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Magnetic Nozzle and Plasma Detachment Scenario[1]

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Some plasma propulsion concepts rely on a strong magnetic field to guide the plasma flow through the thruster nozzle. The question then arises of how the magnetically controlled plasma can detach from the spacecraft. This talk presents a magnetohydrodynamic detachment scenario in which the plasma stretches the magnetic field lines to infinity [1]. Such a scenario is of particular interest for high-power thrusters. As plasma flows along the magnetic field lines, the originally sub-Alfvénic flow becomes super-Alfvénic: this transition is similar to what occurs in the solar wind [2]. In order to describe the detachment quantitatively, the ideal MHD equations have been solved analytically for a plasma flow in a slowly diverging nozzle. The solution exhibits a well-behaved transition from sub- to super-Alfvénic flow inside the nozzle and a rarefaction wave at the edge of the outgoing flow. The magnetic field in the detached plume is almost entirely due to the plasma currents. It is shown that efficient detachment is feasible if the nozzle is sufficiently long. In order to extend the detachment model beyond the idealizations of analytical theory, a Lagrangian fluid code has been developed to solve steady-stated MHD equations and to optimize nozzle efficiency by adjusting the magnetic coil configuration. This numerical tool enables broad parameter scan with modest computational requirements (single workstation). The code has been benchmarked against the idealized analytical picture of plasma detachment and then used to investigate more realistic nozzle configurations that are not analytically tractable. Most recently, the code has been used to interpret experimental data from the Detachment Demonstration Experiment (DDEX) [3] facility at NASA Marshall Space Flight Center. In collabotation with: M. Tushentsov, A. Arefiev, R. Bengtson, J.Meyers (University of Texas at Austin), D. Chavers, C. Dobson, J. Jones (Marshall Space Flight Center), B.Schuettpelz, (University of Alabama in Huntsville), C. Deline (University of Michigan).

[1] A. Arefiev and B. Breizman,Phys. Plasmas **12**, 043504 (2005).
[2] E. N. Parker, Astrophys. J.**128**, 664 (1958).
[3] D. Chavers et al., “Status of Magnetic Nozzle and Plasma Detachment Experiment,” CP813, Space Technology and Applications International Forum, pp. 465-473, AIP 2006.

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