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Experimental Study of the Influence of External Inflow Drive on Energy Conversion Rate in Guide Field Reconnection

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We have observed that the energy conversion rate of guide field reconnection is affected by the strength of external inflow drive in merging start-up of spherical tokamak (ST) experiment. If external inflow drive is attenuated, the effect of ion heating becomes lower, and a larger amount of magnetic energy remains after reconnection merging, compared to the case with strong inflow drive.

The heating effects of magnetic reconnection is an attractive feature for fusion reactors, as it enables direct heating of plasmas from low to high temperatures. Experimental research in TS-3, TS-4, UTST, TS-6, MRX, MAST has been conducted to reveal the mechanism of magnetic reconnection, and merging start-up was proposed as a way to ramp-up high-beta ST without using center solenoid[1]. To investigate the controllability of heating characteristics in merging start-up of high-beta ST, we conducted merging experiments under different external inflow drive forces.

Fig.1 shows the schematic view of our merging experiment. In our merging device TS-6, two plasma rings are made inductively by the current of poloidal field (PF) coils, under a high guide field driven by toroidal field (TF) coil. After the plasma formation, since its direction is opposite to plasma current, reversed current of PF coils push the plasma rings together and drive the reconnection of the poloidal magnetic field. In this experiment, the amplitude of the reversed current of PF coils (I_{push}) was modified by using crowbar circuits to control the intensity of the inflow drive force.

We measured 2D structure of magnetic field by printed circuit board (PCB) type magnetic probe array[2] and radial profile of ion temperature T_i by ion Doppler tomography diagnostic[3] in merging start-up experiments with modified intensity of inflow drive. Fig. 2(a) shows the amplitude of reconnecting magnetic field B_{rec} versus merging rate, and Fig. 2(b) shows time evolution of total amount of poloidal magnetic energy, in three intensities of inflow drive. The stronger external driven force was (the bigger I_{push} was), the smaller amount of magnetic energy remained after the completion of merging, despite that B_{rec} was almost the same in the three cases. Fig. 3 shows the time evolution of radial T_i profile and trajectory of X-point in the same three cases as Fig. 2. In the most strongly driven case ($I_{\mathrm{push}} = 25$ kA), ions were heated up to 30 eV in the downstream region. On the other hand, in the weakly driven case ($I_{\mathrm{push}} = 10$ kA), ion heating remained to approximately 20 eV.

These results suggest that the energy conversion rate of guide field reconnection is affected by the strength of external inflow drive. It may be possible to customize the role of reconnection merging by modifying the inflow drive: merging as plasma heating with strong inflow drive, or merging as helicity injection with attenuated inflow drive.

References

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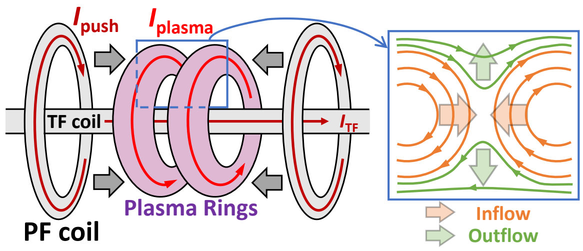

Figure 1. Schematic view of merging experiment.

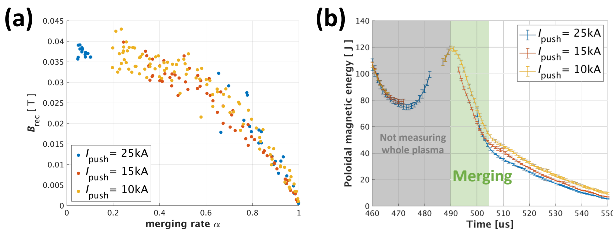

Figure 2. Time evolutions of (a) reconnecting poloidal magnetic field B_{rec} and (b) total amount of poloidal magnetic energy in three intensities of I_{push}.

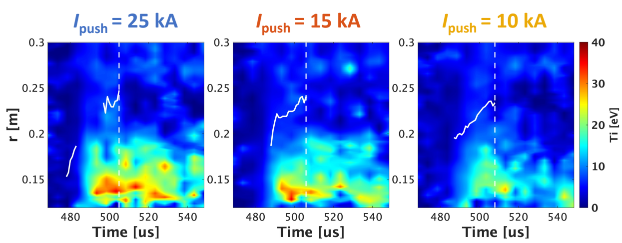

Figure 3. Time evolutions of radial ion temperature profile (color) and trajectory of X-point (white line) in three intensities of I_{push}.