M2 Internship

Laboratoire de Physique de l'ENS (LPENS)
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Internship location: Ecole Normale Supérieure PARIS
Funding: YES
Thesis possibility after internship : YES

Impact of rough boundaries on a turbulent flow

The interaction between turbulent flows and rough walls is a classic problem in fluid mechanics [1], with applications ranging from industrial pipelines to atmospheric boundary layers. While the effects of uncorrelated random roughness on turbulence have been extensively studied, the role of correlated roughness—where surface irregularities exhibit long-range spatial dependencies—remains poorly understood.

During this internship we will study experimentally the flow generated by rotating a rough disk around its axis. The disk's surface is a realization of a random surface modeled as a fractional Gaussian field [2]. The correlations of the height h(r) of this surface are characterized by:

$\langle (h(r)-h(0))^2 \rangle = r^{2H}$, where the Hurst exponent H measure the correlation of the surface.

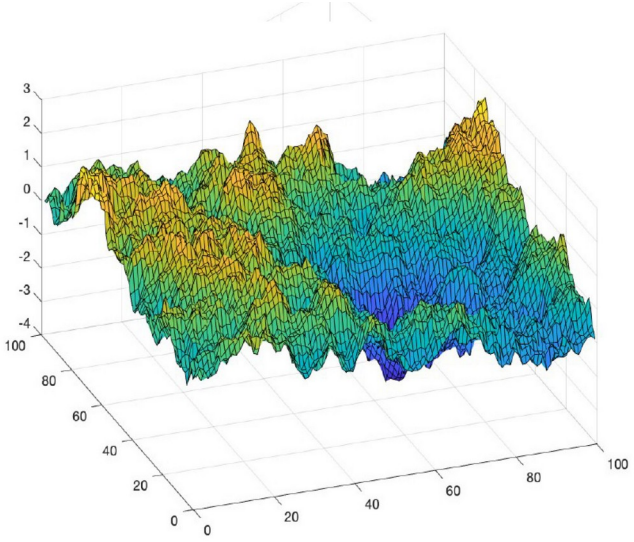


Fig 1 : Example of a rough boundary with H=0.5

Our first experimental observations show that the torque required to rotate the disk varies non-trivially with H. This suggests that the roughness's correlation structure significantly affects the drag and energy dissipation in the flow.

We will perform velocity measurement to investigate how the boundary affects the spatial structure of the flow and in particular we aim to understand how surface correlations alter the energy transfer mechanisms, including the Kolmogorov cascade, and modify velocity fluctuations in the turbulent boundary layer.

During this project, we will first perform measurements of the velocity fluctuations using hot wire anemometry, then analyse the results and attempt to model the evolution of the velocity properties depending on the ones of the rough surface.

For this project, we will use and learn tools from the fields of hydrodynamic, turbulence and statistical physics.

We are looking for a candidate interested in both experimental physics and theoretical modeling of the results. The internship can be continued as a Ph.D. project.

[1] J. Jiménez, Turbulent flows over rough walls. Annual Review of Fluid Mechanics (2004).

[2] M B. Isishenko, Percolation, statistical topography, and transport in random media, Rev. Mod. Physics (1992).