The signature of initial conditions on magnetohydrodynamic turbulence

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Special correlations in the initial conditions of freely evolving, homogeneous magnetohydrodynamic (MHD) turbulence can lead to the formation of enormous current sheets. These coherent structures are observed at the peak of the energy dissipation rate and are the carriers of long-range correlations despite all the non-linear interactions during the formation of turbulence. Even though the largest scale separation has been achieved at this point, these structures are coherent with a size that spans our computational domain dominating the scaling of the energy spectrum, which follows a $E \propto k^{-2}$ power law. As Reynolds number increases curling of the current sheets, due to Kelvin-Helmhotlz type instabilities and reconnection, modifies the scaling of the energy spectrum from k^{-2} towards $k^{-5/3}$. This transition occurs at the highest Reynolds numbers of direct numerical simulations with resolutions up to 2048^3 grid points. Finite Reynolds number behaviour is observed due to the initial correlations without reaching a finite asymptote for the energy dissipation rate and with an unexpected scaling between the Taylor and the integral scale Reynolds numbers, i.e. $Re_\lambda \propto Re^{2/3}$. Our results, therefore, demonstrate that even state-of-the-art numerical simulations of the highest resolution can be influenced by the choice of initial conditions and consequently they are inadequate to deduce unequivocally the fate of universality in MHD turbulence.