Dynamics of Point Defects in Free-Standing Smectic Films

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Disclinations in liquid crystals bear striking analogies to defect structures in a wide variety of physical systems, they are excellent models to study fundamental properties of defect interactions. Freely suspended smectic C films behave like quasi 2D polar nematics and are thus an ideal model system for studying defect dynamics in quasi 2D systems. However, despite its generality, experiments so far only addressed with defects dynamics in nematics, which are more complicated as they are always 3D systems.

One crucial difference between diffusive defect motion and liquid crystals is the presence of (back) –flow interactions. This reduces the annihilation time and introduces an asymmetry between the motion of the positive and negative defects: the flow driven by the director reorientation drives a flow which accelerates the motion of the positive defect. These phenomena predicted in simulations [1] have been confirmed in experiments with nematics, e.g. in Refs. [2]. Svensek and Zumer predicted similar effects in a simulation of free-standing smectic C films [3], albeit limited to the very late stages of annihilation.

We analyze defect dynamics in free-standing smC films experimentally. An experimental procedure is introduced to capture high-strength disclinations in localized spots, see Fig. 1a. After they are released in a controlled way, the motion of the mutually repelling topological charges is studied, see Fig. 1. We demonstrate that the classical models, based on elastic one-constant approximation, fail to describe their dynamics correctly. In realistic liquid crystals, the models work only in ideal configurations. In general, additional director walls modify interactions substantially [4].

Finally, we present a novel method to prepare isolated +1 – (-1) defect pairs and present first experimental conclusions on their annihilation dynamics. We find the predicted asymmetry of defect velocities. The defects' dynamics is strongly influenced by the orientation of the -1 defect with respect to the connecting axis, disorientation inducing strong orbital motion of the defect pairs.

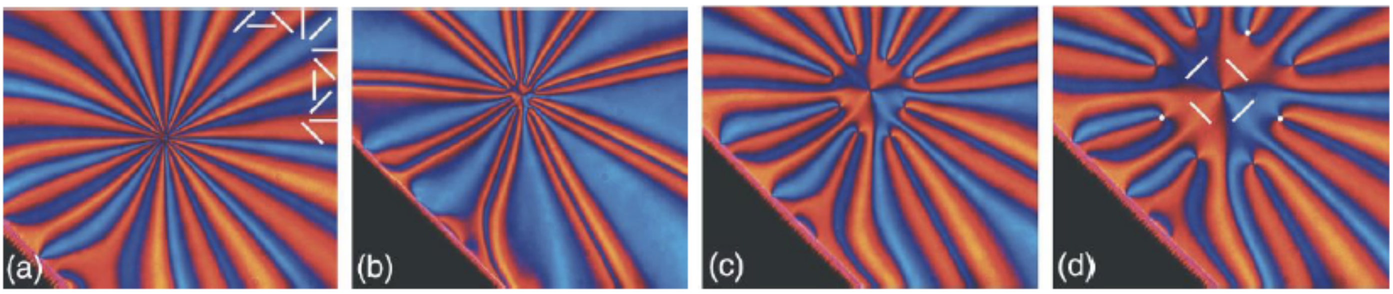

Figure 1: (a) Nine trapped defects in a hole of approximately 10 µm diameter. (b) Exploding configuration immediately after the hole was extinguished. (c) 1.8 s and (d) 5 s after release. Dimensions are 475 µm×400 µm.

References

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