Computational Study Of Adding Magnetic Nozzle In HIIPER Using Multiphysics

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

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

Abstract

Helicon Injected Inertial Plasma Electrostatic Rocket (HIIPER) [1] is a plasma thruster being researched at University of Illinois Urbana-Champaign. It has been shown in Figure 1. It involves a helicon source along with an Inertial Electrostatic Confinement (IEC) chamber. IEC is a fusion concept that has the potential to be applied to advanced space propulsion systems.

Current designs of space propulsion systems that use IEC suffer from excessive losses that make it difficult to generate significant thrust. HIIPER will utilize a conical magnetic nozzle that confines and accelerates the plasma to generate thrust [2]. Use of numerical simulations will allow to test various nozzle designs without investing large amount of time and money on manufacturing. Since installing a magnetic nozzle to the existing HIIPER setup is an intricate and costly job, COMSOL® simulations are being used to finalize an optimized design for the same. After designing and installing a magnetic nozzle, experimental results will be obtained to validate the COMSOL® results.

This setup involves 2D axisymmetric simulations that will utilize a constant plasma density and study its effects with changing magnetic field inside the nozzle. The study will involve an Electrostatic model for the IEC chamber coupled with the Plasma model. The Magnetic Fields interface will be added for simulating the effects of the magnetic nozzle. The Charged Particle Tracing interface will also be used to study the particle movement within the IEC and magnetic nozzle.

The results will involve the magnetic flux density, electric potential and ion trajectory for most favorable magnetic field of the nozzle. These results will be used to estimate ion flow rate and velocity changes due to a magnetic nozzle which in turn will allow to approximate thrust capabilities of the system. Results from the simulations are expected to quantify the improvement in thrust achieved by HIIPER [3] by the addition of a magnetic nozzle.

Reference

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. YungAn Chan and Georg Herdrich, “Inertial Electrostatic Confinement: Innovation for Electric Propulsion and Plasma Systems”, 5th International Electric Propulsion Conference, October 8-12, 2017, Georgia Institute of Technology, Atlanta, Georgia.
3. Drew Ahern, “Investigation of a Space Propulsion Concept Using Inertial Electrostatic Confinement”, PhD Dissertation (2018), University of Illinois at Urbana-Champaign.

