CEA Saclay –Service de Physique de l'Etat Condensé (SPEC) (page web)
Laboratoire *SPHYNX* (page web)

PROPOSITION DE STAGE 2022/2023

TURBULENT FLOWS BEYOND THE KOLMOGOROV BARRIER THROUGH SMALL SCALE 4D-PTV MEASUREMENTS

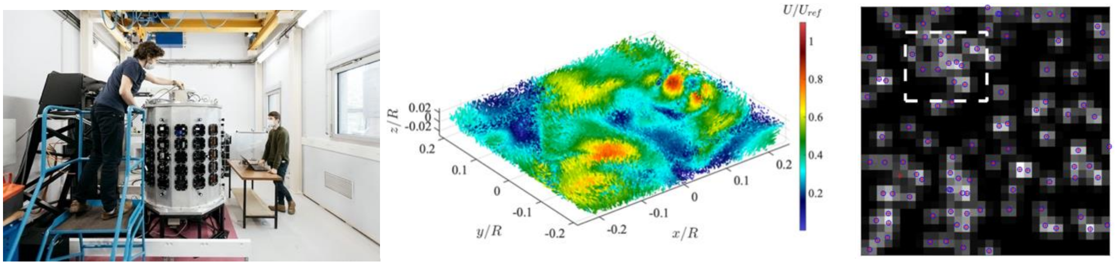

Figure 1: (Left): The Giant Von Karman facility. (Middle) : 4D-PTV measurements : particle trajectories, color coded by their velocities, measured at the center of a Von Karman flow. (Right) : Identification of particles in highly dense image

Viscous flows are ubiquitous in nature and impact many areas of physics, engineering sciences, astrophysics, geophysics, or aeronautics. If you stir strongly enough a viscous flow, it becomes turbulent and displays vortices of various sizes. Typical sizes and organization of such structures can be described by a power-law energy spectrum characteristic of a scale-to-scale energy transfer, by which all the energy injected at large scale is transferred and dissipated at small scale. The typical scale for energy dissipation is called the Kolmogorov scale η and marks the transition between the power law behavior and a steep exponential decay in the wavenumber range. Therefore, scales smaller than η contain a negligible fraction of the kinetic energy. Because of that, it is often thought that scales below η are irrelevant and that "nothing interesting is happening below". Recent theoretical and experimental advances [Dubrulle 2019] however suggest that many interesting phenomena do happen below η and this may impact the validity of Navier-Stokes equations (NSE).

Indeed, below η, energy fluxes can still happen and could create a non-viscous dissipation totally independent of the fluid viscosity. This would constitute dissipative singularities which existence could be the origin of the well-known dissipative anomaly in turbulent flows. Following theoretical work of [Betchov 1957] and confirmed by numerical simulations [Eyink 2022], thermal noise from the molecular agitation of the fluid could compete with macroscopic motions at scales below η. More generally, we may think that the whole structure of small-scale turbulence is affected by thermal fluctuations that may impact or impede the development of quasi-singularities.

In the BANG project, we explore the validity of the NSE as a fluid model by studying the phenomena occurring below the Kolmogorov scale, using multi-scale tools and advanced visualization techniques, *ie* 4D Particle Tracking Velocimetry (4D-PTV), in a dedicated large turbulent experiment called Giant Von Karman (GVK) built at CEA (see Figure 1). To access small scales, we plan to carry out several 4D-PTV measurement campaigns in GVK, using high particle densities as well as unconventional optical conditions with telecentric lenses allowing for a magnification of 2 tested at LMFL. Under such optical conditions, the most difficult step 4D-PTV algorithms must face resides in the image particle detection.

This internship's aim is to develop and assess particle detection methods in order to increase the spatial resolution. The intern will build on the different algorithms and tools developed at ONERA then process and analyze the experimental image data from GVK. At first, he/she will be in charge of creating a preliminary benchmark scenario and datasets that mimics the main features of the experimental setup. This scenario will be the basis for preliminary tuning of the processing tools before the intern handles experimental data processing and analysis from the GVK facility.

The internship is the first step toward a full PHD position devoted to the discovery of sub-Kolmogorov phenomena. (financement ANR-BANG)

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