Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

A multi-layer description of Reynolds stresses in canonical wall bounded flows XI CHEN, FAZLE HUSSAIN, Texas Tech University, ZHEN-SU SHE, Peking University — A complete description of the Reynolds stress tensor is obtained for all three canonical wall turbulence (channel, pipe and turbulent boundary layer - TBL). The result builds on a multi-layer description of length (order) functions and their ratios, including viscous sublayer, buffer layer, meso-layer for the near wall (inner) region, and bulk flow or a central core (absent in TBL) for the outer region. It is shown that the streamwise mean kinetic-energy profile is quantified with high accuracy over the entire flow domain. The model contains only three *Re*-dependent parameters for Reynolds number (*Re*) covering nearly three decades. Furthermore, the inner peak location is predicted to be invariant at $y^+ = 15$, while its magnitude shows notable *Re* and geometry effects, predicted to be .9.2 for high *Re*'s pipe flows. A mechanism is proposed for the emergence of outer peak in pipes, whose magnitude is predicted to scale as $.Re_\tau^{0.05}$ beyond a critical Re_τ about 10^4(). The recently reported logarithmic dependence in the bulk is recovered, but with an alternative explanation. The result is successfully extended to TBL flows by a fractional total stress and an absence of core. Equally accurate descriptions of vertical and spanwise kinetic-energy are also presented for the three flows. The result has been used to modify turbulent engineering models (i.e. k-ω model) with significant improvement.

Xi Chen
Texas Tech University

Date submitted: 27 Jul 2015 Electronic form version 1.4