Figures used in the abstract

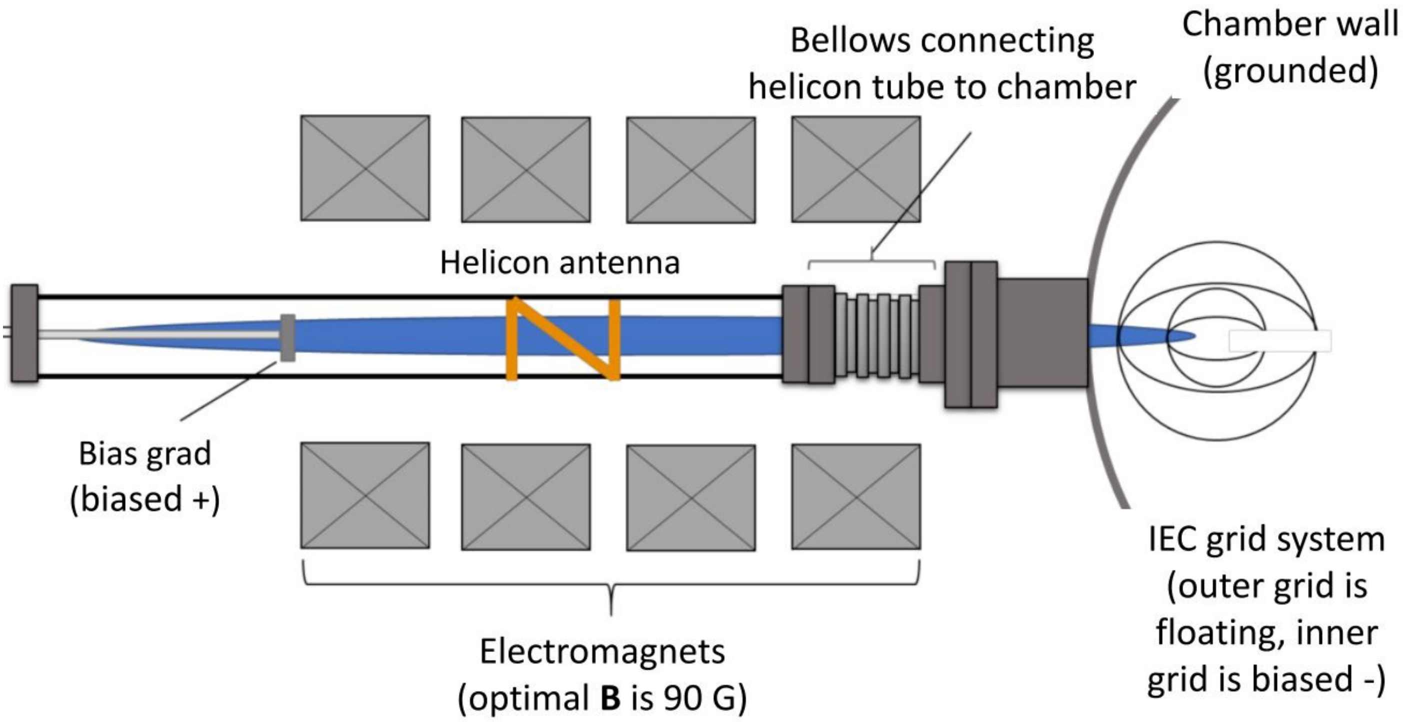

Figure 1 : Current HIIPER Setup

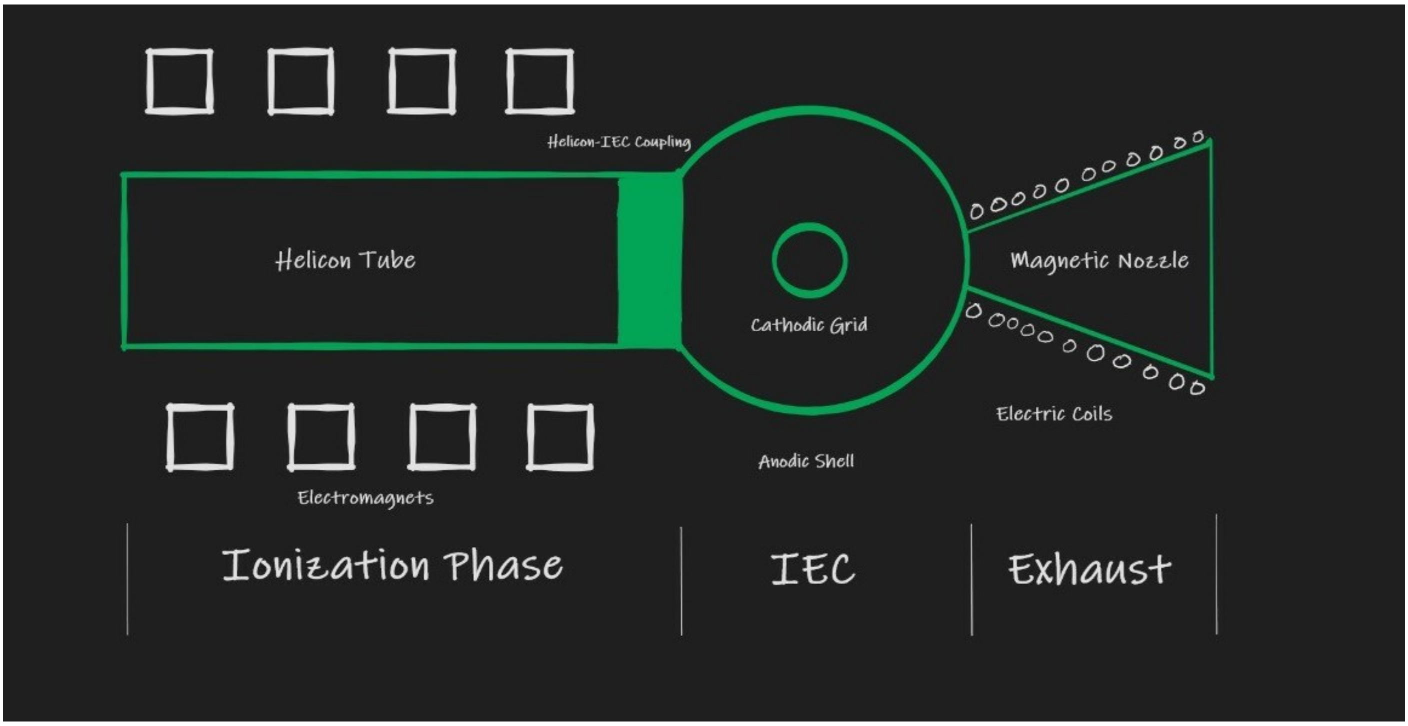

