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PARTICLE SIMULATIONS OF ION DETACHMENT IN THRUSTER MAGNETIC NOZZLE

Abstract

An ion detachment is a crucial issue for an electric propulsion engine having a magnetic nozzle. This is because there is no thrust when the ions follow the magnetic lines and turn back to the satellite. A number of publications were dedicated to study this issue and criteria have been suggested to predict the plasma detachment.

The paper presents numerical results obtained in terms of HPH.com project. The project main goal is a development of helicon thruster. A design loop requires a simple method to estimate the ion detachment. Therefore, the Particle-In-Cell (PIC) and hybrid/PIC methods were applied to perform numerical simulations of plasma expansion in a magnetic nozzle and to compare results with available criteria. XOOPIC software was used for computations. It is an open-source software and has been developed at University of California in Berkeley, USA.

A uniform plasma expansion has been considered in a magnetic field created with a current ring. The ring generates a magnetic field that expands slowly. Ions detach at a distance about 0.02 m from the thruster exit and this distance changes slightly with magnetic field strength, electron temperature and ion velocity at the thruster exit.

For the case under consideration a magnetic induced detachment that was studied for VASIMR project is unlikely possible. Inertia detachment parameter can help to predict a detachment location, however, the correspondent theory is not well developed (see AIAA Paper 2010-6613). Currently, the most reliable approach to find a detachment location is a computation of plasma expansion with PIC or hybrid/PIC methods for a given configuration of the magnetic field. A faster approach is to calculate a detachment position applying an ion-trajectory code that traces ions in the magnetic field. Such codes run much faster than any PIC or even hybrid/PIC codes and can be used in a design loop.