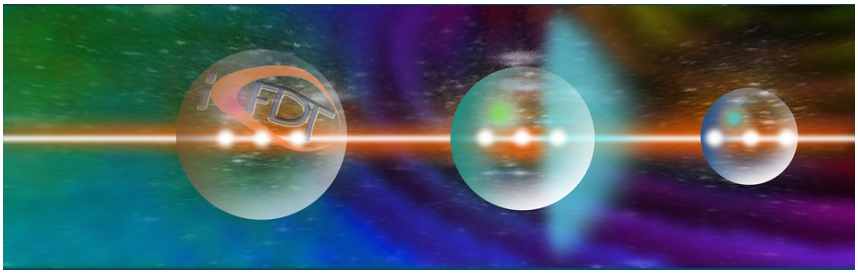

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Plasma characterization in Hall thrusters by Langmuir probes

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Hall thruster (HT) technology is a mature propulsive option for orbit-raising and station-keeping of satellites, benefiting from both widespread R\&D activities and heritage of in-space applications. A typical Hall thruster assembly essentially consists of an acceleration channel, often made of ceramic material, a magnetic circuit and two electrodes, i.e. the anode and the cathode. The magnetic field configuration of the thruster has a significant role in the acceleration process and, at the same time, on the wear of the thruster surfaces due to the ion bombardment. The aim of the present research activity was to study different, non-standard magnetic field configurations of a 5 kW HT, looking for an optimal compromise between the reduction of thruster erosion and its performance. The prototype tested was a flexible thruster mock-up based on SITAEL HT5k. The mock-up thruster was equipped with four arrays of flat tungsten probes, installed in the inner and outer channel walls to characterize the near-wall plasma properties at the channel exit. Furthermore, in order to obtain a complete characterization of the plasma behaviour inside the thruster, a triple Langmuir probe was used. The triple Langmuir probe was mounted on an articulated arm that rapidly inserted the probe inside the thruster channel, giving a clear picture of the relevant plasma properties along the channel centreline, from the near plume to the near-anode region. For each operating condition of the thruster, measurements were performed with different arrangements of the triple probe electrodes and with different applied potential differences between the electrodes. In order to analyse the data gathered by the triple probe, a Bayesian integrated data analysis was used. This method made it possible to combine measurements from different probe configurations and to improve the quality of the inferred plasma parameters. Non-uniformities of the plasma sensed by the probe electrodes were taken into account within the physical model considered to make the analysis. In order to model the interaction of the electrodes with the plasma, a parametrization of the Laframboise sheath solution was used. The performed experimental investigation, coupled with a reduced order model of the thruster plasma discharge, allowed reconstructing the profiles of the plasma properties along the discharge channel and near the thruster walls. The developed diagnostic system, together with the integrated data analysis, proved to be an effective tool to characterize the plasma flow in Hall thrusters.

Summary

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