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Development of Electrodeless Thruster using High-Density Helicon Plasma Sources

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Helicon plasma sources [1-3], using an rf (radio frequency) range, are very useful, because of high-density (~ 10^{13} cm^{-3}) and low electron temperature (from a few to several eV) available with a broad range of external operating parameters. Various kinds of the sources have been developed and characterized by us to control plasmas as required: e.g., very large- [4,5] (up to 74 cm in diameter with an axial length of 486 cm) or very small-area [2,6-9] (from 2 cm in diameter to down to 0.05-0.3 cm plasmas have been established just recently) sources can be found. Particle production efficiency in a wide range of plasma size showed an excellent performance [5], close to a classical diffusion coefficient. High-beta (~ 1) plasma can be easily achieved, showing an importance of neutrals effect [10]. Therefore, these sources can be expected to be utilized in vast areas from fundamental to application fields. Applying these sources to a space propulsion system with an advanced concept of an electrodeless condition (no direct contact between a plasma and electrodes/antennas) [5,7] has been executed, due to a longer life operation expected.

Here, we will overview our studies on various-sized, helicon plasma sources and their application to the electrodeless thrusters under the Helicon Electrodeless Advanced Thruster (HEAT) project [5,7]: Characteristics of very large or small (diameter) sources, and plasma thrust performance [7,11]. Here, a broad range of excitation frequency, 7-435 MHz, was used for optimization of plasma sources. In addition, some trials of electrodeless, additional acceleration methods are introduced, such as Rotating Magnetic Field (RMF) [7,9,12-14] and m = 0 half cycle schemes [7,9,12] (see Fig. 1). We also emphasize the importance of some diagnostics [9,11,12] such as Laser Induced Fluorescence (LIF) method, tomography one using a high-speed camera with interference filters (including a development of a collisional radiative model to deduce electron temperature and its density in argon plasmas) as well as various thrust stands.

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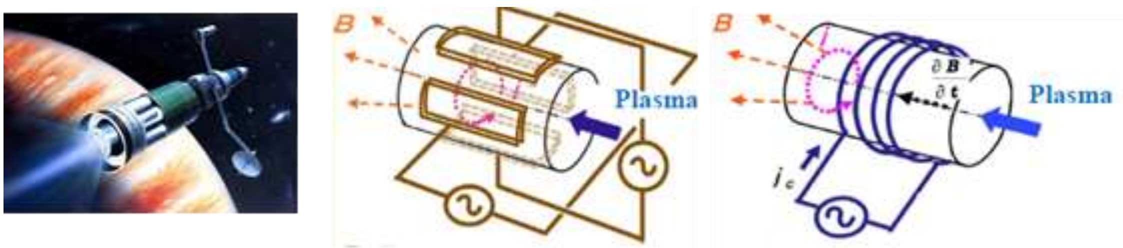

Fig. 1: Imaginary drawing of future helicon thruster (left) with RMF (middle) and m = 0 (right) acceleration methods.