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X-RAY IONIZATION AND ELECTROSTATIC INDUCTION IN SPACE DEBRIS

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Extended 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 low-pressure 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.**

Space debris orbiting around the earth are currently problem of our astronautical work because they are a hindrance to perform space activities. Here, this work proposes the electrostatic induction to deal with small and medium size of space debris. In the space, it seems that space debris are ionized by X-ray from the sun. The number of induced electric charges are larger. 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

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

When the A_μ is the gauge field from the external X-ray, $F_{\mu\nu}$ is field strength tensor and ψ is the bispinor field which represents electrons at the surface of space debris. The electric charge density is written as $e\overline{\psi}\gamma^0\psi \equiv ej^0$ when each field is computed by the Euler-Lagrange equation.

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

The Hamiltonian of the X-ray and electric charges coupling system is written as

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

According to the form of Hamiltonian, the more energy density on the surface of the materials is, the more induced electric charge density in the materials would be when the ionized materials are lying between two electrodes generating external electric fields. The solution of the gauge field is dependent on the angular frequency ω of photons which is expressed in equation 4 and 5

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

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

The X-ray frequency is approximately between 30 petahertz and 30 exahertz. However, the problem during the experiment is the electric charges are not simply held inside materials surrounded by low pressure environment. The electric discharge was clearly seen during the experiment.

We set the pendulum experiment to test the electrostatic induction by observing the motion of the objects. The equipments for the experiment were listed as follows :

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

The experimetal procedure was prepared as follows :

- **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.**

The experimental results of the composite materials and conducting sphere were shown in the figure 1 and 2 respectively.

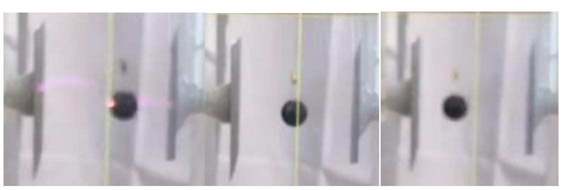

Fig.1 The electrostatic induction experiment of the composite material

Fig.2 The electrostatic induction experiment of the conducting sphere

Referring to the result, the conducting materials could not hold the electric charges inside the materials because the conducting sphere was not attracted by the electrodes and the electron beams simply passing through the conducting sphere. In contrast to the other kind of materials they responsed to the electrodes and electron beam was not passing through the materials easily. In the real situation, space debris orbiting around the earth are ionized by X-ray from the sun. The electric force between the electrodes and the space debris are able to be probably stronger.

Conclusion

The X-ray ionization can increase more electric charge 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.

References

1. **N. Bouldi ,C. Brouder, “Gauge invariance and relativistic effects in photon absorption and scattering by matter”, arXiv:1610.05900v2 [cond-mat.str-el], Apr. 2017.**
2. **V. Rokaj, “Condensed Matter Systems in Cavity Quantum Electrodynamics”, arXiv:2201.01331v1 [quant-ph], Jan 2022.**
3. **Sirapat L., Anol P.,“The electric potential and electric field calculation on cpnducting space debris,” 48th international congress on science technology and technology-based innovation, Walailak Univ., Nakorn Sri Thammarat, Dec. 2022, page.11-17.**
4. **D. Tong, “Quantum field theory”, univ. of cambridge part III mathematical tripos, 2006.**
5. **L. Sirapat, J. Phunika and P. Anol, “Touchless Space Debris Management and Security of Space Technology”, AIAA SciTech Forum, National Harbor, MD & Online, Jan. 2023.**