

High Power Heating of Magnetic Reconnection in ST Merging Experiments: TS-3, TS-4, UTST and MAST

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Since 1985, we have been investigating toroidal plasma merging and reconnection for high-power heating of spherical tokamak (ST) and field-reversed configuration (FRC), using TS-3 (ST, FRC: R~0.2m, 1985~), TS-4 (ST, FRC: R~0.5m, 2000~), UTST (ST: R~0.45m, 2008~) and MAST (ST: R~0.9m, 2000~) devices. Our merging experiments realized a significant reconnection heating over 1.2keV in the world-largest ST merging experiment: MAST [1,2] after detailed 2D elucidation of ion and electron heating up to 250eV in TS-3 and TS-4 ST merging experiments [3,4]. They revealed clear energy-conversion mechanisms of magnetic reconnection: huge outflow heating of ions in the downstream and Ohmic heating of electrons around the X-point. The reconnection outflow accelerates ions up to 70-80% of Alfvén speed of reconnecting magnetic field, and they are thermalized by fast shock-like density pileups in the downstreams. The series of experiments agree that the reconnection heating energy is proportional to square of the reconnecting magnetic field. The guide toroidal field does not affect the bulk heating of ions and electrons, probably because the reconnection/ outflow speeds are determined mostly by the externally driven inflow by the help of several fast reconnection mechanisms. Their detailed mechanisms were further investigated in collaboration with the Hinode satellite observation of solar coronal heating and with various PIC simulations. Those physics, particularly the reconnection heating and acceleration lead us to construction of the new up-graded high magnetic field merging experiment: TS-U (2016~) in University of Tokyo. This talk reviews major progresses in those international and interdisciplinary studies of toroidal plasma merging experiments for physics and fusion applications of magnetic reconnection.

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[2] Y. Ono, et al., Phys. Plasma (in press).

[3] Y. Ono, et al., Phys. Rev. Lett. 107, 185001, (2011).

[4] Y. Ono, et al., Phys. Rev. Lett. 76, 3328, (1996)