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Development of helicon plasma thruster for CubeSats at the University of Brasilia

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CubeSats are miniaturized satellites that have attracted much attention due to the low cost of developing, building and launching a space mission based on this platform, and are a popular choice for university training programs and student projects. Space propulsion systems can extend the lifetime of a CubeSat mission, however, the reduced energy budget available makes the design of propulsion systems a challenge [1].

Electric propulsion is an efficient alternative to chemical propulsion for orbit correction of satellites in Earth's orbit, and has also been employed in deep-space missions. The ambipolar thruster is a plasma propulsion device specifically designed for CubeSats, with several advantages including the absence of electrodes, and its relatively simple construction. Therefore, it is an attracting option for CubeSat propulsion.

The operation of an ambipolar thruster can be briefly described as follows. Neutral gas is injected into a cylindrical tube. Two ring-shaped permanent magnets provide a background magnetic field. A radiofrequency antenna in the center of the rings generates helicon waves that ionize the neutral gas. The resulting plasma is confined at the center of the tube due to the magnetic field from the permanent magnets, and exits the tube through the magnetic nozzle, giving thrust.

The Laboratory of Plasma Physics at the University of Brasilia (LPP-UnB) is currently developing a prototype of an ambipolar thruster to be employed in future Brazilian space missions involving CubeSats. Theoretical studies have been carried out by performing numerical simulations of the plasma particles inside the thruster. We employ the particle-in-cell (PIC) approach to represent electron and ion particles under different configurations of the background magnetic field and neutral gas distribution. These configurations are compared by computing the total thrust and the specific impulse.

A working prototype of an ambipolar thruster has also been constructed at the LPP-UnB. Figure 1 shows the prototype being tested inside a glass tube. The prototype allows to change the permanent magnet rings to test magnetic fields aligned with the axial and radial directions. Tests are being performed in a vacuum chamber including plasma diagnostics such as Langmuir probes, Faraday cusps and a simple thrust measurement system based on a load cell.

The LPP-UnB is also developing a helicon experiment which is a larger version of the ambipolar thruster [2]. This experiment consists of a 10 cm diameter glass tube filled with neutral gas, connected to a 15 cm diameter glass tube using a flange made from dielectric material. A set of two coils generates a magnetic field aligned with the axial direction at the center of the 10 cm tube, and creates a magnetic nozzle at the exit region. This experiment has been recently updated to install a system of rails supporting the magnetic coils, allowing them to move in the axial direction. This update will allow performing parametric studies by changing the position of the coils with respect to the RF antenna, by changing the distance between the coils, and changing the coils current to create different magnetic field topologies (e.g., a magnetic cusp configuration).

References

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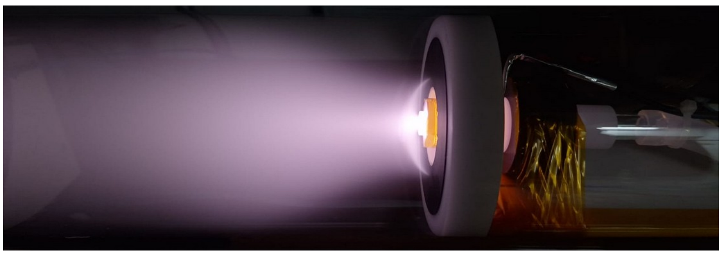

Figure 1: The ambipolar plasma thruster experiment during testing operation at the PPL-UnB.