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ABSTRACTS (MASTER THESIS)

Analysis of Active Spacecraft Charging in the Geostationary Environment

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A new concept of spacecraft orbital control using electromagnetic forces such as the Lorentz force and the Coulomb force has been recently proposed. Spacecraft controls their orbit by controlling their potential using a charged-particle emitter. This control method may provide propellantless orbital control and a very lightweight propulsion system compared with conventional chemical and electric propulsion systems.

To control the electromagnetic force that acts on the spacecraft, it is necessary to actively control the spacecraft's electrical potential. The active spacecraft potential control method, however, has only been used to mitigate spacecraft charging, and little has been reported on active charging. For evaluating the performance and feasibility of electromagnetic orbital control, we reveal the electric potential characteristics of active spacecraft charging by using a 3-D full Particle-in-Cell (PIC) simulation.

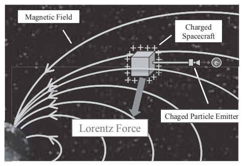

Figure 1. Artistic Image of Electromagnetic Orbital Control

Firstly, we improved an electrostatic spacecraft charging analysis code, called HiPIC, which was developed by the Japan Aerospace Exploration Agency's Engineering Digital Innovation Center. We implemented a beam-emission routine, applied OpenMP parallelization to the code, and adapted it for a multi-compiling.

Secondly, we performed the active spacecraft charging simulations. We defined a cubic spacecraft model and simulated electron beam emission from the surface.

As a result, we showed the simple beam-returning model cannot accurately express the electric potential characteristics of active spacecraft charging We assumed a boundary between ``beam-returning region'' and ``not beam-returning region'' can be determined as the point of background electric current becomes equal to electron beam current, and formularized the theoretical potential characteristics. It roughly agrees with the PIC simulation results, but it does not simulate the potential gradient in the beam-returning region.

Thirdly, we proposed a new active charging model. Our main concept is to modify the return current term in the conventional model. The electric potential of a cubic spacecraft can be numerically calculated with our model; by contrast, the conventional model can only expresses active charging qualitatively.

Finally, we evaluated the Lorentz force characteristics in the geostationary environment to evaluate performance and applications of electromagnetic orbital control. The Lorentz force is in proportion to the spacecraft's potential, so that the force also depends on the background plasma environment. A rod-shaped spacecraft can generate larger Lorentz force than a cubic spacecraft on the same surface area because a spacecraft's capacitance depends on the space shape.