Abstract Submitted
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On the structure of compliant wall deformation forced by a turbulent boundary layer[1] JIN WANG, SUBHRA KOLEY, JOSEPH KATZ, Johns Hopkins University — Our previous (Zhang et al 2017) study examined the pressure-deformation correllations in a compliant wall turbulent channel flow with a stief wall and submicron deformations. Aiming to extend the scope to two-way coupling, where the deformation size is several wall units (δ_ν), theoretical analysis is used for selecting a compliant material (PDMS + silicone gel) with Young's modulus (0.158 MPa), thickness (5mm), and shear speed (7.85 m/s) comparable to the freestream velocity (U =1.2-6 m/s). Time-resolved (2 kHz) Mach-Zehnder Interferometry is used for mapping the deformation, and 2D PIV for measuring the flow. The deformations increase from submicron at U =1.2 m/s to well above 20 μm ($4\delta_\nu$) at 6 m/s. The primary mode is advected at $0.66U$ for all wavenumbers, but the peak wavenumber in both directions remains nearly constant. In addition, high-frequency low wavenumber lateral waves appearing at broad streaks dominate at low U, but persist at high-speed. Comparisons of the measured frequency spectra to 1-D linear models (Chase 1991, Benschop et al. 2019) show a good agreement for advected modes, but not for the lateral ones. At high U, the compliant wall causes a sharp decrease in mean velocity at y<$10\delta_\nu$, consistent with DNS results (Rosti and Brandt 2017).

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