Antiferroelectricity in Liquid Crystals

With an electric field in the plane of a freely suspended smectic film, Link et al. [1] observe for a chiral compound in the antiferroelectric smectic C_A^* phase that the macroscopic polarization in films with an odd number of layers was perpendicular to the macroscopic polarization in films with an even number of layers. They interpret their 90^o effect as evidence for longitudinal surface induced ferroelectricity where the net polarization, **P**, has a component parallel to the director. In this comment we note that their interpretation is inconsistent with the theory they invoke [2] as well as the growing body of evidence [3–6] that antiferroelectricity is a bulk, as opposed to a surface induced, property of smectic C_A^*. The interpretation we give here (Fig. 1) relies on the existence of a polarization (P_x in Fig. 1) ignored by Link et al. [1] but allowed by the additional symmetry of the bi-layer stacking of smectic C_A^* [3,4], and which does not apply to a surface layer .

The question of the direction of **P** in biaxial smectics is now crucial to account for the appearance of a spontaneous **P** in liquid crystal phases formed by *nonchiral* banana-shaped molecules (e.g. [7–9]). It is also important to differentiate the most recent high performance antiferroelectric liquid crystal displays [10] from other liquid crystal display technologies relying principally on surface effects.

The occurrence of a longitudinal macroscopic polarization in the bulk was predicted by Petschek and Wiefling [2] for smectic systems involving three different types of layers. They considered a smectic A-type ferroelectric phase with $C_{\infty v}$ symmetry and a smectic C-type phase with C_{1h} symmetry. In particular, they pointed out that, in the C-type phase, the macroscopic polarization in the bulk lies in the plane spanned by the layer normal and the in-plane projection of the director. When a phase with C_{1h} symmetry is chiralized, the horizontal mirror plane is lost resulting in a phase with C_1 symmetry (meaning no symmetry). Phases with C_1 symmetry are well-known (e.g. [11]) to have a polarization, **P**, in the bulk with three non-vanishing components. This is physically different from the picture proposed in [1] involving only surface ferroelectricity.

In [7] and [3], we noted that tilted systems with C_{2v} symmetry could have a spontaneous polarization in the tilt plane in non-chiral substances. In Fig. 1, we show the expected behavior for **P** in smectic C_A^*. Fig. 1 accounts for the 90^o odd-even effect observed in freely suspended films [1,5] as well as the bulk measurements of Miyachi et al. [4].

In summery, the experimental results reported [1,5] on the effect of an electric field on freely suspended smectic C_A^* films with an even or odd number of layers are fully compatible with the symmetry analysis in [7] and [3]. Furthermore, this interpretation (Fig. 1) is consistent with the growing body of evidence that antiferroelectricity is a bulk, as opposed to a surface induced, property of smectic C_A^*.

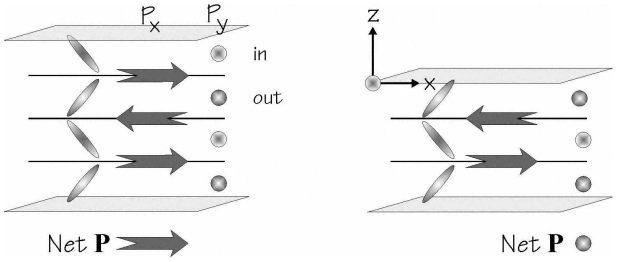

FIG. 1. The net polarizations expected [3] and measured in the bulk of C_A^* [4], for even (*left*) and odd (*right*) number of layers without invoking surface induced ferroelectricity.

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