Trapping of heavy flexible disc within vortical flow

Particle clustering is a key parameter to model aggregation in turbulent flows. For heavy spherical particles, it has been shown that this phenomenon is mainly due to centrifugal forces which expel particles form high vortical regions. For thin flexible particles, the situation seems more complex. Their deformability allow the particle to wrap around the vortex core to follow the streamline. This shape is related to a difference of pressure from each side of the particles, the pressure being higher farther from the vortex core. This pressure difference is responsible of a net force that push the particle toward the vortex core. The balance of this net force and the centrifugal force might be at the origin of a new equilibrium distance from the vortex core, *cf*. Figure 1.

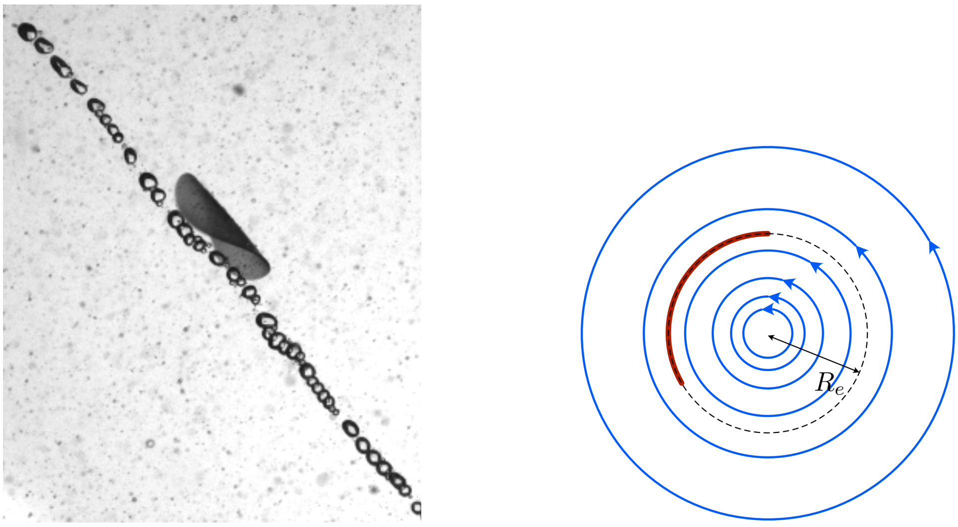

Figure 1. **Left**: Disc trapped by a large scale vortex with a density 10% higher than the carrying fluid and with a diameter of 20 mm. The vortex core is visualised thanks to bubbles. The residence time of the disc is more than 300 turnover time fixed by the rotation frequency of the impellers. A movie of this phenomenon slowed down 10 times can be seen here. **Right**: Sketch of the equilibrium radius

The aim of this project is to characterize this phenomenon both theoretically and experimentally. The flow will be generated in the Cube facility, already used in previous studies on Lagrangian turbulence [1,2,3]. However, the forcing will be different and a series of experiments will be performed at the beginning of the project to characterize accurately this new flow. This will be done using classical Particle Image Velocimetry or Particle Tracking velocimetry methods. Then, a systematic study of the dependence of the equilibrium radius on the particle density and flexibility will be lead. Finally, our results will be compared to theoretical model derived in parallel with F. Candelier.

The duration of this proposal is of one year. The hired student will have a PhD in Physics (Fluid Mechanics) and preferentially have some expertise in particle tracking. She/He will be in charge of the experiments: to manufacture particles, to run the experiments and to post-process the experimental data at IRPHE. She/He will also work in collaboration with F. Candelier to derive theoretical model of this phenomenon. She/He will be host at IRPHE and, as funded by the Institute of Mechanical Engineering of AMU, will have to supervise undergraduate students for 2 months and/or give lectures within the master Fluids and solids.

[1] S. Bounoua, G. Bouchet and G. Verhille,Tumbling of inertial fibers in turbulence *Phys. Rev. Lett.*, 121(12), 124502, 2018.
[2] A.D. Bordoloi, E. Variano and G. Verhille, Lagrangian time scale of passive rotation for mesoscale particles in turbulence, *Front. Mar. Sci.*, 7, 473, 2020.
[3] T. Oehmke *et al.*, Spinning and tumbling of long fibers in isotropic turbulence *Phys. Rev. Fluids*, 6, 044610, 2021.

Contact:

- Gautier Verhille : gautier.verhille@irphe.univ-mrs.fr / +33 413 552 081
- Fabien Candelier : fabien.candelier@univ-amu.fr / +33 491 113 876