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# Scaling Physics of Reconnection Heating for ST Merging Startup Experiments

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The high-power reconnection heating of merging tokamak plasma has been developed mainly in TS-3, TS-4 and MAST experiments. This unique method is caused by the promising scaling of ion heating energy that increases with squire of reconnecting magnetic field Brec. We studied mechanisms for this scaling of reconnection (ion) heating up to 2.3keV mainly using TS-3 and TS-6 experiments and PIC simulations and found the following features:
(i) the ion heating energy is as high as ~40-50% of poloidal magnetic energy of two merging tokamak plasmas and, (ii) the ion heating energy is not affected by (guide) toroidal field Bt, in the region of Bt/ Brec >1, under the two conditions: (a) compression of the current sheet to the order of ion gyroradius and (b) isolation of the merging tokamak plasmas from coils, electrodes and walls. The sheet compression to the order of ion gyroradius was found to be a key condition to realize the fast reconnection as well as the high power ion heating consistent with the Brec2-scaling prediction. Under this condition, the ion heating energy is determined uniquely by Brec ~ Bp not by Bt in the conventional tokamak operation region: Bt/ Brec >2 (or q0>2). The merging tokamak plasmas need to be fully pinched off from the PF coils without any link with coils, electrodes or walls for the purpose of minimizing loss of the hot ions heated by the reconnection/ merging. Most of the laboratory experiments of magnetic reconnection tends to have ion and electron temperatures as low as 5-30 eV due to large energy loss through magnetic fluxes intersecting coils, fluxcores, electrodes and walls. They are sacrificing the plasma confinement for the better controllability of magnetic reconnection. The ion heating was found to occur not only in the local downstream area of reconnection but also in the global merging tokamak area, increasing ratio of the ion heating energy to the electron heating energy of reconnection around 4. This promising scaling realized ion temperature as high as 2.3keV in 2019 and is expected to realize the burning ion temperature >10keV (under electron density ne~1.5x1019 [m-3]) by increasing Brec (~poloidal magnetic field Bp) over 0.6T, leading us to the high-Brec field merging tokamak experiments: ST-40 in Tokamak Energy Inc. and TS-6 in U. Tokyo.
[1] Y. Ono et al., Nuclear Fusion 59, 076025 (7pp) , (2019)

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