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Liquid Crystals

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Reply to the comment by G. Barbero and N. V. Madhusudana 'On a theoretical analysis on the influence of non-uniformity of the order parameter on the surface energy in nematics' (1990, *Liquid Crystals*, 7, 299)

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**Reply to the comment by G. Barbero and N. V. Madhusudana
'On a theoretical analysis on the influence of non-uniformity of the
order parameter on the surface energy in nematics'**

(1990, *Liquid Crystals*, 7, 299)

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In their comment to our recent paper [1] Barbero and Madhusudana argue that the mathematical problem is ill-posed and thus the consideration should be revised. The objection is based on the ideas published in a set of papers [2-4], where it has been shown that if the K_{13} term is used in the usual nematic free energy density, the function $\mathbf{n}(z)$ may be discontinuous at the surface and in this case we have to include second order elasticity $\sim (\nabla^2 n)^2$ into our consideration. In principal, we agree with this objection, although it is very difficult to estimate whether the corresponding contribution to $\mathbf{n}(z)$ is essential, because no real problem with second order elasticity has been solved up to now. At the same time it is obvious that if we do not take the K_{13} term into account, the solution of the minimizing problem with the traditional nematic free energy remains correct and does not contradict experimental observations.

However, we have to point out that the main purpose of our recent paper has been the analysis of the influence of the spatial non-uniformity of the nematic order parameter $S(z)$ on the results of well-known dielectric and flexoelectric problems. If, following the ideas of Barbero and his colleagues, we neglect the contribution of the K_{13} term, our results should be slightly changed (namely, we have to put $K_{13} = 0$ everywhere). But the conclusions of our paper remain valid because the origin of all of the renormalizations discussed is, in fact, the ∇S term, not K_{13} . Namely, the renormalization of the Fredericksz effect is not essential: $W = W(1 + \frac{1}{24})$, as we stated in the first part of our paper. The flexoelectric effect renormalization can be essential

$$f_3 \approx f_3 \left(1 - \frac{3}{48} \frac{d^2 E^2 f_3 (f_1 + f_3)}{(K + Wd)^2} \right). \quad (1)$$

As we said in [1], typical values of the nematic parameters are: $f \approx 10^{-4}$ dyn, $K \approx 10^{-6}$ dyn, $W \approx 10^{-2}-10^{-4}$ erg/cm², the usual cell thickness d is about 10 μ m. We can easily verify that the correction in equation (1) is of the order of unity at electric fields E of about 10^3-10^4 V/cm, which is usual in such experiments.

The difference between the dielectric and the flexoelectric effect in this case is due to the additional ∇S term in the flexoelectric contribution to the free energy density which appears to be sufficient unlike the ∇S terms coming from the Landau expansion of the free energy.

We think that this discussion with Barbero and Madhusudana is useful because it brings a clearness to the results of the various approximations and we thank them for this possibility.

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- [4] BARBERO, G., and STRIGAZZI, A., 1989, *Liq. Crystals*, **5**, 693.