On models of meteoroid disruption into the cloud of fragments

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Fragmentation of meteoroids entering into the Earth's atmosphere with various composition, structure, size and strength, can proceed in different ways. In the case when the meteoroid is disrupted into a large number of fragments, fragments at first move with a common shock wave as long as they do not disperse to a sufficient distance to move independently. We consider four models of the cloud of fragments moving as a single body: model I of Grigoryan [1], often used model II of Hills and Goda [2], developed by the authors model III [3] and model IV which is a modification of model III. It is assumed that a disrupted meteoroid under the action of pressure forces can be deformed: contract in a flight direction and expand in a lateral one. Basic differences between proposed models III, IV and accepted models I, II are as follows. First, models III, IV, in contrast to models I, II, take into account decrease of the density of fragment cloud due to increase of spacing between fragments. Secondly, proposed models also take into account the change of the shape of fragment cloud, so the equation for the rate of its lateral expansion includes a flattening parameter reducing this rate. Thirdly, in models III, IV this rate depends on the current meteoroid mass, which changes due to ablation, so we need to solve the combined problem of meteoroid fragmentation, ablation and motion; in models I, II, the fragmentation problem is separated.

For the above models, numerical solutions of meteor physics equations are obtained by Runge-Kutta method for modelling of the interaction of the Chelyabinsk meteoroid with the atmosphere. To model the meteoroid ablation an approximate formula for the radiative heat transfer coefficient is obtained as a function of the meteoroid velocity, size, and the atmospheric density. An uncertainty factor is introduced to account for effects of precursor, absorption by a vapor layer, and other factors. The effect of variation of heat transfer coefficient (including its constant value) on the mass loss, energy deposition and estimation of initial mass is studied. Solution using model III for the energy deposition of the Chelyabinsk bolide and its light curve normalized to the maximum brightness, is in satisfactory agreement with the observational data [4, 5] and with the analytical solution [3]. Solutions using models I, II, give the altitude of bolide peak brightness a few kilometers more than the observed one. It is shown that model III gives a much smaller increase of the meteoroid midsection radius than models I, II.

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