Direct numerical simulation for turbulent boundary layer flow over a flat plate with two side-by-side dimples

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Dimpled surface has been widely investigated for the purpose of enhancing heat-transfer rate with possibly minimum pressure drop penalties during the last decades[1], improving the aerodynamic performance of the airfoil[2], and the drag reduction on autonomous underwater vehicles[3], offshore cylindrical structures [4], etc. The previous results for the dimpled plate suggested that the shallow dimples have great potential for drag reduction than the deep dimples.

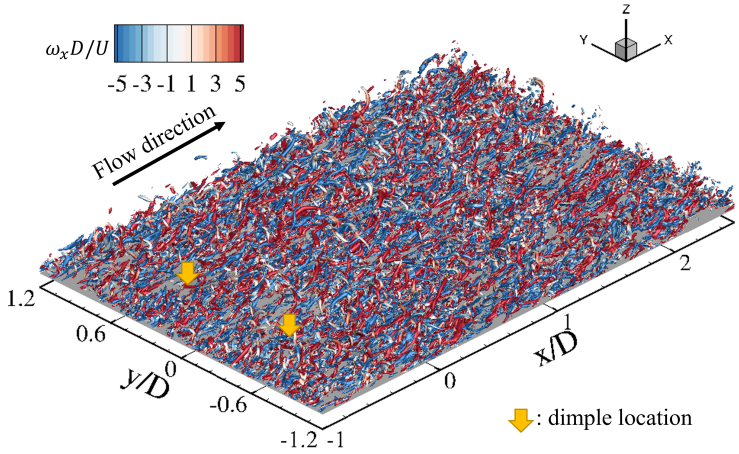

Figure 1: Instantaneous isosurfaces of $\lambda_{ci} = 5$ for turbulent boundary layer flow over a flat plate with two side-by-side dimples. The distance between the two dimple centers is $1.2D$.

The present work focuses on the turbulent statistics and coherent structures of a zero-pressure-gradient turbulent boundary layer flow over a flat plate with two side-by-side dimples. Here the momentum Reynolds number Re_θ (based on the momentum thickness θ and the freestream velocity U) of the inlet flow and the Reynolds number Re_D (based on the dimple diameter D and the freestream velocity U) is 670 and 20000, respectively. The dimple depth is equal to $0.05D$. The vortex-detection technique known as swirling strength (λ_{ci}) [5] is applied in the present work for visualizing the instantaneous coherent structures as shown in figure 1.

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