Bistable mechanisms for strips with controlled clamped ends

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Keywords: elastica, snap-back

A strip constrained at its ends by clamps with controlled position and rotation is considered. With reference to the quasi-static solution of the elastica expressed in terms of elliptic functions, the number of stable configurations is disclosed for every admissible triad of primary kinematical boundary conditions, namely the rotations at the two ends and the distance between the clamps. The complete set of critical boundary conditions, corresponding to snap-back mechanisms, is evaluated and represented as two different surfaces within the space defined by the primary kinematical parameters. At any fixed distance between the clamps, cross sections of these surfaces display the shape of typical catastrophic cusps, revealing the dramatic influence of imperfections also in the case of nearly symmetric rotating clamps. The obtained surfaces allow for the prediction of the snap conditions for any specific evolution in the boundary conditions. Inspired by Zeeman's catastrophe machine, where stretchy rubbers are involved, a design of a catastrophe machine for elasticae is proposed.

The present theoretical model is confirmed by numerical simulations performed through the commercial code Abaqus, and is in agreement with the experimental results obtained by Plaut and Virgin[1] and Beharic et al.[2], performed under symmetric conditions and fixed distance between the clamps.

References

[1] *Plaut R. H., Virgin L. N., Vibration and Snap-Through of Bent Elastica Strips Subjected to End Rotations, Journal of Applied Mechanics,* **76** */ 041011, (2009)*

[2] *Beharic J., Lucas T. M., Harnett C. K., Analysis of a Compressed Bistable Buckled Beam on a Flexible Support, Journal of Applied Mechanics ,* **81** */ 081011, (2014)*

Acknowledgements: Support from the ERC Advanced Grant Instabilities and non-local multiscale modelling of materials 340561-FP7-PEOPLE-IDEAS-ERC-2013-AdG (2014-2019) is gratefully acknowledged.