Laboratoire de Mécanique de Lille
(Laboratoire de Mécanique des Fluides de Lille : Kampé de Fériet)

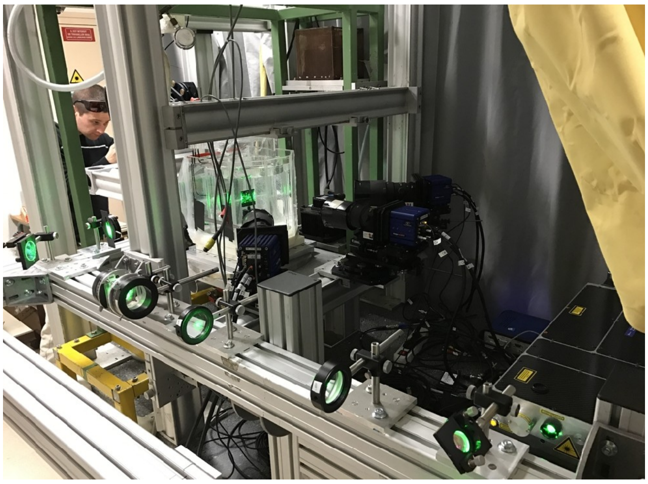
PhD fellowship 2017

EXPERIMENAL STUDY OF THE DISSIPATIVE ANOMALY IN A TURBULENT FLOW

The dissipative anomaly, discused by G.I. Taylor in 1935, reflects the fact that the energy dissipation does not decrease with the viscosity or when the turbulence increases, but, instead, tends toward a constant asymptotic value which seems not universal. This observation is the basis of the Kolmogorov theory of turbulence. It has been used by Onsager in 1949 to draw a outstanding conclusion: in the limit of zero viscosity, the velocity field is not differentiable. This means that the dissipative anomaly could be connected to the existence of singularities in the Navier Stokes equations.

The singularities are defined as points in space where the velocity of the fluid is not enough regular to satisfy that the Navier Stokes equations is not twice derivable. Recent work from Duchon & Robert, 2000 has proved that this question is not a pure mathematical curiosity as they evidence a non-viscous energy dissipation in the vicinity of the singularities. This could explain partly the dissipation anomaly as Onsager already noticed. The search of singularities in the Navier Stokes equations is an open problem (cf. AMS Millenium Clay Prize) However, recent progress both from numerical and experimental point of view, make the problem interesting again. Using the recent progress in visualisation, it is now possible to probe turbulent flows at Kolmogorov scale and to obtain the three component velocity statistics with sufficiently good convergence.

A french ANR research project was financed in 2016 with the « Laboratoire de Mécanique de Lille » and the « SPHYNX » team of CEA Saclay (B. Dubrulle, F. Daviaud) to analyse the dissipative structures and to try to detect the occurrence of singularities in a turbulent von Karman flow. The SPHINX team has a strong experience with this type of turbulent flows which is a good candidat for the study of possible singularities. The purpose of this PhD fellowship is to use this flow forced with several propelers including fractal ones. The aim is to force the flow at different scales in order to promote the development of singularities. Direct measurements of the velocity fields will be obtained by zooming at different scales in order to search, in the physical space, for coherent structures responsible of the dissipative anomaly. In the framework of the ANR projet, three components Particle Image Velocimetry (PIV) in 2D and 3D will be used and adapted and new multi-scale post-processing methods, similar to the wavelet transform, will be developped.



Priliminary experiment of tomographic PIV (using 5 cameras) performed in January 2017 on the experimental setup at CEA/SPHINX in the framework of the ANR project "EXPLOIT".

The PhD fellowship, entirely financed by the ANR project will be conducted in close collaboration with the SPHINX team of CEA. The program will be conducted in parallel with two other PhD thesis in theory, numerics and experiments that already started on the problem of singularity detection in turbulent flows. The aim of the present thesis is to define the setup of the experiments in 3D PIV and to participate to the post-processing of the experimental results. The thesis will be supervised jointly between J-P Laval (CNRS) and J.-M. Foucaut (Prof. Centrale Lille). It requires a strong background in theory of fluid mechanics and ideally in statistical mechanics as well as a strong interest for experimental technics and numerical analysis. Some skills in programming (Fortran, C, Matlab or Python) will also be valuable.

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