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Fast magnetic reconnection by current sheet ejection

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Magnetic reconnection plays a key role in the evolution of the solar flares and many other phenomena in the space and fusion plasmas. Magnetic reconnection is a topological change of the magnetic field lines and brings about a conversion of magnetic energy to plasma kinetic or thermal energy. To explain the eruptive evolution of the solar flares, comprehension of the fast magnetic reconnection mechanism in MHD regime is strongly required. In laboratory experiments, magnetic reconnection has been intensively investigated by using plasma merging devices, in which autonomously-evolving magnetic reconnection condition in high magnetic Reynolds number is achieved. When the reconnecting inflow magnetic flux is strongly driven by external boundary condition, anomalous resistivity is induced by the ion's meandering motion when the current sheet width is compressed shorter than the ion gyro radius. On the other hand, the guide field parallel to the sheet current reduces the ion gyro radius and suppresses the onset of the anomalous resistivity, which leads to slow down the reconnection rate and results in a quasi-steady magnetic reconnection. Under the strong guide field, nevertheless, fast magnetic reconnection is observed when the inflow flux is extremely driven by the external condition. In this case, the current sheet starts to move in the radial (outflow) direction when the current density at the X-point becomes large. Before the onset of the sheet motion, the plasma inflow is too large compared with the quasi -steady outflow. The discrepancy between the inflow and the outflow fluxes will bring the increase of plasma and magnetic flux densities near the sheet region, resulting in the increase of the sheet current density. Large negative current on the X-point will induce a global instability to push the sheet current away from the X-point. Reconnection rate was observed to be enhanced during the sheet motion. Large reconnection electric field is sustained by the motional electric field of the current sheet. In conclusion, extremely strong external driving force and large guide field brings about impulsive and fast reconnection in the MHD conditions by the current sheet ejection from the X-point region.

Keywords: magnetic reconnection, plasma merging, laboratory experiment