Dimensionality effects in the annihilation of nematic umbilics

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Liquid crystals (LCs) exhibit a rich variety of orientational structures and topological defects due to their anisotropic molecular arrangement, which can be manipulated via external electric, magnetic, or optical fields. In particular, assemblies of umbilics with topological charge +1 and -1 spontaneously form from initially uniform homeotropic nematic film under the influence of an electric field for nematic liquid crystals with negative dielectric anisotropy [1]. As the umbilics further interact, annihilation dynamics takes place. While the role of the dimensionality of assemblies of umbilics remains an open problem, so far, the annihilation problem has been addressed experimentally only in 2D [2,3].

Here we experimentally explore the role of the spatial dimensionality in the annihilation of umbilics by leveraging the combined action of electric and magnetic fields, the experimental results being supported by numerical simulations. In practice the relevant observable is the number of defects, which evolves with time, that is retrieved using polarization microscopy [4]. In the 2D situation, we extend previous works, which are restricted to high reorientation regime (V>> V_F, V_F being the Fréedericksz threshold voltage), to arbitrary levels of field-induced reorientation. Moreover, by combining the role of electric fields with that of magnetic fields [5,6], we propose to take control over the dimensionality of the umbilics assemblies, thereby going from 2D to 1D situations and demonstrate how this affects the annihilation process that is basically characterized by a decay exponent. In addition, the flexible character of our experimental approach allows us to explore curved 1D geometries, thus opening for rejuvenated theoretical studies.

Figure 1. Snapshot of umbilics spatial distribution at a voltage V~1.1 V_F, recorded between crossed circular polarizers for a 2D (a), straight 1D (b) and curved 1D-like (c) geometries.

References

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