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無電極回転磁場加速法による電磁加速効果の回転周波数依存性検証

Investigation of Dependence of Electromagnetic Acceleration Effect on rotational Frequency by Electrodeless Rotating Magnetic Field Acceleration Method

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Electric plasma thruster is widely used for space propulsion system owing to its higher specific impulse by one order magnitude than that of typical chemical propulsion. Conventional plasma thruster systems, e.g., ion gridded engine and Hall thruster, have successfully accomplished many space missions such as sample return and attitude/orbit control of artificial satellites. In these conventional electric thrusters, however, degradation of the thrust performance and limitation of the operation time are present due to erosion of the electrodes. The fatal issues result in a difficulty of future long-term space missions such as deep space expedition and manned space probe to Mars.

Electrodeless radio frequency (RF)/helicon[1] plasma propulsion system[2,3] is a promising way to overcome the fatal issues because neither electrodes nor grids directly contacting a plasma are present. We are proposing rotating magnetic field (RMF)[4,5] additional plasma acceleration method[2,6–8] for further performance improvement of the rf thrusters. RMF current drive has been utilized to maintain a field reversed configuration (FRC)[4] in the field of the magnetically confined plasma fusion research. In this RMF scheme, a plasma generated by using a RF antenna is accelerated by the electromagnetic force. Note that the additional force is given as a cross product of the driven azimuthal current, j_θ, and a radial component of the external diverging magnetic field (magnetic nozzle).

For proof-of-principle of the RMF method, dependences of plasma parameters and RMF penetration on RMF operational parameters are being investigated. In particular, RMF rotational frequency, f_{RMF}, is an important factor to determine the plasma acceleration effect in the RMF method. Oscillating RMF components in three-axis were measured by using a three-axis B-dot probe.[8] Figure 1 compares radial B-field profiles under the RMF antennas between two f_{RMF} cases (0.7 and 5 MHz). In the presence of the plasma with f_{RMF} = 5 MHz, the central amplitude, especially, orthogonal component decreased. The partial penetration corresponds to theoretical estimation of the RMF penetration expressed by *Milroy*,[5] as well as that in the f_{RMF} = 0.7 MHz case.[8]

The RMF drove j_θ oscillating with $2f_{\mathrm{RMF}}$ in time via the non-linear Hall term effect,[8] as shown in Fig. 2. We have successfully confirmed the existence of the electromagnetic acceleration effect by the RMF method.

In this conference, we will present current experimental results regarding the frequency dependences of plasma parameters and the j_θ drive.

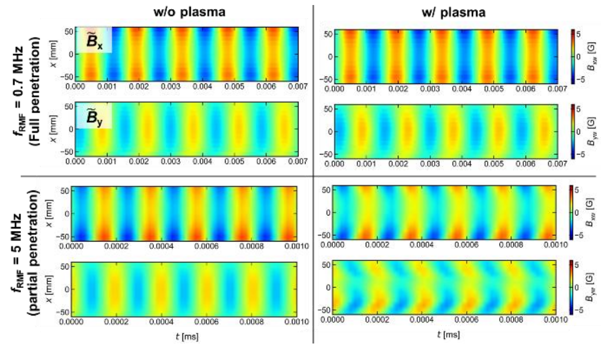

Fig. 1 Time evolution of radial profiles of time-varying orthogonal components of RMF measured in the middle of the RMF antennas.

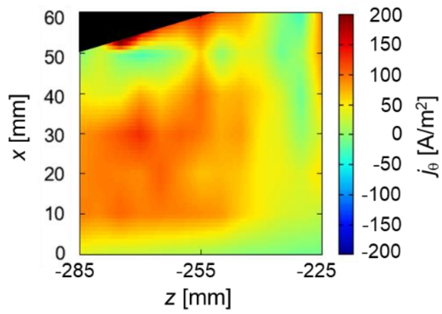

Fig. 2 Time evolution of spatial profile of the j_θ in the RMF antenna region in the case of f_{RMF} = 0.7 MHz.

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