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Numerical studies of turbulent supersonic plane-channel flows -- Implications for modeling high-speed boundary layers

This two-part talk begins with an overview of the `turbulence problem', the computational strategies used to address it, and the role of direct numerical simulation (DNS). The second part presents DNS results to determine the turbulent Prandtl number Pr_t above cold (isothermal) and hot (adiabatic) walls in a family of low-supersonic channel flows. A range of mean temperature/density variations, corresponding to effective/edge Mach numbers between 1.1 to 2.2, and wall-variable-based Reynolds number $Re_{\tau w}$ from 73 to 3800, is considered. The adiabatic condition is a new feature of special interest. The value of Pr_t away from the wall approaches 0.85 above both the isothermal and adiabatic walls. The variations of the near-wall Pr_t profiles in both the present and previous, passive-scalar simulations collapse as a function of the semilocal y^* wall scaling proposed by Huang et al. (1995), with only a weak dependence on $Re_{\tau w}$. This leads to a rather simple proposal for a model of heat transfer, attached to an eddy-viscosity model.