Optimization Of Helicon In HIIPER Space Engine Using The Particle Tracing Module

R. Puri[1], G. H. Miley[1], R. Najam[1]

[1]University of Illinois at Urbana-Champaign, Illinois, USA

Abstract

Helicon Injected Inertial Plasma Electrostatic Rocket (HIIPER) [1] is an advanced space propulsion system being studied in University of Illinois Urbana-Champaign. It has been depicted in Figure 1. An experimental setup is already being used to gather dynamics of plasma with the help of Langmuir probe measurements. The experimental procedure involved is complex and thus numerical simulations are used as a simplification tool. Computational studies in COMSOL® reduces the cost of running the experiment and time taken in investigating results of unfavorable operating conditions. Optimization of the system is being done by COMSOL® using inductively coupled plasma (ICP) in the simulations [3].

This poster represents the studies being done on the helicon component of HIIPER, that generates plasma using Argon as propellant gas. Ion extraction from the system creates the thrust force needed to propel the spacecraft. Electromagnetic waves are generated due to the radio frequency (RF) antenna wrapped around the quartz tube which in turn convert the Argon gas into a plasma. Simulations of the helicon part in HIIPER involve integrating the Magnetic Field, Plasma, and Electromagnetic Waves interfaces. Based on previous experimental and numerical results, there are not enough ions going to the IEC grids from the helicon source [1,3].

To understand what system designs are causing these heavy ion losses, Charged Particle Tracing interface has also been used to determine the ion trajectory within the helicon quartz tube. In the setup for this study, 2D axisymmetric simulations are being carried out with the (RF) input power ranging from 10 W to 1 MW [2]. The COMSOL® model setup can be seen in Figure 2.

The results will involve RF input power kept as an independent variable to estimate plasma parameters such as ion density, electron temperature and ion trajectory (velocity after ionization). It is expected that the plasma density and temperature in general will be directly proportional to the RF power. It is also expected that the ion losses occurring in the system are in general ion-wall collision at the downstream end of the helicon quartz tube. The simulations and plots of ion movement against RF power will be a key factor in better optimizing HIIPER's design and proving the usefulness of COMSOL® simulations in understanding these ion losses.

Reference

References
1. Drew M. Ahern, Hussein Al-Rashdan, Oguzhan Altun, Grant Berland, Emil Broemmelsiek, Zhengyu Chen, Patchara Choakpichitchai, Zongxu Dong, Patrick Drew, Nicklaus Richardson, Nicholas St.Lawrence, Kyle Stanevich, Albert Valiaveedu, and George H. Miley. "Experimental Studies of the Helicon Injected Inertial Plasma Electrostatic Rocket (HIIPER)", 53rd AIAA/SAE/ASEE Joint Propulsion Conference, Atlanta, GA, 2017.
2. Wen, Xiaodong, Tianping Zhang, Yanhui Jia, Chenchen Wu, Ning Guo and Xinfeng Sun.

“Magnetohydrodynamics simulation of plasma processes in a helicon plasma source for a MW-level electromagnetic thruster.”, IEPC-2017-77.
3. Z. Chen, D. Ahern, G. Miley "HIIPER Space Propulsion Simulation Using AC/DC Module," COMSOL Conference, Boston, MA, Oct. 2017.

Figures used in the abstract

Figure 1 : HIIPER Schematic

Figure 2 : COMSOL Model of HIIPER