Ablation of small iron meteoroids – first results

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Introduction

Among the video meteors, there is a population which is characterized by low speeds, asteroidal orbits, low beginning heights, short duration, and quick increase of brightness [1]. In accordance with spectral observations it has been suggested, that they are caused by small iron meteoroids. The shape of the light curves is very unusual. It has a quick increase of brightness with maximum near the beginning of its luminous trajectory. Such shape is hard to explain by classical single body ablation theory and also by fragmentation of parent meteoroid. The hypothesis is that the unusual ablation process is caused by thorough preheating of an iron meteoroid due to high thermal conductivity, melting of the whole volume of the body, and rapid ablation of the thus formed liquid iron droplet [2].

Model

To check our hypothesis, we developed a numerical model which mathematically describes the above mentioned phenomena and gives theoretical predictions for the light curves.

The model assumes iron spherical meteoroids with temperature – dependent thermal parameters. Temperature field has radial symmetry and it is determined numerically by solving the heat diffusion equation. On the surface, the incoming energy (in free molecular flow regime) is balanced by heat conduction into the body, thermal radiation and melting or fusion if sufficient temperature is reached. There are also one or two moving boundaries (solid/melt and melt/vapor) if the phase change occurs. The resulting theoretical light curve is determined on the basis of the amount of ablated material.

Results

We will show first results of our model, especially the comparison of the synthetic light curves (i.e. beginning heights and the shape) with the observed ones for several model parameters. Finally, we will determine if the ablation of iron meteoroids (liquid iron droplet, as described above) is able to describe the observed meteors.

References

[1] Campbell-Brown, M., Planetary and Space Science, Vol. 118, pp. 8–13, 2015.
[2] Borovička, J. et al., Icarus, Vol. 174, pp. 15-30, 2005.