

The nickel content in most cores was much higher than the average value for continental rocks and sediments, with maximum values ten times higher than the continental average. The highest nickel values were found in material with a low rate of sedimentation (of the order of 1 millimeter in 1,000 years).

The authors found considerable variation with depth in the nickel content below the sediment surface. No correlation with manganese and iron contents was evident except in places where a change in the rate of sedimentation appears to have affected all three elements similarly.

The authors tentatively suggest that the abyssal nickel may derive partly from the settling of cosmic dust over the earth's surface.

Pich, R. (see under Schoenberg and Pich)

Piotrowski, S. L.

1952. The collisions of asteroids. Astron. Journ., vol. 57, p. 23.

Several million tons of matter are pulverized to dust annually by collisions between minor planets. This dust is thought to replenish the dust of the zodiacal light that slowly spirals into the sun.

Ramage, H. (see under Hartley and Ramage)

Ranyard, A. C.

1878. On the presence of particles of iron in the atmosphere. Astron. Register, vol. 16, pp. 299–300.

This paper, abstracted as read at the meeting of the Royal Astronomical Society, Nov. 8, 1878, discusses Murray's deep-sea magnetic globules, Nordenskiöld's snow samples, Flight's experiments, and Ranyard's observations on shipboard.

1879. Note on the presence of meteoric dust in the atmosphere. Monthly Notices Roy. Astron. Soc. London, vol. 39, pp. 161–167.

Redman, R. O.

1959. Dust and gas between the earth and the sun. The Observatory, vol. 79, pp. 172–181.

The distribution of gas and dust is fairly continuous between the sun and the earth. Blackwell's photography from aircraft at eclipses, with subsequent measures and analyses, has closed the gap between the corona and the zodiacal light measures. Evidence shows a variability of the zodiacal light, which probably results from variation in the number of electrons in the gas rather than from a changing amount of dust. Although satellite research, with measurements from places far beyond the moon, will be valuable in later years, the best optical techniques used either from the ground or from conventional aircraft can still add to our present knowledge.

Reichenbach, K. L. F. von

1859. Captain Callum's meteoric spherules. [Poggendorf's] Annalen der Physik und Chemie, ser. 2, vol. 106, pp. 476–490. (In German.)

The author discusses meteoric dust from the *Joshua Bates*, 1856, and argues against Ehrenberg's volcanic theory to explain these spherules. He concludes that the Fe_3O_4 dust of a great iron or iron-rich meteor had fallen upon the deck of the *Joshua Bates*, and that the sample submitted to Ehrenberg showed what the train of such a meteorite consists of.

Renard, A. V. (see under Murray and Renard)

Revelle, R. R.

1944. Marine bottom samples collected in the Pacific Ocean by the *Carnegie* on its seventh cruise. Carnegie Inst. of Washington, Publication No. 556, pp. 1–180.

One magnetic spherule was found in red clay. The author quotes Murray on cosmic constituents.

Richter, N.

1955. Experimental investigations concerning the illumination of clouds of reflecting particles. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 80–88.

The author investigated the illumination of clouds of reflecting particles by experiments on small grains of various metals.

Rinehart, J. S. (see also under Hodge and Rinehart)

1957a. Distribution of meteoritic debris about the Arizona meteorite crater. Smithsonian Contr. Astrophys., vol. 2, pp. 145–160.

The author systematically investigated the distribution of meteoritic dust and of bits and pieces of meteoritic material scattered in the soil around the Arizona Meteorite Crater, in order to fix the direction of flight and the mass of the meteorite that made the crater.

Seven hundred samples of soil were collected from an area of 80 square miles around the crater. Three types of strongly magnetic material were separated from the soil: (1) particles of nickel-iron; (2) iron-oxide particles; and (3) black shiny particles, probably bits of magnetite. The author concludes that 12,000 tons of meteoritic material surround the crater in the form of dust. He believes that the meteorite approached from a southwest direction and, when it hit the earth, pitched forward large amounts of fragmented and molten material.

