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

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Abstract: Liquid crystal elastomers combine the orientational order of liquid crystals with the elasticity of polymers. Remarkably, these materials flex and deform under stimuli such as a change of temperature, and 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, or "blueprinted," to induce a programmed shape transformation. Incorporation of photoactive azobenzene makes these materials move in response to illumination. We model the dynamics of these shape transformations using finite element elastodynamics, examining director fields incorporating twist, splay, and high-order topological defects. We also model the generation of light-driven mechanical wave motion in a photoactive liquid crystal polymer film [1], in collaboration with the Broer experimental group at TU Eindhoven. Our simulations demonstrate the mechanism that produces continuous, directional, macroscopic mechanical waves under constant light illumination, with a feedback loop driven by self-shadowing. Potential applications include autonomous light-driven locomotion and self-cleaning surfaces. Work supported by NSF-DMR 1409658 and NSF-CMMI 1436565.

[1] Anne Helene Gelebart, Dirk Jan Mulder, Michael Varga, Andrew Konya, Ghislaine Vantomme, E. W. Meijer, Robin L. B. Selinger, and Dirk J. Broer, "*Making waves in a photoactive polymer film*," *Nature* v. 546, p. 632, 29 JUNE **2017**.