Geophysical Research Abstracts
Vol. 12, EGU2010-4771, 2010
EGU General Assembly 2010

Kinetic pressure force in collisioness magnetic reconnection

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We present a numerical study of symmetric collisionless magnetic reconnection. Using a 2D hybrid simulation code we focused on the ion acceleration both from the kinetic and the fluid point of vue. We show that an off-diagonal pressure force originating from the particle dynamics contributes to the fluid bulk energy budget roughly as much as the Hall electric field.

The fast electron flow created by the reconnection electric field, is responsible for a sharp electrostatic potential drop inside of the separatrix region, normal to the magnetic field. From the kinetic perspective, individual ions coming from the inflow region are demagnetized and greatly accelerated when going through this potential drop. Then they bounce in the potential well and, thanks to the small divergence of the structure, transfert some of their kinetic energy to the outflow direction.

From the fluid perspective it is understood for many years now that this Hall electric field plays a crucial role in increasing the downstream bulk velocity of the ions, allowing a fast reconnection rate, as opposed to the MHD regime where such effect is prohibited. However, we show here that the kinetic dynamics of the ions inside the seperatrix region creates a quadrupolar structure of the in-plane off-diagonal pressure around the reconnection site. When taken into account into the fluid momentum equation, the resulting pressure force , located on the separatrices, is found to work against the electric field and has roughly the same amplitude. A small but finite difference between these to forces allows the fluid to be accelerated. This pressure tensor effect is rarely taken into account in fluid simulations despite its apparent importance on the energy point of view.