Title of Project: Research and Development of a Novel Electrodeless Plasma Rocket Engine Using a Helicon Source

Shunjiro Shinohara
(Kyushu University, Interdisciplinary Graduate School of Engineering Sciences, Associate Professor)

Research Area: Aerospace Engineering, Plasma Science
Keywords: Propulsion/Engine, Plasma Applications, Aerodynamics

【Purpose and Background of the Research】

Electric propulsion is a form of spacecraft propulsion that uses electric energy (obtained from solar panels, for instance) to accelerate ionized gas or plasma propellant. Compared with chemical thrusters, electric thrusters can offer much higher fuel efficiency, so that many attractive future missions can be realized. In fact, ion engines, one variation of the electric propulsion scheme, has been successfully utilized in the Japanese asteroid mission, *Hayabusa*. However, conventional electric thrusters share an intrinsic weak point, namely a finite lifetime due to the erosion of electrodes that are in direct contact with dense plasma.

The objective of our project is to develop a *completely electrodeless* (i.e., no components that exchange particles with the plasma propellant) *plasma rocket engine* by integrating and advancing our knowledge on electrodeless plasma production and acceleration.

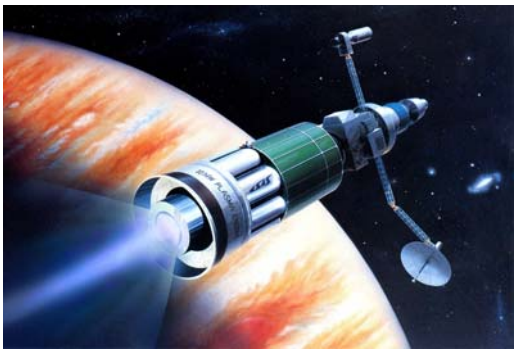

Figure 1 Artist's rendition of a spaceship with an electrodeless plasma thruster.

【Research Methods】

In our advanced-concept thruster, a background magnetic field is applied so as to avoid the propellant plasma to make contact with the thruster vessel. An efficient and convenient way to produce plasma in a magnetic field is to utilize the helicon wave, one of the plasma wave families. The performance of helicon sources will be optimized by the leading experts in our group, so that they can be adopted in our thruster systems.

We have so far proposed six different electrodelss schemes to accelerate the propellant plasma, in which the plasma is driven by externally applied electromagnetic fields. Two of them have already been successfully tested in the laboratory. Theoretical modeling, computer simulations, and laboratory experiments will all be performed, keeping close contact to one another, to examine the performance of all the six proposed schemes. The ultimate goal is to achieve the exhaust velocity of 40 km/s and the propulsive efficiency of 50 %.

【Expected Research Achievements and Scientific Significance】

Development of our electrodeless, thus extremely long-lasting plasma rocket engines will make a substantial impact on future space missions, as they are at present hindered by a few years lifetime of conventional electric thrusters. The ideas and technologies created during the course of our project will lead to some novel concepts in developing a plasma engine for interstellar travel using interstellar plasma as a propellant and some spin-offs, such as a completely electrodeless plasma processing system for manufacturing computer chips and an advanced-concept plasma incinerator for waste treatment.

【Publications Relevant to the Project】

・S. Shinohara, *et al.*: Development of High-Density Helicon Plasma Sources and Their Applications, Phys. Plasmas **16**, 057104 1-10 (2009).
・K. Toki, *et al.*: Compact Helicon Source Experiments for Electrodeless Electromagnetic Thruster, *Proc. 43rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit* (Cincinnati, Ohio, 2007) AIAA-2007-5260.

【Term of Project】 FY2009 – 2013

【Budget Allocation】 160,700 Thousand Yen

【Homepage Address and Other Contact Information】

http://zone.aees.kyushu-u.ac.jp/~sinohara/Homepage/shinohara.html
sinohara@aees.kyushu-u.ac.jp