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SED-based theoretical determination of empirical coefficients in an engineering turbulence model.

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— Based on a recent symmetry-based SED theory of wall turbulence, we derive a series of empirical coefficients used in a popular engineering $k-\omega$ model for simulating turbulent pipe flow. The SED theory proposes multi-layer expressions for two length (order) functions (e.g. a stress-length and an energy length), which determine the distribution of the Reynolds stress and kinetic energy in the wall-normal direction. Three local solutions, corresponding to viscous sublayer, overlap region and central core layer, respectively, are derived, and empirical model coefficients are determined in terms of universal physical constants of wall turbulence, including the thicknesses of the viscous sublayer, buffer layer and central core layer, as well as a centerline kinetic energy. This derivation rectifies a mistake of the wall scaling in the current $k-\omega$ model. The most interesting outcome is the prediction of an anomalous scaling in a meso-layer as a part of the overlap region. This derivation yields an explanation why $k-\omega$ model gives reasonable predictions for industrial flows.

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