Figure 2 : Proposed HIIPER Setup

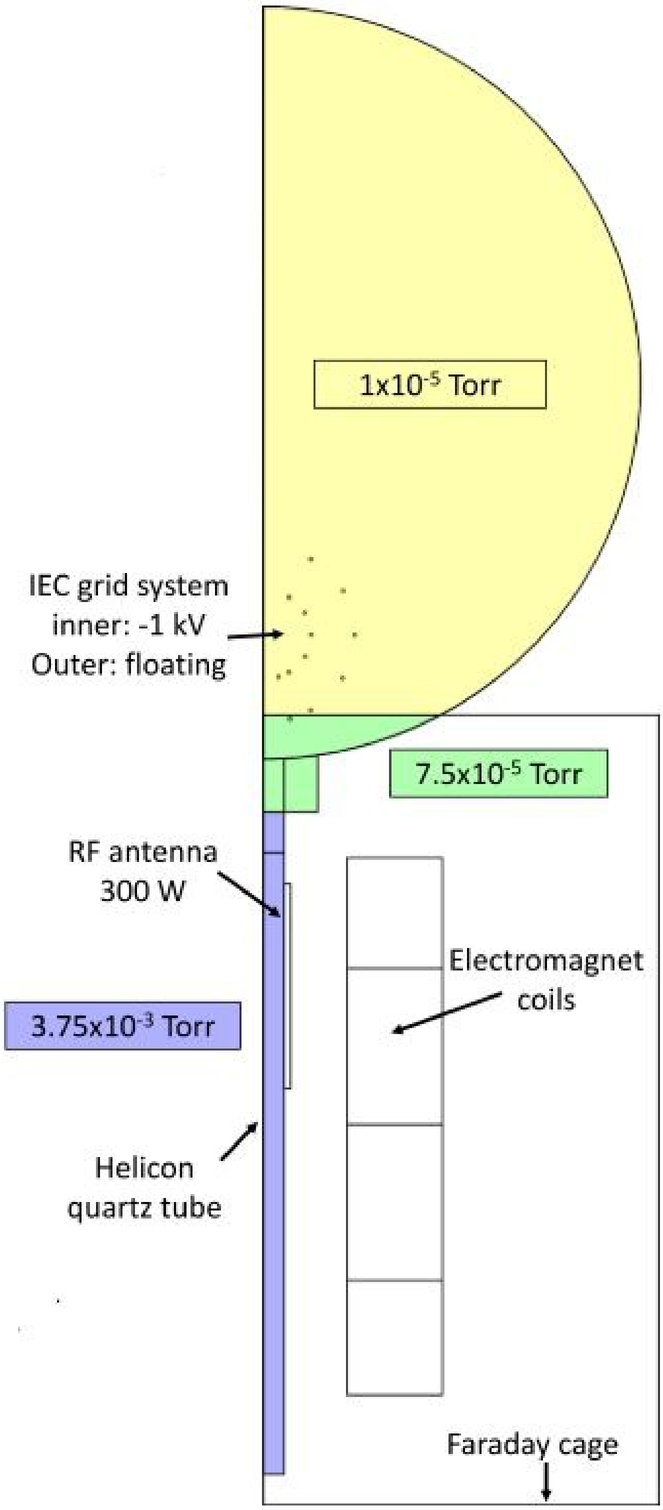

Figure 3 : HIIPER COMSOL Model