Fast Magnetic Reconnection by Turbulence with High Landquist Number

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We report detailed numerical studies of magnetic reconnection in high-Lundquist-number, turbulent plasma by means of a three-dimensional (3D) resistive magnetohydrodynamics model. It is found that although turbulence is pre-existing, magnetic fields still restructure themselves to shape many X-points with evident mean inflow/outflow as well as the hierarchically generated magnetic flux ropes (plasmoids in 2D) with twist field lines. Moreover, the turbulence facilitates magnetic reconnections, and makes the normalized global reconnection rate reach $\sim 0.02 - 0.1$, corresponding to turbulence level from very low to high and magnetic energy release from feeble to violent. The rate is nearly independent on the Lundquist number, and thus the fast turbulent reconnection occurs. A stochastic separation of the reconnected magnetic field lines with large opening angles follows a super-diffusion, indicating the broadening of outflow regions owing to the turbulence. These findings manifest that with the high Lundquist numbers ($S \geq 10^4$), the 3D reconnection is turbulent and fast.