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On the masses and bulk densities of small interplanetary bodies

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Techniques of determining the masses and bulk densities of small interplanetary bodies have long been discussed in the literature dedicated to meteor studies. These data are of current importance because of their implications for gaining information on cosmic-matter influx onto planets, for more reliably and quickly finding meteorites on the Earth's surface, for the studying of composition and structure of cometary nuclei, for calculating the orbital evolution timescale and the peak temperature reached on atmospheric entry. Majority of the existing conclusions in these applications are quite sensitive to assumed masses and bulk densities values. In turn these values received by means of various approaches and real measurements sometimes differ from each other by more than on order. Our preference in such conditions should be based on correct physical models and the accessible experimental data, which allow avoiding rough assumptions and uncertainties in the explanation.

However, in the processing the observational data, we widely exploit the conception of the photometric mass of a meteor body. Alternative methods for estimating meteor parameters are based on the analysis of observed deceleration. The discrepancy of the estimates obtained using these techniques is usually diminished by selecting suitable values of the meteoroid's bulk density. However, this leads to evidently underestimated values for this density. In order to eliminate these discrepancies, it was proposed to consider a swarm of similar-size fragments instead of a single meteoroid. In this case, it is the photometric-to-dynamic mass ratio that determines the number of such fragments.

In the present report, the mass is calculated using the data of actual observations, by selecting the parameters describing bodies' deceleration and ablation along the luminous segment of the trajectory. The model is based on the best fitting of the observational data by an analytical solution of the equations of meteor physics. In doing so, the author tried to take into account all of the peculiarities of the events noted in the literature, as well as the newest results of numerical experiments on the 3D aerodynamics of bodies of complicated shapes. Distributions of initial and terminal mass of bright fireballs captured by the Canadian camera network are presented. The proximity of results obtained using different dynamic methods implies that observational data on the deceleration and ablation of meteoroids provide objective information on the basic parameters of fireballs and the accompanying physical processes.