Abstract Submitted
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Direct numerical simulations of hypersonic boundary layers varying wall-to-freestream temperature ratio[1] LIAN DUAN, IZAAK BEEKMAN, PINO MARTIN, Princeton University — The effects of wall-temperature condition on the statistics of compressible turbulent boundary layers are investigated using direct numerical simulation (DNS). DNS of turbulent boundary layers at Mach 5 with the ratio of wall-to-edge temperature Tw/Te from 1.0 to 5.4 (Cases M5T1 through M5T5) are performed. Case M5T5 corresponds to nearly adiabatic wall, and cases M5T1 through M5T4 correspond to cooled isothermal walls. The validity of Morkovin's scaling, Walz's equation, and the standard and modified strong Reynolds analogy are assessed. Turbulent kinetic energy, contours of spanwise vorticity, near-wall streaks, and two-point correlations show that the temperature cooling stabilizes the turbulence in compressible boundary layers. Compressibility effects are enhanced by wall cooling but remain secondary to the dynamics already appearing in incompressible flow, and the turbulence dissipation remains primarily solenoidal. Hairpin packets are stronger and more coherent for colder wall simulations, while the average hairpin angle remains insensitive to wall temperature.

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