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Origin of the Interplanetary Dust Cloud around the Earth

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1. COUNTERS installed on Soviet and American rockets and satellites to record meteoritic impacts outside the earth's atmosphere have provided evidence that the intensity of bombardment reaches a maximum close to the earth and gradually decreases with distance from it. If impact frequency is assumed to be proportional to the space density of solid particles with masses of more than 10^{-9} g, then the dust concentration at a height of 100–300 km above the earth's surface is 10^5 times greater than the dust concentration in the zodiacal cloud in the vicinity of the earth. At a height of 2000 km it is about 10^3 times greater, at 100,000 km about 10 times, and at greater distances the ratio seems to tend toward 1:1, that is, the dust density there appears not to differ from the density in interplanetary space.[1, 2]

The experimental data are rather sparse, so that it is too early to try to derive a quantitative density/distance relationship. But it is already safe to say that there is a substantial concentration of interplanetary dust around the earth. This concentration cannot be produced by the contraction of the orbits of interplanetary particles in the earth's gravitational field, since this effect would give an increase in density at small distances from the earth only and would double or triple the figure at most. Deceleration by the atmosphere of the stream of particles as it approaches the earth would raise their density relative to the interplanetary level, but this effect is of importance only very near the earth, in the zone 100–300 km above its surface. We thus can infer that above 300 km the concentration consists chiefly of particles having circumterrestrial orbits.

F. L. Whipple,[1] after weighing various hypotheses on the formation of this rarefied dust cloud around the earth, comes to the conclusion that two mechanisms are impossible (or doubtful): 1) capture of dust particles through the action of electrical forces arising between the charged dust particles and the streams of charged particles in the earth's radiation belts; 2) gravitational capture into temporary circumterrestrial orbits in the four-body system of sun-earth-moon-particle. The latter mechanism is inefficient and would not produce an observable concentration of dust toward the earth. Whipple considers it more likely that the cloud is fed by material ejected when craters are formed on the moon. When meteorites strike the moon's surface at average velocities of 15–20 km/sec a few percent of the particles ejected by the explosion may be given velocities of 2.4–3.4 km/sec. After leaving the moon, such particles, when ejected in certain directions, may describe circumterrestrial orbits of lunar scale. Whipple considers it possible that these orbits may be attracted toward the earth by gravitation, which might explain the observed effect of concentration, but he gives no quantitative basis for this hypothesis.

As shown by V. I. Moroz,[3] the high particle density in the area 100–2000 km above the earth's surface cannot be due to a lunar source. Gravitational attraction of the orbits of the particles from the orbit of the moon toward the earth's surface as a result of aerodynamic drag in a gaseous medium gives, for the stationary case, a distribution of particle density

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