Diffusion and Dispersion of Particles in Turbulent Flows

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Experimental techniques: Lagrangian Tracking, Tomographic Imaging, and PIV

Motivations and context

Despite significant advancements in our understanding of particle mixing in recent decades, the influence of turbulent flows on the dispersion of passive scalars remains an open and complex topic with several unanswered questions. The statistical properties of "passive scalar" turbulence are distinct from those of the velocity field, emphasizing the importance of comprehending the physics of mixing in turbulent flows. This knowledge is therefore crucial for validating theoretical models and has practical applications in fields such as process engineering and atmospheric science.

Experimental approach

This experimental internship aims to develop a system for measuring the Lagrangian dynamics of fluid tracers in turbulent flows generated by centimeter-scale magnetic stirrers, as detailed in references [1, 3, 2] and shown in Figure 1.
In the initial phase, we will conduct Lagrangian tracking measurements in two dimensions to establish the foundation of experimental Lagrangian tracking techniques. Subsequently, the project will progress to its full scope by conducting measurements in three dimensions (see figure).

Research focus

We will focus on the dynamics of a single particle by measuring the probability density functions of Lagrangian acceleration and the evolution of the curvature along the trajectories. We will also look at vortex trapping events and the dot product of the velocity and acceleration. The dynamics of multiple particles by studying the short-time dynamics of the pair separation will be investigated as well, providing insights into the turbulence-induced relative dispersion and the influence of coherent structures on particle trajectories.

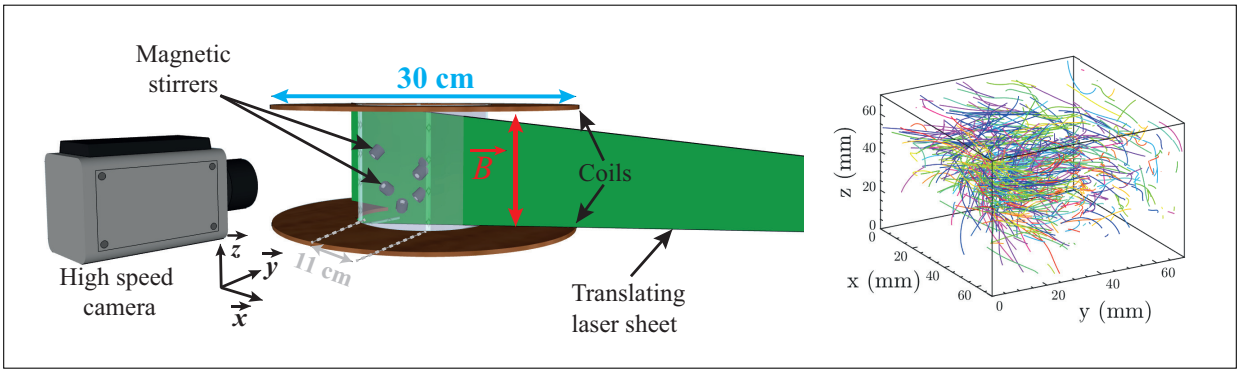

Figure 1: Left: Experimental setup showing the liquid reservoir and the encapsulated magnets together with the translating laser sheet. The liquid reservoir has the dimensions $11 \times 11 \times 8$ cm^3 and is filled with water. The fluid is seeded with silver coated glass sphere tracers. Right: Reconstructed trajectories of the passive fluid tracers in the fluid container.

References

[1] A. Cazaubiel, J.-B. Gorce, J.-C. Bacri, M. Berhanu, C. Laroche, and E. Falcon, Three-dimensional turbulence generated homogeneously by magnetic particles, Phys. Rev. Fluids **6**, L112601 (2021).
[2] J.-B. Gorce and E. Falcon, Statistics of a two-dimensional immersed granular gas magnetically forced in volume, Phys. Rev. E **107**, 034903 (2023).
[3] J.-B. Gorce and E. Falcon, Statistical Equilibrium of Large Scales in Three-Dimensional Hydrodynamic Turbulence, Phys. Rev. Lett. **129**, 054501 (2022).