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Analysis of Thermal Boundary-Layer Structure and Scale-Dependence in Transcritical Flows at Turbulent Conditions[1] JACK GUO, Department of Mechanical Engineering, Stanford University, XIANG YANG, Department of Mechanical and Nuclear Engineering, Pennsylvania State University, MATTHIAS IHME, Department of Mechanical Engineering, Stanford University — Previous literature has shown inadequacies of commonly employed scaling transformations to collapse the mean temperature profile for flows with large property gradients. This is particularly relevant for flows with large density gradients that are encountered in transcritical wall-bounded flows. Here, we examine the breakdown of the temperature law of the wall as a function of compressibility via direct numerical simulation (DNS) of transcritical channel flows at turbulent conditions. We propose scaling corrections and suggestions towards the development of more accurate temperature profiles, representing an important step towards reliable predictions of highly compressible turbulent flows. We also analyze and discuss turbulent statistics and budgets related to the temperature transport and heat transfer and provide estimates under which conditions commonly employed transformations remain valid at transcritical flow regimes.

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