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Modeling of metamaterials subjected to differential swelling

Master of Science project

Abstract

This M.Sc. project aims at modeling metamaterials subjected to differential swelling, which would produce large deformations. The student will implement advanced numerical methods for the optimization of such complex materials within hybrida, a rapidly growing in-house finite element library that is currently being developed at the Structural Optimization and Mechanics (SOM) group.

Introduction Contrary to natural materials, whose behavior is mainly determined by their composition, metamaterials obtain functionality that is not often seen in nature by means of the way they are structured at relatively small length scales. Metamaterials have tremendous potential as they broaden the spectrum of functionalities with new applications that not too long ago were undreamed of. The realm of metamaterials has spread out from its origin in the field of electromagnetism, and regarding mechanical metamaterials alone, many new functionalities have been investigated, including energy absorption, acoustic/phononic wave propagation, heat conduction, and negative Poisson's ratio.

Responsive and tunable metamaterials are the latest trend in metamaterial research. Differential swelling can drastically change the shape and mechanical response of a structure. This effect can be used for self-folding across different scales, as illustrated in Figure 1. Buckling by a mismatch in the swelling geometry might be exploited to achieve more complex shapes. The aim of this project is to create a numerical tool for the analysis and design of these responsive metamaterials.

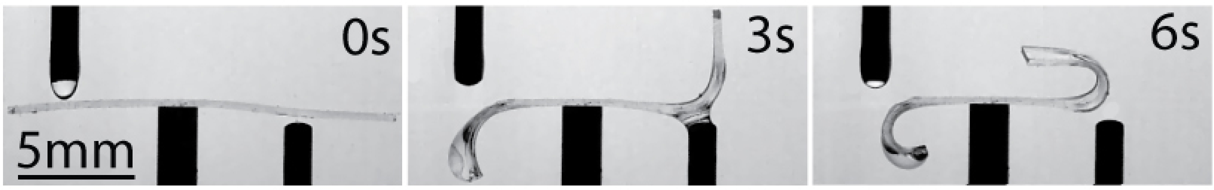

Figure 1: Self-folding of an elostomer by localized swelling [1]

Tasks *i)* Conducting a thorough literature review on the different methodologies used for the modeling of swelling and swelling-induced buckling; *ii)* Implementing the required formulation within hybrida, our in-house finite element library; *iii)* Analysis of thermal response of different plates with differential swelling; *iv)* Presenting the results and preparing a report that could lead to a peer-reviewed journal publication.

Requirements The student should have modeling experience and basic knowledge of finite element analysis. Python programming experience is recommended.

References

[1] Douglas P. Holmes, Matthieu Roche, and Tarun Sinha. Bending and twisting of soft materials by non-homogenous swelling. *Soft Matter*, 7:5188–5193.