RESISTIVE INSTABILITIES IN A TWO-DIMENSIONAL MHD TURBULENT FLOW

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Direct numerical simulations of decaying two-dimensional incompressible MHD flows at Reynolds numbers of several thousands are reported here, using resolutions of 1024^2 collocation points on a uniform grid. Spatial derivation is performed using Fourier decomposition, assuming periodic boundary conditions, and nonlinear terms are computed in configuration space. The time-stepping scheme is semi-implicit, Crank–Nicolson and third–order Runge–Kutta. The magnetic Prandtl number is equal to unity in all runs. Both deterministic and random initial conditions are used, concentrated in the large scales, with quasi–equipartition between kinetic and magnetic energy. The dynamic range in amplitude of the fields is 10^7, ensuring well–resolved current and vorticity sheets, over roughly 20 grid points. This leaves sufficient space for tearing instabilities to develop, embedded in a turbulent flow.

We shall stress here three main results, a detailed account of which can be found elsewhere (Politano et al., 1989):

i) After an initial growth, the total enstrophy (space-averaged squared current and vorticity) which is a measure of the amount of dissipation taking place in the flow, displays a quasi-stationary plateau which lasts a few eddy turnover times. Several current sheets have been established, intermittent in space and of finite duration as well. Although turbulent dissipation decreases with Reynolds number in the initial phase, a secondary phase mainly associated with tearing develops,

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in which dissipation tends to reach a constant level irrespective of the Reynolds number.

ii) An inertial range extending on more than one decade of wavenumbers is observed, with constancy of the flux of energy, and with detailed spectral properties depending on the amount of velocity-magnetic field correlation $\rho_C = <\mathbf{v} \cdot \mathbf{b}> / E^T$ where E^T is the total (kinetic and magnetic) energy and where **b** is the Alfvén velocity. During the quasi-stationary phase, the spectral indices $m^{\pm}$ of the Elsassër variables $\mathbf{z}^{\pm} = \mathbf{v} \pm \mathbf{b}$ depend on ρ_C, with $m^+ + m^- = 3$, as predicted by two-point turbulence closures (Grappin et al., 1983), to within less than 10%.

iii) Resistive tearing destabilizes current sheets generated by the inertial dynamics (Matthaeus and Lamkin, 1986) for a small enough aspect ratio of the sheet. This leads to the formation of small-scale magnetic islands, which may grow and reach dimensions within the inertial scales. These islands are ejected at the border of the sheet, which then recovers its original shape, with however a more complex structure in its smallest scales. Eventual temporal recurrence may take place, provided the Reynolds number is not too low. Other types of reconnection events, such as the *impulsive bursty reconnection* (Priest,1985) are also observed.

Pursuing this work at the higher Reynolds numbers that are encountered in Astrophysical flows may require the use of parametrising the small scales, for example through the use of large eddy simulation techniques or *LES*. These methods are widely used in the Meteorological context (Smagorinsky, 1963). One formulation has been proposed recently for MHD (Yoshizawa, 1987) in the context of the *DIA* and performing a two-scale analysis; restricting the final evaluation of the transport coefficients to the kinematic case, the standard α–effect is recovered. Two methods pertaining to the *LES* class are being presently tested for two-dimensional MHD (Passot et al., 1989) by comparison to high resolution direct numerical simulations.

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