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Guide-field dependence of a merging process of two spherical-tokamak-type plasmoids

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A merging process of two spherical-tokamak-type (ST) plasmoids, which are confined inside a rectangular conducting vessel, has been examined by means of two-dimensional PIC simulation [1].

Because two STs are in a high-energy unstable state at initial, they start to move and approach each other under the action of an attracting $\mathbf{J} \times \mathbf{B}$ force. Magnetic reconnection takes place at a contact point of two STs and a part of magnetic energy is transferred to the ion and electron kinetic energies first, and then dissipates into particle thermal energies in a final relaxed state. The total thermal pressure increases in the central confinement region and expands towards the edge region while changing the total confinement profile. Finally, a trapezoid-shaped pressure profile with a flat top (red dashed curve) and a hollow magnetic pressure profile (black dashed curve) are formed in the central confinement region, as shown in Fig.1. It is interesting to note that shielding current density (blue dashed curve) is formed around the a flat top region of the pressure profile to sustain a hollow magnetic pressure profile.

A series of simulation runs with different guide fields were carried out to clarify the role of a guide field in the ST merging process. As shown in Fig. 2, energy partition rate of ions to electrons (red curve) increases as a guide field becomes weak, and the rate is about 2.7 for a strong guide-field case of B_{z0}=5.0, where B_{z0} is a guide field normalized by a typical poloidal magnetic field. These results are consistent with the TS3 merging experiments [2,3]. It is also found that this strong dependence on a guide field comes dominantly from the difference in ion and electron heating mechanisms. The ion kinetic energy is transferred into ion thermal energy mainly through compressional heating mechanism [1], and its amount decreases as a guide field increases. On the other hand, the electron kinetic energy is transferred into electron thermal energy mainly through viscous heating mechanism [1], and its amount increases as a guide field increases. An average plasma beta increases to about 3 times of an initial value through the ST merging process for each case. This study was partially supported by JSPS Grant-in-Aid for Scientific Research under grant numbers 20H00136 and 22K03581.

References
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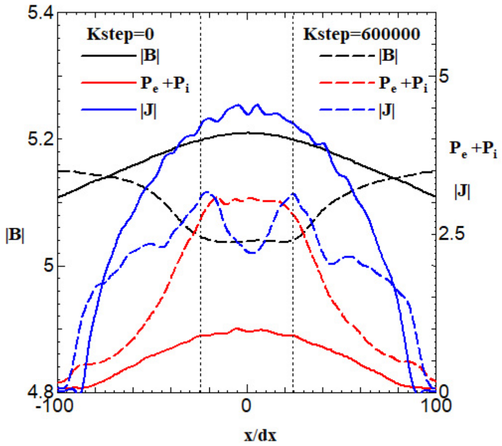

Figure 1. Initial and final spatial profiles of absolute magnetic field (black), total thermal pressure (red), and total current density (blue).

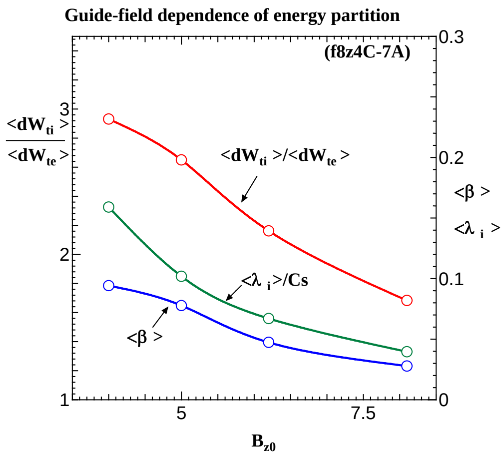

Figure 2. Guide-field dependence of energy partition rate of ions to electrons (red), ion Larmor Radius (green), and plasma beta (blue).