Effect of cross-helicity on the forced two-dimensional MHD turbulence

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The peculiarity of two-dimensional (2D) MHD turbulence is manifested in the presence of two intervals with the inverse and direct cascades of positively defined conservative quantities, i.e., the total energy ($E(k)$) and the square of the vector potential ($E_A(k)$). There is a third important integral of motion, the cross-helicity (H_c), which is not sign-defined and is in units of energy. Therefore H_c usually cascades without additional constrains. However, in 3D MHD turbulence H_c may reduce the efficiency of nonlinear interactions and steepening the spectral slope[1]. In this study, we focused on H_c effect in 2D MHD turbulence.

We performed direct numerical simulations of forced 2D MHD with random initial conditions, and varying energy and cross-helicity injection rates. We force the Elsässer variables $\mathbf{z}_\pm$ with injection rates $\epsilon_+ = 0.3$ and $\epsilon_- = 0.1$ to avoid the consequences of the anti-dynamo theorem and control the injection rates of cross-helicity[2]. Since 2D MHD turbulence exhibits dual cascades of conserved quantities, we considered a large-scale dissipation mechanism[3] in addition to normal viscosity for small scales. For $k < k_f$, the spectrum of magnetic vector potential scales $k^{-5/3}$ where k_f is the forcing wavenumber, with constant flux (Fig. 1(a)). However, we observe the forward cascade for $E(k)$ and H_c as shown in Fig. 1(b). Also, there is a weak inverse cascade of $E(k)$, which seems to be enhanced by H_c. We will present these findings along with other results (such as the spectra and fluxes of velocity and magnetic fields, as well as variations in scaling laws for different Prandtl numbers, etc.) for this and higher grid sizes, at the conference.

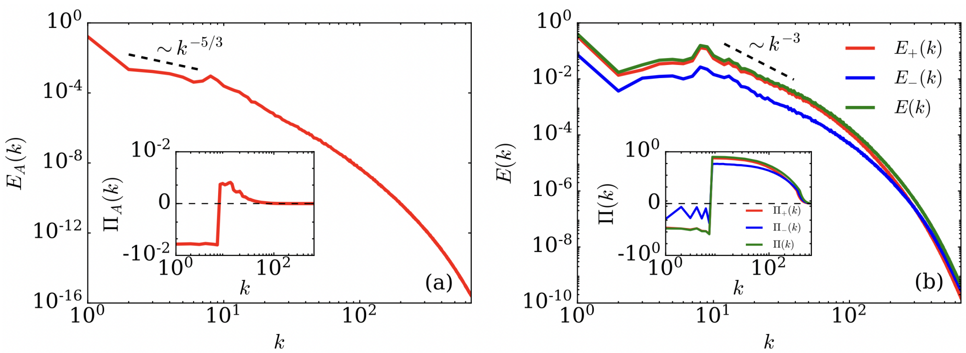

Figure 1: (a) The spectrum ($E_A(k)$) and flux ($\Pi_A(k)$) of the magnetic vector potential A, obtained for the ratio of injection rate ($\epsilon_+/\epsilon_- = 3$), grid size of 2048^2, and $k_f = 8$. (b) The spectrum ($E_\pm(k)$) and fluxes ($\Pi_\pm(k)$) of Elsässer variables, $\mathbf{z}_\pm$.

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[3] Seshasayanan et al., *Phys. Rev. E.* **90**, 051003 (2014).