

Hierarchical Clustering Structures in Turbulent Channel Flow at $Re_\tau = 1160$

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Direct numerical simulation of a turbulent channel flow at $Re_\tau = 1160$ was made in order to examine the relationship between the near-wall quasi-streamwise vortices (QSVs) and the large-scale outer-layer structures. The visualized flow field and the statistics suggest that not only the QSVs but also edges of the large-scale structures appear near the wall ($y^+ \sim 30$). Away from the wall, the low/high-speed large-scale structures prevail, and the QSVs are clustered preferably in the low-speed ones. The contribution of the large-scale structures to the Reynolds stress is much larger than that of the clustering QSVs in the outer layer. These large-scale structures seem to have an autonomous cycle that does not depend on the near-wall coherent structures.