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Transient Phenomena in a 100 W Hall Thrusters: Experimental Measurements of Discharge Current and Plasma Parameter Evolution

Authors : Clémence Royer, Stéphane Mazouffre

Abstract : Nowadays, electric propulsion systems play a crucial role in space exploration missions due to their high specific impulse and long operational life. The Hall thrusters are one of the most mature EP technologies. It is a gridless ion thruster that has proved reliable and high-performance for decades in various space missions. Operation of HT relies on electron emissions through a cathode placed outside a hollow dielectric channel that includes an anode at the back. Negatively charged particles are trapped in a magnetic field and efficiently slow down. By collisions, the electron cloud ionizes xenon atoms. A large electric field is generated in the axial direction due to the low electron transverse mobility in the region of a strong magnetic field. Positive particles are pulled out of the chamber at high velocity and are neutralized directly at the exhaust area. This phenomenon leads to the acceleration of the spacecraft system at a high specific impulse. While HT's architecture and operating principle are relatively simple, the physics behind thrust is complex and still partly unknown. Current and voltage oscillations, as well as electron properties, have been captured over a 30 mn time period after ignition. The observed low-frequency oscillations exhibited specific frequency ranges, amplitudes, and stability patterns. Correlations between the oscillations and plasma characteristics we analyzed. The impact of these instabilities on thruster performance, including thrust efficiency, has been evaluated as well. Moreover, strategies for mitigating and controlling these instabilities have been developed, such as filtering. In this contribution, in addition to presenting a summary of the results obtained in the transient regime, we will present and discuss recent advances in Hall thruster plasma discharge filtering and control.

Keywords : electric propulsion, Hall Thruster, plasma diagnostics, low-frequency oscillations
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