Abstract Submitted
for the DFD10 Meeting of
The American Physical Society

Large-eddy and direct simulations of accelerating boundary layers JUNLIN YUAN, VALERIO GRAZIOSO, UGO PIOMELLI, Queens University, Kingston (Ontario), Canada — Turbulent boundary layers subject to a favorable pressure gradient (which induces freestream acceleration) are found in many engineering applications, such as airfoils or curved ducts. If the acceleration is sufficiently large, turbulence production decreases, and the flow reverts to a laminar or quasi-laminar state. Once the cause of relaminarization is removed, the flow re-transitions to turbulence in a process that may depend critically on the residual levels of turbulent fluctuation during the relaminarization. We performed direct and large-eddy simulations (DNS and LES) of accelerating boundary layers, on smooth and rough flat plates. The DNS allows to study both the relaminarization and re-transition without requiring any turbulence model that may alter the physics. It also validates the LES, which can be extended to higher Reynolds numbers. The roughness is included using an Immersed Boundary Method. The entrainment of the irrotational freestream fluid into the boundary layer plays a critical role in the formation of a well-mixed outer layer and the stabilization of the inner layer. The wall-normal and shear components of the Reynolds stress decay more rapidly than the streamwise one, leading to a state of inactive turbulence that is advected from the upstream boundary layer into the relaminarization region. Roughness effects are limited to the near wall, but are nonetheless visible.

Junlin Yuan
Queen's University, Kingston (Ontario), Canada

Date submitted: 04 Aug 2010 Electronic form version 1.4