

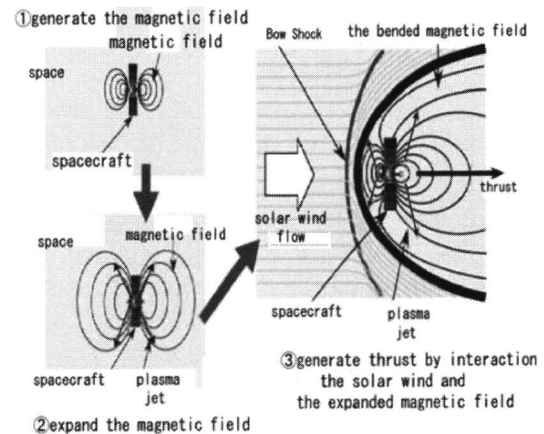
Magnetohydrodynamic Analysis for Magneto-Plasma Sail Spacecraft

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Exploration of the solar system can be accelerated using an advanced space propulsion system. One of the new propulsion systems suitable for deep space exploration is a magnetic sail propulsion system. Magnetic Sail (MS) is a sail propulsion system using an interaction between the solar wind and the artificial magnetic field around the spacecraft, and Magneto-Plasma Sail (MPS) is an advanced concept of the MS with plasma jet from the spacecraft in order to expand the magnetosphere. The solar wind energy is converted to the thrust of the MS and MPS. It generates a continuous, high thrust in the outward direction from the sun (see Figure on the right).

In this thesis, we investigate the thrust characteristics of the MPS [1-4]. First, we simulate the formation of a magnetosphere when the solar wind interacts with the magnetic field in axisymmetric two-dimensional MHD analysis. The magnetospheric size is found to be inflated by a plasma jet emitted from the spacecraft. The simulation results show that the magnetospheric size is unchanged as long as β value (plasma dynamic pressure divided by magnetic pressure at spacecraft position) is constant. Second, we study the thrust magnitude of the MPS. In the MPS, the thrust increases compared with the MS, whose magnitude depends on β of the plasma jet. The maximum strength of thrust is obtained in low β condition rather than in high β condition. The thrust is generated by the induced magnetic field produced by the magnetospheric current. In a case of high β , a termination shock is produced inside the magnetosphere, where the current flows in the opposite direction to that on the magnetosphere. Therefore, in high β case, although the magnetosphere is more expanded than that of the MS, the thrust is decreased by the current on the termination shock compared to that with low β condition. Finally, we compare the specific impulse (Isp) and thrust/power ratio of the MPS with those of the conventional electric propulsion system (EP). We found that both Isp and the thrust/power ratio of MPS with low β case are higher than those of the EP.



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