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Electron and Ion Transport in Hall Effect Thrusters[1]

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Hall Effect Thrusters (HETs) are gridless ion sources that can provide thrust on the order of 80 mN per kW of electrical power, with propellant velocity in the 20-30 km/s range. HETs are well suited for tasks such as satellite station keeping and are also considered for interplanetary missions. For these missions, where a small thrust is needed over a long period of time, their large propellant velocity makes them much more efficient than chemical thrusters and allows important cost reduction. The plasma in HETs is generated in the channel between two concentric dielectric cylinders. The anode is located at one end of the channel and the cathode is outside the channel. Gas (xenon) is injected through the anode and is ionized by electrons flowing to the anode. Xenon ions are accelerated by the electric field resulting from a drop of electron conductivity induced by the presence of a magnetic field barrier perpendicular to the electron path from cathode to anode. After a general introduction on space propulsion, the lecture will focus on basic physics questions related to electron and ion transport in a HET. Since most of the neutral flow is ionized, the neutral gas density in the exhaust region of a HET is not large enough to allow collisional electron transport across the magnetic field and to explain experimental measurements. We will describe recent efforts[1] aimed at understanding the observed anomalous transport, and present a synthesis of results from Particle-In-Cell (PIC) models, Hybrid Models, Laser Induced Fluorescence measurements and Collective Scattering (CS) experiments. PIC simulations predict and CS experiments seem to confirm that electron transport perpendicular to the magnetic field is due to the development of an azimuthal drift instability.

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