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Under-resolved Direct Numerical Simulation of NACA0012 at Stall

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This study aims at revealing the fluid dynamics underpinning the separation and laminar to turbulent transition mechanism in the separated shear layer over NACA0012 airfoil section at the stall. Moreover, we seek to gain insight into the coherent structures formed during the separation. To achieve this, simulations are conducted at the large Reynolds number of $Re = 150,000$ in the Nektar++ framework using the high-order spectral/hp element method. Simulations are performed using quasi-3D assumptions which assumes the homogeneous flow in the spanwise direction and Under resolved Direct numerical simulations is used to resolve the turbulent structures. The flow dynamics is investigated at several angles of attack from the triggering of the stall at $\alpha = 10^\circ$ to the deep stall at $\alpha = 16^\circ$. Moreover, the effect of spanwise length and polynomial expansions on the prediction of flow dynamics and aerodynamic coefficients are studied. Our early results indicate that the flow features low-frequency three dimensional structures in spanwise direction. Further, our simulations suggest that the accuracy of aerodynamic coefficients are much sensitive to the mesh resolution in normal and tangential flow directions than the spanwise direction. However, this sensitivity is more noticeable near the angles of attack close to the onset of the stall and relaxes as the airfoil is tilted further towards deep stall.