Local and Non-Local Enstrophy Transfers in Generalized Two-Dimensional Turbulence

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We investigate the enstrophy inertial range of a family of two-dimensional turbulent flows, so-called alpha-turbulence, theoretically and numerically (Watanabe and Iwayama (2004)). A unified form of the enstrophy spectrum for the local and non-local enstrohy transfers of alpha-turbulence is derived by introducing the large-scale correction into Kraichnan-Leith-Batchelor theory. An asymptotic scaling behavior of the derived enstrophy spectrum precisely explains the transition between the local and non-local transfers at alpha = 2 observed in the recent numerical studies by Pierrehumbert et al. (1994) and Schorghofer (2000). This behavior is comprehensively tested by performing direct numerical simulations of alpha-turbulence. It is also numerically examined the validity of the phenomenological expression of the enstrophy transfer flux responsible for the derivation of the transition of scaling behavior. Furthermore, the characteristics of physical space structures are discussed in connection with the local and non-local transfers. It is found that the physical space structure for the local transfer is dominated by the small scale vortical structure, while it for the non-local transfer is done by the smooth and thin striped structures caused by the random straining motions.

References:
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