§9. Impulsive Nature in Collisional Driven Reconnection

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Compressible magnetohydrodynamic (MHD) simulation is carried out in order to investigate energy relaxation process of the driven magnetic reconnection in an open finite system through a long time calculation. The initial condition we adopt is Harris-Type equilibrium that is anti-parallel magnetic type, and resistivity is assumed to be uniform.

Recently, it has been revealed through a simulation study that an open system where a flux of energy is continuously supplied exhibits significant characteristics such as intermittency and recurrent behavior.[1] The study was made on global scale nonlinear behavior in a resistive MHD plasma. Here we suppose that intermittency would arise in various classes of nonlinear response in a complex system of plasma. In this work, having in mind a similar expectation, we focus on an important elementary process in a resistive MHD plasma, that is, magnetic reconnection. Another expectation is that existence of such intermittent nature in reconnection, if any, may be directly related with a possible mechanism of what is called ' fast reconnection '. Magnetic reconnection has been thought to play a fundamental role in the dynamics of various impulsive magnetic phenomena, for instance, the fast crash in sawtooth oscillations observed in tokamak plasmas and an impulsive energy release observed in the solar flare. In this work, we examine whether or not the fast reconnection can occur in a ' pure ' resistive MHD plasma where the Ohm's law in its simplest form is used.

Surprisingly and in contrast to the conventional simulations, long time scale calculations have disclosed intermittent and very impulsive phenomena in the energy relaxation process of the driven magnetic reconnection. Figure 1 shows the temporal evolution of the electric field E_z at origin which is nearly equal to E_z at the X-point for three different driving rate E_{z0}. Recalling that E_z at the X-point is equivalent to the rate of magnetic flux change on the X-point, the reconnection rate is found to be impulsively and intermittently intensified. It is usually believed that in the MHD driven reconnection the saturated level of the reconnection rate must be as large as the external driving electric field E_{z0}(dashed line) that is expressed as $\boldsymbol{v} \times \boldsymbol{B}$ on the boundary.[2] The appearance of the strong peak of E_z at the X-point in the impulsive phase indicates a very fast reconnection. It follows from Fig.1 that the peak intensity of an impulse is proportional to the intensity of the driving electric field E_{z0}.

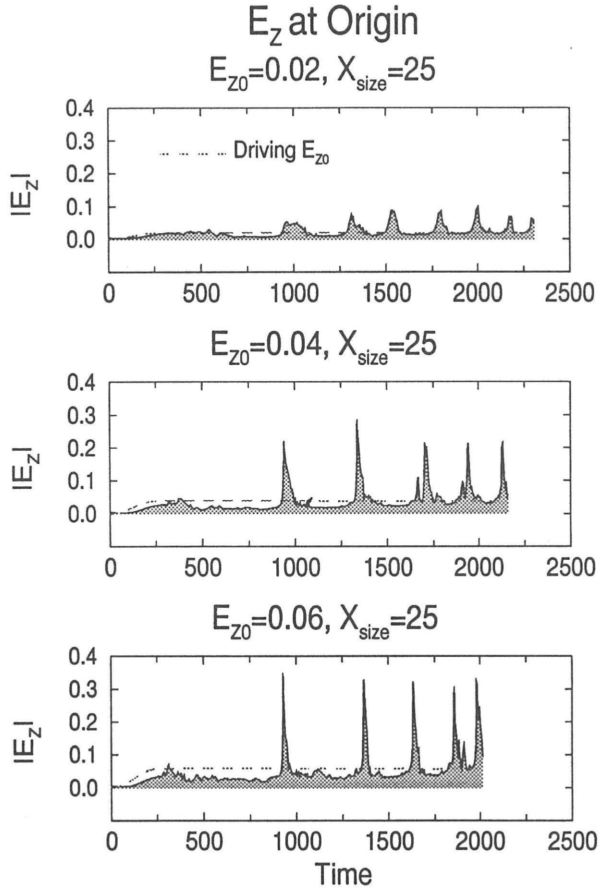

Fig. 1. Temporal evolution of electric field E_z at origin for three different driving rate E_{z0}.

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References

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2)Sato, T., Hayashi, T., Phys. Fluids 22 (1979) 1189.