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Experiment of fast reconnection with plasmoid ejection

Yoshinori Hayashi[1*], Toru Ii[1], Michiaki Inomoto[2], Yasushi Ono[2]

[1]Univ. Tokyo, [2]Univ. Tokyo

Magnetic field-line reconnection is a key for solving topological change of magnetic configuration, which is universally observed in magnetized plasmas in laboratory and space. Magnetic reconnection occurs in the local diffusion region and consequently rearrange the global magnetic field configuration. During the reconnection, magnetic energy is converted to thermal or kinetic energy usually in short time scale compared to resistive MHD theory. ?The transition from slow steady reconnection to fast impulsive reconnection is important to understand fast reconnection event such as resistive instability of fusion plasma or solar flare.
In this research, transient effect of magnetic reconnection has been investigated to explain such fast reconnection. Two torus plasmas are formed in the TS-4 device and merge axisymmetrically by pull or push method. Their major and minor radii are R=50cm and r=30cm, their magnetic Reynolds number is 10^3. We measured both local and global magnetic profile by two magnetic probe arrays with different special resolution and found several effects of fast reconnection mechanisms. Their current density and electric field are calculated by magnetic profile and effective resistivity is calculated from E(toroidal electric fields)/j(toroidal current density) at reconnection point.
Anomalous resistivity effect was dominant for the fast reconnection when Larmor radius is smaller than current sheet thickness in our previous research. So guide field , five times of reconnecting field, was applied to the merging toroids for the purpose of reducing Larmor radius shorter than current sheet width and suppressing the anomalous resistivity. When the magnetic pressure of coils drive the reconnection inflow strongly, the plasma density and magnetic flux inflow exceeded the outflow ones, causing flux and density piled-up in the current sheet. This pile-up effect was found to increase the inflow speed transiently without anomalous resistivity effect.
In pull reconnection experiment, a plasmoid (closed magnetic flux) was observed to grow inside the current sheet during plasma pile-up. It is because two torus plasma currents and sheet current are parallel in pull reconnection, while they are anti-parallel in the push one. When the flux pile-up exceeded the critical value, a plasmoid was ejected from reconnection region, increasing transiently the reconnection electric field. This is similar to the plasmoid induced reconnection in the solar flare. The plasmoid ejection maximized the reconnection rate when its acceleration reached the maximum value in the experiment.
The plasmoid ejection was not always reproducible in the present pull type reconnection experiment. In some case, plasmoid grow as large without any ejection.
In the present experiment, the number of plasmoid ejection is just one, because the magnetic flux provided by the coils is limited. When the PF coils provide sufficient amount of fluxes in the push type reconnection, a series of pile-up and ejection was observed to occur repeatedly.

Keywords: magnetic reconnection, current sheet, plasmoid