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Author: Mr. Alfio Vinci
ICARE-CNRS, France, alfio.vinci@cnrs-orleans.fr

Dr. Stephane MAZOUFFRE
CNRS, France, stephane.mazouffre@cnrs-orleans.fr

EFFECTS OF MAGNETIC NOZZLE GEOMETRY ON ION AND ELECTRON PROPERTIES

Abstract

Electrodeless plasma thrusters and magnetic nozzles (MN) offer interesting features for the purpose of producing thrust in space. Qualities like a current-free nature, the removal of plasma-electrodes interaction, the design simplicity, are the asset of this technology which can nominally operate without a dedicated neutralizer and on virtually any propellant. Most of the exploited kind of electrodeless devices, e.g. helicon plasma thrusters (HPT) and electron cyclotron resonance thrusters (ECRT), integrate a MN to increase the momentum of the ejected ions. A MN consists in an externally applied steady magnetic field with convergent-divergent geometry (or divergent only for ECRT) which enables the transport and acceleration of ions up to supersonic speeds into vacuum.

A number of transport phenomena occur in a MN as the result of inlet thermal energy usually stored in the electron population, such as an ambipolar electric diffusion and an azimuthal diamagnetic electron current. Both of them act in converting the electron energy in ion kinetic energy, the former as an electrostatic force term and the latter as an electromagnetic contribution. Under these circumstances, the geometry of the magnetic nozzle and the location of the throat are presumably strongly linked to the amount of the input energy that can be usefully converted into axial thrust.

Direct measurements of plasma properties throughout the MN are of particular interest for the purpose of deepening the physical understanding of this technology with the primary aim of improving the propulsive performance and consequently increase its maturity level. To this end, the present work reports on experimental results obtained in a helicon plasma source operating under several different external parameters. Ion and electron properties, e.g. density, ion current and electron cooling rate, are spatially resolved using a suite of diagnostics to study the effect of the external magnetic field geometry.