1957b. A soil survey around the Barringer Crater. Sky and Tel., vol. 16, pp. 366–369.

The author gives a popular presentation of the data given in Rinehart (1957a).

Rotschi, H. (see under Pettersson and Rotschi)

Roy, F. de

1935. Report of Commission 22. Transactions of the Int. Astron. Union, vol. 5, pp. 326–328, 373–374.

It is important to determine if the magnetic metallic dust present in the atmosphere is of meteoric origin. This dust can easily be collected by simple methods. Simultaneous observations in different regions could eventually establish a correlation between the number of metallic particles collected and periods of meteoric activity. If a sufficient quantity could be collected, it might be submitted to chemical analysis.

1938. Item 9 on meteoric dust. Transactions of the Int. Astron. Union, vol. 6, p. 160. (Abstract.)

The problem of the origin of metallic dust deposited from the atmosphere or found in the soil or on the ocean floor has recently attracted renewed attention. From 10-day collections of such dust made in July to October during the years from 1927 to 1936, L. Rudaux infers that magnetic particles were more plentiful at the beginning of August, and finds another maximum at the end of August and in early September. In 1928 and 1933, copious deposits also occurred in October (Giacobinids). Systematic observations are desirable.

Rudaux, L.

1930a. Meteors. L'Illustration, vol. 88, p. 513ff. (In French.)

Magnetic dust-deposits are more abundant in the period of the year that is rich in meteors. The number of such particles does not increase proportionally with the very variable deposits of atmospheric dust. At Donville the deposits are even more abundant when the wind blows constantly off the sea. Two days after the passage of a great bolide in September 1927, the fragments were so voluminous that they could be seen with the naked eye on the receiving surface. The author thinks this tends to break down the distinction between meteors and bolides.

1930b. Meteors and the earth. Aerial dust. La Nature, vol. 58, part 2, p. 439ff. (In French.)

In this general, illustrated article, the author discusses magnetic particles of extraterrestrial origin.

1933. Magnetic particles collected after the meteor shower of October 9. La Nature, vol. 61, part 2, p. 436ff. (In French.)

The author describes a meteor shower followed by a dust shower.

—— and Vaucouleurs, G. de

1952. Meteorites. Manuel Pratique d'Astronomie, pp. 239–242. (In French.)

Microscopic meteoritic particles or remains of their disintegration are continuously received by the atmosphere, as proved by particles found abundantly on the snows of high mountain summits or on polar glaciers. Small particles were especially numerous after the meteor shower of October 9, 1933.

Sandig, H.

1941. The spatial arrangement of the zodiacal light material. Astron. Nachr., vol. 272, p. 1.

The author does not support Hoffmeister's theory.

Schewick, H. van

1939. Mass and density of the zodiacal light. Vierteljahrschrift Astron. Gesellschaft, vol. 74, p. 233ff. (In German.)

Schloss, L.

1935. Meteoric dust. Pop. Astron., vol. 43, pp. 63–64.

The author describes a first attempt at collecting meteoritic dust by means of a magnet.

Schmid, F.

1928. The zodiacal light, its nature and its cosmic or terrestrial formation. Hamburg, 128 pp. (In German.)

1940. New contributions to the problem of the zodiacal light. Astron. Nachr., vol. 270, p. 220ff. (In German.)

Some inconsistencies might be explained if the zodiacal light were considered as part of the earth's atmosphere.

Schoenberg, E.

1941. On the position of the axis of the zodiacal light. Astron. Nachr., vol 272, p. 25ff. (In German.)

The author opposes Hoffmeister's views.

—— and Pich, R.

1939. Investigations of the zodiacal light. Mitt. Univ. Sternwarte Breslau, vol. 5, p. 1ff. (In German.)

This paper presents a study based on observations made in the tropics, and includes a section on the height of the earth's atmosphere at which light scattering occurs.

Schuster, A.

