Multiscale Organization of Turbulent Structures in Wall-Bounded Shear Flow Simulations

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Turbulent flows over smooth walls contain complex motions with a wide range of scales, but evidence supports the organization of relatively small structures to form longer structures, with very long structures playing an important role in these flows. Direct numerical simulation(DNS) of such flows in very large domains provides the flow fields necessary to gain insight into the structural organization characterizing the wide range of scales present. This talk presents analysis of turbulent pipe flow DNS to describe structural features of the various scales and reduce their organizational patterns. The results support the scenario proposed by Kim & Adrian (1999 Phys. Fluids) of very long scale motions (characterized by stream wise wavelengths greater than 3 pipe radii) consisting of concatenations of shorter coherent motions. However, multiple techniques, including proper orthogonal decomposition (POD), suggest that such concatenations preferentially occur with characteristic spiraling angles around the pipe circumference, instead of the stream wise concatenations originally proposed. POD further suggests that these very long scales organize as roll cells that are primarily significant in organizing the smaller, more intense motions. The temporal evolution of the longest scales indicates that these motions persist for long durations of time and advent significantly faster than the mean velocity near the wall, accelerating the mean flow in this region. POD is also applied to turbulent boundary layer DNS to address the influence of the transitional region on the flow that has evolved into fully developed turbulence.