

高密度ヘリコンプラズマによる完全無電極電気推進の研究(II):  
回転磁場コイルによる加速

**Study on Completely Electrodeless Electric Propulsion System using  
High-Density Helicon Plasma (II):  
Acceleration by Rotating Magnetic Field Coils**

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An electrical rocket engine has a higher efficiency compared to a chemical one. Therefore, it is expected to utilize the electric engine for a deep space exploration. However, this type of engine contacts directly with plasmas in a process of accelerating or generating plasmas, which shortens operating lifetime of the engine. Therefore, we are proposing a Rotating Magnetic Field (RMF) scheme [1] for solving this problem.

In the field of nuclear fusion, RMF is used to sustain the plasma by inducing continuous toroidal current, and the scheme we propose here comes from this concept. However, a principle of RMF has not been proved in the field of propulsion, which should be clarified.

RMF is generated by two opposing sets of currents, which have a phase difference of 90 degrees (Fig. 1). If  $\omega_{ci} < \omega < \omega_{ce}$ , only electron rotates, then  $j_\theta$  can be generated. External radial magnetic field  $B_r$  and azimuthal current  $j_\theta$  generate Lorentz force  $F_z$ . Here,  $\omega_{ci}$  ( $\omega_{ce}$ ) is an ion (electron) cyclotron angular frequency and  $\omega$  is an angular frequency of RMF.

Large Mirror Device [2] (LMD) is used in the experiment (Fig. 2), whose inner diameter and axial length are 445 mm and 1,700 mm, respectively. A quartz tube is connected with LMD, pumped by a turbo molecular pump and a rotary pump. To generate plasma, a double-loop antenna is wound around the tube with rf power of 2,000 ~ 3,000 W and rf frequency of 7 MHz.

Size of RMF coils, shown in Fig. 3, is  $100 \times 150$  mm and each number of turns is 5. Electron density and flow velocity are measured in the downstream of RMF coils by Mach probes.

Penetration of rotating magnetic field is needed to generate azimuthal current [3]. In the previous study [4], we have confirmed the field penetration and operating conditions can be

extended.

Initial test shows that electron density increases slightly by applying RMF, which suggests that RMF power generate the plasma. We will make a parameter survey for getting optimum target plasmas in order to clarify the RMF acceleration scheme.

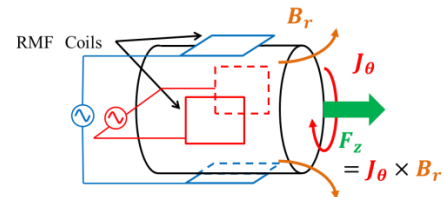


Fig. 1 Principle of RMF acceleration.

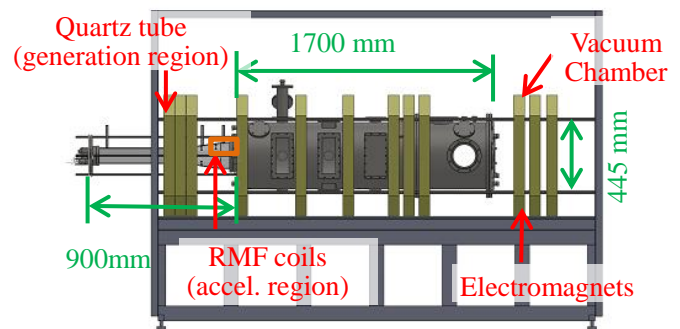


Fig. 2 Experimental device (LMD).

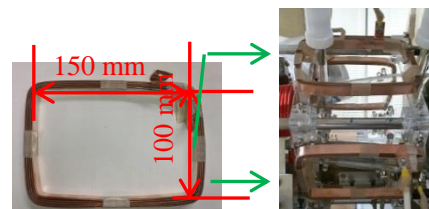


Fig. 3 RMF coils.

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