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A symmetry based approach to quantifying the compressible turbulent boundary layer BIN WU, WEI-TAO BI, ZHEN-SU SHE, Peking University, FAZLE HUSSAIN, Texas Tech University — Developing analytical description of the compressible turbulent boundary layer (CTBL) is of great importance to many technological applications and to the understanding and modeling of compressible turbulence. Here a symmetry-based approach is applied to analyze the CTBL data acquired from DNS, covering a wide range of Reynolds number (Re), Mach number (Ma) and wall temperature. The Reynolds stress length scale displays a four-layer structure in the direction normal to the wall and obeys the dilation group invariance as in the incompressible TBL. A newly-identified turbulent heat flux length scale behaves similarly, which is the classical temperature mixing length weighted by the mean temperature. A significant result is the identification of three physical parameters for each length function to characterize the adiabatic flow: a bulk flow constant, a buffer layer thickness and a boundary layer edge, which vary with Re and Ma. For the diabatic flow, the sublayer thickness and the inner layer scaling exponents vary additionally with the wall temperature. These parameters are modeled empirically, leading to a highly accurate prediction of the mean fields of the CTBL. Thus we reveal that the symmetry principle found in canonical wall-bounded flows holds also for the CTBL, and a quantitative mean field theory is viable with appropriate symmetry considerations.

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