Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Quantifying wall turbulence via a symmetry approach: A Lie group theory. ZHEN-SU SHE, SKLTCS, COE, Peking Univ., XI CHEN, FAZLE HUSSAIN, DOME, Texas Tech Univ. — We present a symmetry-based approach which yields analytic expressions for the mean velocity and kinetic energy profiles from a Lie-group analysis. After verifying the dilation-group invariance of the Reynolds averaged Navier-Stokes equation in the presence of a wall, we select a stress and energy length function as similarity variables which are assumed to have a simple dilation-invariant form. Three kinds of (local) invariant forms of the length functions are postulated, a combination of which yields a multi-layer formula giving its distribution in the entire flow region normal to the wall. The mean velocity profile is then predicted using the mean momentum equation, which yields, in particular, analytic expressions for the (universal) wall function and separate wake functions for pipe and channel - which are validated by data from direct numerical simulations (DNS). Future applications to a variety of wall flows such as flows around flat plate or airfoil, in a Rayleigh-Benard cell or Taylor-Couette system, etc., are discussed, for which the dilation group invariance is valid in the wall-normal direction.

Zhen-Su She
SKLTCS, COE, Peking Univ.

Date submitted: 30 Jul 2017 Electronic form version 1.4