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Particle Simulation Studies on Ion Effective Heating through Merging Plasmas

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The merging of spherical tokamaks (STs) attract the attention as a candidate of future fusion reactors. In plasma merging experiments of STs, through magnetic reconnection, two torus plasmas are merged into a single torus plasmas with higher beta. In experiments, it is reported that electrons are significantly heated in the vicinity of the X-point, while ions are mainly heated in the downstream [1]. The comprehension of the heating mechanism can lead to the higher-performance for realizing economical ST reactors. In this paper, we show a new mechanism of ion heating.

We investigate the ion heating mechanism by means of particle simulations, which mimic merging plasmas in a ST. Plasmas are pushed by the driving electric field imposed at the upstream boundary in order to express pushed plasmas by the poloidal field coil current in experiments. The initial condition is one-dimensional equilibrium with a uniform toroidal (guide) magnetic field.

Our simulations demonstrate that the ion temperature perpendicular to the magnetic field grows mainly in the downstream as in experiments. It is further found that ring-like velocity distributions are formed at local points in the downstream. That is, ions are effectively heated [2]. The formation process of the ring-like distribution is as follows. Ions behave as nonadiabatic upon crossing the separatrix, since the period of time during which they pass through the separatrix is shorter than the gyroperiod. The entry speed of the ions is much less than the outflow speed. The ions rotate around the toroidal magnetic field while ExB drifting in the downstream. The ion orbit in the velocity space is a circle. The ring-like velocity distribution is formed by such ions with different phases of the gyromotion.

It is found that the profile of the ion temperature by our simulation fits well to that by a TS-3 experiment [1]. Furthermore, the dependence of the ion temperature on the toroidal magnetic field is investigated. Our simulations show that the ion temperature decreases as the toroidal field is stronger, but the dependence becomes small for the high toroidal field. This tendency is consistent with that in TS-3 experiments [3].

References

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