HIIPER Space Propulsion Simulation Using AC/DC Module

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Abstract

The Helicon Injected Inertial Plasma Electrostatic Rocket (HIIPER) is an electric space propulsion concept being studied that utilizes a helicon source to generate a plasma and metal grids from inertial electrostatic confinement (IEC) fusion experiments to accelerate ions, generating a thrust. The IEC-type grids are of interest as a way to simultaneously generate a beam of high energy electrons to neutralize the ion exhaust [1]. Having a neutralized exhaust is beneficial in that a separate electron injection instrument is not needed. Regarding plasma generation, a helicon section is advantageous because it can create a denser, more ionized plasma than other methods using similar power levels [2]. An image of HIIPER's setup modeled in COMSOL® is shown in Figure 1.

Aspects of the experiments can be complex and difficult to predict. To aid in these experiments, simulations in COMSOL® have been created. These simulations follow largely from previous COMSOL® work [3]. Simulations provide an efficient way for us to improve and design HIIPER.

In the COMSOL® simulations, we apply the AC/DC Module, specifically using electrostatics, magnetic fields, and charged particle tracing. To optimize the run time of our simulation, we use a 2D axisymmetric model. We use electrostatics to simulate the electric fields in the IEC grids and the bias of the helicon. A magnetic field is used to simulate the electromagnet coils of the helicon section. Charged particle tracing is employed to simulate the electron particle and ion particle motion of the HIIPER experiment.

With these simulations, we are able to compare experimental results with the simulation results and improve the design of the HIIPER experiment. Some experimental data that can be compared directly with COMSOL® results, such as the magnetic field data, shows good agreement. Other COMSOL® results, such as particle trajectories and electric potentials, are used to help understand the experimental operation. Also, new components are being set up in the simulation to collect corresponding data from different test cases.

In conclusion, COMSOL® makes it possible to compare and verify experimental data in HIIPER with the simulation data. Additionally, the simulations allow for understanding various characteristics of the experiment. Consequently COMSOL® simulations play an important role in testing and optimizing our experimental design.

References

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[2] Chen, F. F., "Plasma ionization by helicon waves," Plasma Physics and Controlled Fusion, Vol. 33, No. 4, 1991, pp. 339-364.
[3] Ahern, D., Chen, G., Krishnamurthy, A., Ulmen, B., and Miley, G., "Simulating Experimental Conditions of the HIIPER Space Propulsion Device," Proceedings of COMSOL® Conference 2013, Boston, MA, 2013.

Figures used in the abstract

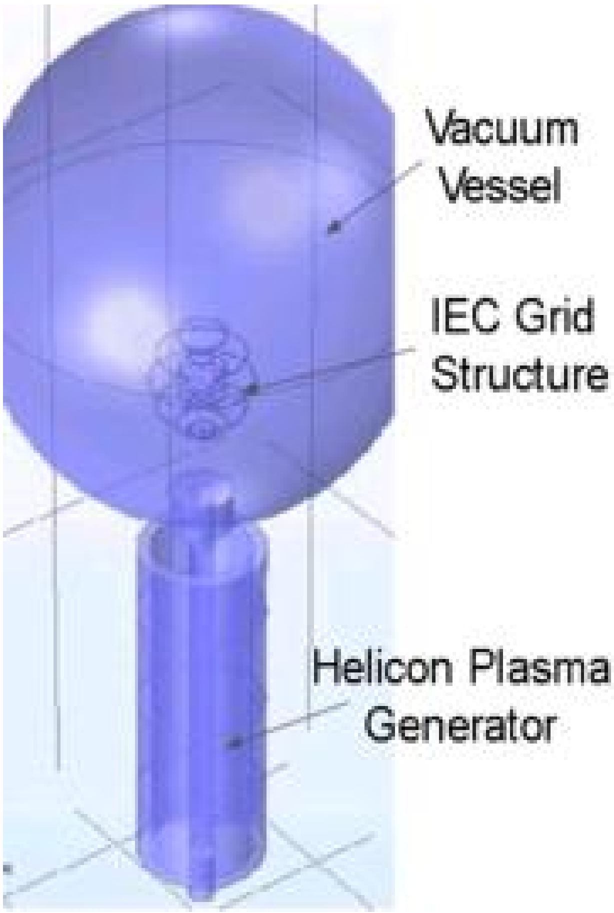

Figure 1: Figure 1: The model for the helicon section and IEC grids.