THE MECHANICS AND PREDICTION OF WALL-TURBULENCE

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Turbulent eddies near a wall are known to play essential role in the dynamics of turbulent boundary layers and are responsible for large contributions to the skin friction drag. The spatial dimensions of these structures scale with viscous units, and thus are small compared to physical flow dimensions. The resolution of these structures in high fidelity numerical simulations is not practical, and one must resort to reduced order models to account for the effect of near wall turbulence on the outer flow structures. Based on recent direct numerical simulations, there is mounting evidence that the near wall structures are more robust and ordered than the outer layer structures independent of boundary and initial conditions, and thus are more amenable to reduced order modeling. We will show that there is a remarkable qualitative and quantitative similarity between the near wall structures in turbulent spots and in fully developed turbulence. Our work on the development and application of wall models for complex engineering calculations will be presented.

Prediction of the location of laminar/turbulence transition in boundary layers is a pacing item for numerical simulations. We will demonstrate that the dynamic subgrid scale models used in large eddy simulations lead to negligible eddy viscosity in the laminar region, and therefore correctly predict the location of transition independent of the particular route to transition.

Keywords: wall-turbulence;