TTF Abstract

Memory, Cascades and Spectra in Models of 2D MHD and Elastic Turbulence

Xiang Fan[1], P H Diamond[1], Luis Chacon[2], and Hui Li[2]
[1] University of California, San Diego
[2] Los Alamos National Laboratory

Virtually all models of drift-Alfven, EM, ITG, etc. turbulence are based upon a vorticity equation, Ohm's Law and (usually multiple) scalar advection equations. The appearance of the Alfven wave introduces a crucial element of *memory* to the dynamics. Such Alfvenization-induced-memory can significantly impact structure formation and transport in turbulence.

In this work, we study the fundamental physics of memory and cascades in *very* simple models such as 2D MHD and elastic turbulence. The 2D Cahn-Hilliard Navier-Stokes (CHNS) turbulence is a challenging analogue to 2D MHD turbulence. The important similarities include basic equations, ideal quadratic conserved quantities, cascade directions and elastic waves. The domain surface tension induces elasticity, and the balance between surface tension energy and turbulent kinetic energy determines an emergent length scale (Hinze Scale) of the system. The Hinze Scale may be thought of as the scale of emergent critical balance between fluid straining and elastic restoring forces. The range between Hinze Scale and dissipation scale is defined to be the elastic range of 2D CHNS system, where the elasticity offered by surface tension play a major role, just as the elasticity offered by magnetic field is of central significance in 2D MHD. In the elastic range, the mean square concentration spectrum is $H_k^{\psi} \sim k^{-7/3}$. Because the power is the same as the mean square magnetic potential spectrum $H_k^{A} \sim k^{-7/3}$ in the regime of inverse cascade of H^A, this result suggests the dominating mechanism for the dynamics of concentration fluctuation is the inverse cascade of H^{ψ}. In 2D MHD, a weak mean magnetic field can result in a large mean square fluctuation, and then the strong small scale magnetic fields lead to enhanced memory. The enhanced memory suppresses the turbulent transport. A similar turbulent transport suppression process also occurs in 2D CHNS system. Memory due to elasticity effects is of central importance in regulating the growth of zonal flows and fields in drift-Alfven turbulence. This study elucidates the physics of elasticity-induced-memory in the context of a simple system. The implications for the more complex case of drift-Alfven turbulence will be discussed.

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