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Experimental investigation of compliant wall surface deformation in a turbulent channel flow.[1] CAO ZHANG, JIN WANG, JOSEPH KATZ, Johns Hopkins University — The dynamic response of a compliant wall under a turbulent channel flow is investigated by simultaneously measuring the time-resolved, 3D flow field (using tomographic PIV) and the 2D surface deformation (using interferometry). The pressure distributions are calculated by spatially integrating the material acceleration field. The Reynolds number is Re_τ =2300, and the centerline velocity (U_0) is 15% of the material shear speed. The wavenumber-frequency spectra of the wall deformation contain a non-advected low-frequency component and advected modes, some traveling downstream at U_0 and others at $0.72U_0$. Trends in the wall dynamics are elucidated by correlating the deformation with flow variables. The spatial pressure-deformation correlations peak at $y/h \approx 0.12$ (h is half channel height), the elevation of Reynolds shear stress maximum in the log-layer. Streamwise lagging of the deformation behind the pressure is caused in part by phase-lag of the pressure with decreasing distance from the wall, and in part by material damping. Positive deformations (bumps) are preferentially associated with ejections, which involve spanwise vortices located downstream and quasi-streamwise vortices with spanwise offset, consistent with hairpin-like structures. The negative deformations (dents) are preferentially associated with pressure maxima at the transition between an upstream sweep to a downstream ejection.

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