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Fast magnetic reconnection in a kinked current sheet

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Magnetic reconnection processes in a kinked current sheet are investigated using 3D electromagnetic particle-in-cell simulations in a large system where both the tearing and kink modes are able to be captured. The spatial resolution is efficiently enhanced using the adaptive mesh refinement and particle splitting-coalescence method. The kink mode scaled by the current sheet width such as $k_y L$ ~1 is driven by the ions that are accelerated due to the reconnection electric field in the ion-scale diffusion region. Although the kink mode deforms the current sheet structure drastically, the gross rate of reconnection is almost identical to the case without the kink mode and fast magnetic reconnection is achieved. The magnetic dissipation mechanism is, however, found very different between the cases with and without the kink mode. The kink mode broadens the current sheet width and reduces the electron flow velocity, so that the electron inertia resistivity is decreased. Nevertheless, anomalous dissipation through the electron thermalization compensates the decrease in the inertia resistivity so as to keep a high reconnection rate. This suggests that the electron dynamics in the electron diffusion region is automatically adjusted so as to generate sufficient dissipation for fast magnetic reconnection. The electron thermalization occurs effectively because the electron meandering scale along the current sheet is comparable with the wavelength of the kink mode. On the other hand, 2D simulations in the plane orthogonal to the magnetic field shows that in higher mass ratio cases with m_i/m_e greater than 100 the electron thermalization is caused due to a hybrid-scale mode with wavelength intermediate between the ion and electron inertia lengths k_y¥sqrt{¥lambda$_i$ ¥lambda$_e$} ~1 rather than the large-scale kink mode with $k_y L$ ~1, because the electron meandering scale is shortened as the mass ratio increases.