# A nemato-elastic phase-field model for liquid crystal elastomers

**Omkar Nadgir*** **and Marc-André Keip**

University of Stuttgart
Institute of Applied Mechanics (CE)
Pfaffenwaldring 7, 70569 Stuttgart, Germany
e-mail: omkar.nadgir@mechbau.uni-stuttgart.de
web page: www.mechbau.uni-stuttgart.de/ls1

## ABSTRACT

Nematic liquid crystal elastomers are soft materials that are characterized by a heterogeneous microstructure [1]. They are made of crosslinked polymeric backbones and attached nematic mesogens [2]. When these materials are cooled down below a certain temperature, they exhibit an isotropic–nematic phase transition. The phase transition is accompanied by large spontaneous deformations, which makes them prototype candidates for the design of soft actuators.

This talk presents a coupled nemato-elastic phase-field model for liquid crystal elastomers that builds upon two main ingredients. First, we account for nematicity through the definition of a suitable order parameter, whose evolution is predicted by the phase-field theory [3]. Second, we consider a neo-classical Warner-Terentjev elastic energy for the elastic part of the problem [1]. The resulting large-deformation model is implemented within a finite element framework and a series of numerical simulations is given. The examples demonstrate crucial characteristics of nematic elastomers such as isotropic–nematic phase transition and the creation of stripe domains under applied stretch [4, 5].

## REFERENCES

[1] Warner, M. and Terentjev, E.M. *Liquid crystal elastomers*, volume 120 of International Series of Monographs on Physics, Oxford University Press (2003).

[2] Biggins, J.S. and Warner, M. and Bhattacharya, K. Elasticity of polydomain liquid crystal elastomers. *Journal of the Mechanics and Physics of Solids* (2012) **60**(4):573–590.

[3] Sonnet, A. and Kilian, A. and Hess, S. Alignment tensor versus director: Description of defects in nematic liquid crystals. *Physical Review E* (1995) **52**(1):718–722.

[4] Kundler, I. and Finkelmann, H. Director reorientation via stripe-domains in nematic elastomers: influence of cross-link density, anisotropy of the network and smectic clusters. *Macromolecular Chemistry and Physics* (1998) **199**(4):677–686.

[5] Conti, S. and DeSimone, A. and Dolzmann, G. Semisoft elasticity and director reorientation in stretched sheets of nematic elastomers. *Physical Review E* (2002) **66**(6):061710.