Volume phase transitions of cholesteric liquid crystalline gels

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We present a mean field theory to describe anisotropic deformations of a cholesteric elastomer without solvent molecules and a cholesteric liquid crystalline gel immersed in isotropic solvents. Based on the neoclassical rubber theory of nematic elastomers, we derive an elastic energy of cholesteric elastomers and a twist distortion energy,[1] which are important to determine the shape of a cholesteric elastomer (or gel). We demonstrate that when the elastic energy dominates in the free energy, the cholesteric elastomer causes a spontaneous compression in the pitch axis and elongates along the director on the plane perpendicular the pitch axis. Our theory can qualitatively describe the experimental results of a cholesteric elastomer. We also predict the first-order volume phase transitions and anisotropic deformations at the cholesteric-isotropic phase transition temperature. Depending on the chirality of the gels, we find a prolate or oblate shape of cholesteric gels. Figure 1 shows the deformations $\kappa_i$ plotted against the temperature $T/T_{CI}$.

Figure 1: Deformations $\kappa_i$ ($i = x, y, z$) plotted against the temperature $T/T_{CI}$, where $T_{CI}$ shows the temperature of the cholesteric-isotropic phase transition. Solid circles show the experimental results $\kappa_x$ of a cholesteric elastomer.[2] As decreasing temperature we have the first-order CIT and the values of the deformations $\kappa_i$ jump at $T = T_{CI}$.

References


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