9th European Solid Mechanics Conference (ESMC 2015)
July 6 - 10, 2015, Leganés-Madrid, Spain

Flexural propulsion

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Key words: Configurational mechanics, Locomotion, Snaking

The problem is analysed ofan elastic rod, straight in its undeformed configuration, and constrained within a rigid and frictionless curved channel, Fig. 1. This is a simplified version (in which friction is not considered) of the famous problem of snake locomotion analysed also by Gray [1-3] under the restrictive assumption that the rod is discretized in rigid pieces connected by rotational elastic springs.

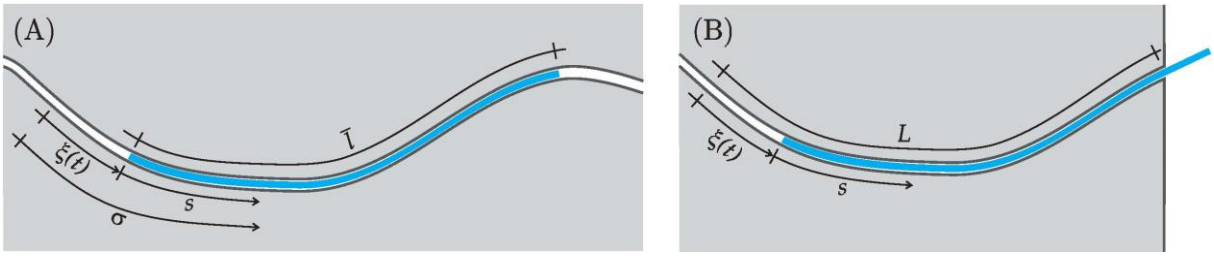

Figure 1:An extensible elastic rod (rectilinear in its undeformed configiguration) of length $\bar{l}$ within a smooth curvinlinear channel. Its configuration is defined by the evolution in time of the curvilinear coordinate $\xi(t)$. Both cases of the rod fully (A) and only partially (B) constrained within the smooth rigid channel are considered.

The analysed problem is an example of an inflected structure dominated by configurational (or Eshelby-like) forces, as pointed out in [4], providing the locomotion to the system.
The problem is analysed analytically (by using variational calculus and micromechanics), numerically (through ABAQUS simulations) and experimentally (with apparatuses *ad hoc* designed and realized). In particular, the propulsive force is derived taking into account a series of conditions never analysed before, but important to explain animal locomotion and to design compliant mechanical devices. The obtained results are fully validated through both simulations and experiments.

Acknowledgement: Financial support from the ERC Advanced Grant 'Instabilities and nonlocal multiscale modelling of materials' FP7-PEOPLE-IDEAS-ERC-2013-AdG (2014-2019) is gratefully acknowledged.

REFERENCES

[1] J. Gray, J. Exp. Biol. 23 (1946) 101.

[2] J. Gray, H.W. Lissmann J. Exp. Biol. 26 (1950) 354.

[3] J. Gray, J. How animals move. Cambridge University Press, 1953.

[4] D. Bigoni, F. Dal Corso, D. Misseroni, F. Bosi, Proc. Roy. Soc. A (2014) 470.