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The 3D flow structures generated by a pair of cubic roughness elements in a turbulent channel flow resolved using holographic microscopy[1]

JIAN GAO, JOSEPH KATZ, Johns Hopkins University — In studies of turbulent flows over rough walls, considerable efforts have been put on the overall effects of roughness parameters such as roughness height and spatial arrangement on the mean profiles and turbulence statistics. However there is very little experimental data on the generation, evolution, and interaction among roughness-initiated turbulent structures, which are essential for elucidating the near-wall turbulence production. As a first step, we approach this problem experimentally by applying digital holographic microscopy (DHM) to measure the flow and turbulence around a pair of cubic roughness elements embedded in the inner part of a high Reynolds number turbulent channel flow ($Re_\tau = 2000 - 5000$). The ratio of half-channel height (h) to cube height (a) is 25, and the cubes are aligned in the spanwise direction, and separated by $1.5a$. DHM provides high-resolution three-dimensional (3D) three-component (3C) velocity distributions. The presentation discusses methods to improve the data accuracy, both during the hologram acquisition and particle tracking phases. First, we compare and mutually validate velocity fields obtained from a two-view DHM system. Subsequently, during data processing, the seven criteria used for particle tracking is validated and augmented by planar tracking of particle image projections. Sample results reveal instantaneous 3D velocity fields and vortical structures resolved in fine details of several wall units.

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