1882. B.A.A.S. report of the committee on meteoric dust. Nature, vol. 26, p. 488. (Abstract.)

All the volcanic dust that the author had at his disposal was carefully examined under the microscope, and its appearance found to be altogether different from the supposed meteoric dust. The author agrees with Tissandier.

Searle, A.

1899. The zodiacal light. Astrophys. Journ., vol. 8, pp. 244–245.

Progress of knowledge of the subject removes the difficulties attending the hypothesis that the zodiacal light is light reflected from meteoritic dust forming a part of the solar system. Lambert's theory is found inapplicable.

Seaton, M. J. (see under Kaiser and Seaton)

Seely, B. K. (see under Crozier and Seely)

Sen Gupta, P. K.

1954. Periodic influx of interplanetary dust particles into the terrestrial atmosphere. Indian Journ. Meteorol. Geophys., vol. 5, pp. 272–276.

The author gives a brief review of earlier papers relating to the influx of interplanetary dust particles to the terrestrial atmosphere. He favors the theory that

solar corpuscular streams repeatedly push the particles towards the earth and concentrate them near the earth and in the ecliptic.

SIEDENTOPF, H. (see under Behr and Siedentopf)

SLIPHER, V. M.
1931. A preliminary note on the spectrum of the zodiacal light. Lowell Observatory Circular, February 20.

The author obtained spectra with dispersion 6 mm from H to K. Reflected sunlight with superposed emissions suggests that the zodiacal light arises in part in the earth's atmosphere.

SLOCUM, F.
1934. Iridescent clouds and cosmic dust. Journ. Roy. Astron. Soc. Canada, vol. 28, pp. 145–148.

SMALES, A. A.; MAPPER, D.; AND WOOD, A. J.
1958. Radioactivation analysis of "cosmic" and other magnetic spherules. Geochim. et Cosmochim. Acta, vol. 13, pp. 123–126.

By neutron activation analysis, the authors found the chemical content of magnetic spherules to lie in the range 0.03 to 3.9 micrograms for nickel, 0.01 to 0.3 micrograms for cobalt, and 0.0006 to 0.53 micrograms for copper. From the ratios of nickel to copper, nickel to cobalt, copper to cobalt, and nickel to iron, two samples from deep-sea cores are identified as being closely related to iron meteorites. A sample from the roof of a station off the coast of Sweden and another from sand of the River Danube have quite different chemical compositions.

—— AND WISEMAN, J. D.
1955. Origin of nickel in deep-sea sediments. Nature, vol. 175, pp. 464–465.

The ratios of nickel to cobalt, nickel to copper, and copper to cobalt are 13.1, 92, and 0.14 for meteorites, and 3.5, 1.1, and 3.0 for igneous rocks. Using radioactivation methods on samples of globigerina ooze, red clay, and oceanic rocks from the Atlantic, Pacific, and Indian Oceans, the authors found that meteoritic material made little significant contribution to deep-sea sediments, unless some remarkable differential behavior of the three elements, nickel, cobalt, and copper, has taken place.

SPENCER, L. J.
1933. Meteoric iron and silica glass from the meteorite craters of Henbury (Central Australia) and Wabar (Arabia). Mineralog. Mag., vol. 23, pp. 387–404.

Spherical particles resembling meteoritic dust were found.

STAUDE, N.
1923. On the astronomical theory of meteors. Astron. Nachr., vol. 218, p. 155ff. (In German.)

The author discusses the daily variation in the brightness of the night sky on the basis of the meteoritic hypothesis for the zodiacal light. There are comments by C. Hoffmeister.

STOIBER, R. E.; LYONS, J. B.; ELBERTY, W. T.; AND MCCREHAN, R. H.
1956. The source area and age of Ice-Island T–3. Final Report under Contract AF19(604)–1075, Dartmouth College, Department of Geology.

The authors identified magnetic spherules found in deep cores in Arctic Ice-Island T–3 as probably extraterrestrial. The composition was magnetite and the surfaces were sometimes striated. Particle size ranged from 5 to 100μ and more.

