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A Flute Instability under the ExB Shear Flow in an Open System

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A flute mode is the most dangerous instability in an open system such as the GAMMA10 tandem mirror. So how to stabilize the flute instability is an important problem. This paper studies the stabilizing effects of the ExB shear flow on a flute instability in the Cartesian geometry by the particle simulation and in the GAMMA10 magnetic field by the reduced MHD simulation. The particle simulation uses the (2 and 1/2) dimensional electrostatic implicit code with 128x128 meshes. Ions (electrons) are distributed to have the step functional density profile in x and the ions (electrons) flow in the y-direction with the ExB drift shear as an initial condition. The gravitational acceleration force g is applied in the x-direction. It was found that the flute mode was always unstable to the step functional density profile in x, where conducting boundary condition in x and the periodic boundary condition in y were adopted. The shear flow can excite the Kelvin-Helmholtz (K-H) instability which is stable in the uniform shear flow. A flute instability was transformed into a K-H instability after linearly growing phase. Whether the system is unstable to a flute mode depends on whether the excited K-H mode has an enough power of collapsing the system. It was newly found the suppression condition of plasma collapse (or the stability condition of secondary instability) with discontinuous density step under the uniform shear flow. The flute instability under the shear flow in GAMMA10 was investigated by using the reduced MHD code. Here the centrifugal acceleration of ions resulting from a magnetic field line curvature is included in the radial dependence of magnetic field line specific volume in the code. The shear flow is inputted initially by the equilibrium dynamic plasma vorticity and the resultant electrostatic potential. The reduced MHD simulation adopts the smooth radial pressure profile as an initial condition with uniform azimuthal shear flow. It was found that the linear growth rate of a flute instability was decreased by the ExB shear flow, so that the linear stability analysis was applicable in the smooth pressure radial profile. The reduced MHD simulation found that the flute instability was stabilized by the ExB shear flow in the linear phase. So it was newly determined the stability condition of the flute instability by the ExB uniform shear flow in GAMMA10.

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