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PLASMA FLOWS AND ACCELERATION IN A MAGNETIC NOZZLE AND MIRROR

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Plasma flow and acceleration in the magnetic nozzle (mirror) with converging-diverging magnetic configuration are important for applications in electric propulsion and fusion systems such as open mirrors and tokamak divertors. A relatively simple quasi two dimensional paraxial model offers useful analytical insights on many processes in the nozzle. We present some recent results of recent analytical and computational studies. The non-monotonic magnetic field with a local maximum of the magnetic field is necessary for forming the quasi-neutral accelerating potential structure with a unique velocity profile entirely determined by the magnetic field. The explicit form of the solution can be obtained in the form of the Lambert function. The fluid model for acceleration of cold ions has been further extended to include the effects of warm ions with anisotropic ion pressure. It is shown that the perpendicular ion pressure enhances plasma acceleration due to the mirror force. The kinetic effects have been investigated using the fully kinetic model also taking into account the sheath effects formed in the expansion region near the absorbing walls. Further generalization includes the role of the induced azimuthal magnetic field and plasma rotation, i.e., coupling with Alfven wave dynamics. It is shown that the inhomogeneous magnetic field couples the axial plasma flow with the evolution of the azimuthal magnetic field and plasma rotation resembling the problem of the magnetically driven flow in astrophysical jets and winds. The role of the Alfven, slow, and fast magnetosonic point singularities in plasma acceleration and plasma detachment are discussed.