§4. Ion and Electron Acceleration and Heating Mechanism of Magnetic Reconnection under High Guide Field

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The high-power reconnection heating has been studied in TS-3, TS-4 and MAST merging ST experiments as a promising solenoid (CS)-free startup with significant heating. Two ST plasmas axially merge together, forming a current sheet around the X-point. An important question is how the reconnection heats ions and electrons under the high toroidal field. Our UTST tokamak merging experiments and 2D PIC simulation (with 2×10^9 particles in a domain of $x\times y = 512\times256\ \lambda_{DE}$, where λ_{DE} is Debye length) reveal a small and peaked electron heating as well as fast energy conversion from magnetic to ion kinetic / thermal energies in downstream regions.

Figure 1 shows 2D contour of electron temperature around the X-point in the two merging tokamak plasma experiment UTST. It is noted that the electron heating is localized at the X-point and partly around the downstream. The total energy of electron heating as as small as 10J, which is about 1/8 of the global ion heating energy mainly in the downstream od reconnection.

Figure 2 shows 2D contour of electron temperature around he X-point in the PIC simulation with slab model. The electron temperature is observed to peak inside the long current sheet. The high T_e area forms another sheet in sharp contrast with the peaked high T_e area in the UTST experiment. This difference is the important research subject to solve the electron heating mechanism of high guide field magnetic reconnection. The electron temperature tends to peak at the X-point as we increases the guide field and the magnetic Reynolds number in the UTST experiment. The possible mechanism for this localized electron heating is 1) betatron-type fast acceleration of electrons along the X-line with zero poloidal and high toroidal field and 2) a stable plasma formation at the X-point that can confine the high energy electrons.

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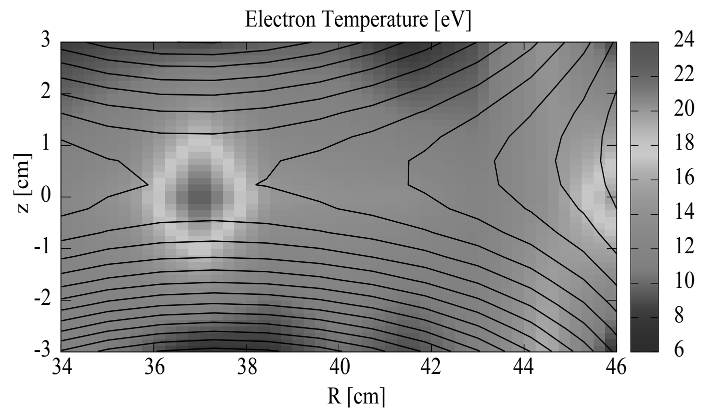

Fig. 1 2D contour of electron temperature around the X-point in the two merging tokamak plasma Experiment: UTST under high guide field (B_g~$5B_{rec}$.)

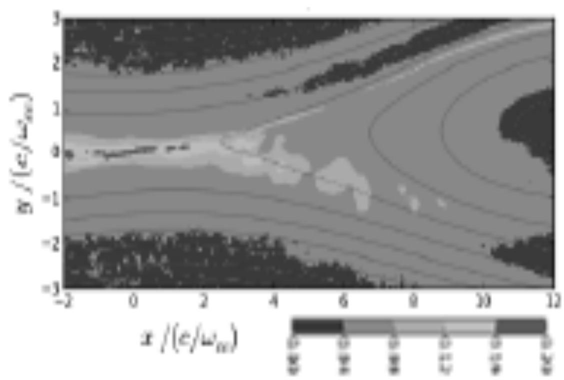

Fig. 2 2D contour of electron temperature around the X-point in the PIC simulation with slab model under high guide field (B_g~$4B_{rec}$.)