§ 44. Development of an Electromagnetic Particle Code for Space Propulsion Application Using ECR Discharge

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The electric propulsion was adopted as thruster for a stationary satellite and a planetary explorer because of its high efficiency. Among the electric propulsion systems, an ion engine electrostatically extracts an ion from plasma. An ion engine with microwave discharge could extend lifetime as compared with DC discharge. In sample return mission MUSES-C of The Institute of Space and Astronautical Science (ISAS), 10cm class microwave discharge ion engine (8mN/400W) shown in Fig. 1 is adopted as a main thruster. In addition, this ion engine system has the neutralizer with the microwave discharge.[1)]

Due to improvement of performances for ion engine with the microwave discharge, codes adopting various assumptions are being developed to analyze the plasma behavior and microwave propagation in the ion engine with the microwave discharge.[2)] The purpose of the present study is to analyze plasma behavior and microwave propagation in the 10cm class ion engine and neutralizer. For this purpose, we have developed an electromagnetic particle code. This code is constituted of particle-in-cell (PIC) method to solve the equation of motion for electron and of finite-difference-time-domain (FDTD) method to solve the Maxwell's equation of microwave[3)]. The coupling code can solve the plasma behavior and microwave propagation in a self-consistent manner without complex assumptions. The coupling code is available not only to solve time evolution of the plasma but also to obtain collision and energy distribution function.

To check the accuracy of the coupling code, numerical results of this code are compared with analytical results from the cold plasma theory. The microwave propagation in plasma is analyzed in a model. Calculation conditions are 1) B=0, 2) perpendicular to B and 3) parallel to B. The plasma is assumed as uniform in the model. The initial electron energy is 0eV and only electrons are traced, ions being considered as background. Calculation results and analytical solutions are compared. The resonance is occurring in the vicinity of $\omega_c/\omega=1$ and the increase in the electron energy is observed. The calculation results agree well with analytical solutions, the validity of the coupling code being established.

The microwave propagation is calculated in the 10cm ion engine shown in Fig. 1. Mode change of the microwave from TE_{11} to TM_{11} was observed in the discharge chamber. The reason is that another mode can propagate because the radius increases in the discharge chamber.

The plasma behavior and microwave propagation in the ion engine are calculated. The electric field intensity is found to be smaller for the case with plasma than the case without plasma in all the regions. Furthermore, in the ECR layer, increase in the electron energy is observed, which is consistent with the experimental results. From these results, the energy of the microwave is transferred to the energy of plasma in the ECR layer.

The initial conditions such as initial electron energy and position should be reconsidered for further study.

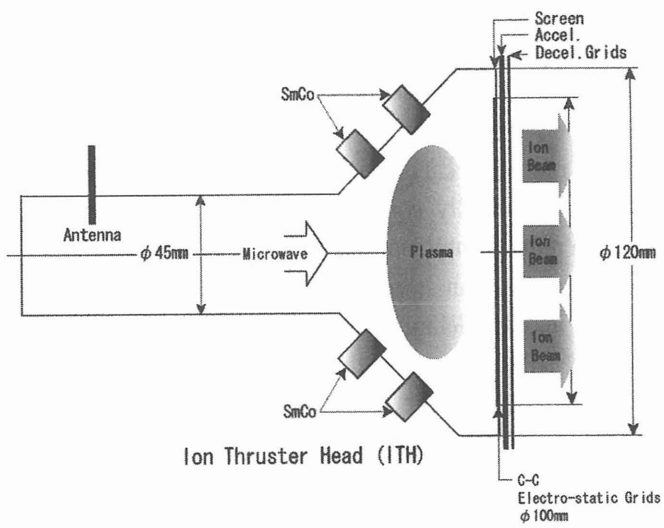

Fig. 1 10cm microwave discharge ion

Reference

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