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Comment to "Dielectric Degrees of Freedom in Chiral Smectic C Liquid Crystals"

H. Pleiner [a] & H. R. Brand [a]
[a] FB7, Physik, Universität Essen, 04300, Essen 1, F. R. Germany
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Comment to "Dielectric Degrees of Freedom in Chiral Smectic C Liquid Crystals"

H. PLEINER and H. R. BRAND

FB7, Physik, Universität Essen, D4300 Essen 1, F. R. Germany

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In order to clarify the misunderstanding about the existence or non-existence of four order parameter excitation modes at the smectic A → smectic C* transition we would like to point out the following:

i) The symmetry of order parameter fluctuation modes is generally lower than the average symmetry of the phase where this fluctuations occur (e.g. phonons in crystals).

ii) Whereas it is true that the average direction of the polarization is perpendicular to the direction of the tilt in the smectic C* phase, this is not necessarily so with the fluctuations of these quantities. It is therefore not appropriate to conclude that the requirement of orthogonality between the average polarization and the average tilt reduces the number of independent dielectric modes from 4 to 3. We still have four independent variables: two of them correspond to fluctuations in the magnitude and the direction of the tilt whereas the other two correspond to fluctuations in the magnitude and the direction of the polarization as stated in our earlier papers.[1]

iii) The above four independent variables lead to four independent dielectric modes. They can be described as "in-phase" and "out of phase" fluctuations in the magnitudes of the tilt and the polarization and in the directions of the tilt and the polarization. An analysis of the eigenvectors further allows the introduction of an approximate description where we have two low frequency tilt and two high frequency polarization modes.

iv) Since the average values of the tilt and the polarization are zero in the smectic A phase, where the phase symmetry is D_{∞}, we have in this phase a low frequency doubly degenerate soft tilt mode and a high frequency doubly degenerate polarization mode.

v) In view of the second order character of the Sm A → Sm C* transition and the resulting continuous variation of the relaxation frequencies, the splitting of the two doubly degenerate modes on going through T_C must be continuous. Therefore the two doubly degenerate modes of the Sm A phase must continuously change into four modes of the smectic C* phase.

It is thus clear that in contrast to the statements of Pleiner and Brand, the fluctuations in the magnitude of the polarization and the fluctuations in the direction of the polarization must have nearly the same frequency close to T_C.

We would like to add that the polarization modes are not soft modes, are not expected to vary strongly with temperature and their splitting is not expected to be large.

We would also like to mention that the above picture is valid in the "rigid rod" description of ferroelectric liquid crystal molecules. This description is an excellent approximation for the low frequency tilt modes. It is however not such a good approximation for the polarization modes as their frequencies may fall into a range where internal degrees of freedom of the liquid crystal molecules become important.

One should also note that the use of 4 order parameters (two tilt variables and two polarization variables) does not lead to a phase with C_1 symmetry as stated by Brand and Pleiner but leads to the normal C_2 symmetry of the Sm C* phase.

R. Blinc
B. Žekš

Reference

1. B. Žekš and R. Blinc, *Mol. Cryst. Liq. Cryst.*, **220**, 63 (1992) and references therein.