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X-RAY IONIZATION AND ELECTROSTATIC INDUCTION IN SPACE DEBRIS

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Abstract

Space debris has been causing damage to many spaceships and satellites. Remarkably, small space debris is difficult to be precisely detected and avoided. The protection system to save space technologies is indispensable. In a low earth orbit (LEO) in which fully occupied space debris is, the high energy X-ray from the sun can ionize and heat the space debris slowly orbiting around the earth. Elementary particle physics will concisely describe an ionization process in any substance in this work. The idea of deflecting the space objects by combining electrostatic induction and surface ionization by the X-ray from the sun will be proposed. After the ionization, the external electric field will be easier to split electric charges in the materials. The pendulum experiment can confirm electrostatic induction, which is tested in the lowpressure chamber when two electrodes for generating electric fields are attached at the lateral side of the chamber. The objects are made of composite materials, and conductors. The result shows that all of them swing back and forth except that the conductors only stay at rest because they discharge immediately, which is observed by the curve of the electron beam.

Objective

This work will propose the effect of the X-ray on the electrostatic induction in the space debris and show the electrostatic induction of space debris in the low pressure environment

Theoretical Background

The number of electric charges are larger when space debris are ionized by the X-ray whose the frequency is between 30 petahartz and 30 texahertz. The electric charge from X-ray ionization can be described by elementary particle physics. Suppose that $c = \hbar = 1$. The Lagrange density for the model is written as in the equation 1

$$L = \int d^3x\left(-\frac{1}{4}F^{\mu\nu}F_{\mu\nu} + i\bar\psi\gamma^\mu\partial_\mu\psi - e\bar\psi\gamma^\mu A_\mu\psi - m\psi\bar\psi\right) \quad (1)$$

The electric charge density is written as $e\bar\psi\gamma^0\psi \equiv ej^0$

The solution of each field is computed from Euler-Lagrange equation

$$\frac{\partial L}{\partial\psi} - \partial_\mu\left(\frac{\partial L}{\partial_\mu\psi}\right) = 0 \quad (2)$$

The energy of the X-ray and electric charges coupling system is the eigenvalue of the Hamiltonian which is written as in equation 3

$$H = \int d^3x\left(\frac{1}{2}\left|\dot{\vec A}\right|^2 + \frac{1}{2}\left|\vec B\right|^2 + \bar\psi(-i\gamma^i\partial_i + m)\psi - e\vec j\cdot\vec A + \frac{e^2}{2}\int d^3x'\frac{j^0(\vec x)j^0(\vec x')}{4\pi|\vec x - \vec x'|}\right) \quad (3)$$

The more energy density is, the more induced electric charge density would be. The solution of the gauge field is dependent on the angular frequency ω of photons which is expressed in equation 4 and 5

$$\dot{\vec A} = \sum_{\kappa,\lambda}\sqrt{\frac{\omega(\kappa)}{2\epsilon_0 V}}\, i\vec\epsilon_\lambda(\vec\kappa)(\hat a_{\kappa,\lambda} - \hat a^\dagger_{\kappa,\lambda}) \quad (4)$$

$$\vec B = \sum_{\kappa,\lambda}\sqrt{\frac{1}{2\epsilon_0 V\omega(\vec\kappa)}}\, i\vec\kappa \times \vec\epsilon_\lambda(\vec\kappa)(\hat a_{\kappa,\lambda} - \hat a^\dagger_{\kappa,\lambda}) \quad (5)$$

Electrostatic Induction Experiment

The lists of equipments are :

- **Vacuum chamber**
- **Objects ; conducting sphere, and composite meterial**
- **DC Electric generator**
- **Two stainless electrodes**
- **Carbon nylon rope**
- **Camera**

The experimental procedures are the following :

- **Hanging an object between the parallel electrodes connecting to the DC electric generator.**
- **Opening the air vacuum machine to decrease the presure of the chamber until it reaches the lowest point.**
- **Turning on the electric generator at 3 kV and recording the oscillation of the object**
- **Increasing the voltage 3 kV and recording the oscillation of the object until it reaches 30 kV.**

Experimental results

The conducting materials could not hold the electric charges inside themselves while the composite materials responsed to the electrodes and electron beam was not passing through the materials easily.

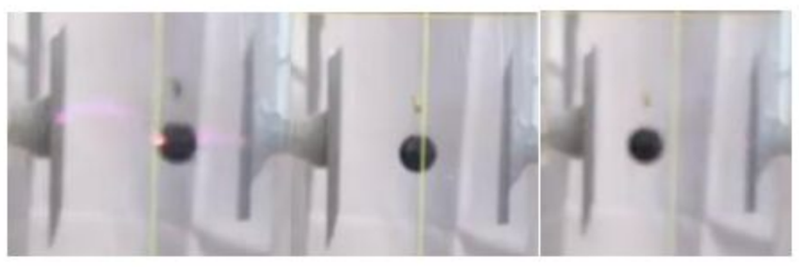

Fig.1 The electrostatic induction experiment of the composite material

Fig.2 The electrostatic induction experiment of the conducting sphere

Conclusion

The X-ray ionization can increase more electric charges inside the material referring to elementary particle physics model. The restriction is that electric charges can not be held properly in the materials in the low pressure environment. Especially, conducting materials are able to release electrons immediately meanwhile all electrons are not released from composite meterials which can be observed in the pendulum experiment.

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