Patterns induced by superposed AC and DC electric voltages in nematic liquid crystals

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Electric field often induces spatially periodic patterns in nematic liquid crystals. The patterns may be of equilibrium type characterized by pure director distortions (e.g. flexoelectric domains, FD) or of dissipative type where the director modulation is accompanied with material flow and electric current (electroconvection, EC) [1]. Experimental and theoretical studies so far mostly focused on pattern forming phenomena driven by either DC or AC voltages. A manifold of pattern morphologies have been reported depending on the control parameters (frequency and rms value of the applied voltage, temperature), the sample orientation and the material parameters. The latter play a decisive role in selecting which instability mechanism may be responsible for the observed patterns.

Though the DC and AC pattern morphologies may be quite similar, their temporal symmetries are different. Thus the DC case should not correspond simply to the AC case in the $\omega \to 0$ limit [2]. Consequently, it is not trivial what the effect of the superposition of AC and DC voltages could be on the pattern formation. The few experiments carried out so far at such combined driving focused on materials exhibiting FDs [3-4] or nonstandard EC [5].

In this work we report on our results on nematics exhibiting standard electroconvection. The experiments were carried out using two nematic compounds, being representatives for two different scenarios: Phase 5 exhibited standard EC at both DC and AC, 4-n-octyloxyphenyl 4-n-methoxybenzoate (1008) showed FD at DC and standard EC at AC driving.

Observing the patterns with a polarizing microscope, recording them by digital cameras and evaluating by digital image processing, we determined how the threshold voltages and the pattern morphologies are affected by the superposition of the AC and DC voltages of various amplitude and frequency. The electric current flowing through the sample was recorded simultaneously, in order to monitor possible changes in the conductivity of the sample.

Experimental results were compared to theoretical expectations obtained from a linear stability analysis of the governing equations of the extended standard model of EC [2].

References:

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