Multiple Plasmoid Formation and Current Sheet Dynamics of Two Merging Tokamak

K. Doi[1], M. Akimitsu[2], Y. Cai[1], H. Tanabe[1] and Y. Ono[1]
[1]*University of Tokyo, Tokyo, Japan*
[2]*National Institutes for Quantum Science and Technology (QST), Ibaragi, Japan*

We have experimentally observed the interaction between the reconnection speed and the dynamical change of the magnetic field and current sheet structure of magnetic reconnection.

Magnetic reconnection is a phenomenon in which antiparallel magnetic field lines reconnect with each other, forming a thin current sheet in the diffusion area. Its time scale is shorter than that of the Sweet-Parker model and an important candidate for its speed-up mechanism is unsteady reconnection with plasmoid. It is theoretically argued that multiple plasmoid production needs a high Reynolds number above 10^4. We observed multiple plasmoid formations over 10^3 in a merging experiment of tokamak plasmas with the highest magnetic Reynolds number in the reconnection chamber. We have developed a newly magnetic measurement system using printed circuit boards with coils densely spaced as small as 5 mm apart and successfully measured the detailed magnetic field structure of the merging center.

We found that the current sheet of two merging tokamaks is not a thin sheet but is composed of multiple blobs. The reconnection electric field increases when the thin current sheet splits into multiple blobs. At the same time, the reconnection speed increased accordingly. The result suggests that multiple blobs form the multiple diffusion regions whose thickness is as short as ion gyro-radius ρ_i, causing the fast reconnection. We already reported the effective resistivity of the current sheet increases significantly when the sheet is compressed to ρ_i. We also found that the sheet compression causes the current sheet to tilt significantly. The most probable explanation for this phenomenon is the Hall effect caused by unmagnetized ions around the current sheet compressed to ρ_i. The $j \times B$ force to tilt the current sheet is provided by the Hall current and toroidal magnetic field. This interpretation agrees well with our observation that the tilting direction of the current sheet is reversed when the direction of the toroidal magnetic field is reversed.