

The art of folding structures and solids

Davide Bigoni¹

¹ Instabilities Lab, Università di Trento, Italy, davide.bigoni@unitn.it

Abstract

During the process of folding, curvature localizes in space and progressively forms sharp edges, separated by almost undeformed elements. Origami is created by inducing folding in thin films, which can be made from paper or other materials. Differently from the creation of origami, folding in rock formations, marine shells, or other natural elements is a spontaneous process, driven by forces and, for living matter, growth. The purpose of the presentation is to develop the modelling of spontaneous folding in structures and solids.

A new continuous model of shearable rod, subject to large elastic deformation, is derived from nonlinear homogenization of a one-dimensional periodic microstructured chain. As particular cases, the governing equations reduce to the Euler elastica and to the shearable elastica known as ‘Engesser’. The postcritical response of the simply supported equivalent continuous rod exhibits the emergence of folding, an infinite curvature occurring at a point of the rod axis, developing into a curvature jump at increasing load [1]. In solids, folding is shown to occur in an elastic solid obeying the couple-stress theory with extreme anisotropy [2].

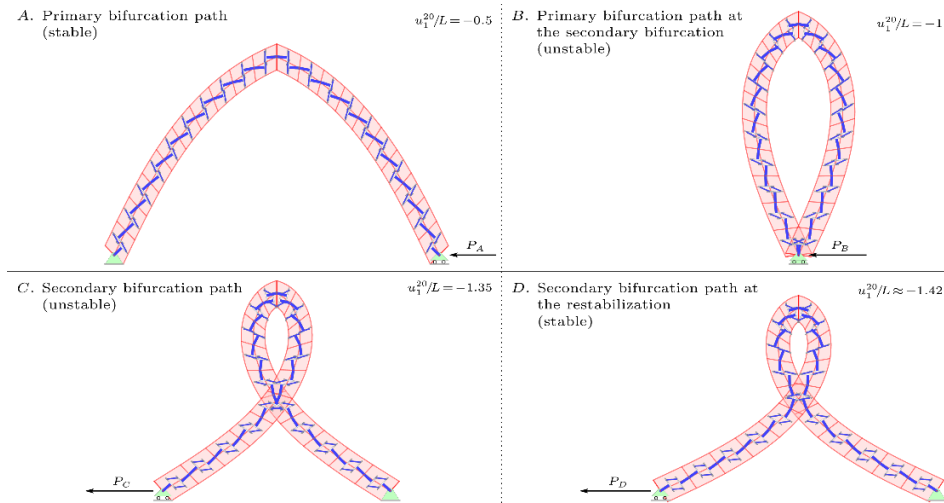


Figure 1. Folding formation during the postcritical path of a doubly-supported microstructured rod.

The obtained results can be applied to various technological contexts involving highly compliant mechanisms, such as the achievement of objective trajectories with soft robot arms through folding and localized displacement of origami-inspired or multi-material mechanisms.

Acknowledgments

Financial support from ERC-ADG-2021-101052956-BEYOND.

References

- [1] Paradiso, M, Dal Corso, F., Bigoni, D. 2025, “A nonlinear model of shearable elastic rod from an origami-like microstructure displaying folding and faulting”, J. Mech. Phys. Solids, in press.
- [2] Bigoni, D., Gourgiotis, P.A. 2016, “Folding and faulting of an elastic continuum”, Proc. Royal Soc. A, vol. 472, pp. 20160018.