Fluid and gyrokinetic simulations of plasmoid formation in collisionless plasmas

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Non-collisional current sheets that form due to the nonlinear development of the tearing instability are characterized by a very small thickness, of the order of the electron skin depth. They can break up into several plasmoids (Fig. 1) and make it possible to achieve high reconnection rates. However, no work has so far investigated the instability conditions for the development of plasmoids when the forming current sheet is purely collisionless ($S = \mu_0 L_{cs} v_A / \eta \to \infty$).

We investigated the plasmoid formation employing both fluid and gyrokinetic simulations, assuming a plasma with cold ions that is immersed in a strong guide field, resulting in low plasma β. The fluid model is a two-field model that retains electron inertia [1], while the adopted gyrokinetic model is a δf model, from which the fluid model can be derived with appropriate approximations and closure hypotheses. The gyrokinetic equations are solved by means of the Astro GK code, used in [2]. By comparing the fluid and the gyrokinetic simulations of reconnection triggered by collisionless effects, we analyzed the geometry that characterizes the current sheet, and what promotes its elongation. Once the current sheet is formed, it is then possible to identify the regimes for which it is plasmoid unstable. This study shows that plasmoids can be obtained, in this context, from current sheets with an aspect ratio smaller than what was anticipated so far.

References

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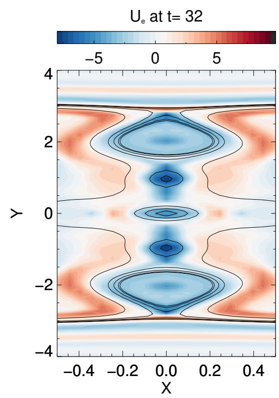

Figure 1: *Parallel current density with isolines of the magnetic potential.*