Designing elastic snap-through instabilities

B. Radisson[1], E. Kanso[1]

Department of Aerospace and Mechanical Engineering, University of Southern California, Los Angeles, CA 90089-1191, USA

bradisso@usc.edu

Multistable elastic structures are considered as the ideal building block to design new metamaterials that can change their shape or mechanical properties on demand. These functionalities are traditionally achieved by triggering shape transitions at the building block level. While these transitions are known to be related to the type of bifurcation the system undergoes [1], there is no general understanding of the mechanisms that select these bifurcations. Here we analyze numerically and analytically a set of simple systems in which an elastic strip is initially maintained in a buckled state (Fig. 1A-B) and driven through shape transitions by either translating (Fig. 1C-D) or rotating its boundaries. We first identify the relevant frame of reference to analyze this kind of problem and extract three configurations that illustrate the entire range of shape transitions described by previous authors. For each of these systems, we establish the nature of the bifurcation they undergo using reduction order methods and provide the evidence that the selection of these standard bifurcation forms is governed only by the geometrical symmetries of the system. Being based solely on the universal concept of symmetry, these findings are likely expandable to more complex systems and could be applied to design new metamaterials that can change their shapes on demand.

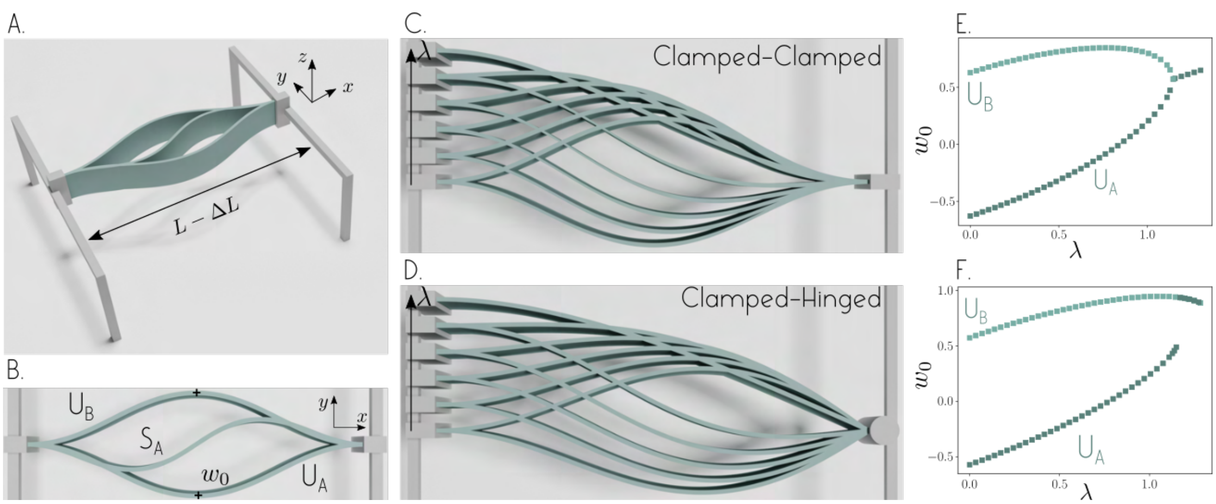

Figure 1. Translational actuation of a buckled beam. A-B : A geometrically constrained elastic strip constitutes a bistable system where U_A and U_B are the two stable equilibria available **C-D :** Translating the left boundary by a non-dimensional distance λ, ultimately leads to loss of bistability and a shape transition whose nature depends on the set of bcs. **E-F :** This is evidenced by plotting the evolution of the mid-point deflection w_0 for U_A and U_B in term of λ. In the case of clamped-clamped (E.) (respectively clamped-hinged (F.)) bcs the transition is smooth (respectively violent).

Références

1. M. Gomez, D. E. Moulton and D. Vella, *Nature Physics*, **13.2**, 142-145, (2017)