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Predicting the mean fields of compressible turbulent boundary layer via a symmetry approach. WEI-TAO BI, BIN WU, ZHEN-SU SHE, SKLTCS, COE, Peking Univ. — A symmetry approach for canonical wall turbulence is extended to develop mean-field predictions for compressible turbulent boundary layer (CTBL). A stress length and a weighted heat flux length are identified to obey the multilayer dilation symmetry of canonical flows, giving rise to predictions of the mean velocity and temperature profiles for a range of Reynolds number (Re), Mach number (Ma) and wall temperature (Tw). Also predicted are the streamwise developments of the shape factor, the boundary layer edge velocity and the boundary layer thicknesses, etc. Only three parameters are involved in the predictions, which have sound physics and organized behaviors with respect to the Re, Ma and Tw effects. The predictions are extensively validated by direct numerical simulation and experimental data, showing better accuracies than the previous theories. The results provide new quantifications that can be used to assess computations, measurements and turbulence models of CTBL, as well as to provide new insights for the CTBL physics.

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