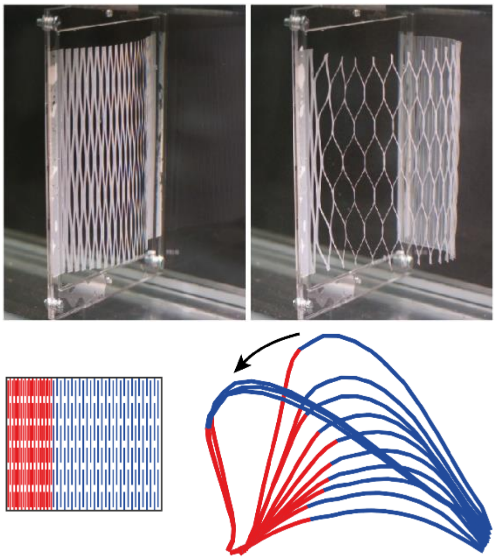
POSTDOC POSITION

Programmable rapid shape transformations in Kirigami under flow

LAB : LadHyX, Ecole Polytechnique, Palaiseau, France

Start date : anytime starting in January 2026

CONTACT : Sophie Ramananarivo – LadHyX (sophie.ramananarivo@polytechnique.edu)



Context. Compliant and flexible structures are emerging as versatile alternatives to traditional rigid components in devices interacting with fluid flows. By passively changing shape, they can reduce drag, adapt to varying flow conditions, and autonomously perform multiple functions without additional actuation. **Kirigami-inspired designs, drawing on the Japanese art of paper cutting, offer a promising approach to program shape morphing in response to flow** [1], with applications in flow control or parachute design [2]. While previous research has mainly addressed static and quasi-static behaviors, dynamic fluid-elastic responses are equally critical. Slender structures in transverse or axial flows can experience self-induced oscillations or divergence instabilities, abruptly shifting from one equilibrium shape to another [3]. In our laboratory, we have observed such instabilities in composite kirigami structures with regions of varying stiffness, where sudden shape transitions occur beyond a critical flow velocity. These fluid-elastic instabilities can be harnessed for dynamic functionalities: rapid geometric changes can reduce loads by adopting drag-minimizing shapes or function as velocity-threshold sensors. Conversely, some applications require stability to preserve structural integrity, highlighting the need to carefully evaluate and control the stability of deformed configurations for robust design.

Objectives. This postdoctoral position aims to **investigate how the substructure of kirigami cuts influences static fluid-elastic instabilities, with the goal of understanding, predicting, and harnessing sudden shape transformations**. The research will combine systematic experiments and theoretical modeling to uncover the key mechanisms driving these instabilities. Experiments will focus on characterizing kirigami specimens with varying cut patterns in controlled water flows, using imaging and flow visualization to capture deformation and flow-structure interactions. Theoretical efforts will build on existing models for flexible structures under fluid loading [2], extending them to dynamic regimes. Linear stability analyses will help identify the conditions leading to static divergence and guide the development of predictive, programmable strategies for controlling kirigami instabilities. **Active control approaches will also be explored to suppress or trigger instabilities, enabling the design of underactuated systems with enhanced functionality**. This first case study will establish a framework for investigating kirigami dynamics in flow and pave the way for exploring diverse cut patterns, pore morphologies, and mechanical properties. Kirigami designs offer a unique platform to revisit canonical fluid–structure interaction problems beyond conventional frameworks, presenting new challenges due to their extreme stretchability, nonlinear mechanics, and porous architecture.

Environment. The research will be conducted at LadHyX, a joint CNRS–École Polytechnique laboratory near Paris, offering a dynamic and interdisciplinary research environment. The lab has recognized expertise in fluid mechanics, soft matter physics, and fluid–structure interactions, with strong connections to fields such as biology and sports physics. The candidate will join the ANR-funded project KiDyFlow, led by S. Ramananarivo (LadHyX) in collaboration with J. Marthelot and M. Bento Santana at IUSTI in Marseille. A PhD student at LadHyX, and a postdoctoral researcher at IUSTI will work on complementary aspects of this project, fostering strong synergy and a stimulating collaborative atmosphere.

Profile. Candidates should hold a PhD degree and have experience in at least one of these areas: fluid mechanics, fluid/structure interaction, mechanical metamaterials, or continuum mechanics. A strong taste for both experiments and theoretical analysis is a plus. Expertise in areas such as flow imaging, fluid-structure instabilities, stability analysis, and dynamical systems is particularly welcome.

Dates. 1 year, with the possibility of a 1-year extension. The position can start anytime from January 2026.

Contact. Interested candidates are encouraged to contact Sophie Ramananarivo for informal inquiries or to discuss the position in more detail. Applications should include a detailed CV and the names and email addresses of two references.

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[1] Marzin, T., Le Hay, K., de Langre, E., Ramananarivo, S., 2022. Flow-induced deformation of kirigami sheets. *Phys. Rev. Fluids* 7, 023906.
[2] Lamoureux, D., Fillion, J., Ramananarivo, S., Gosselin, F. P., & Melancon, D. (2025). Kirigami-inspired parachutes with programmable reconfiguration. *Nature*, 646(8083), 88-94.
[3] M. P. Paidoussis, Fluid-structure interactions: slender structures and axial flow, Academic press, 1998.