THE SAND BAG MODEL OF THE DISPERSION OF THE COSMIC BODY IN THE ATMOSPHERE

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The strength of the extraterrestrial bodies depends on their structure, composition, dimensions and the history of this body but usually is low enough. So the fragmentation of the body due to aerodynamic stresses [2] begins at sufficiently large heights above the surface of the Earth.

The process of fragmentation and dispersion of the fragments usually is studied by the hydrodynamic [1-3] or even gasdynamic [4-5] models. If the fragmentation process begins due the initial cracks and faults of the body, or this body consists of large boulders glued by ice the strength of these boulders after fragmentation remains higher than the aerodynamic stresses exerted at the remaining part of the body. We suppose that fragmentation occurs at initial moment $t = 0$ at some height z_0 above the surface of the air, these fragments remain solid. We do no take into account the possibility of further fragmentation during the remaining part of the trajectory. If the number of these parts is large enough and their size is small in comparison to the initial radius of the body than we can use the sand bag model proposed in [6] in qualitative form.

The quantitative sand bag model used in our computer simulation is as follows. There is a number N of fragments loosely packed in the sand bag, N is large in comparison to unity. For instance, in the computations the results of which are presented in this paper $N = 9\cdot10^5$, the initial radius of the sand bag R_0 = 100 m, the size of the stony boulders R_0 = 1 m and their density $\rho_0 = 2.7$ g/cm^2, the shape of the boulders is spherical, and they do not interact directly between each other.

The motion of the fragments or of the boulders (we call them particles) is governed by the set of simple ordinary differentially equations.

Keeping in mind the uncertainties of the initial stage of fragmentation we have supposed that all the particles have the same size. For the motion of the air we use the equations of gas dynamics and take into account the energy release due to the motion of the particles with the respect to the air. As we have supposed that the initial size of the particles is large enough (boulders with the mass ~ 10^4 kg) the effects of evaporation and ablation are small.

The particles are decelerated by the air and the decrease of their kinetic energy leads to the increase of the internal energy of the air. Due to these processes the shock wave in the air isformed, the density and the velocity of the air before and between the boulders is changing and thus the motion of the airis coupled to the motion of the particles.

The results for z_0 = 10 km, initial velocity of the particles V = 50 km/sec, and the initial ratio of the volume of the boulders to the whole volume of the sand bag 0.9 are presented. It was assumed that at the initial stage of fragmentation all the particles in the spherical sandbag have attained radial velocities proportional to the their distance from the center of the sphere and the maximum velocity is 0.3 km/sec which is less than the estimates [1] of the lateral velocities [1] due to the aerodynamic forces in the stage of fragmentation and initial separation of the fragments. The shape of the sand bag becomes conical and some of the boulders leave the main volume of the sand bag into the trail, similarly to the gas dynamic simulations [5]. But the main number of the boulders exhibit collective behavior. At the moment 0.2 sec just before the impact the diameter of the sandbag reached 400 m and the its thickness remained 200 m. So the average density before the impact decreases 4 times in comparison to the initial density. The average velocity of the particles in the sand bag and of the sand bag as a whole has slightly decreased but much less than in the case of the fluid volume with the same cross section without the pores when the drag increases proportionally to the area of the cross section. The distances between the boulders is still not large enough and the single bow shock wave which encloses them has not been dissolved into separate bow shock waves yet.

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