Ecole Doctorale Science Pour L'Ingénieur – 072
Université Lille Nord de France
Ecole Centrale de Lille

Tittle: Modeling and prediction of near wall turbulent flows

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Laboratory: The Laboratoire de Mécanique de Lille (LML, UMR CNRS 8107, http://www.univ-lille1.fr/lml/) is a joint research lab between Lille 1 University, École Centrale de Lille, Ecole Nationale des Arts et Métiers and CNRS. Approximately 70 researchers and professors work in Fluid mechanics, Civil engineering and Solids Mechanics . The research team working on turbulence is recognized for his experimental works using optical metrology in wall turbulent flows (http://wallturb.univ-lille1.fr/).

Fellowship: Region & Ecole Centrale de Lille, 01/10/2013, 3 Years

Candidate: Very motivated by the research in the domain of Fluid Mechanics, he has a good background in mathematics and Fluid Dynamics. He enjoys to work in a small team with a certain level of autonomy and a sense of initiative. A good level of English is required.

Subject: Turbulent boundary layers subjected to adverse pressure gradients (APG) induced by wall curvature are of crucial importance for many applications including aerodynamics of airfoils, ground vehicles or turbine blades. Significant progress is needed in understanding this near wall turbulence in order to improve the corresponding theoretical and numerical models. The available numerical models are, at the moment, not able to predict flows under pressure gradient as they are mostly based on the zero pressure gradient boundary layer physics which is no more valid.

Recently, LML performed both detailed experiments and a large Direct Numerical Simulation (DNS) of Adverse Pressure Gradient (APG) flow at significant Reynolds number. These databases are part of a larger database generated within the European project WALLTURB on zero and adverse pressure gradient turbulent wall bounded flows.

Based on these studies, the team has showed that the peak of turbulent kinetic energy which develops in APG flows may be related to the instability of near wall turbulent structures. This discovery is of real interest as it is unlikely that usual turbulent models be able to take this behavior into account. That may explain why these models do not predict correctly such flows with adverse pressure gradient.

The objective of the thesis is to pursue the study of such flows in order to generalize the behavior observed in the present configuration to other adverse pressure gradient flows at large Reynolds number. For that purpose, the exiting databases will be first analyzed in detail to extract the physics specific of APG flows in terms of statistics and coherent structures. Focus will be put on the region of intense kinetic energy production. Then a specific experiment of turbulent boundary layer with adverse pressure gradient, based on the most advanced optical measurement technique such as time resolved stereoscopic particle image velocimetry, will be defined and performed in order to improve the understanding and suggest a modeling strategy.