Abstract Submitted
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Mach-number-invariant mean velocity profile of compressible turbulent boundary layers YOU-SHENG ZHANG, WEI-TAO BI, ZHEN-SU SHE, College of Engineering, Peking University, FAZLE HUSSAIN, Department of Mechanical Engineering, University of Houston, XIN-LIANG LI, Chinese Academy of Sciences — A series of Mach-number- (M) invariant scalings are derived for compressible turbulent boundary layers (CTBLs), leading to a viscosity weighted transformation for the mean velocity profile (MVP) that is superior to van Driest transformation. The new scalings are derived from an analysis of turbulent kinetic energy balance equation, and their finding substantiates Morkovin's hypothesis. In particular, a boundary layer edge, δ_{vw}, is defined by equaling the intensities of wall-normal and spanwise velocity fluctuations, and is shown to better represent the M-invariant structure of CTBLs. The M-invariant mixing length has a weight of $\sqrt{\bar{\rho}^{+}}\bar{\mu}^{+}$ to the Prandtl's mixing length, which leads to a viscosity weighted transformation for the MVP of CTBLs, in contrast to the density weighted van Driest transformation. The theory is validated by direct numerical simulation of spatially-developing adiabatic CTBLs with M up to 6. These results suggest new tools for validating turbulence models and improving computations in CTBLs.

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