STRUVE, O.
1943. Recent progress in astrophysics: V. G. Fesenkov's dynamical theory of the zodiacal light. Astrophys. Journ., vol. 98, pp. 129–130.
1951a. Dust in the solar system. Sky and Telescope, vol. 10, pp. 88–91.

The author gives a general review of relevant current literature.

1951b. Photography of the counterglow. Sky and Telescope, vol. 10, pp. 215–218.

In addition to describing the wide angle equipment constructed by Greenstein and Henyey, Struve reviews the theory by Fesenkov that the gegenschein or "false zodiacal light" is the earth's tail. He also presents the arguments of M. G. Karimov and of N. B. Divari opposing this view.

SVESTKA, Z.

1950. A note on the brightness of lunar eclipses. Bull. Astron. Inst. Czechoslovakia, vol. 2, pp. 41–43.

The author discusses the variation of the brightness of lunar eclipses with respect to an atmospheric dust layer. An earlier theory of a yearly periodicity is replaced by the theory that the brightness may depend in part on the quantity of meteoric dust in the earth's atmosphere.

1954. The problem of a meteoritic dust layer in the earth's atmosphere. Bull. Astron. Inst. Czechoslovakia, vol. 5, pp. 91–98.

The author discusses again the evidence for a high atmosphere dust layer, as deduced from lunar eclipse observations. He calculates that only particles of radius 10^{-5} or 10^{-6} cm are consistent with the observations. Such small particles would have to be carried to the lower parts of the atmosphere much faster than the rate computed for a quiet atmosphere. The author believes that turbulence could do this.

SWINGS, P.

1949. The spectra of the night sky and the aurora. *In*, Kuiper, ed., The atmospheres of the earth and planets, pp. 159–212.

THERNÖE, K.

1941. The zodiacal light. Nordisk Astron. Tidsskrift, vol. 22, pp. 73–80. (In Danish.)

The author discusses various problems of the zodiacal light.

THIESSEN, G.

1948. Associations between the solar corona and the zodiacal light. Himmelswelt, vol. 55, p. 161ff. (In German.)

The interplanetary dust-cloud is discussed.

THOMSEN, W. J.

1953. The annual deposit of meteoritic dust. Sky and Telescope, vol. 12, pp. 147–148.

The author collected magnetic spherules from rooftops and buckets in Iowa City. He assumed that they were meteoritic. Spectroscopic analysis of the magnetic spheres showed iron, silicon, and magnesium. A gravimetric check gave SiO_2, 28 percent; Fe_2O_3, 72 percent. No nickel was detected. The spheres were 8 to 80μ in diameter. The rate of fall was calculated to be 2×10^9 kg/yr for the entire earth.

TISSANDIER, G. (see also under Meunier and Tissandier)

1875. On the existence of iron and magnetic particles in atmospheric dust. Comptes Rendus, Paris, vol. 81, p. 576ff. (In French.)

The author concludes that some magnetic particles are not terrestrial in origin.

TROWBRIDGE, C. C.

1907. Physical nature of meteor trains. Astrophys. Journ., vol. 26, pp. 95–116.

Meteor trains are self-luminous gas clouds combined with very minute meteoric dust particles; the latter in daylight reflect light like ordinary clouds.

TSCHERKASS, W. K. (see under Tscherwinsky and Tscherkass)

TSCHERWINSKY, P. N., AND TSCHERKASS, W. K.

1929. On why it is so difficult to prove the presence of cosmic dust on the surface of the earth. Mirovédénié, vol. 18, No. 2; Centralblatt Min. Geol. Pol., Abt. A, pp. 127–129.

The authors compute that only 0.00007 milligram of meteoritic dust falls per square meter, annually.

VAETH, J. F.
1951. 200 miles up (the conquest of the upper air). New York, 207 pp.

The author discusses atmospheric dust on pages 24–25 and 67.

