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Turbulence Scalings in Supersonic Channel Flow

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Direct numerical simulations of compressible channel flow have been performed at subsonic and supersonic Mach numbers with the aim to better understand effects of compressibility in wall-bounded turbulence. The ability of outer and inner scalings to collapse profiles of turbulence stresses on to their incompressible counterparts is investigated. It turns out that such collapse is possible with outer scaling when sufficiently far from the wall, but not with inner scaling. Compressibility effects on the turbulent stresses, their anisotropy, and their balance equations are identified. A reduction in the near-wall pressure–strain, which is found to be responsible for the changed Reynolds stress profiles, is explained using a Green's function-based analysis of the pressure field. In the case of isothermal walls which are considered here, the density variation is primarily responsible for the decrease of the pressure-strain correlations, a result that should inspire turbulence modellers.

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