ECOLE DOCTORALE
« Mécanique, Energétique, Génie Civil, Procédés »
ED 468

Thesis proposal for a Doctoral position 2024-2027

Title	Interaction of a vortex ring with a freely moving body
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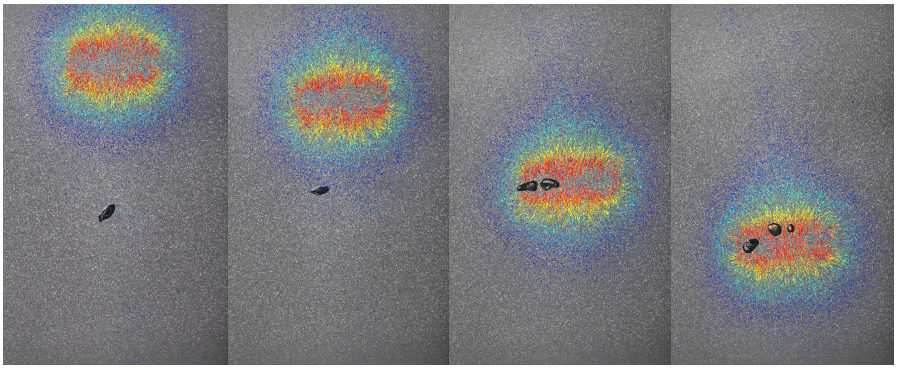
Deadline	May 1, 2024

Research project description :

In environmental and industrial flows involving dispersed two-phase flows, the interaction of solid or gaseous inclusions with vortical structures (generated for instance by the unsteady wakes of other inclusions) gives rise to a wide range of behaviors that need to be better understood, characterized and modeled. These include, for instance, the capture and entrainment of the body by the vortex, its deformation and even fragmentation in the case of bubbles (see illustration below). The interaction may also lead to the destabilization and destruction of the vortex due to the body passage (see for instance, [1]). To investigate these phenomena, we built a generic experimental facility allowing us to study the interaction of a vortex ring with a freely rising or falling body following either a rectilinear or periodic motion in a fluid otherwise at rest. The size of the vortex ring is chosen comparable to that of the body and its intensity comparable to the hydrodynamical perturbation induced by the body motion. Thanks to a time-resolved 3D-PTV technique coupled to a shadowgraphy technique (recently used to characterize the path and wake of cylindrical bodies freely moving in fluid at rest [2]), our goal is here to obtain simultaneous measurements of the body motion and of the fluid behavior during their interaction. We aim at characterizing experimentally the dynamics of the interacting pair, by capturing simultaneously the body kinematics, the body deformation as well as the fluid motion, for a panel of situations featuring vortex rings of well-controlled intensity and size interacting with bubbles, spheres, rigid or flexible cylinders of variable aspect ratios. This exploration will provide a better understanding of the effect of the body deformation and of the body geometry on the observed phenomena (for instance, on the capture dynamics). The analysis of the results will also aim at modeling the loads induced on the body by the vortical structure, as well as the mechanisms leading to the destabilization and decrease of the vortex. The study of bubble fragmentation will be carried out in collaboration with J. Ruiz Rus (Univ. of Jaén, Spain) and C. Martínez Bazán (Univ. of Granada, Spain) [3]. In addition, as an opening towards ethology and environmental questions, a first exploratory investigation will also be carried out during the Thesis on the interaction between a vortex ring and a fish (active) or its corresponding lure (passive body), in order to identify the preferred maneuvering and interaction strategies of the fish.

[1] A. Filella, P. Ern, V. Roig (2020). J. Fluid Mech., vol. 888, A13.
[2] M. Lorite-Díez, P. Ern, S. Cazin, J. Mougel, R. Bourguet (2022). J. Fluid Mech., vol. 946, A16.
[3] C. Martínez-Bazán (2015), J. Fluid Mech., vol. 780, pp 1–4 (Focus on Fluids).



Sequence of images showing the vortex velocity field and the fragmentation it induces on a bubble.