Response and Characterization 11: 9:55 - 10:30 a.m.

Nematic fluctuations and semi-soft elasticity in liquid crystal elastomers

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In monodomain samples of liquid crystal elastomers a symmetry-breaking locked-in anisotropy causes semi-soft elastic response characterized by a plateau in the stress-strain curve in which stress changes very little with strain. We show by dynamic light scattering performed as a function of deformation that the onset of the semi-soft plateau is associated with a dynamic soft mode. With increasing strain perpendicular to the director the relaxation rate of the nematic director fluctuations decreases to a very small value at the onset of the soft elastic response. At this point the director becomes unstable and starts to rotate. This phenomenon is analogous to the Freederickz transition in simple nematics. Above the nematic-isotropic transition we also observe a weak fast signal showing that there is a residual nematic order also in the high temperature phase, in agreement with other experiments showing that due to the internal strain field the system is super-critical. The results are in complete agreement with the predictions of the theory of semi-soft elasticity and allow us to determine all the constants of the model, including the nematic elastic constant and viscosity.