Electric field quenching of fluctuations and field induced order in nematic liquid crystals

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We investigated the effect of the applied electric field on a planar cell with a nematic liquid crystal (NLC) with the director $\hat{\mathbf{n}}$ oriented parallel to its substrates. We chose the NLC with the negative dielectric anisotropy ($\Delta\epsilon = \epsilon_{\parallel} - \epsilon_{\perp} < 0$). In this case, the director does not reorient, but two effects are responsible for the change of the refractive indices, and, therefore, the optical phase retardation: a) quenching of fluctuations (QF), and b) field-induced change of the order parameter (FIO). The QF is dominant and proportional to the applied field, whereas the FIO depends quadratically on the applied field. The dynamics of the QF contribution is expected to be field dependent with characteristic times around hundreds of nanoseconds (for the fields of ~ 10^8 V/m) and longer for lower fields. The FIO is expected to be constant for various fields and much faster (< 100 ns).

We studied the nanosecond dynamics of field-induced optical birefringence changes in a dielectrically negative uniaxial nematic, with the goal of experimental separation of QF and FIO. We developed a model for dynamic contributions of QF and FIO to the effective birefringence. We explored the response of a uniaxial NLC CCN-47 with a negative dielectric anisotropy to the electric field applied normally to the director. Fitting the experimental data with our model demonstrates that the dynamics of optical response does indeed allows one to extract the effects of FIO from the background of QF despite the fact that the studied material CCN-47 shows no signs of the biaxial nematic order in the field-free state. This approach is used in studies of FIO in uniaxial NLCs and in the search of the materials in which the biaxial nematic order can appear even without the applied field.

This work was supported by DOE Grant DE-FG02-06ER 46331.