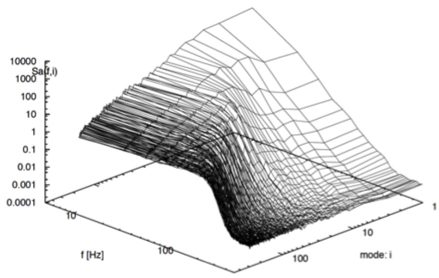
About "High" R_e Turbulent Boundary Layer Dynamics

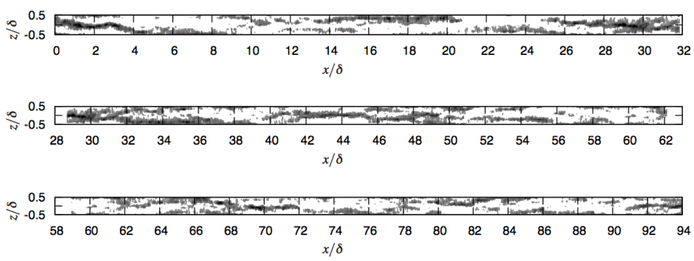
Joël Delville[1]
[1]Institut Pprime - Université de Poitiers - ENSMA - CNRS UPR 3346.
Presenting author email: Joel.Delville@univ-poitiers.fr

Turbulence is not only the "last great unsolved problem of classical physics" according to R. Feynman. It is also responsible for most of human energy consumption, from commercial aircraft to thermal transfers in buildings, as well as for a number of geophysical phenomena in the atmosphere and in the oceans. Despite constant increases in computing power - as exemplified by GENCI, which plans to increase its computing capacity by about two order of magnitudes within 5 years, numerical simulation of real-life turbulent flows remains an inaccessible goal. In this framework, wall-bounded turbulence and Turbulent Boundary Layers (TBL) are characterized by small-scale mechanisms, which cannot be captured directly without a very high resolution. These small scales are coupled to 'perturbations' at larger, even very larger scales, that makes this problem even harder to solve. Understanding the organization of the TBL and its dynamics is therefore crucial for such a purpose. As an example of the application of such approaches, the problem of frontiers or zonal coupling between simulations of different kinds can be cited.

Getting a dynamical model of these TBL scales and of their interactions can be attempted by use of simple *ad hoc* models, obtained from the analysis of experimental data. This can also be performed by deriving Reduced Order Models by Galerkin projection of the governing equations on to some candidate basis or by identification/assimilation techniques. Moreover the instantaneous dynamics and interactions can be 'estimated', by using stochastic approaches. In this talk, after a review of TBL concepts and scalings and of the *zoo of structures* that are generally admitted to exist in this flow configuration, we will focus on low order modelisation based on the Proper Orthogonal Decomposition and Stochastic Estimations, and on some scaling and interactions rules that can be derived from such approaches.



(a)



(b)

Figure 1: : Example of Scaling Law of the POD modes coefficients in a Turbulent Boundary Layer ($Re_\theta = 7500$ $y^+ = 100$): Distribution of Energy of POD coefficients vs mode index and frequency (left). Estimated streamwise low-speed fluctuations $u'/U_\infty < -0.15$ in a plane parallel to the wall located at $y^+ = 361$ using simultaneous PIV hot wires rake measurement $Re_\theta = 9800$ (right).

Acknowledgments....

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