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On the mechanism of crushing meteoroid with end flash effect

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Abstract

The report aim is to explain the destruction of a large cosmic body from the simple two-stage calculations using the observational data. At the fist stage the number of fragments determined regarding of change of light intensity. Using the statistical strength theory of Weibull the path length and time of luminescence of the fragments was determined. A model of sudden disappearance in the second stage was constructed. We estimate the mean free paths to evaporation for small particles suggesting an explosive outbreak in the final stage.

1. Introduction

Cosmic body moving in the atmosphere have exposed high temperatures and pressure. There exist a powerful emission and the loss of mass due to meteoroid heating and crushing. Constructing the model of meteoroid destruction one must take into account features of gas-dynamic flow and physical-chemical processes in the shock layer and the ablative surface of the meteoroid [10]. Comprehensive models of these phenomena still required. Therefore various simple models of motion and the destruction of meteoroids in the atmosphere of the planet could be useful to explain the phenomena. More detailed discussion of the fragmentation of the meteoroid in the final stages of its flight is presented.

2. Fragmentation and destruction of meteoroids in the atmosphere

In meteor physics equation for the center of mass of the meteoroid with variable mass and area of the midsection with a given coefficient of resistance are solved together with equation of mass loss with a given heat transfer coefficient and the effective enthalpy of ablation from the surface of the meteoroid (elementary physical theory of meteors) [5, 7, 19-10].

Equations can be written as

$$M\frac{dV}{dt} = -\frac{1}{2}AC_D\rho V^2, \quad Q\frac{dM}{dt} = -\frac{1}{2}AC_H\rho V^3 \quad (1)$$

where V, M, A, Q - the current speed, the mass of the meteoroid, the area of his midsection and the effective enthalpy of ablation of the meteoroid surface by aerodynamic forces and aerodynamic heating, C_D, C_H - resistance and heat transfer coefficients.

We assume that the destruction begins when the shear stress reaches the strength limit of the material [2-4]. The father breakup of body fragments could be because of elastic stress, thermoplastic stress, ablation and evaporation [3-4,7].

The number of fragments can be determined regarding of change of light intensity

$$I = -\tau\frac{V^2}{2}\frac{dM}{dt} \quad (2)$$

We assumed that luminosity increase because of rise of surface area.

3. The end flushes of meteoroid

According to the observations of meteors glow often ends in a bright flash [1]. So the final problem we solved was done to explain the thermal explosion hypothesis. As we conclude, at a final stage of the body break to pieces. As we do not know exactly the particle size distribution we supposed, that particles have the distribution as ones of a body immediately breakup by explosion [6]. The equation of mass loss (1) permits us to find the time of vanishing. So we could find the luminosity of the cloud of dust at the final stage of meteoroid destruction. We used for the

luminosity of each particle the relation (2). Integrating the mass for the entire spectrum of the fragments, we obtain the luminosity curve for the final stage of the extinction of the body.

4. Summary and Conclusions

We consider the entry into Earth's atmosphere cosmic body at hypersonic speeds. Large aerodynamic loads, the forces of inertia and heat flow to the body leads to a surface ablation, and even the destruction of the body. The movement formed by the destructing fragments cloud is a separate problem. Under the observations we know that flight of a space body completes a powerful end flash [7,8]. We offer one possible estimate of energy release in the final stages of destruction of the body supporting the possibility of the observed effect of "thermal explosion" of the meteoroid.

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References

[1] Ceplecha Z.J., Spurny P., Borovicka J., and Keclikova J.: Atmospheric fragmentation of meteoroids, Astron. Astrophys.Vol.279, pp. 615-626, 1993.

[2] Egorova L.A., Lokhin V.V.: Destruction models for the bodies entering planetary atmosphere. Proceedings of the International Conference “Asteroid-Comet Hazard – 2009”, St. Petersburg, “Nauka”, 2010, pp. 222-227.

[3] Egorova L.A.: The stress–stran state and disintegration of a meteoroid moving through the atmosphere, Journal of Applied Mathematics and Mechanics, 2011, Vol. 75, pp 363-366, 2011.

[4] Egorova L.A.: Modern models of fracture meteoroids. Proceedings of IMC-2010, pp. 25-27, 2012.

[5] Grigoryan S.S.: Motion and destruction of meteors in planetary atmospheres, Cosmic Research, v.17, pp.724–740, 1979.

[6] Nemtchinov I.V., Popova O.P., Teterev A V.: Entering the large meteotroids into atmosphere: theory and practice, Inzhen. Phis. Zhurn. Vol. 72, pp. 1233 – 1265, 1999. (in Russian)

[7] Popova O.P.: Meteoroid ablation models, Earth, Moon and Planets, Vol. 95, pp. 303-319.

[8] ReVelle D.O.: Bolide fragmentation processes: single-body modeling versus catastrophic fragmentation limit”. Meteoroids2001. 2001. – Kiruna, Sweden, ESA-SP-495, ESTEC, Noordwijk, the Netherlands, pp. 491-496.

[9] Tirskiy G. A. and Khanukaeva D. Yu.: Ballistics of a Fragmenting Meteor Body with Allowance Made for Ablation in the Non-isothermal Atmosphere. II, Cosmic Research, V. 46, No. 2, P. 120-132, 2008.

[10] Tirskiy G.A., Khanuckaeva D.Y.: Aerothermoballistics of breaking up large cosmic bodies Proc. of the 22nd ISSW. Imperial College, London, UK, pp.739-744, 1999.

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