Chapter 1

The Discovery of Helicity in Tilted Bent-Core Smectics: $\mathrm{Sm(CP)}_\alpha$

The interplay between polarization and chirality has always been front and centre in the developlment of the bananna phases of liquid crystals. From the short-range (bilayer) chiral B2 phases[1], to the long-range helicity of the twist-bend nematic phase, bent-core liquid crystals have been an interesting playground to observe the emergence of spontaneous chirality.

Our discovery of a B2-like phase, with polar, ferrieletric switching that also has a spontaneous twist-bend like helix is the first link between the twist-bend and B2 phases.

1.1 A Brief History of Chirality in Bent-Core Smectics

1.2 Characteristics of the $\mathrm{Sm(CP)}_\alpha$ phase

1.2.1 The PAL30 Molecule and Phases

Go bottom up, to get the boring phases out of the way. (maybe put this in the introduction of PAL30)

add phase description with Sm2

1.2.2 Textures of the Sm(CP)$_\alpha$ phase

1.2.2.1 Planar Aligned Textures

As discussed in Section ??, in planar-aligned cells, the optic axis of the liquid crystal is perpendicular to the $\vec{k}$ of the applied light–meaning we will be sensitive to relative orientations of the long-axis.

In Figure ??, the planar textures of the Sm2 phase of PAL30 are shown. Comparing with previously published micropictographs reveals a strong similarity to the SmC$_\mathrm{A}P_\mathrm{A}$ phases[1, ?]. As discussed in Section ??, the PAL30 phase directly below the Sm2 is a SmC$_\mathrm{A}P_\mathrm{A}$, but with a strikingly long-range and regular conglomerate chiral structure, where the handedness is grouped together into stripes. There exists no clear phase transition in the textures between the Sm2 and Sm3 in planar aligned cells.

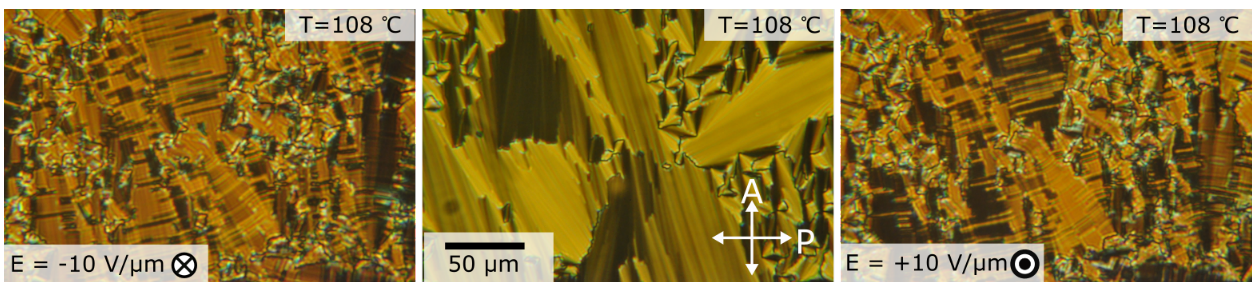

Figure 1.1: Textures of the Sm(CP)$_\alpha$ phase of PAL30: reminiscent of a SmC$_\mathrm{A}P_\mathrm{A}$ texture.

This similarity is due to the fact that, broadly, the SmC$_\mathrm{A}P_\mathrm{A}$ and phases are identical optically. Both phases have unit-cells whose dielectric tensor is uniaxial (where the $\epsilon_{xx} = \epsilon_{yy}$), so the optic axis will be parallel to the layer normal and the texture appears like a SmA in it's ground.

Both phases are polar, so with a high enough field both states will switch into an aligned SmC$_\mathrm{S}P_\mathrm{F}$ state, which gives a birefringent contrast between domains with different handedness. This contrast is because of the synclinic nature of the SmC$_\mathrm{S}P_\mathrm{F}$ phase— because the tilt is now aligned between the layers the optic axis is now tilted with respect to the layer normal.

figure describ- ing this switching mecha-

However, the differences between these two phases is present in homoeotropic.

