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Scaling Study of Reconnection/ Merging Heating of Spherical Tokamak Plasmas for Direct Access to Burning Plasma

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The high-power reconnection heating of ST plasma has been developed in TS-3U, TS-4U and MAST experiments, leading us to direct access to burning plasma. This unique method is caused by the promising scaling of ion heating energy that increases with squire of reconnecting magnetic field B_rec. We studied mechanisms for this B_rec^2-scaling of reconnection (ion) heating mainly using TS-3U experiment and PIC simulations and found the following issues: (i) the ion heating energy is as high as ~40-50% of poloidal magnetic energy of two merging ST plasmas and (ii) is not affected by (guide) toroidal field B_t, in the region of B_t/B_rec >1 under two important conditions: (iii) compression of current sheet to order of ion gryoradius and (iv) the ST plasmas fully isolated from coils and walls. The sheet compression to ion gryoradius was found to be a key condition to realize the fast reconnection as well as the high power ion heating consistent with the B_rec^2-scaling prediction. Under this condition, the ion heating energy is determined uniquely by B_rec~B_p not by B_t in the conventional tokamak operation region: B_t/B_p>1. The merging ST plasmas need to be fully pinched off from the PF coils for the purpose of minimizing the hot ions heated by the reconnection/ merging. This promising scaling is expected to realize the burning plasma temperature T_i>10keV just by increasing B_rec over 0.6T (under the constant electron density n_e~1.5x10^19 [m^-3]), leading us to construction of new high-B_rec field merging ST devices: TS-U in U. Tokyo and ST-40 in Tokamak Energy Inc

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