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Making Faces: Thin Nematic Elastomer Sheets in Theory and in Practice

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Thin nematic elastomer sheets attain 3D configurations that depend on the nematic director field upon heating. Recent experiments from various groups demonstrate excellent control over the director fields embedded into such sheets, thus opening a door for achieving accurate and versatile designs of shape-shifting surfaces.

In this talk we describe the intrinsic geometry of such sheets at different temperatures, depending on their preprogrammed nematic director field. We focus on investigating the inverse problem – constructing a director field that would induce a specified geometry. We provide analytical solutions for certain classes of desired geometries, and show how arbitrary geometries can be designed using approximate numerical methods. We show how further control over resultant shapes can be achieved by inscribing gradients in the director field across the sheets thickness, thus prescribing nontrivial local curvatures.

Finally, we combine these methods to create designs that are micropatterned onto a mold using photolithography, and then embedded via the mold into thin nematic elastomer sheets polymerized within it. Using this method we show success in experimentally producing flat sheets that, upon activation, take an arbitrary desired shape.