DPP17-2017-000116

Abstract for an Invited Paper
for the DPP17 Meeting of
the American Physical Society

Cascades, "Blobby" Turbulence, and Target Pattern Formation in Elastic Systems: A New Take on Classic Themes in Plasma Turbulence[1]

XIANG FAN, Univ of California - San Diego

Concerns central to understanding turbulence and transport include: 1) Dynamics of dual cascades in EM turbulence; 2) Understanding negative viscosity phenomena in drift-ZF systems; 3) The physics of blobby turbulence (re: SOL). Here, we present a study of a simple model that of Cahn-Hilliard Navier-Stokes (CHNS) Turbulence which sheds important new light on these issues. The CHNS equations describe the motion of binary fluid undergoing a second order phase transition and separation called spinodal decomposition. The CHNS system and 2D MHD are analogous [1], as they both contain a vorticity equation and a diffusion equation. The CHNS system differs from 2D MHD by the appearance of negative diffusivity, and a nonlinear dissipative flux. An analogue of the Alfven wave exists in the 2D CHNS system. DNS shows that mean square concentration spectrum H_k scales as $k^{7/3}$ in the elastic range. This suggests an inverse cascade of H. However, the kinetic energy spectrum E_k^K scales as k^3, as in the direct enstrophy cascade range for a 2D fluid (not MHD!). The resolution is that the feedback of capillarity acts only at blob interfaces. Thus, as blob merger progresses, the packing fraction of interfaces decreases, thus explaining the weakened surface tension feedback and the outcome for E_k^K. We also examine the evolution of scalar concentration in a single eddy in the Cahn-Hilliard system. This extends the classic problem of flux expulsion in 2D MHD. The simulation results show that a target pattern is formed. Target pattern is a meta stable state, since the band merger process continues on a time scale exponentially long relative to the eddy turnover time. Band merger resembles step merger in drift-ZF staircases. [1] Phys. Rev. Fluids 1, 054403.

Collaborators: P H Diamond, and Luis Chacon.

[1]This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Fusion Energy Sciences,under Award Number DE-FG02-04ER54738.