Contribution ID: **10** Type: **not specified**

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 $k_{\rm eff}$ 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-$k_{\rm eff}$ configurations from reaching the Taylor state.Due to the constraints of PIC simulations, the initial magnetization is a decreasing function of increasing $k_{\rm eff}$, hence the high-$k_{\rm eff}$ configurations are inefficient particle accelerators, despite showing magnetic dissipation efficiencies of order $\epsilon_{\rm diss} \simeq 60\%$.Our results are compared with two shorter 3D PIC simulations of ABC fields — in the case of $k_{\rm eff} = 4$ 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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Session Classification: Student presentations