The mass distribution of fragments in modelling of the meteoroid disruption

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Meteoroid fragmentation in the atmosphere is a complex process, which depends on many factors: the composition of a cosmic body, its structure, density, size, velocity, and therefore can occur in different ways. When the meteoroid is disrupted into a large number of fragments they at first move, united by a common shock wave, as a single cloud of fragments. Gradually or quickly, the fragments diverge and when removed at a sufficient distance from each other begin to move independently. When modelling of independent motion and ablation of meteoroid fragments, it is necessary to know their mass distribution. In this context an analogy is drawn with experiments on catastrophic fragmentation at high-speed collision.

Based on results of numerous experiments expressed as a power law incremental frequency distribution, and using the mass conservation equation we obtained the distribution function describing the probability for finding a fragment of mass m in dependence on current mass m, power index, mass of the largest fragment, and the total mass of fragments. The expression for the cumulative number of fragments N with a mass greater than m is also obtained as a function of m, power index, the largest fragment mass, and the total mass. The formula for N describes adequately experimental data in high-speed collisions of gypsum balls [1]. The proposed cumulative distribution is also compared with the mass distributions of recovered meteorites in cases where a sufficiently large number of them have been collected. The curves for cumulative number of fragments versus mass were constructed for Kosice [2, 3], Bassikounou [4], 2008 TC3 (Almahata-Sitta) [5], and Chelyabinsk [6, 7] meteorite falls. These curves satisfactorily agree with the theoretical ones.

The mass loss, energy deposition and luminous intensity of the fragmented meteoroid are determined by integration over all masses using the obtained mass distribution of fragments as initial. In the process the mass and velocity of each fragment are determined from the meteor physics equations.

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