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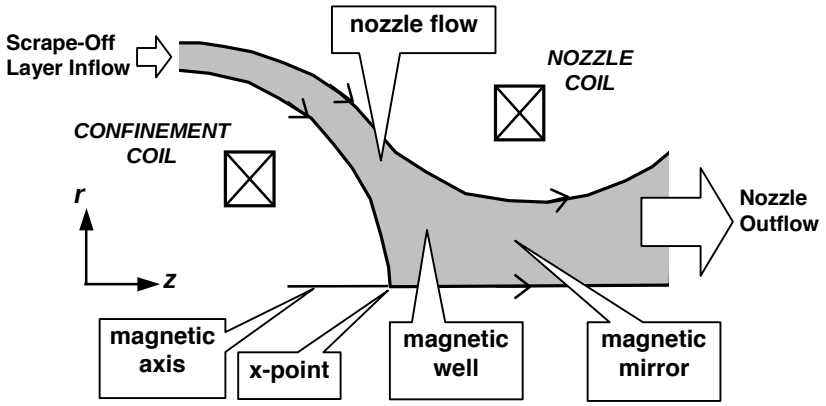
# Plasma Flow Control in a Magnetic Nozzle for Electric Propulsion and Fusion Scrape-Off Layer Applications*

Alfonso G. Tarditi[1] and Loren C. Steinhauer[2]

[1]Advanced Space Propulsion Laboratory, NASA Johnson Space Center, Houston, TX (USA)
[2]University of Washington, Redmond Plasma Physics Laboratory, Seattle, WA (USA)

The control of the plasma flow in a magnetic nozzle configuration has application to both space plasma propulsion and to the design of the scrape-off layer (SOL) region in fusion devices. A conceptual flow-control scheme is derived, for example, by merging a field-reversed configuration (FRC) confinement topology with a magnetic nozzle, as illustrated in the figure below. The confinement coil can be thought as one of the two mirror coils of an FRC. The structure is characterized by an x-point on the axis, which creates a magnetic well region, while the nozzle coil generates another mirror downstream, now external to the SOL flow. The nozzle is annular at the source end with a spindle-like channel at the exit. The combination of magnetic well and mirror may allow control of both the flow rate and exit jet speed. In some ways the flow resembles that in the fluid-dynamics Laval nozzle in which the flow rate is regulated by a sonic "choking" condition at the nozzle throat (that in this case corresponds to the magnetic mirror).




Effects peculiar to this magnetic topology can be exploited to control the flow: when the mean free-path is comparable to the magnetic well length then the overall flow rate can be strongly throttled. Furthermore, a conducting end plate in the SOL region (for example, on the opposite side of the nozzle) causes a shorting of the magnetic field lines. The current drawn on the plate sets a $\boldsymbol{j}\times\boldsymbol{B}$ rotation of the plasma in the duct along the azimuthal direction: this centrifugal effect can also regulate the overall flow.

This configuration is being modeled both analytically, by a double-adiabatic flow model, and numerically, by a fluid simulation with the *NIMROD* code. Details of the model developments and preliminary simulation results are presented.

** Work supported by NASA (AGT) and by USDOE Grant DE-FG03-98ER54480 (LCS)*