Ion and Electron Heating Characteristics of Magnetic Reconnection in Tokamak Plasma Merging Experiments

Y. Ono[1], M. Inomoto[1], T. Yamada[1], H. Tanabe[1], T. Ii[1], S. Inoue[1], K. Gi[1], T. Watanabe[1], M. Gryaznevich[2], R. Scannell[2], C. Michael[2], C. Z. Cheng[3]

[1] *University of Tokyo, Tokyo, Japan,*

[2] *EURATOM/CCFE Fusion Association, Abingdon, UK,*

[3] *National Cheng-Kung University, Tainan, Taiwan*

A series of two flux loop (tokamak) merging experiments: TS-3, TS-4 and UTST revealed high-power reconnection heating of plasma ions up to 30MW [1,2]. Two dimensional profiles of ion and electron temperatures were measured for the first time around the X-point by means of 2-D Doppler tomography and 2-D electrostatic probe/ 2-D Thomson scattering diagnostics. These 2-D measurements clearly indicate two hot spots of plasma ions in the reconnection downstream and a peaked electron temperature profile inside the current sheet [1]. While electrons are heated around the X-point by ohmic heating of the current sheet, ions are accelerated by the reconnection outflow (~Alfven speed) and are thermalized by fast shock and/or viscosity damping in the two downstream areas. Since the maximum outflow speed almost equals the Alfven speed, scales with the reconnecting magnetic field B_p, the maximum reconnection heating energy transformed from the outflow energy is proportional to B_p^2 under no guide field condition. The ion heating power increases with the reconnection speed, indicating that several fast reconnection mechanisms can increase the reconnection heating power [2]. Based on those results, we started the largest-scale tokamak (ST) merging experiment MAST for the reconnection heating study and documented its strong ion and electron heating over 1keV during the merging/ reconnection [3]. The fine-scale Thomson scattering system measured a significantly peaked electron temperature profile during the reconnection and a caldera type profile after the reconnection. The reconnection heating characteristics of those merging tokamaks have similar properties except for their confinement times and magnetic field amplitudes. The merging tokamak plasmas can easily produce MW-order heating power, transforming the low-beta (~5%) tokamaks into a high-beta (~20-50%) one within a short reconnection time.

References

[1] Y. Ono, H. Tanabe, Y. Hayashi et al., Phys. Rev. Lett **107**, 1850991, (2011).
[2] Y. Ono, Y. Hayashi, T. Ii, H. Tanabe et al, Phys. Plasmas **18**, 111213, (2011).
[3] Y. Ono et al., in Proc. MR2010 Workshop, Nara, Japan, Dec. 2010; T. Yamada et al, ibid.