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高密度ヘリコンプラズマによる完全無電極電気推進法の研究(I)：永久磁石による生成と加速

Study on Completely Electrodeless Electric Propulsion System using High-Density Helicon Plasma (I): Generation and Acceleration using Permanent Magnets

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A completely electrodeless electric propulsion system is effective for long-term space missions, since electrodes are not in contact with plasmas directly, leading to a longer lifetime operation. In our proposed system of the electrodeless propulsion [1], high-density (~ 10^{13} cm^{-3}) helicon plasmas [2] are accelerated by the Lorentz force, i.e., the product of the azimuthal current j_θ and the radial magnetic field B_r. We were using electromagnets (EMs) to produce the magnetic field in our previous study, but there is a problem that B_r required for plasma acceleration is insufficient (few tens of G).

In this study, we have tried to solve this problem by introducing permanent magnets (PMs) [3] as the external magnetic field sources. Advantages of PMs are three points, shown below; (1) PMs' magnetic field (surface magnetic field is ~ 1.5 kG) is very strong in spite of the smaller size than EMs. (2) It is possible to generate a magnetic field in a localized region, because PMs' magnetic field becomes weaker very rapidly away from PMs unlike EMs. (3) Since PMs do not consume electric power, PMs are useful sources to produce the magnetic field in space with a limited electric power. Here, the purpose of this study is to demonstrate the electromagnetic plasma acceleration using the magnetic field of PMs with larger B_r in addition to helicon plasma production.

A structure called "Magnet holder", for fixing the PMs around a quartz tube (source of plasma generation) was made [see Fig. 1]. The magnetic field strength can be changed by selecting a number of PM sheets (between 1 and 3) in each position. The PMs are easy to form the divergent B, having a large B_r suitable for plasma acceleration.

In this presentation, we will report the results of comparison of the plasma parameters (electron temperature T_e, electron density n_e, and ion velocity v_i) between the cases of only PMs or EMs, by different measurement methods (electrostatic probe, spectrometer, and Laser Induced Fluorescence). Furthermore, in order to optimize the magnetic field in combination with PMs and EMs [see Fig. 2], changes of n_e and v_i will be presented.

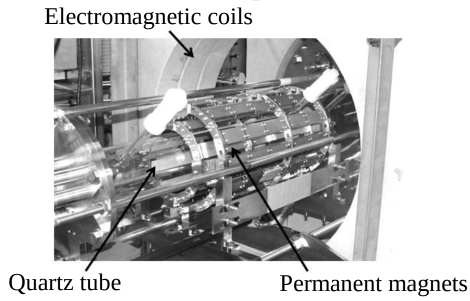

Fig. 1. Permanent magnets around the quartz tube.

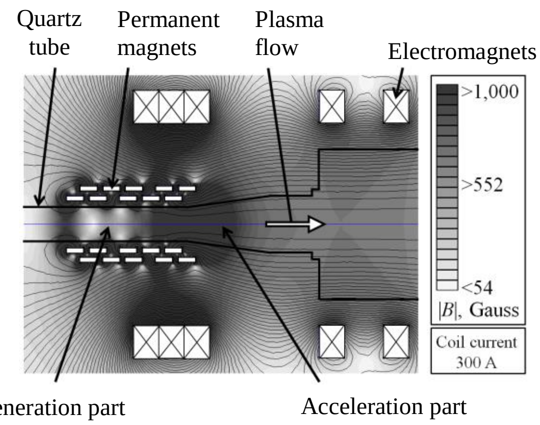

Fig. 2. Magnetic field strength and its field lines.

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[2] R. W. Boswell, Phys. Lett. **33A** (1970) 457.
[3] K. Takahashi, Y. Itoh and T. Fujiwara, Phys. D: Appl. Phys. **44** (2011) 01524.