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Title

First ignition of a magnetic arch EPT cluster composed of two ECR plasma sources

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Abstract

Existing Electrodeless Plasma Thrusters (EPTs) such as the Helicon Plasma Thruster (HPT) or the Electron-Cyclotron Resonance Thruster (ECRT) consist of a cylindrical ionization vessel into which propellant is injected, and an external magnetic nozzle to expand the plasma and generate magnetic thrust[1][2]. While magnetic nozzles bring advantages such as contactless acceleration of the plasma or tuning of the magnetic topology, it imprints a high divergence angle to the plasma jet, increasing radial losses and creating a highly energetic plasma environment around the spacecraft[3]. As a consequence of this issue, EPTs have not yet proved competitive in terms of performances in comparison with mature technologies like Hall effect and gridded ion thrusters.

This work proposes and explores a new geometry for an EPT based on the interaction of two ECR sources and presents the design and experimental characterization of its laboratory prototype. The MAT2 thruster consists of two identical ECR sources with opposing polarities, each constituted of four main parts: a first coil meant to produce a sufficient magnetic field strength to enable Electron-Cyclotron Resonance (ECR) of the plasma, a magnetic nozzle coil, a cylindrical ionization vessel and an antenna allowing the transmission of the microwave power to ionize the neutral gas by ECR. The sources can be estranged one from another and can be tilted around their center. The main interest of this geometry lies on one key factor. The magnetic arch topology that forms outside of the thruster as the magnetic lines of the two magnetic nozzles with opposing polarity connect features a lower divergence than a single diverging, axisymmetric magnetic nozzle, and different expansion physics where the plasma-induced magnetic field is expected to play a major role. The MAT2 represents more a new type of EPTs than a simple combination of existing ones based on its magnetic arch and on the interaction in between the sources.

Moreover, the external expansion and interaction of the jointed plumes is placed at the center of this work as the new magnetic topology implies the possibility of enabling thrust vectoring and improved performances. Opposed polarity magnetic nozzles also raise new questions around the detachment of the plasma and its effects on the thruster's characteristics. RPA, Langmuir probe and Faraday cup measurements are carried out on the plume region of the MAT2 thruster prototype to characterize key plasma properties including plasma density, electron temperature, electrostatic potential, magnetic field, and ion current density.

References

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