VAUCOULEURS, G. DE (see under Rudaux and de Vaucouleurs)

VEGARD, L.
1923a. The constitution of the upper strata of the atmosphere. Philos. Mag., vol. 46, p. 557ff.

The author assumes a dust atmosphere above the gaseous atmosphere, the gaseous ending at about 80–100 km above the surface, with the dust comparatively dense at 100–120 km, slowly decreasing upward.

1923b. Distribution of matter in the highest strata of the atmosphere. Videnskapsselskapets Skrifter, Mat.-Naturv. Klasse (Kristiania), no. 10.

The author discusses nitrogen dust in the upper atmosphere, the tendency for electrified dust to drift toward the magnetic equator, and the bearing of his theory on the interpretation of the zodiacal light and gegenschein.

1923c. On the constitution of the upper layers of the atmosphere. Comptes Rendus, Paris, vol. 176, p. 1488ff. (In French.)

This paper discusses nitrogen dust in the highest layers of the atmosphere, and its bearing on color changes along the paths of meteors.

VOLZ, F., AND GOODY, R. M.
1960. Twilight intensity at 20° elevation. Scientific Report No. 1, pp. 1–46, on Air Force Contract AF19–604(4546), Blue Hill Meteorological Observatory, AFCRC–TN–60–284, 1960.

The authors designed a photometer to measure the absolute intensity of the twilight in five narrow bands of wavelengths from the red to the ultra-violet region of the spectrum. Gradients of the logarithm of intensity and color ratios give complex but sensitive indicators of dust scattering, which is small but measurable if precise absolute methods are used. The problem is very complex, but the authors think that useful information can be obtained up to 120 km for observations in blue light, and up to 75 km for observations in red light.

WATSON, F. G.
1956. Between the planets. Ed. 2, Cambridge.

WEIL, M.
1922. Theories on the nature of meteor trains, with a note on Professor Trowbridge's contributions to our knowledge of meteor trains. Pop. Astron., vol. 30, pp. 524–535.

The paper gives a historical bibliography, including references to reflection and other theories that assume meteor trains are composed of cosmic dust or a disintegrated meteoroid.

WHIPPLE, F. J. W.
1934. Phenomena related to the great Siberian meteor. Journ. Roy. Meteorol. Soc., vol. 60, pp. 505–513.

Concerning the illumination of the sky on the nights following the arrival of the meteor, the author suggests that the meteor had a tail that was captured by the earth's atmosphere.

WHIPPLE, F. L.
1949. Report of Commission 22. Transactions of the Int. Astron. Union, vol. 7, pp. 240–244.

Meteoritic dust has been collected by H. H. Nininger and H. E. Landsberg, and its consequences considered theoretically by J. Kaplan and A. R. Khan.

1951a. Comets and the zodiacal light. Astron. Journ., vol. 56, p. 51. (Abstract.)

The icy-conglomerate model of comets, coupled with the Poynting-Robertson effect

and planetary perturbations, provides the required rate of addition of material to the zodiacal cloud and also predicts the required distribution of particle sizes.

1951b. Origin of the zodiacal light. Sky and Tel., vol. 10, p. 94.

The author suggests that particles are blown off comets when icy surfaces of the comets vaporize in sunlight; the particles then spiral around the sun to form the zodiacal light.

1952a. Report of Commission 22. Trans. Int. Astron. Union, vol. 8, pp. 293–300.

Work in Czechoslovakia included investigation by M. Plavek on the Poynting-Robertson effect, the age of showers, and the dimensions of comets; Link studied the concentration of meteoritic dust falling through the atmosphere. In Japan, Huruhata carried out investigations on the light of the night sky and the zodiacal light; he found a relation between the zodiacal light and Comet Encke, and between the zodiacal light and the solar corona. In the U.S.S.R., Fesenkov's work on meteoritic matter in interplanetary space dealt also with the zodiacal light. Astapovich and Khvostikov studied noctilucent clouds and found that they are not caused by meteoritic dust but by condensation of water vapor.

