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On the distribution of local dissipation scales in turbulent flows

IAN MAY, KHANDAKAR MORSHED, KARAN VENAYAGAMOORTHY, LAKSHMI DASI, Colorado State University — Universality of dissipation scales in turbulence relies on self-similar scaling and large scale independence. We show that the probability density function of dissipation scales, $Q(\eta)$, is analytically defined by the two-point correlation function, and the Reynolds number (Re). We also present a new analytical form for the two-point correlation function for the dissipation scales through a generalized definition of a directional Taylor microscale. Comparison of $Q(\eta)$ predicted within this framework and published DNS data shows excellent agreement. It is shown that for finite Re no single similarity law exists even for the case of homogeneous isotropic turbulence. Instead a family of scaling is presented, defined by Re and a dimensionless local inhomogeneity parameter based on the spatial gradient of the rms velocity. For moderate Re inhomogeneous flows, we note a strong directional dependence of $Q(\eta)$ dictated by the principal Reynolds stresses. It is shown that the mode of the distribution $Q(\eta)$ significantly shifts to sub-Kolmogorov scales along the inhomogeneous directions, as in wall bounded turbulence. This work extends the classical Kolmogorov's theory to finite Re homogeneous isotropic turbulence as well as the case of inhomogeneous anisotropic turbulence.

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