

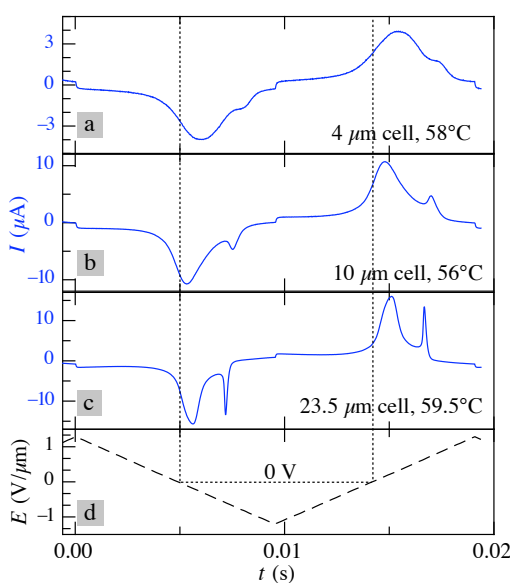
# Helielasticity and its consequences in chiral smectic liquid crystal research

Jan P. F. Lagerwall

Universität Stuttgart, Institute of Physical Chemistry, 70569 Stuttgart, Germany

Chiral tilted smectic liquid crystals (LCs) constitute the only known example of fluids with an inherent spontaneous polarization  $\mathbf{P}$ . The basic member of this family, the  $\text{SmC}^*$  phase, is therefore often called ferroelectric. However, while chirality is a necessary condition for  $\mathbf{P} \neq \mathbf{0}$  in these systems [1], it also generates<sup>1</sup> a helical modulation of the director, and thereby of the direction of  $\mathbf{P}$ . Consequently, the polarization is cancelled out on a mesoscopic scale and the bulk smectic formed by chiral molecules is thus helical (incommensurate) antiferroelectric, or helielectric [2-3]. Only under the condition of strong confinement, preventing the formation of the helical superstructure, can the  $\text{SmC}^*$  phase display the characteristic ferroelectric behavior [2]. While the distinction between heli- and ferroelectricity in LCs might be regarded as an academic issue, it actually has great importance when drawing conclusions about the structures of novel phases from electrooptic switching experiments, one of the most commonly employed techniques to investigate chiral smectics. In this talk I will show with experimental data that the incommensurate antiferroelectricity of the helical modulation in a short-pitch  $\text{SmC}^*$  phase can generate qualitatively the same type of electrooptic response as in the commensurately antiferroelectric  $\text{SmC}_a^*$  phase, in which tilt and polarization reverse at every layer boundary (anticlinic structure). A simple numerical simulation reveals that the similarity can even be quantitative.

Three examples serve to illustrate the importance of these issues in the experimental study of chiral smectics. First, the complex switching behavior of  $\text{SmC}_a^*$ —an enigma throughout the fifteen years that have passed since the discovery of this exotic phase—can be explained very naturally, simply by recognizing the relevance of the antiferroelectric aspect of the extreme short-pitch helical modulation [3]. Second, the current response to an applied triangular wave electric field from a short-pitch  $\text{SmC}_a^*$  phase turns out to exhibit up to four peaks per half period, a fact that can be understood only by considering the superposition of anticlinic (commensurate) and helical (incommensurate) antiferroelectricity [3]. Finally, the electrooptic behavior of a recently discovered dimeric mesogen with a complex phase sequence is incomprehensible without acknowledging the difference between heli-, ferro- and antiferroelectricity [4].



Current response curves to an applied triangular wave electric field from a short-pitch helielectric  $\text{SmC}^*$  phase in cells of varying thickness. The antiferroelectric aspect of the helical structure is somewhat hidden in the thin cell, due to influence of the sample surfaces, but is easily recognized in the thick sample.

[1] R. B. Meyer, L. Liebert, L. Strzelecki, and P. Keller, *J. Phys. (Paris) Lett.*, **36**, p. L69 (1975)  
[2] N. A. Clark, S. T. Lagerwall, *Appl. Phys. Lett.* **36**, p. 899 (1980)  
[3] J. P. F. Lagerwall, *Phys. Rev. E*, **71**, 051703 (2005)  
[4] J. P. F. Lagerwall, F. Giesselmann, M.D. Wand, and D. M. Walba, *Chem. Mater.*, **16**, p. 3606 (2004)

<sup>1</sup> This applies to the case of *molecular* chirality, not necessarily to the chiral smectic *phases* that can be formed by non-chiral bent-shaped mesogens.