1952b. Results of rocket and meteor research. Bull. Amer. Meteorol. Soc., vol. 33, pp. 13–25.

This paper discusses the pitting of shiny surfaces of rockets probably by micrometeorites, and the possibility of their contributing to E-layer ionization, light scattering, and twilight sodium radiation.

1955a. A comet model. III. The zodiacal light. Astrophys. Journ., vol. 121, pp. 750–770.

The author considers the probable cometary contributions to the zodiacal cloud on the basis of the icy-comet model. He assumes the zodiacal cloud to be of the nature deduced by van de Hulst and Allen from their studies of the Fraunhofer corona and the zodiacal light. According to the Poynting-Robertson effect, the zodiacal cloud needs for its maintenance about 1 ton/sec of small particles in the 10^{-4} to 1.0 cm range. Comets continuously contribute some 30 tons/sec. They lose matter by the following four physical forces or processes: (1) interstellar wind, (2) Jupiter's random perturbations, (3) the Jupiter perturbation barrier, and (4) collisional destruction. The first and fourth of these seem to be the most important. Collisions among the particles seem to be most responsible for the cutoff in zodiacal particle size above 0.03 cm, as found by van de Hulst.

If it is great enough, corpuscular radiation may be more important than the Poynting-Robertson effect; it may also require more material for the zodiacal cloud. If this is true, corpuscular radiation will increase the critical cutoff dimension.

1955b. On the origin of the zodiacal particles. Mém. Soc. Roy. Sci. Liège, ser. 4, vol. 15, pp. 183–184.

The author states that the Poynting-Robertson effect requires approximately one ton/sec of small particles 10^{-4} to 1.0 cm in diameter to maintain the zodiacal cloud. Consideration of the effect of corpuscular radiation may indicate a considerably larger source of material for the zodiacal cloud. The probable contribution to the zodiacal cloud from comets is considered on the basis of the icy comet model.

1958. The meteoric risk to space vehicles. Proc. 8th Int. Astronaut. Congr. Barcelona, 1957, pp. 418–428.

The author discusses the distribution and rate of fall of meteoritic material as functions of mass and velocity, and presents a table concerning meteoroids and gives formulas for computing the probabilities of penetration in space vehicles. The author calculates upper limits for the effects of erosion on a space-exposed surface subject to erosion by meteoritic dust, corpuscular radiation from the sun, and gases of the extended solar corona. He concludes that the corrosive effect from meteoritic dust is comparable to the combined effects from the other two factors.

1959. Solid particles in the solar system. Journ. Geophys. Res., vol. 64, pp. 1653–1664.

The author discusses the present state of our knowledge concerning solid particles in the solar system. Our best information comes primarily from studies of optical meteors, radio meteors, the zodiacal cloud and meteorite analysis. Both space observations and ground-based experiments are important for the future. The author believes that 70 to 90 percent of the expected results from meteoritic studies can be provided from the ground, but such observations cannot give good information on solid particles in space much beyond 1 a.u., and unexpected results may come from space observations.

Detailed knowledge of particles in the solar system is of practical importance to designers of space equipment and to operational planners. Theoretically, meteoritic material can provide basic information on the evolution of the earth and the solar system. He discusses possibilities for meteorite instrumentation in space vehicles.

—— and Gossner, J. L.

1949. An upper limit to the electron density near the earth's orbit. Astrophys. Journ., vol. 109, pp. 380–390.

Brightness and polarization observations are used. Observed polarization can probably be accounted for by the reflection of sunlight by dust particles.

—— and Hawkins, G. S.

1956. On meteors and rainfall. Journ. Meteorol., vol. 13, pp. 236–240.

The authors consider the role of micrometeorites that enter the atmosphere without producing detectable light or ionization. A large number of micrometeorites in a stream could affect rainfall. To explain the removal of particles from the stream the authors suggest a mechanism that depends upon the gradual disintegration of micrometeorites under the influence of corpuscular radiation from the sun. The rate of orbital spiralling is calculated to be 15 times greater than that due to the light pressure component of the Poynting-Robertson effect. To affect amounts of rainfall, more cometary material than was originally postulated to supply the zodiacal cloud would be necessary.

