Can sheet cuttings control flow-induced deformation ?

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Kirigami, the japanese art of paper cutting, turns inextensible sheets into ultra-stretchable devices via the opening of pores [1]. The morphological and mechanical properties can be tuned through the cutting pattern, providing control strategies for the sheet deformation in a flow.
We use water-tunnel experiments on clamped kirigami sheets to analyse the complex interplay of pore opening (Figure 1a), sheet deformation and fluid loading. In particular, we characterize the surprising asymmetric deployment observed for increasing flow speed.

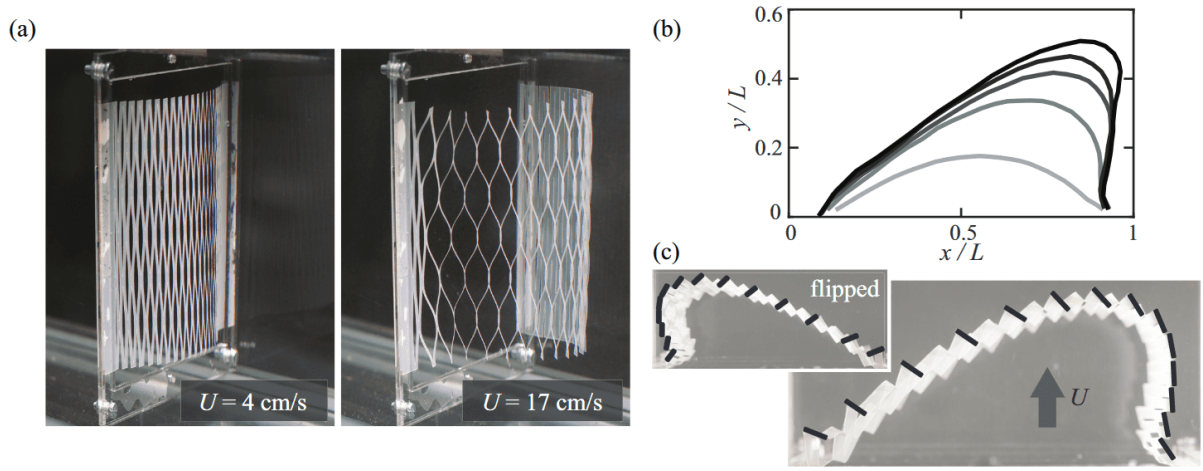

Figure 1. (a) Deployment in a water crossflow. (b) Typicalshape profiles extracted from top-view pictures of the structure of length L, when increasing the flow speed $U = [4, 8, 13, 17, 21]cm/s$ (denoted by the grayscale). (c) The tilting of buckled cut units (outlined in black)induces tangential fluid forces, resulting in asymmetric profiles prescribed by the buckling direction (reversedin the inset)

Deformations are mainly govern by the balance between fluid loading and elastic restoring forces. Knowing that a close link between the cutting pattern and the elasticity of the structure has been established, changing this parameters offers to modulates expansion and shape in a flow.
We have shown that the local scale leads observed symmetry breaking : the evolution of the pore morphology affecting the directionality of fluid forces (Figure 1b-c).
A continuous theoretical model completes our approach faithfully describes the expansion of these complex structures under flow.

Références

1. Isobe, M., & Okumura, K., Initial rigid response and softening transition of highly stretchable kirigami sheet materials. Scientific reports, *Scientific reports*, 6(1), 1-6 (2016).