Variational integration for ideal MHD and formation of current singularity

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Recently a variational integrator for ideal MHD in Lagrangian labeling has been developed by discretizing Newcomb's Lagrangian on a moving mesh using discretized exterior calculus [1]. With the frozen-in equation built-in, the method is free of artificial reconnection, and therefore optimal for studying current sheet formation. Using this method, we confirm that the nonlinear solution to the ideal Hahm-Kulsrud-Taylor problem in 2D yields a singular current sheet [2]. We identify it by showing that the equilibrium solution converges with increasing resolution, except where there is singularity. This approach is in contrast to previous studies which use diverging peak current density as sole evidence of current singularity. We then extend the problem to 3D line-tied geometry. The linear solution, which is singular in 2D, is found to be smooth, but pathological when the system is sufficiently long. Accordingly, the nonlinear solution turns out to be smooth for short systems, but tends to become more singular for long ones. A resolution to this problem can potentially settle the long-standing controversy over Parker's conjecture on the formation of current singularity in 3D line-tied geometry.

References

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