Magnetic field effects on plasma plumes

F. Ebersohn[1;2], J. Shebalin[1], S. Girimaji[2], D. Staack[2]

[1]*NASA Johnson Space Centre, Houston, TX, USA*

[2]*Texas A&M University, College Station, TX, USA*

Here, we will discuss our numerical studies of plasma jets and loops, of basic interest for plasma propulsion and plasma astrophysics. Space plasma propulsion systems require strong guiding magnetic fields known as magnetic nozzles to control plasma flow and produce thrust. Propulsion methods currently being developed that require magnetic nozzles include the VAriable Specific Impulse Magnetoplasma Rocket (VASIMR) [1] and magnetoplasmadynamic thrusters. Magnetic nozzles are functionally similar to de Laval nozzles, but are inherently more complex due to electromagnetic field interactions. The two crucial physical phenomenon are thrust production and plasma detachment. Thrust production encompasses the energy conversion within the nozzle and momentum transfer to a spacecraft. Plasma detachment through magnetic reconnection addresses the problem of the fluid separating efficiently from the magnetic field lines to produce maximum thrust. Plasma jets similar to those of VASIMR will be studied with particular interest in dual jet configurations, which begin as a plasma loops between two nozzles. This research strives to fulfil a need for computational study of these systems and should culminate with a greater understanding of the crucial physics of magnetic nozzles with dual jet plasma thrusters, as well as astrophysics problems such as magnetic reconnection and dynamics of coronal loops.[2] To study this problem a novel, hybrid kinetic theory and single fluid magnetohydrodynamic (MHD) solver known as the Magneto-Gas Kinetic Method is used.[3] The solver is comprised of a "hydrodynamic" portion based on the Gas Kinetic Method and a "magnetic" portion that accounts for the electromagnetic behaviour of the fluid through source terms based on the resistive MHD equations. This method is being further developed to include additional physics such as the Hall effect. Here, we will discuss the current level of code development, as well as numerical simulation results.

References

[1]   F. Chang-Diaz, "The VASIMR Rocket," Scientific American, 10, pp.90-97 (2000).

[2]   R.A. Kopp, Solar Physics, 50, pp.85-98 (1976).

[3]   D. Araya, "Resistive MHD Simulations of Laminar Round Jets with Application to Magnetic Nozzle Flows", M.Sc. Texas A&M University: U.S.A. (2011).