2D MHD simulation of ST formation and merging for maximization of reconnection heating energy

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In this research, we search for the conditions to maximize reconnection heating of two merging spherical tokamak (ST) plasmas using 2D MHD simulation. Magnetic reconnection is a plasma fundamental process which heats the plasma through reconnecting magnetic field lines when two magnetized plasmas merge. Reconnection heating is expected to be a high performance start-up in torus plasma fusion devices. Previous studies indicates that magnetic reconnection convert about half of the reconnecting magnetic energy of the ST plasmas before reconnection into ion heating energy [1]. To maximize this heating energy, we have to maximize poloidal private flux.[2] Due to the limitations of the MHD models, any MHD simulations cannot calculate accurately reconnection heating but it can estimate global physical quantities such as magnetic fields and flux. Therefore, we can estimate the reconnection heating by calculating the magnetic energy of the private flux using 2D MHD simulation.

In this study, we calculated the merging prosses in a cylindrical vacuum vessel by PF, TF and EF coils outside the vessel as shown in Figure 1 and found the optimized condition for maximizing the private poloidal magnetic flux when the spherical tokamaks are separated from the vessel wall under the fixed amount of PF coil energy. A toroidal magnetic field is applied by TF coil and EF coils stabilize the plasma hoop force. We swing down the PF coil currents (current periodic time is T), forming two ST plasmas followed by their merging/ reconnection, as shown in Figure 2. In this study, plasma density and temperature are assumed to be uniform, indicating zero beta plasma. If common flux (flux of reconnected magnetic field lines) line is connected with the vessel wall, the plasma heated by reconnection will be cooled by colliding with the wall. Because of this reason, we counted the magnetic energy of the private flux as the reconnection heating energy right after the common flux line separated from the wall.

Figure 3 shows the comparison of private/peak/common flux (left axis) and ion heating energy (right axis) as a function of the separation length d of the two PF coils. The ion heating is estimated by assuming that 50% of magnetic energy in private flux is converted into heating energy [2]. In this case, private flux and ion heating energy is maximized in certain d(d=0.65). In other result, changing EF coils currents increased heating energy and private flux. It was found that reconnection heating can be optimized by PF coils position and EF coils currents.

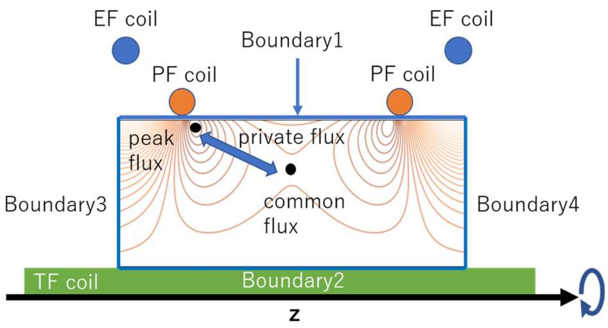

Figure 1 Cylindrical simulation model with PF, EF and TF coils.

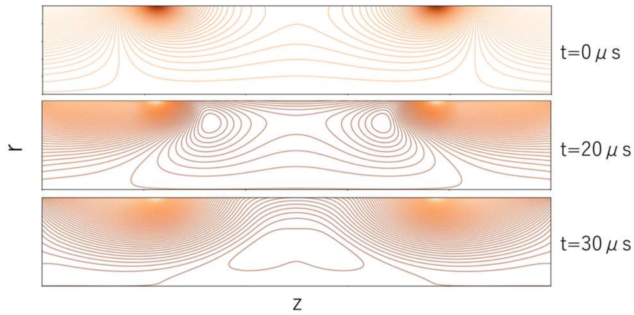

Figure 2 Poloidal flux contours of two merging ST plasmas during ST formation and merging(T=80μs).

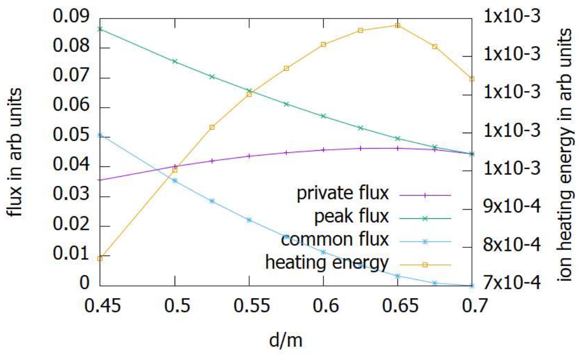

Figure 3 Flux and ion heating against PF coil distance.

References\
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