Unified description of logarithmic profiles in a turbulent channel and pipe

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— 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 em-
pirical 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.