

Scaling of magnetic dissipation and particle acceleration in ABC fields

Using particle-in-cell (PIC) numerical simulations, we study how the efficiencies of magnetic dissipation and particle acceleration scale with the initial effective wavenumber k_{eff} of the two-dimensional “Arnold-Beltrami-Childress”(ABC) magnetic field configurations. All simulations are run for at least 25 light crossing times in order to achieve a saturation stage. We confirm the existence of topological constraints on the distribution of magnetic helicity specific to the 2D systems, identified earlier in relativistic force-free simulations, which prevent the high- k_{eff} configurations from reaching the Taylor state. Due to the constraints of PIC simulations, the initial magnetization is a decreasing function of increasing k_{eff} , hence the high- k_{eff} configurations are inefficient particle accelerators, despite showing magnetic dissipation efficiencies of order $\epsilon_{\text{diss}} \simeq 60\%$. Our results are compared with two shorter 3D PIC simulations of ABC fields — in the case of $k_{\text{eff}} = 4$ we find that the 3D system is even more efficient in terms of magnetic dissipation, while less efficient in terms of particle acceleration.

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