Modeling of the meteoroids entry

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Cosmic bodies entering the Earth' atmosphere lose a part of their mass or even the total mass during the interaction with the atmosphere. Meteor radiation and ionization, which allows us to observe meteor phenomena, are determined by ablation rate (more general – by the meteoroid energy deposition).

Meteoroids differ very much by their ability to penetrate the atmosphere. Small and large meteoroids in the atmosphere are observed by different methods, have different ablation altitudes and their interaction with atmosphere occurs in different flow regimes [1-3]. Large meteoroids are losing most of their mass in the continuum flow regime whereas small meteoroids interact with atmosphere mainly in the conditions of free molecular flow or transition flow regime [1-3]. Very roughly the boundary between small and large meteoroids may be estimated as ~1 cm [4].

The physical conditions during the meteoroid entry change considerable as a function of altitude and different processes may be responsible for ablation at different stage of meteoroid flight through the atmosphere. Meteoroids are subjected by direct impacts of molecules of the individual constituents of the atmosphere, when the body entering the Earth atmosphere. The energy flux received from the impacting air molecules is used for meteoroid heating, ablation and thermal radiation cooling, these processes are important mainly for small meteoroids. At a given altitude the behavior of entering particles in the atmosphere is determined by their size, velocity and material properties. Ablation may include thermal (evaporation, spraying) and non-thermal processes (sputtering).

Local flow regime realized around the falling body determines the heat transfer and mass loss processes. The screening of meteoroid surface by evaporated and sputtered material and subsequent decrease of the heat transfer coefficient should be taken into account in the transition flow conditions [2].

Large meteoroids are able to penetrate deeper in the atmosphere where their sizes are greater than the mean free path of the atmosphere. Fireballs and bolides are observed at altitudes between 70 and 20 km [1]. In these circumstances the meteoroid interacts with atmosphere in the continuous flow conditions and generates a shock wave. For large bodies the heat transfer is determined mainly by radiation.

Fragmentation is a very important phenomenon, which occurs during the meteoroid entry into the atmosphere. Fragmentation affects observed meteor parameters and is responsible for many differences between single-body predictions and observations. Numerous studies have been carried out to show the influence of fragmentation on light curves and deceleration.

Different models are used for description of small and large meteoroids entry. Many models are aimed to reproduce the meteoroids behavior in the atmosphere (deceleration and/or light curves) in different flow conditions. Other models are trying to describe physical conditions that occur around meteor body. Several self-consistent hydrodynamical models are developed, but similar models for transition and free molecule regimes are still under elaboration. This presentation will review entry models and discuss their boundaries and limitations.

References

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