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MMM02 : Mechanics of slender structures, metamaterials, and their multiphysics couplings

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Content:

This mini-colloquim aims at presenting the lastest advances in the field of slender structures, metamaterials, and their multiphysics coupling. Physicists, mechanicians, and material scientists interested in these objects are welcome to share their experimental, numerical and theoretical results.

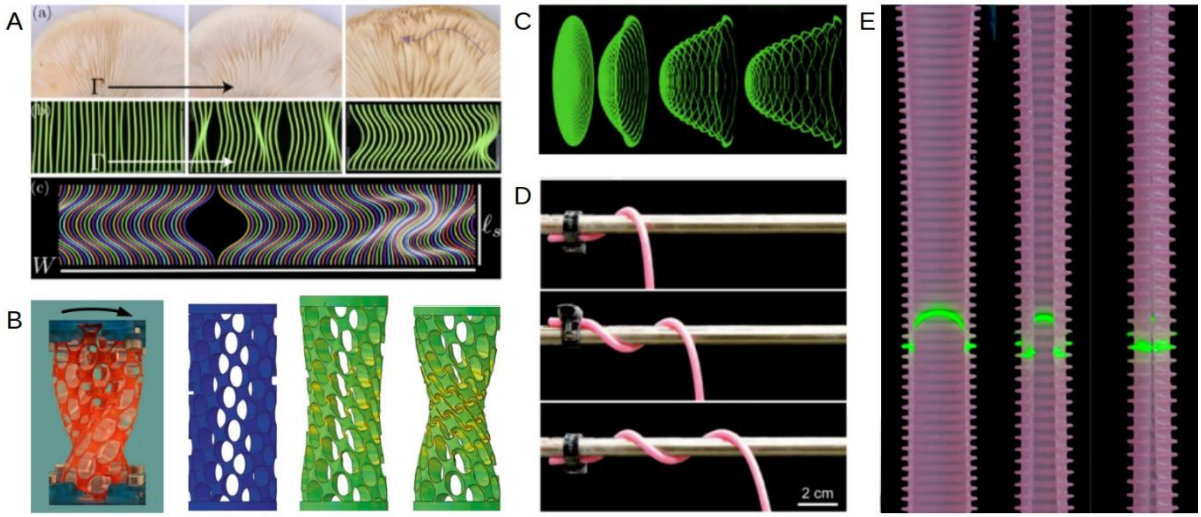

Figure 1: A) Lamella buckling in a mushroom and buckling experiments with compressed elastic beams (from Guerra et al. [1]). B) Torsion of a meta-shell in experiments and simulation (from Ghorbani et al. [2]). C) Kirigami-inspired parachute in a flow (from Lamoureux et al. [3]). D) Wrapping of an elastic rod around a rotating cylinder (from Tani et al. [4]). E) Bending of a ribbed strip induced by stretching (from Siéfert et al. [5])

Slender structures such as rods, plates, and shells are objects with at least one of their dimensions, the thickness, much smaller than the others. This geometrical specificity makes them compliant, with bending deformation allowing large displacements at relatively low forcings. More strikingly, this geometric slenderness triggers mechanical instabilities, such as buckling, and rich nonlinear behaviors

that are primarily governed by geometry rather than the constitutive law of the material composing them.

Metamaterials, or architected materials, extend this philosophy: their macroscopic mechanical properties emerge from the assembly of elementary units that interact with each other and with their environment. This mesoscale design unlocks unconventional, often nonlinear behaviors that are inaccessible in homogeneous materials, such as zero-energy deformation modes, multistability, and vibrational band gaps.

Harnessing these nonlinear properties for applications, modelling the effective behavior of these structures through homogenization, and understanding their coupling with other physics — such as fluid flow, or biological growth — remain open and fertile challenges. This colloquium aims to stimulate interactions across communities to address them.

[1] A. Guerra, A. C. Slim, D. P. Holmes, and O. Kodio, Self-ordering of buckling, bending, and bumping beams, Phys. Rev. Lett 2023
[2] A. Ghorbani, M. J. Mirzaali, T. Roebroek, C. Coulais, D. Bonn, E. van der Linden, and M. Habibi, Suppressing torsional buckling in auxetic meta-shells, Nat. Comm. 2024
[3] D. Lamoureux, J. Fillion, S. Ramananarivo, F. P. Gosselin, and D. Melancon, Kirigami-inspired parachutes with programmable reconfiguration, Nature 2025
[4] M. Tani and H. Wada, How a soft rod wraps around a rotating cylinder, Phys. Rev. Lett. 2024
[5] E. Siéfert, N. Cattaud, E. Reyssat, B. Roman, and J. Bico, Stretch-induced bending of soft ribbed strips, Phys. Rev. Lett. 2021