Experimental study of electron acceleration mechanism during high guide field reconnection

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Electron energization mechanism during merging startup is experimentally investigated in the University of Tokyo Spherical Tokamak (UTST). Magnetic probe and Langmuir probe measurements indicate that the diffusion region extends in the downstream direction. Trajectory calculation using the measured magnetic field and electric field indicates that the electrons are energized by field-aligned electric field within the diffusion region. Under the condition of same initial plasma current, the electron energy gain inside the diffusion region increases with the toroidal magnetic field.

Floating potential profile around the X-point was measured using Langmuir probe array during merging startup. Right after transition to the fast reconnection phase, the measured potential profile abruptly shows a quadrupole structure around the X-point, whose polarity changes with guide field direction. Its diffusion region profile was estimated using the potential profile and magnetic field profile, which was measured by 2D magnetic probe array. According to the Ohm's law, field-aligned electric field (E||) must have a finite value in diffusion region, while inductive E|| and electrostatic E|| must cancel out with each other in ideal MHD region. Therefore, the region where inductive E|| is much greater than electrostatic E|| was adopted as the diffusion region. The diffusion region was observed to extend in downstream region, which is quite different from the VTF result [1]. Particle trajectory calculation was performed using the obtained electric field and magnetic field profile. The trajectory analysis indicates that electrons gain energy from E|| inside the diffusion region and the obtained energy increases with stronger guide field. Also, soft X-ray measurement exhibits similar trend. Trajectory analysis also indicates that the electrons which gain significant kinetic energy inside the diffusion region are localized along the separatrices as shown in figure 1. The CIII emission profile obtained by fast camera also indicates the increase in the number of energetic electrons along the separatrices during fast reconnection phase.

Using the trajectory calculation results, inertia term was estimated and was compared with other non-ideal term in Ohm's law. It was found that resistivity term and inertia term are 3-5 order smaller than the reconnection electric field, which indicates that electron pressure term or fluctuation might play the key role in high guide field reconnection where Bg/Brec > 10.

[1] J. Egedal, A. Fasoli, *et. al.*, Physical Review Letter, **90**, 135003, (2003)

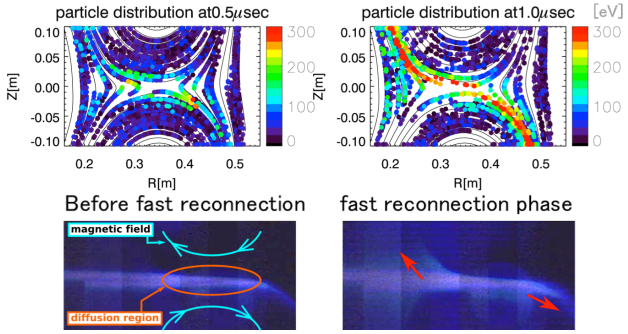

fig 1 Test particle locations and their kinetic energy at 0.5 and 1.0 μ sec from calculation start (upper left and right panel). Fast camera image of CIII emission before fast reconnection phase and during fast reconnection phase are shown in lower left and right panel, respectively.