Simulating Experimental Conditions of the HIIPER Space Propulsion Device

A. Krishnamurthy[1], G. Chen[1], B. Ulmen[1], D. Ahern[1], G. Miley[1]

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

Abstract

The Helicon-Injected Inertial Plasma Electrostatic Rocket (HIIPER) is a two-stage electric propulsion system comprising of a helicon plasma source and an Inertial Electrostatic Confinement (IEC) device for plasma production and acceleration, respectively. The helicon source, consisting of an antenna surrounded by magnetic coils, ionizes argon gas, and the plasma produced diffuses into the IEC chamber. The 61 cm diameter IEC chamber acts as an anode and houses a 12.5 cm diameter spherical wire grid that acts as a cathode. The ions form a core around the hollow center of the grid, and a small specified asymmetry in the grid causes a thin plasma jet to form. At present, experimental diagnostics are being developed to properly identify the properties of the plasma and the jet. A force sensor is being used to measure the thrust of the IEC plasma jet, a Langmuir probe is being developed to measure the net current exiting the helicon, a Faraday cup has been developed for current and thermal power measurements of the plasma jet, and a gridded energy analyzer (GEA) is being used to measure the jet energy spectrum and ion/electron densities.

To supplement this experimental analysis, COMSOL Multiphysics® has been used to create models of the experiment and predict results. The voltage as a function of the path from the helicon through the IEC chamber has been simulated. This has been used in predicting and analyzing experimental GEA results. These COMSOL simulations show most of the voltage drop occurring between the grid and IEC chamber, with a relatively small voltage drop along the helicon. Second, the spherical Langmuir probe (which replaces the cathode grid) has been modeled, and a diagram of the experimental setup used in the modeling can be seen below in Figure 1. The Langmuir probe has been biased to -5 kV, and a multi-slice of the COMSOL voltage profile without plasma is shown below in Figure 2. Additionally, COMSOL results have been obtained for the Faraday cup: a model has been created in COMSOL, and the conductive heat transfer has been simulated. This has allowed for an estimate of the rate of temperature increase, which has been used to obtain an input heat flux rate.

Reference

1. Akshata Krishnamurthy, et al, "Numerical and Experimental Measurements in a Helicon-IEC Thruster," 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, San Jose, CA. AIAA 2013-3830.

Figures used in the abstract

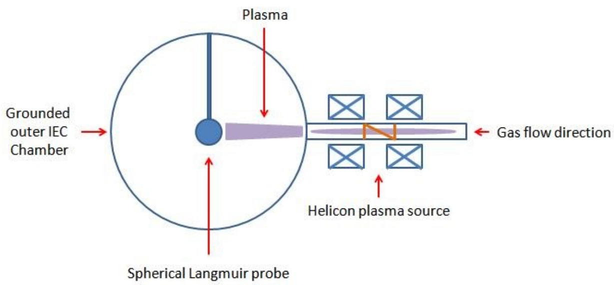

Figure 1: Experimental Langmuir probe setup.

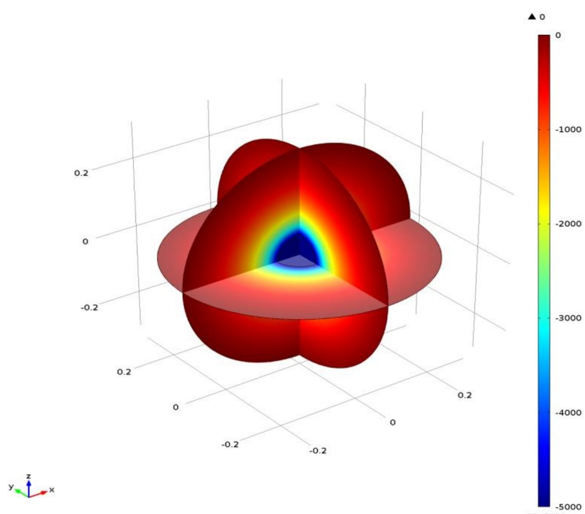

Figure 2: Voltage multi-slice COMSOL simulation of spherical Langmuir probe.