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Study on Switch-off Magnetic Reconnection Due to the Parallel Shear Flow

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Magnetic reconnections take place in many regions in space. In the process of magnetic reconnection, magnetic energy stored in the magnetic field is converted into the plasma kinetic energy rapidly. Usually, magnetic reconnection takes place at the current sheet that separates two plasma regions which have anti-parallel magnetic field components. A layered plasma structure composed of MHD discontinuities and expansion waves is formed in the outflow region.This layered plasma structure is called the reconnection layer. In this paper, the development of the structure of symmetric and asymmetric reconnection layer in the presence of a shear flow parallel to the anti-parallel magnetic field component is studied by using a set of one-dimensional (1D) magnetohydrodynamic (MHD) equations. The Riemann problem is simulated through a second-order conservative TVD scheme, in conjunction with Roe's averages for the Riemann problem.

The simulation results indicate that besides the MHD shocks and expansion waves, there exist some new small-scale structures in the reconnection layer. The capturing of these small scale structures depicts that the numerical method used has high resolution and accuracy. For the case of zero initial guide magnetic field (i.e., B_{y0}=0), a pair of intermediate shock (IS) and slow shock (SS) is formed in the presence of the parallel shear flow. The critical velocity of initial shear flow V_{zc} is just the Alfven velocity in the inflow region. As $V_{z\infty}$increases to the value larger thanV_{zc}, a new slow expansion wave (SE) appears in the position of SS in the case $V_{z\infty}$ <V_{zc}, and the magnetic reconnection is switched off. For B_{y0} ≠0, a pair of SSs and an additional pair of time-dependent intermediate shocks (TDISs) are found to be present. Similar to the case of B_{y0}=0, there exists a critical velocity of initial shear flow V_{zc}. The value of V_{zc} is, however, smaller than the Alfven velocity of the inflow region.

Numerical investigations showed that in the symmetric anti-parallel reconnection case, the critical shear flow velocity V_{zc} is the inflow Alfven velocity V_A, which has been proved by Mitchell and La Belle-Hamer. As for the symmetric component reconnection case, V_{zc} decreases with the guide field increasing and has the same value of $z$direction component of inflow Alfven velocity. However, an interesting result that the critical shear flow is independent with the inflow Alfven velocity, was found in the case of asymmetric reconnection, in which V_{zc} is between the z direction components of magnetosheath and magnetosphere. A new hybrid velocity $V_{Azm} = B_{zms}/(\mu*\rho_m)^{1/2} = 2 * B_{zm} * B_{zs}/((B_{zm} + B_{zs})*(\mu*\rho_m)^{1/2})$ was introduced, where B_{zms} is z direction component of hybrid magnetic field. Numerical results indicated that V_{Azm} is the critical shear flow velocity in the case of asymmetric magnetic reconnection.