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Unified description of logarithmic profiles in a turbulent channel and pipe ZHEN-SU SHE, XI CHEN, College of Engineering, Peking University, FAZLE HUSSAIN, Department of Mechanical Engineering, University of Houston
— A similarity is discovered between the transports of the mean momentum and turbulent kinetic-energy, based on empirical analysis of the two balance equations in DNS data. It yields a new invariant distribution characterizing universal bulk flow dynamics in a channel or a pipe. The theory derives a logarithmic law for the mean kinetic-energy profile at high enough Reynolds numbers (Re). In particular, a Karman-like constant (0.8) for energy is obtained, which yields a quantitative explanation for a recent discovery of Hulkmark et al. (PRL, 2012) with right empirical constants. Together with the momentum Karman constant (0.45), we offer a unified description of the logarithmic distribution for both momentum and kinetic energy. Finally, the newly-found similarity governs also the temperature variations in Rayleigh-Benard convection, and the common log law originates from a sub-leading-order effect of turbulent transport in balancing the difference between turbulence production and dissipation.

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