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Experimental investigation of turbulent channel flow over a compliant wall using tomographic PIV and Mach-Zehnder interferometry[1]
CAO ZHANG, Johns Hopkins University, RINALDO MIORINI, General Electric Global Research Center, JOSEPH KATZ, Johns Hopkins University — The time-resolved 3D flow field and 2D distribution of wall-normal deformation in turbulent channel flow over a compliant surface are simultaneously measured by a combination of tomographic PIV (TPIV) and Mach-Zehnder Interferometry (MZI). The compliant wall is made of PDMS, and the friction Reynolds number is 2.3×10^3. The mean velocity profile in the log layer is consistent with that of a channel flow over a smooth rigid wall. The flow resolution of the TPIV measurement is enhanced using single-pixel ensemble correlations to resolve the buffer layer. Extensive calibrations of the MZI system show a wall-normal resolution of deformation in the order of 10 nm. The power spectral density of the surface deformation indicates a wide range of the time-scales. The streamwise wavenumber-frequency spectrum displays two main features: (i) An inclined band corresponding to deformations advected with the flow at approximately 80% of the freestream speed, i.e. the velocity in the log layer. Their amplitudes are in the submicron range. (ii) Non advected, low frequency (<500 Hz) events that are larger than the field-of-view, and have much higher amplitudes, up to 100 μm. Ongoing analyses examine the deformation-velocity and deformation-pressure correlations to identify structures that influence the interactions with the compliant wall.

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