1.2.2.2 Homeotropic Aligned Textures

Though we were unable to achieve good homeotropic alignment, we can rely on the published results of the Dublin group, who published a series of papers on the PAL30 homolog series. Though their interpretation is wrong (PAL30 is not an orthogonal phase), they report beautifully aligned homeotropic textures and study the response of these textures to an applied in-plane electric field. This textures are reproduced from Sreenilayam et al[2] in Figure 1.2.

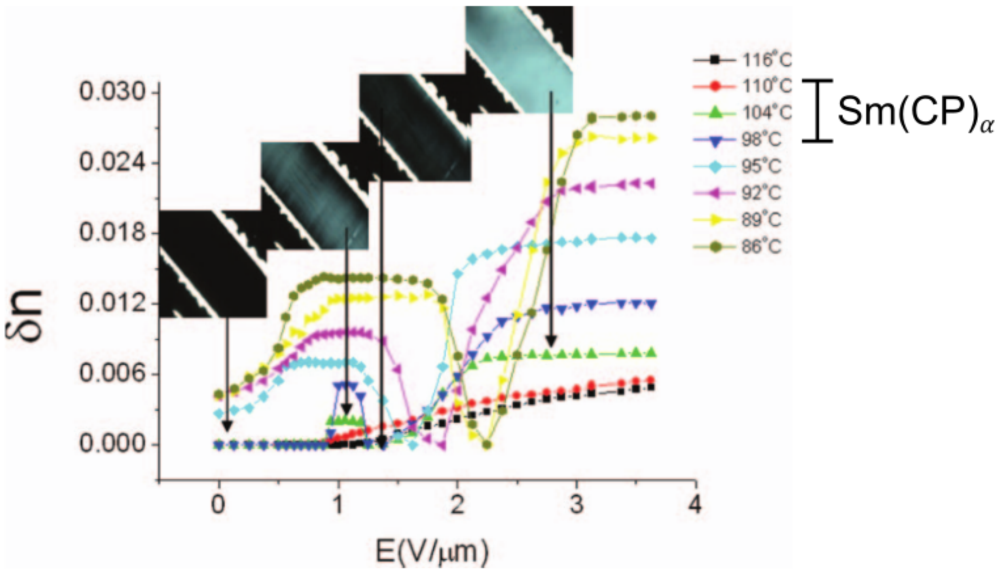

Figure 1.2: Homeotropic textures of PAL30. The relevant temperatures for the Sm2 phases are 104 °C, and 98 °C. The biaxiality in the Sm2 is distinguished by a small 'hump' with small applied field, that gets larger on cooling, and changes in character on cooling through the Sm2→Sm3 phase transition at 99 °C, where it broadens. Reproduced from Sreenilayam et al[2].

The phase of interest, Sm2, occurs in the temperature range 110 °C to 99 °C. There is a clear change in the field-behaviour of the biaxiality at the Sm2→Sm3 transition temperature. However, because these phases are tilted the authors original interpretation of the data needs to be revisited.

read the keith paper, to understand their dark state ar-

1.2.3 Polar Switching of the $\mathrm{Sm(CP)}_\alpha$ phase

1.2.4 Freely-Suspended Films of the $\mathrm{Sm(CP)}_\alpha$ phase

1.2.5 X-ray Analysis of the $\mathrm{Sm(CP)}_\alpha$ phase

1.2.5.1 Umklapp Peaks

1.3 Discussion of the $\mathrm{Sm(CP)}_\alpha$ phase

Bibliography

[1] Darren R. Link, Giorgio Natale, Renfan Shao, Joseph E. Maclennan, Noel A. Clark, Eva Körblova, and David M. Walba. Spontaneous Formation of Macroscopic Chiral Domains in a Fluid Smectic Phase of Achiral Molecules. Science, 278(5345):1924–1927, December 1997.

[2] S. Sreenilayam, M. Nagaraj, Y. P. Panarin, J. K. Vij, A. Lehmann, and C. Tschierske. Properties of Non-Tilted Bent-Core Orthogonal Smectic Liquid Crystal. Mol. Cryst. Liq. Cryst., 553(1):140–146, January 2012.