Thermomechanical Lehmann effect in cholesteric liquid crystals

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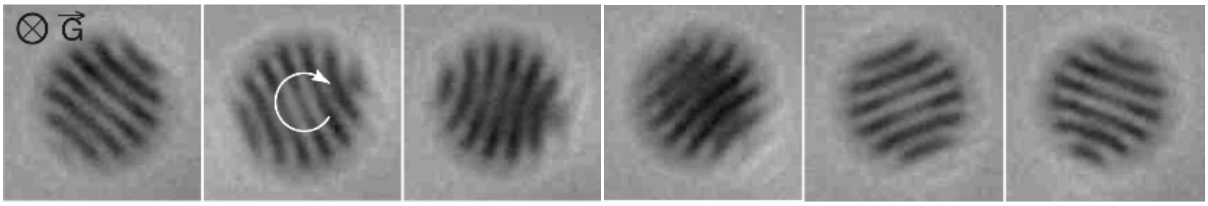
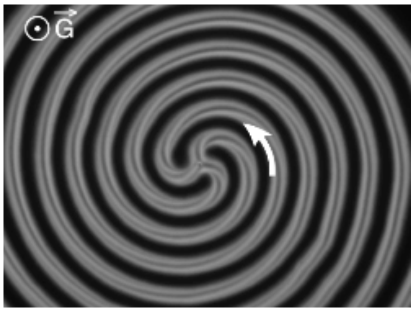
A cholesteric phase is a twisted nematic characterized at equilibrium by its spontaneous twist $q=2\pi/p$, where p is the pitch. In 1900, Otto Lehmann observed the continuous rotation of cholesteric drops when heated from below. This thermomechanical phenomenon was explained 68 years later by Leslie from symmetry arguments.

Recently we performed experiments allowing us to analyze quantitatively this effect.



The first experiment [1] we realized dealt with the Lehmann experiment, i.e. the rotation of cholesteric drops subjected to a controlled temperature gradient (see the sequence of photographs shown above). We emphasize that this experiment, to our knowledge, has not been reproduced since Lehmann's original work. By measuring the drop angular velocity as a function of the drop size and the temperature gradient we estimated from a simplified model the ratio of the Lehmann thermomechanical coefficient over the rotational viscosity. This experiment was performed at the coexistence temperature between the cholesteric phase and the isotropic liquid at which the drops were observed.



The second experiment [2] concerned the continuous cholesteric fingers which form in homeotropic samples when the cholesteric pitch becomes comparable to the sample thickness. Under this condition the cholesteric phase tends to unwind, which leads to fingers coexisting with the nematic phase (unwound cholesteric). We observed that the fingers drift perpendicularly to their axis and form spirals when they are subjected to a temperature gradient (see the opposite photo). This phenomenon is again due to the thermomechanical Lehmann effect. From measurements of the finger drift velocity in a compensated cholesteric mixture (i.e., a mixture in which the twist vanishes and changes sign at a given temperature, called compensation temperature T_c), we deduce the ratio of the Lehmann coefficient over the rotational viscosity at different temperatures above and below T_c. We found that the Lehmann coefficient does not vanish nor change sign at T_c contrary to the equilibrium twist, in agreement with previous findings of Eber and Janossy (Mol Cryst. Liq. Cryst., 72 (1982) 233).

The third experiment [3] consisted of observing the continuous rotation of the director in samples treated for planar and sliding anchoring when a temperature gradient is applied perpendicularly to the director. This experiment again confirmed that the Lehmann coefficient does not vanish at T_c in a compensated cholesteric.

These results show that there is no obvious relationship between the cholesteric pitch and the Lehmann coefficient.

[1] P. Oswald, A. Dequidt, Phys. Rev. Lett., 100 (2008) 217802.
[2] P. Oswald, A. Dequidt, Phys. Rev. E, Phys. Rev. E, 77 (2008) 051706.
[3] P. Oswald, A. Dequidt, Europhys. Lett., 83 (2008) 16005.