EPSC Abstracts
Vol. 7 EPSC2012-911 2012
European Planetary Science Congress 2012

What did we learn from the fireball aerodynamics?

M.I. Gritsevich (1, 2), D.V. Kuznetsova (2), V.P. Stulov (2), L.I. Turchak (3)

(1) Department of Physics, University of Helsinki (maria.gritsevich@helsinki.fi) (2) Institute of Mechanics and Faculty of Mechanics and Mathematics, Lomonosov Moscow State University, (3) Dorodnitsyn Computing Center, Russian Academy of Sciences

In this study we describe how to calculate meteoroid's pre-atmospheric mass and other properties from the observed deceleration rate in an atmosphere, complementary to conventionally used luminosity. Using the basic differential equations [1] one can introduce dimensionless parameters describing a problem. Then we distinguish two key dimensionless parameters with following physical meaning: (1) the ballistic coefficient, which shows the ratio between the mass of the atmospheric column along the trajectory and the body's pre-entry mass; (2) the mass loss parameter, which is proportional to the ratio between the initial kinetic energy of the unit body's mass and the effective destruction enthalpy. These parameters explicitly characterize the ability of entering body to survive during atmospheric entry and to reach the planetary surface [2]. The physical processes accompanying atmospheric entry essentially depend on values of these two parameters as well. Thus different events could be associated with different groups with similar predictable consequences. The ballistic coefficient and mass loss parameter can be derived by several existing techniques, see e.g. [3]. Proposed model is suitable to categorize various impact events in terms of meteor survivability and impact damage, and thus to analyze consequences that accompany collisions of cosmic bodies with planetary atmosphere and surface. The different types of events, namely, formation of a massive single crater (Barringer, Lonar Lake), dispersion of craters and meteorites over a large area (Sikhote-Alin), absent of craters and meteorites, but huge damage (Tunguska) are considered as illustrative examples. The proposed approach helps to summarize the data on existing terrestrial impacts and to formulate recommendations for further studies valuable for planetary defense. It also significantly increases chances of successful meteorite recoveries in the future. In other words, the study represents a 'cheap' possibility to probe cosmic matter reaching planetary surface and it complements results of sample-return missions bringing back pristine samples of the material.

References

[1] Stulov, V.P., Interactions of Space Bodies with Atmospheres of Planets. Applied Mechanics Reviews, 50, pp. 671-688, 1997.

[2] Gritsevich, M.I., Estimating the Mass of a Fireball Projectile. Doklady Physics, 53 (11), pp. 588–593, 2008.

[3] Gritsevich, M.I., Determination of Parameters of Meteor Bodies Based on Flight Observational Data. Advances in Space Research, 44 (3), pp. 323–334, 2009.