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Hierarchical energy spectra in quasi-steady turbulence KIYOSI HORIUTI, TAKEHARU FUJISAWA, Tokyo Institute of Technology — The Kolmogorov $-5/3$ law, $E_0(k) = C_K \varepsilon^{2/3} k^{-3/5}$, forms a base state for the energy spectrum in the inertial subrange, which is applied only to a steady state. An expansion for the spectrum about this base state using the perturbation method (Yoshizawa 1998, Woodroff & Rubinstein 2006) yields a nonequilibrium spectrum as

$$E(k) = E_0(k) + C_N \dot{\varepsilon}\, \varepsilon^{-2/3} k^{-7/3} + C_3(\ddot{\varepsilon}\, \varepsilon^{-1} - 2\dot{\varepsilon}^2 \varepsilon^{-2}/3) k^{-9/3} + \cdots,$$

where ε and $\dot{\varepsilon}$ denote the dissipation rate and its time derivative, respectively. This formula indicates that the spectrum contains the hierarchical scaling exponents, and the $-7/3$ and $-9/3$ scalings can be induced by the fluctuation of ε. Long term-temporal average yields $E(k) \approx E_0(k)$, but the $-7/3$ component can be extracted by conditionally sampling on $\dot{\varepsilon}$. We carried out this extraction using the DNS data for quasi- steady forced homogeneous isotropic turbulence and homogeneous sheared turbulence. It is shown that the $-7/3$ spectrum is indeed identified in both flows. The relationship between the each decomposed spectra and those induced by the three modes of vorticity configurations in the stretched spiral vortex model (Lundgren 1982, Horiuti & Fujisawa 2007) will be discussed.

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