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Electron and Ion Heating/Acceleration in Driving Magnetic Reconnection

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Driven magnetic reconnection is a key physical process of converting magnetic energy into plasma energy. As plasma embedded in oppositely directed magnetic fields merge toward each other, the oppositely directed magnetic fields reconnect so that the plasma and magnetic field flow to the downstream regions. During the driven magnetic reconnection process a part of the magnetic energy is converted into the plasma energy. We will first introduce the concept of driven magnetic reconnection. Then, we will show that the kinetic physics of magnetic reconnection gives very different physics from fluid models. In particular, we will explain how the parallel electric field and electrostatic electric field are produced by the decoupling of the electron and ion dynamics and how and where electrons and ions are accelerated/heated.

In the weak guide field case ($B_g < B_p$), The electrons are accelerated around the separatrix regions by the parallel electric field and in the reconnection region by the reconnection electric field and the converging normal electrostatic electric field. The ions gain energy mainly from the electrostatic potential drop as they move from the upstream into the downstream region. We show that the potential drop and thus the increase of ion temperature are proportional to the square of the upstream merging poloidal field.

When a strong guide field is present ($B_g >> B_p$), the physical mechanisms of the parallel electric field and electrostatic electric field and thus the electron and ion heating/acceleration are quite different from the weak guide field case because both the electron and ion dynamics become magnetized in the entire reconnection domain in the strong guide field case. We will explain these physical processes based on the first principle.

Finally, we will show that the electron and ion heating/acceleration results from the kinetic simulations/theory are consistent with those obtained in the laboratory magnetic reconnection experiments and in space observations.

References

C. Z. Cheng, S. Inoue, Y. Ono, R. Horiuchi, Physical processes of driven magnetic reconnection in collisionless plasmas: Zero guide field case, Phys. Plasmas 22, 101205 (2015)

C. Z. Cheng, S. Inoue, Y. Ono, R. Horiuchi, Decoupling of electron and ion dynamics in driven magnetic reconnection in collisionless plasmas, Plasma Fusion Res. 11, 1401081 (2016)

S. Inoue, Y. Ono, H. Tanabe, R. Horiuchi, C. Z. Cheng, Numerical study of energy conversion mechanism of magnetic reconnection in the presence of high guide field, Nucl. Fusion 55, 083014 (2015)

Y. Ono, et al., Ion and electron heating characteristics of magnetic reconnection in two flux loop merging experiment, Phys. Rev. Lett. 107, 185001 (2011)

H. Tanabe, et al., Electron and ion heating characteristics during magnetic reconnection in MAST, Phys. Rev. Lett. 115, 215004 (2015)