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Electron drift instability and secondary electron emission in Hall effect thrusters: An insight from bidimensional particle-in-cell simulations

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Despite electric propulsion (EP) having its beginning in the 1960's, its full potential has only been realized in the last few years, with all-electric communication satellites and large small-satellite constellation projects. Since Hall effect thrusters (HETs) are one of the most successful EP technologies, there is an increasing need for accurate and predictive models, in order to develop more effective, more powerful, and more energy efficient thrusters.

Typical HETs consist of three main components: (1) An external hollow cathode, providing electrons to sustain the plasma discharge and to neutralize the ion beam. (2) An annular ceramic channel where the propellant gas is injected through an anode, ionized, and accelerated (due to a potential difference applied between the anode and cathode). (3) A specially designed magnetic circuit used to produce a predominantly radial magnetic field to trap electrons in the channel region.

Numerous studies have shown that the electron mobility across this imposed magnetic field tends to be anomalously high in comparison to the predictions from classical diffusion theories. Historically, multiple mechanisms have been proposed to explain this anomaly: Intense secondary electron emissions (SEE), sheath instabilities, gradient driven instabilities, or electron drift instabilities.

The effect of these latter drift instabilities on the electron mobility has been recently investigated theoretically, and since unscaled 3D PIC simulations are still out of reach, r-theta simulations using a 2.5D PIC simulation model where used to investigate this correlation. However experimental as well as simulation studies show that walls materials, and thus secondary electron emissions, do play an important role in the plasma discharge behavior. Hence the model was extended with a well-known linear SEE model in order to investigate their effects on the electron anomalous transport through a parametric study.

These model improvements enabled a deeper look into the thruster operation, and allow us to differentiate the relative importance of some of the mechanisms producing enhanced electron transport as well as identifying plasma discharge regimes.

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