§9. Direct Control of Magnetic Reconnection by Localized ECH and NBI Heating

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The high-power reconnection heating has been studied in TS-3, TS-4 and UTST merging tokamak experiments as a promising solenoid (CS)-free startup with significant heating. Two spherical tokamak (ST) plasmas axially merge together, forming a current sheet around the X-point. An important question is whether localized ECH or NBI can control the reconnection speed/ heating or not. We found that our NBI into the current sheet decreases the reconnection speed in the TS-4 merging ST experiment and also that the shape of high electron temperature (T_e) area tends to peak at the X-point as the magnetic Reynolds number is increased in the series of merging ST experiment.

Figures shows 2D contour of electron temperature around the X-point in the two merging tokamak plasmas under high guide field (Bg~5Brec) . Top: TS-3 experiment (R_m~700), Middle: UTST experiment (R_m~1500), Bottom: MAST (R_m~10000). In the low R_m experiment: TS-3, the high T_e area is broad inside the current sheet though its aspect ratio is smaller than that of the current sheet. However, in the high R_m experiments: UTST and MAST, the electron heating is localized at the X-point and partly around the downstream. As the Reynolds number R_m increases, the electron temperature profile peaks at around the X-point. 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 of reconnection.

This difference is the important research subject for the purpose of solving the effect of electron heating on the reconnection speed and heating in the high guide field magnetic reconnection. As we increases the guide field and the magntic Reynolds number, the electron temperature tends to peak at the X-point, decreasing the reconnection speed and heating 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. The high power ECH of the current sheet is expected to decrease the reconnection speed and reconnection heating through localized electron heating of current sheet. We are also solving causes and mechanisms for the observed NBI effect on the reconnection speed.

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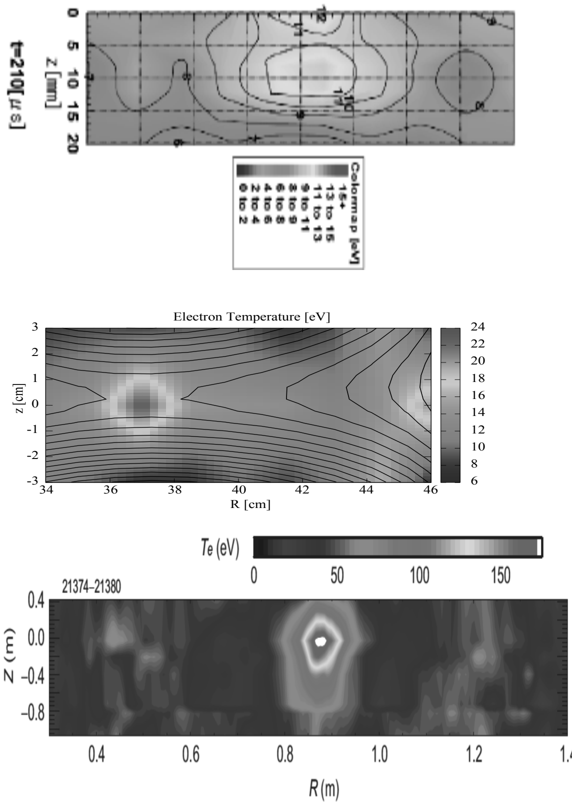

Fig. 2D contour of electron temperature around the X-point in the two merging tokamak plasmas under high guide field (B_g~$5B_{rec}$.). Top: TS-3 experiment (R_m~700), Middle: UTST experiment (R_m~1500), Bottom: MAST (R_m~10000).