SIMULATIONS OF THE COMET FALL IN THE JOVIAN ATMOSPHERE

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The fall and disintegration of the comet Shoemaker-Levy 9 in the Jovian atmosphere were numerically simulated in [1-9]. The comet fragments were treated as strenthless impactors having a shape of a sphere or a cylinder. A ratio of a cylinder length to its diameter was varied from 0.33 to 3 in [5].

Results [7,8] are close to that simple analytic and semianalytic models [10] predict. But substantially deeper energy release is seen in [1-5]. This disagreement is ascribed in [3] to distinctions in equation of state used for the fragment. In contrast, the disagreement is explained in [7] by mesh resolutions. In fact, simulations made in the different works for similar regular shapes disagree to a greater extent than the results demonstrated by the same authors for variously shaped impactors. This is not surprizing because Rayleigh-Taylor and Kelvin-Helmholtz instabilities play an important role in the fragment disintegration. It seems quite natural that numerical solution for a spherical or cylindrical impactor, being dependent on initial subgrid perturbations, depends also on the method employed and mesh resolution.

A question arises, how can we compare simulation results in this situation at all? It would be reasonable to compare a growth rate of small initial perturbations predetermined on the smooth surface. But since the fragments were formed by tidal breakup [11] or by breakup of the parent "rubble pile" [12], it is very unlikely that the real fragment has a smooth and perfect shape. The surface could have ridges and troughs comparable in size to the fragment diameter.

I try to study an influence of surface configuration on the fragment deformation using a free-Lagrangian method [13]. Computations made by this method in [14] for a spherical and cylindrical impactors in the Earth's atmosphere have not revealed substantial difference in their behavior. Here, for the Jovian atmosphere, a 2 km spherical body and an equivalent in mass spherical body with sinusoidal undulations of the surface are considered. An amplitude of the surface distortion is 5 per cent of the diameter. Other assumptions are the same as in [8]. An entry velocity is 60 km/s, an entry angle is 45^0, and a bulk density is 1 g/cm^3. Material of the comet bears no strength and obeys Tillotson's equation of state for water. Ablation is neglected. The comet movement and the air flow around the comet are governed by 2D axially symmetric hydrodynamic equations. A total of about 10,000 lagrangian particles were used in the simulation, 650 particles formed the comet fragment. The calculations started at an altitude of 200 km above the 1-bar level.

Fig. 1 demonstrates deformation of a spherical fragment in a frame of reference connected with a body. A comet surface and a front of a bow shock wave are shown by solid lines. Circles are the particles of the comet swept away from the bulk body. A dent and then a hole appear on the leading face of the comet. The comet is disrupted at an altitude of -70 km. Strong disintegration occurs at an altitude of about -130 km when the comet becomes a cloud of debris.

Deformation of an undulating fragment is shown in Fig.2. Initially, average pressures at the first and second depressions on the leading face are about 0.8 and 0.3 of the stagnation pressure correspondingly, i.e., a force acting on the second ridge is almost the same as the average transverse force acting on a half of a mass of a smooth body ([10]). For this reason, appreciable deformation of the undulating fragment starts higher and the effective radius increases at a greater rate. While the undulations grow on the leading face, they diminish on the rear side.

But the computations for the undulating object are not still finished, and it is unclear how an altitude of explosion is changed. At the moment, I conclude that a shape of the

fragment may play a key role at the initial stage of disintegration. A smaller fragment of irregular shape could shed a noticeable fraction of its mass above the cloud top.

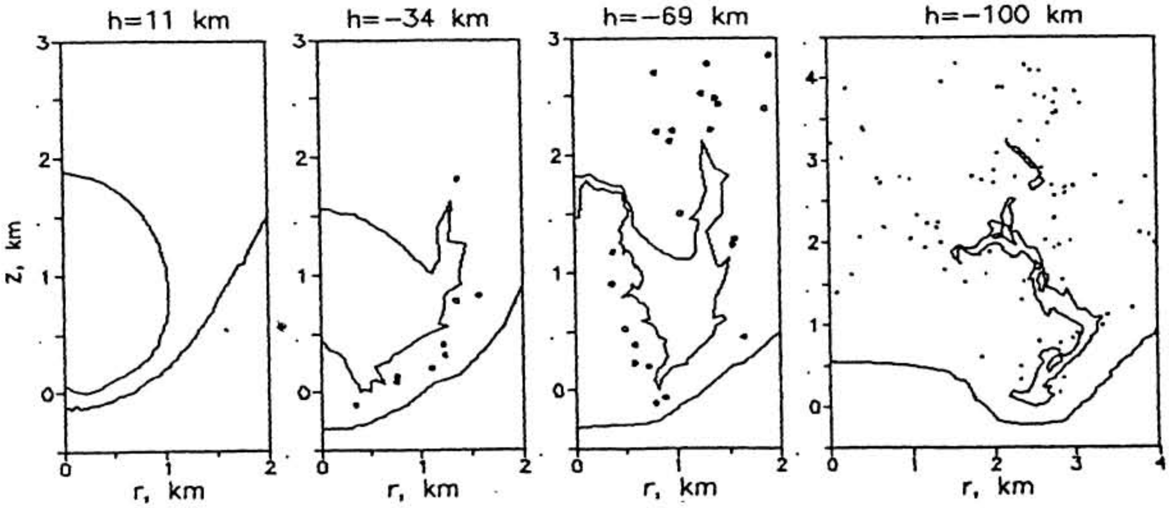

Fig. 1

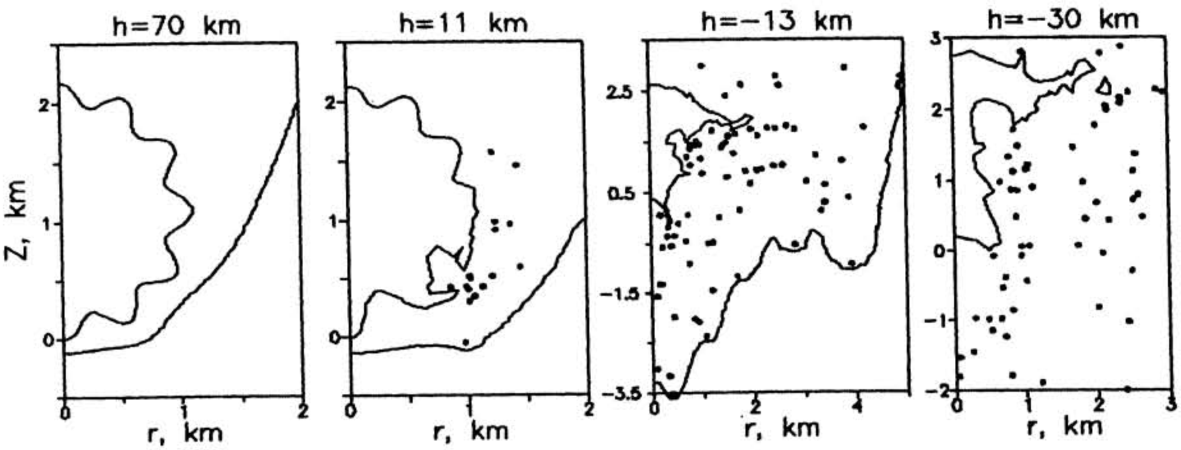

Fig. 2

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