INVESTIGATION OF SHOCK FLASH IN MDM – THE STRUCTURE UNDER THE IMPACT OF HIGH DUST

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ABSTRACT

The paper shows that the electric field applied to the MDM - structure influences processes flash observed during high-speed interaction of bodies.

1 THE THEORETICAL MODEL

The phenomenon of photoemission at high-speed collision of solids is the subject of research due to the fact that it has been used in the construction of transformers dust particles [1].

According to experimental data [2], the light intensity I and the total light energy is related to the mass and velocity of the particle in the following Eq.1 [3].

$$I = c_1 m W^{4,1}; \qquad (1)$$
$$E = c_2 m W^{3,2}.$$

Depending on the existing experimental data have a large scatter. There is a method of calculation, assuming the numerical solution of the resulting equations. Getting a clear functional relationship between the parameters of high-speed particles and light intensity implies an unjustified increase in the amount of computation.

Consider a simple analytical model for calculating the parameters of the shock light flash, which allows to get a signal in relation to the parameters of a dust particle. At an impact speed of more 20 km / s in the region of contact with the target particles produced plasma cluster. In the first stages of the expansion of the plasmoid because of its high density plasma is opaque to visible light. [4] Temperature plasma cluster, in which the plasma becomes optically thin (Eq.2 [3]).

$$T_0 = G_0 \cdot \frac{W}{1+\sqrt{\rho_y / \rho_M}} = G_0 \cdot \frac{W}{1+a} \qquad (2)$$

a - aspect ratio, W - the speed of the impactor, G_0 -the coefficient of proportionality, ρ_y, ρ_M –the density of the impactor and the target, respectively. It is assumed that the plasma radiates as a black body, that is in accordance with the law of Planck. The initial size of the plasmoid R_0. The characteristic time of the formation of a plasmoid.

$$R_0 = 10 \cdot R_Y,\ t_0 = \frac{R_0}{W} \cdot (1+a) \qquad (3)$$

The laws of expansion and cooling take as Eq.4.

$$T = T_0 \cdot (t_o / t)\ ,\ R = R_0 \cdot (t/t_o). \qquad (4)$$

And in accordance with the proposed model emissivity of plasmoid will be determined by the Eq. 5.

$$u_\lambda = \frac{2\pi hc^3}{\lambda^5} \cdot \frac{1}{\exp(hc/(kT\lambda)) - 1}. \qquad (5)$$

where $h\nu$ -energy photons; ν - frequency radiation; c - speed of light; h-Planck's constant; λ - wavelength.

We write the expression for the amplitude of the light intensity and the total light energy E as a function of the parameters of the particle (Eq.6).

$$I_{\max} = 2\pi \cdot \sigma \cdot \frac{G_0^4 \cdot W^4}{(1+a)^4} \cdot R_0^2, \qquad (6)$$
$$E = 2\pi \cdot \sigma \cdot \frac{G_0^4 \cdot W^3}{(1+a)^3} \cdot R_0^3.$$

Photoemission method-informed within this elementary model is incomplete. In this case, to obtain the information necessary to complete the combination of this method with others.

The disadvantage of this model is a series of rather strong simplifications, in particular, the model of a black body. Coefficient of conversion of light into electrical signal values more accurately determined from experience.

It may be noted that the energy of the electric field for heating of plasma, with the belief that by Joule heating is an increase in the electron temperature according to the Eq.7[5].

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$$\frac{3}{2} \cdot n_e \cdot k \cdot \frac{dT_e}{dt} = \sigma_e \cdot E^2. \qquad (7)$$

Temperature of the ions in the plasma is enhanced by heat exchange with electrons, and the temperature is hundreds of times less than [5].

Then the formula for the calculation of the intensity and the energy flux will be in the form of Eq.8.

$$I_0 = 2\pi\sigma \cdot R_0^2 \cdot (T_0 + \Delta T)^4 \cdot \left(\frac{t_0}{t}\right)^2; \qquad (8)$$
$$E = 2\pi\sigma \cdot R_0^2 \cdot (T_0 + \Delta T)^4 \cdot t_0$$

where ΔT - temperature increment due to Joule heating of the plasma.

Obtain the Eq.9.

$$I_{\max} = 2\pi \cdot \sigma \cdot \frac{G_0^4 \cdot (W + \Delta W)^4}{(1+a)^4} \cdot R_0^2; \qquad (9)$$
$$E = 2\pi \cdot \sigma \cdot \frac{G_0^4 \cdot (W + \Delta W)^3 R_0^3}{(1+a)^3};$$
$$\Delta W = \sqrt[4]{\frac{\Delta T \cdot (1+a)}{G_0}};$$
$$G_0 \text{ - const.}$$

2 EXPERIMENT

The experiment is as follows. High particle mass g with speeds of 1-10 km / s, measured on an electrodynamic particle accelerator, hit the target, which is a MDM - structure (the thickness of the top plates of 0.1 mm, dielectric - 1 mm, 50 mm of the lower end). With PMT mounted at an angle of 45 °, measured amplitude of the flash (Fig. 1).

According to the results of the experiment to increase the voltage MDM - structure leads to an increase in the amplitude of flash, which is consistent with theoretical calculations.

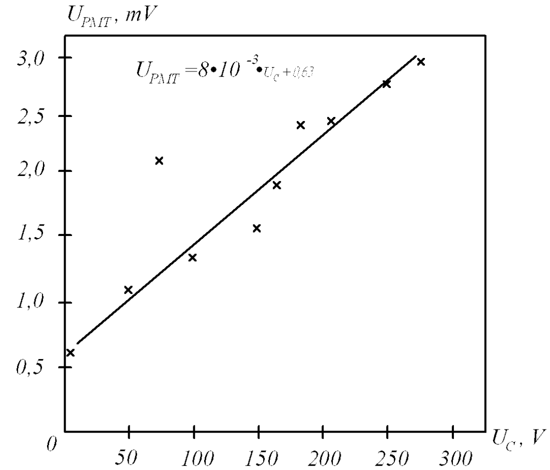

Figure 1. The relationship between the PMT voltage of the capacitor voltage [6]

3 CONCLUSIONS

Photoemission effect can be used to record high-speed dust particles in near-Earth space. However, to increase the reliability of the method, it must be combined with other types of measurements. The results showed that, if as a target for a high-speed projectile use MDM structure, increase the amplitude of the light pulse, resulting in a more accurate record of the dust particles.

4 REFERENCES

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