Progress in Numerical Simulation of HIIPER Space Propulsion Device

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Abstract

A coupled helicon/asymmetric inertial electrostatic confinement (IEC) plasma jet source is currently in development for space propulsion applications. This device takes a unique approach by decoupling the processes of ionization and acceleration. Collecting data about particle paths and energies in an asymmetric IEC device has been attempted for many years without success. Numerical computation is the only method currently available to attempt predictions about the behavior of this system. It is also critical to the rapid design of this thruster, named the Helicon Injected Inertial Plasma Electrostatic Rocket (HIIPER), that accurate predictions can be made. With COMSOL, rapid and detailed development and design of this new class of space thruster is possible. HIIPER is separated into two major components - the helicon for ionization and the IEC for acceleration. Both will be simulated independently to reduce overall computation time. The solution of the exit interface from the helicon with be the entry interface condition for the IEC. The helicon uses the RF and Plasma packages and is an inductively wound antenna of approximately 15 cm in axial length driven at 13.56 MHz. Geometrical effects on wave propagation such as domain radius, antenna length, and oscillator frequency are also considered in order to solve for an optimal antenna resonance configuration. The initial dielectric domain considered was vacuum, relative permittivity = 1.0, however, a more realistic model is to consider a plasma media in which the relative permittivity is negative or imaginary. Toward this end, COMSOL readily considers complex permittivity values, enabling a first attempt at modeling a plasma domain. The IEC uses the AC/DC package and is a sphere approximately 44 cm in diameter with a 13 cm diameter confinement grid with a three dimensional varying geometry, biased at -5000 Volts. At the lone asymmetric aperture there is a modified Einzel lens currently being developed with the aid of COMSOL to guide and extract ions and electrons to maintain space charge neutrality. COMSOL will be used to optimize the geometry and properly design the components to achieve this design goal. Since COMSOL is being used to aid in the design of this device, the expected result would be to fully model a system where a neutral gas enters the helicon, ionizes, passes to the IEC where it is accelerated, and then the modified Einzel lens collimates and extracts both ions and electrons out of the system to achieve space charge neutrality.

Figures used in the abstract

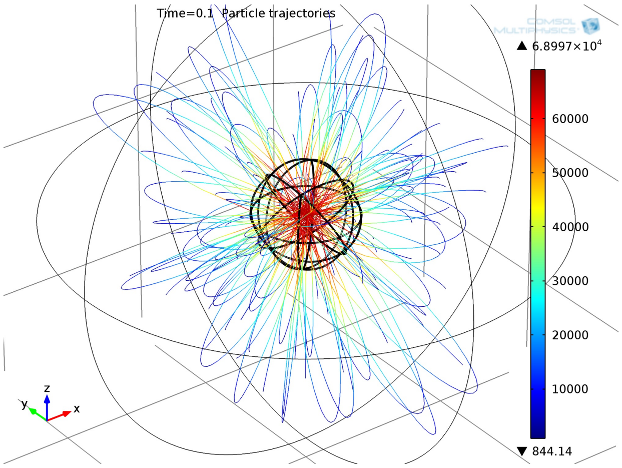

Figure 1: Ion Trajectories in Asymmetric Inertial Electrostatic Confinement Device.