Modeling liquid crystal elastomers: from auto-origami to responsive surfaces and light-driven autonomous soft robotics

Robin Selinger

Liquid Crystal Institute, Kent State University

Liquid crystal elastomers combine the orientational order of liquid crystals with the elasticity of polymers. Remarkably, these materials flex and deform reversibly, driven by stimuli such as illumination or heating, and can undergo autonomous folding, or "auto-origami," into complex shapes. The material's liquid crystal director field defines the local axis of extension/contraction, and can be patterned to induce a programmed shape trajectory. We model the dynamics of these shape transformations using finite element elastodynamics, examining director fields incorporating twist, splay, and high-order topological defects to create twisting ribbons, folding boxes, and deformable surfaces. We also model the generation of continuous light-driven mechanical wave motion in a photoactive liquid crystal polymer film [1], via a feedback loop driven by self-shadowing. Potential applications include autonomous light-driven locomotion and self-cleaning surfaces.

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