INTERNSHIP/PHD

FLOW CONTROL USING KIRIGAMI SHEETS

Supervisors: Sophie Ramananarivo, sophie.ramananarivo@polytechnique.edu
Agathe Schmider, agathe.schmider@polytechnique.edu
Start date: anytime from Jan. 2024
Host laboratory: LadHyX, Ecole Polytechnique

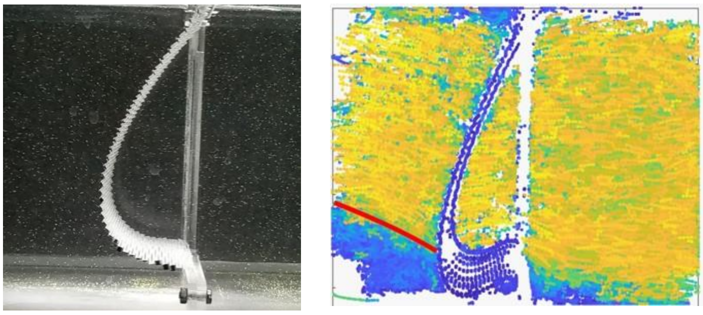

Figure: (left) Deformation of a poro-elastic kirigami sheet in a uniform flow seeded with particles. (right) Preliminary particle tracking shows an upward deflection of the flow in the wake, with a recirculation region (in blue).

Context: The ability to manipulate flow fields is of importance in various engineering applications, influencing efficiency, performance, and safety. It can be achieved either actively or passively. Active flow control typically involves the use of external energy input, such as valves, pumps or actuators, to manipulate fluid dynamics. On the other hand, passive flow control usually entails optimizing the shape or constituent material of a structure to influence fluid behavior without the need for external input. The use of reconfigurable materials that deform in response to fluid loading is then an ideal candidate to pursue such a purpose [1,2]. However, it necessitates control over the deformation of the object, and its subsequent effects on the flow.

A promising approach involves the use of kirigami technique, inspired by the Japanese art of paper cutting. Kirigami provides a means to program the flow-induced deformation of a sheet through the cutting pattern [3]. When subjected to a flow of increasing speed, the incised sheet stretches, opening pores that allow fluid to pass through. Consequently, it functions as a poro-elastic membrane with significant fluid-structure couplings: the fluid loading deforms the membrane, which, in turn, retroactively alters the flow. This can notably lead to flow deviation in the wake of the sheet (see Figure).

Goals: The objective of this internship is to investigate the impact of kirigami sheets on fluid dynamics and explore their potential for passive flow control. We will characterize experimentally the effects of altering cutting pattern parameters on the velocity profile in the wake of the flow. We will employ flow visualization with hydrogen bubbles to gain qualitative insights into fluid flow patterns and use 2D Particle Image Velocimetry (PIV) for precise velocity measurements. This characterization will serve as the foundation for constructing a simplified predictive model that will help elucidate the underlying mechanisms of flow-structure interaction and allow to generate specific velocity profiles in the flow wake.

Profile: Candidates should have a good training in Fluid mechanics. A strong taste for both experiments and theoretical analysis is a plus. *PhD opportunity after the internship.*

[1] Gomez, M., Moulton, D.E., Vella, D., 2017. Passive Control of Viscous Flow via Elastic Snap-Through. Phys. Rev. Lett. 119, 144502.
[2] Louf, J.-F., Knoblauch, J., Jensen, K.H., 2020. Bending and Stretching of Soft Pores Enable Passive Control of Fluid Flows. Phys. Rev. Lett. 125, 098101.
[3] Marzin, T., Le Hay, K., de Langre, E., Ramananarivo, S., 2022. Flow-induced deformation of kirigami sheets. Phys. Rev. Fluids 7, 023906.