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A unified description of spatial and spectral distribution of fluctuation intensities in wall turbulence YONG JI, ZHEN-SU SHE, SKLTCS, COE, Peking Univ. — The streamwise turbulent intensity in wall turbulence (pipe and boundary layer) presents non-uniform distribution in both physical and wave number space. The well-known Townsend-Perry attached eddy hypothesis divides the energy spectrum into three distinct ranges: a constant range at small wavenumbers k<kc, a k-1 law in the "attached eddy" range k<ki and the Kolmogorov form k-5/3 in the inertial range k<kd. However, the latest boundary layer experiment (Vallikivi et al., J. Fluid Mech., vol. 771, 2015, pp. 303-326) indicates that a more precise spectral model is needed. We present here a unified analytical expression, based on a generalized dilation-invariant ansatz. It will be shown that analytic description of a stress length ell giving rise to accurate description of the mean velocity profile yields equally accurate prediction of the integral scale wavenumber ki, and the predicted dissipation gives rise of good prediction of the Kolmorogov dissipation wavenumber kd. Finally, the large-scale characteristic wavenumber kc follows a simple scaling law in terms of the stress length ell. Furthermore, we find that the Princeton data reveals possible anomalous scaling in the k-1 and k-5/3 range. The spectral curves based on our generalized dilation-invariant ansatz agree very well with the experimental spectrum, and the kinetic energy profile is also accurately reproduced. We have thus achieved, for the first time, a unified description of spatial and spectral distribution of fluctuation intensity from a recently developed symmetry approach.

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