Laser induced florescence spectroscopy for Hall thruster plasma diagnostics

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Ion-propelled space propulsion is gaining increasing popularity due to its ability to drastically reduce spacecraft propellant mass, with Hall thrusters standing out as one of the most extensively utilized types. In a Hall thruster, plasma is generated and sustained by utilizing crossed electric and magnetic fields, and ions are accelerated outward along a hollow discharge channel by the axial electric field. Due to the fact that thrust is generated by ions, studying ion dynamics holds significant importance in investigating not only physics but also performance of Hall thrusters. Laser-induced fluorescence (LIF) spectroscopy is a highly effective ion diagnostic technique that allows for local measurements of ion velocity distribution functions (IVDFs) with minimal disturbance to the plasma. This presentation focuses on the two-dimensional measurement of ionization and ion acceleration in Hall thruster plasmas using time-averaged LIF spectroscopy as the primary diagnostic tool. The axial and radial IVDFs were measured in two different xenon-fueled Hall thrusters that exhibit distinct magnetic field configurations. In the cylindrical Hall thruster, the magnetic field strength was found to have no correlation with ionization and ion acceleration in the region dominated by an axial magnetic field. The ionization region was located approximately 2/3 of the discharge channel length upstream from the channel exit, while the ion acceleration region extended over a length approximately 3.5 times that of the discharge channel. However, as the radial component of the magnetic field increased to a level comparable to the axial component, both the ionization region and the location of maximum electric field shifted toward the position of maximum radial magnetic field. Simultaneously, the length of the ion acceleration region decreased. Within the region dominated by the axial magnetic field, a notable population of high-speed ions was observed.

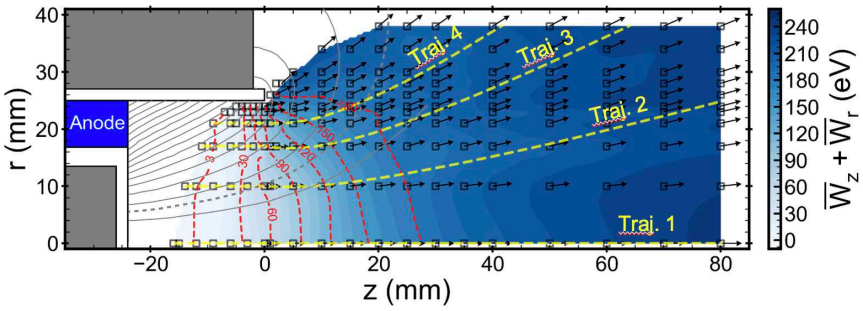

Figure 1. Mean energy (W) and velocity vector of xenon ions measured by time-averaged LIF spectroscopy in a cylindrical Hall thruster. Gray solid lines indicate magnetic field lines.

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