Wildt, R. (see under Hodge and Wildt)

Wiseman, J. D. (see under Smales and Wiseman)

Wood, A. J. (see under Smales, Mapper, and Wood)

Yagoda, H.

1959. Observations on nickel-bearing cosmic dust collected in the stratosphere. Geophysics Research Directorate Research Notes No. 9, AFCRC–TN–59–200, ASTIA Document No. AD–212422, pp. 1–13.

The author used microchemical methods to examine stratospheric dust particles collected on four balloon flights at altitudes between 77,000 and 112,000 feet. Collections were made on simple plastic dishes mounted at the top of the balloon and at the gondola level, with continuous exposure at both levels. The preliminary data showed that the relative abundance of nickel-bearing dust ranged between 0.17 and 0.36 particle per cm^2 of collection surface per day of exposure. Most of the color reactions for nickel were given by particles of diameters between 20 and 40μ, but positive reactions were also given by smaller particles with diameters of 1 to 2μ.

Yamamoto, I.

1938. Report of the sub-commission on zodiacal light. Trans. Int. Astron. Union, vol. 6, pp. 172–175.

The author summarizes theories on the nature of the zodiacal light by Hoffmeister, Schmid, Brunner, Larmor, and Donitch, and brings out the major differences in these theories.

YAVNEL, A. A.
1957. Meteoritic matter at the place of fall of the Tunguska Meteorite. Russian Astron. Journ., vol. 34, pp. 794–796. (In Russian.) English translation by F. W. Wright and P. W. Hodge, Tech. Rep. No. 7, AF18(600)–1596, ASTIA Document No. AD 154 146, 1958.

The author gives results of investigations of the magnetic portion of soil samples collected in 1927 to 1930 at the place of fall of the Tunguska meteorite. Visual examination with a microscope showed small metallic particles and black shiny globules of magnetite, 30 to 60μ in diameter. Spectroscopic analysis showed that the particles are composed of nickel-iron. The author concludes that these particles are part of the Tunguska meteorite, which was evidently an iron. The data show a great similarity with those for the Sikhote-Alin meteorite, as determined by Krinov and Fonton (1952, 1954).

YOKOYAMA, E.
1950. Interim report on observations of atmospherics which may be caused by meteoric showers. Proc. Imp. Acad. Tokyo, vol. 6, p. 154ff.

YUDIN, I. A. (see under Kolomensky and Yudin).

YUNG, E.
1883. A fall of cosmic dust. Comptes Rendus, Paris, vol. 97, p. 1449ff. (In French.)

The paper describes the great snowfall of Wednesday, December 5, 1883, at Geneva. The author notes that fine metallic dust is prevalent after the times of meteor showers and believes the dust is due to the rupture of a large meteorite and to microscopic meteorites.

ZACHAROV, I.
1952. Influence of the Perseids on atmospheric transparency. Bull. Astron. Inst. Czechoslovakia, vol. 3, pp. 82–85. (In French.)

Measures of the darkness and size of the earth's shadow during lunar eclipses show that after the appearance of several of the most active meteor streams, our atmosphere is polluted in the upper region by dust. These are either interplanetary dust particles or the residue of meteors, which dissipate at 80 to 150 km. The author uses limited Mt. Wilson measurements to show that a slight decrease in the amount of atmospheric transparency follows a meteor shower. The relatively short duration of the depression is inconsistent with the time of fall of the particles. This discrepancy is explained by the agglomeration of particles, which diminishes their absorbing power and increases the speed of fall. The pollution of the atmosphere has a maximum duration of 24 days. Particles with diameters less than 0.1μ and of density 4 would fall for some tens of years.

ZIMMERMANN, H. (see under Hoppe and Zimmermann)

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