Beauty and the Beast: A Novel Approach to the Reasons of Plasma Instabilities in Hall Thrusters

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Plasma propulsion engines are devices that use electromagnetic fields to excite and accelerate gases to generate thrust. One of the major challenges plasma propulsion engines face today is their shortened lifespan and decreased efficiency due to plasma instabilities. Thus, understanding the reasons why plasma instabilities occur, how they affect the overall efficiency of the engines, and how they differ in practical applications still remains as an intellectual challenge that needs to be solved. In this research, a specific type of plasma propulsion engine called hall thruster is selected as the control group for the experiment. During the data collection stage, different voltage, current, and gas flow rates are selected as independent variables for two cathode setups. Thrust output, power consumption, and plasma formation are used as dependent variables of the experiment. Hollow cathode and filament cathode setups are compared to each other in terms of efficiency and stability. The hollow cathode configuration is shown to produce less thrust than the filament cathode configuration with 3-11 millinewtons and 7-23 millinewtons of optimum thrust outputs respectively. The hollow cathode configuration is shown to suffer from ion-electron and electron-electron instabilities, making the plasma highly unstable throughout experiments, whereas the filament cathode configuration is shown to have minor signs of electron-ion instabilities with a stable plasma formation. This study showed that the filament cathode configuration performed better than hollow cathode configuration in terms of not only thrust output, put also the stability of plasma formation, and is more applicable for long-term space missions when compared to hollow cathode configuration.