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Experimental investigation of compliant wall deformation under a fully developed turbulent channel flow using tomographic PIV and Mach-Zehnder interferometry[1] CAO ZHANG, JIN WANG, JOSEPH KATZ, Johns Hopkins University — A fully developed turbulent channel flow bounded by a transparent, compliant wall made of polydimethylsiloxane is experimentally investigated at friction Reynolds number of 2.3x10^3. The time-resolved 3D flow field and 2D distribution of wall-normal deformation are measured simultaneously using tomographic PIV combined with Mach-Zehnder interferometry. A new interferogram filtration technique based on spatial correlations of small windows, followed by phase calculation from intensity arccosines, is introduced to capture submicron deformations. It has lower errors and sensitivity to fringe shape compared to spectral band-pass filtering. The measured wavenumber-frequency spectra show the deformation consists of patterns that are larger than the field-of-view, surface waves, and small-scale patterns. Some of the latter are advected at the channel centerline velocity, U_c, but most are advected at $0.7U_c$, the mean speed at 10% of the channel half height, h. Correlations between deformation and velocity conditioned on the sign of the deformation indicate the positive and negative deformations are related to the ejection and sweeping events, respectively. The correlation peaks also reside at about $0.1h$, suggesting this is the elevation where relevant coherent structures are concentrated.

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Cao Zhang
Johns Hopkins University

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