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Cross-field diffusion in Hall thrusters and other plasma thrusters

J.P. BOEUF, LAPLACE, Universite de Toulouse, France — Understanding and quantifying electron transport perpendicular to the magnetic field is a challenge in many low temperature plasma applications. Hall effect thrusters (HETs) provide an excellent example of cross-field transport. The HET is a very successful concept that can be considered both as a gridless ion source and an electromagnetic thruster. In HETs, the electric field E accelerating the ions is a consequence of the Lorentz force due to an external magnetic field B acting on the $E \times B$ Hall electron current. An essential aspect of HETs is that the $E \times B$ drift is closed, i.e. is in the azimuthal direction of a cylindrical channel. In the first part of this presentation we will discuss the physics of cross-field electron transport in HETs, and the current understanding (or non-understanding) of the possible role of turbulence and wall collisions on cross-field diffusion. We will also briefly comment on alternative designs of ion sources based on the same principles as the conventional HET (Anode Layer Thruster, Diverging Cusp Field Thrusters, End-Hall ion sources). In a second part of the presentation we show that the Lorentz force acting on diamagnetic currents (associated with the $\nabla P_e \times B$ term in the electron momentum equation) can also provide thrust. This is the case for example in helicon thrusters where the plasma expands in a magnetic nozzle. We will report and discuss recent work on helicon thrusters and other devices where the diamagnetic current is dominant (with some examples where the $\nabla P_e \times B$ current is not closed and is directed toward a wall!).

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