Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

Symmetry-based theory for mean velocities in the flat plate turbulent boundary layer XI CHEN, College of Engineering, Peking University, FAZLE HUSSAIN, Department of Mechanical Engineering, Texas Tech University, ZHEN-SU SHE, College of Engineering, Peking University — A major difference from channel and pipe flow in zero-pressure-gradient turbulent boundary layer – ZPG-TBL is the streamwise development of the mean velocity components. We report a symmetry-based theory for ZPG-TBL, which yields a complete prediction for both the streamwise and vertical mean velocities, i.e. U(x,y) and V(x,y). A significant result is the identification of a bulk flow constantκ_b, which achieves a highly accurate description of U above $y^+ \sim 150$; for a set of DNS data (Schlatter et al. 2010); the relative error is bounded within 0.1%. It is found that κ_b has a non-trivial streamwise development, and asymptote to 0.45 for large *Re's*; the latter is consistent with the true Karman constant recently discovered for channel and pipe flows. The theory assumes a fractional scaling for the total stress, which yields, for the first time, an analytical prediction for V, Reynolds stress profile, friction coefficient and shape factor in ZPG-TBL, in good agreement with both DNS and experimental data. In conclusion, a complete analytical theory is viable for both laminar (i.e. Blasius) and turbulent boundary layers.

Xi Chen
College of Engineering, Peking University

Date submitted: 01 Aug 2014 Electronic form version 1.4