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Modeling magnetized plasma jets in electric propulsion

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Understanding the expansion of the plasma plume produced by an electric propulsion system into vacuum is a fundamental problem for predicting the thruster performance, improving thruster design, and flagging any potential spacecraft integration problems due to plasma-surface interaction.
This talk covers, firstly, the key challenges of modelling a magnetized plasma jet in a divergent magnetic field or magnetic nozzle (MN). A MN is the main acceleration stage in several electrodeless plasma thrusters such as the helicon plasma thruster (HPT), the electron cyclotron resonance thruster (ECRT), the VASIMR, and the applied-field MPD thruster.
A two-fluid, steady-state model with fully-magnetized electrons but partially-magnetized ions is used as the basis to understand the magnetized plasma expansion. Ion acceleration, thrust generation, and plasma detachment are analyzed as a function of the parameters of the problem. The possibility of using a 3D MN to obtain contactless thrust vector control capabilities is also presented.
Secondly, the talk comments on other aspects related to magnetized (and unmagnetized) plasma plumes:
In HPTs and ECRTs an electromagnetic wave is used to create and heat the plasma in the thruster chamber. The propagation and absorption pattern of this wave is essential for the operation of the device. An approach to understand plasma-wave effects in the MN region of these thrusters and optimize thruster design is presented.
Then, a kinetic model that integrates directly Vlasov's equation to explore the EVDF response in the collisionless plasma is discussed, with the main goal of understanding collisionless electron cooling mechanisms and its effect in setting the total electric potential drop and the final energy of the supersonic ion beam. The unmagnetized counterpart to this kinetic model is also presented to compare the analogies and differences that exist with magnetized plasma plumes.

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