Gas Kinetic Study of Magnetic Field Effects on Plasma Plumes
Master of Science Thesis Defense

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Abstract

Plasma flow physics in magnetic nozzles must be clearly understood for optimal design of plasma propulsion devices. The crucial steps necessary for thrust generation in magnetic nozzles are energy conversion, plasma detachment, and momentum transfer. These three physical phenomena must be understood to optimize magnetic nozzle design and are discussed. The operating dimensionless parameter ranges of six prominent experiments are considered and the corresponding mechanisms are discussed. An order of magnitude analysis of the governing equations reveal: i) most magnetic nozzles under consideration operate at the edge of the continuum regime rendering continuum-based description and computation valid; ii) in the context of MHD framework, the generalized Ohm's law must be used to capture all of the relevant physics. We continue the development of the Magneto Gas Kinetic Method (MGKM) computational tool. Validation of the solver is performed in shock-tube and Hartmann channel flows in the Hall physics regime. Novel numerical experiments of magnetic nozzle plasma jets in the Hall regime are performed, confirming the theoretically predicted azimuthal rotation of the plasma jet due to Hall physics. Preliminary results are encouraging for future magnetic nozzle studies and further challenges are identified.

Frans Ebersohn is a MS candidate in the Aerospace Engineering Department working under the supervision of Professor Girimaji. His research interests are in the areas of space propulsion and plasma physics. He is continuing to the PHD at the University of Texas-Austin.