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(I) Plasma flow and acceleration in the magnetic flux tubes

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Plasma flow and acceleration in the magnetic nozzle with converging-diverging magnetic configuration are important for applications in electric propulsion and fusion systems such as open mirrors and tokamak divertors. We report on some features of plasma acceleration in the magnetic nozzle that have been revealed in recent analytical and computational studies. The non-monotonic magnetic field with a local maximum of the magnetic field is necessary for forming the quasineutral 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 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 quasineutral hybrid model with kinetic ions and isothermal Boltzmann electrons. It is shown that in the cold ions limit the velocity profile agrees well with the analytical theory. The full kinetic simulations, including the ions and electrons within the quasi- two dimensional paraxial model, further confirmed these results. 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 is discussed.

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Magnetic flux tubes

Keyword-2

Alfven waves

Keyword-3

magnetic nozzle

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