

# Disclinations in nematic elastomers

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## Abstract

Formed by cross-linking a polymeric fluid consisting of chains to which nematic mesogens are attached as pendant side-groups or directly incorporated as spacer elements, a nematic elastomer is a rubber-like analogue of a nematic liquid-crystalline fluid. The coupling between the orientation of nematic mesogens and the distortion of the polymer network that results from such molecular architectures endows nematic elastomers with novel mechano-optical properties.

The first successful synthesis of a nematic elastomer was reported in 1981. Subsequent advances in synthesis have led to smectic and cholesteric elastomers. These optically-active elastomers are examples of a broad class of molecular composites with potential for use in mechanical, electrical, optical, and biomedical technologies. In particular, nematic, smectic, and cholesteric elastomers show promise for use as nano- and micro-scale optical-mechanical switches, sensors, and actuators, as components in integrated optical circuits and tunable lasers, as bifocal contact lenses, and as artificial muscle.

To develop technologies based on nematic and other optically-active elastomers, the capacity to control and manipulate defects will almost certainly be crucial. Such an ability will require an understanding of the types of defects that may occur and the manner in which those defects react to external conditions and interact with one another.

In this talk, we will introduce a continuum theory for nematic elastomers. We will apply the theory to study the isochoric radial expansion of a cylindrical specimen composed of a nematic elastomer. Numerical solutions of the governing equations arising from that model show that, above a certain threshold of radial expansion, the material has a definitive energetic preference for a state involving a disclination of strength +1 along the cylinder axis. Surrounding such a disclination is a core with radial dimension on the order of  $10^{-2}$   $\mu\text{m}$ , which coincides with observations in conventional liquid-crystal melts. Examination of the normal-stress differences demonstrates that the first of these differences depends non-monotonically on the extent of radial expansion and possesses a local minimum at the point where a disclination becomes energetically preferred. This suggests a practical experimental method for testing the predictions of the model.