MATERIALS SCIENCE GRADUATE PROGRAM

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Sessile Droplets of Nematic and Polar Nematic Materials

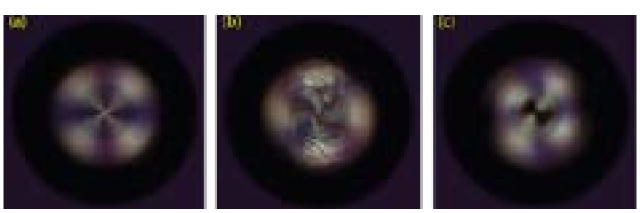
Sessile droplets of liquid crystals are interesting objects with non-trivial topology and structure depending on the constituting phase, and boundary conditions. Unusual properties may arise due to the different symmetry and curvature of one bounding surface compared to the common geometry of liquid crystal studies and applications, namely the confinement between two flat solid walls.

Firstly, we will see how the director structure of sessile drops is affected by the boundary conditions at the solid base plate and at the curved interface with air. For that, we studied a number compounds, and we investigated different types of temperature triggered anchoring transitions at the solid, as well as at the air interfaces. We established a searching algorithm based on sessile droplets allowing an efficient discovery of materials that exhibit orientational transitions. As a consequence of the two types of anchoring transitions, we revealed two distinct textures involving topological defects in spherical caps of nematics governed by the reorganisation of the director field. Apart from a known discontinuous anchoring transition, we also identified a continuous director restructuring. Moreover, we detected a double transition, involving a re-entrant behaviour [1].

Secondly, we will see how the director structure in sessile droplets is tunable by external magnetic [2] and electric [3] fields. This may be interesting from an application point of view as well because spherical cap shaped liquid crystal drops have potential for use in tunable multifocal optical lenses. We show that at sufficiently high magnetic fields a metastable inversion wall forms in the middle of the drop. Applying fields above a critical angle between the plate of the spherical cap and the magnetic field, a uniform director structure can be seen. Drops with uniform director structure can be used as tunable optical lenses, where the focal length can be controlled by light polarization, viewing angle, magnetic, or electric fields. The effect of electric field can be quite similar compared to the magnetic case, but strikingly different as well, depending on the frequency of the applied field.

Thirdly, we shall see the extraordinary case of sessile droplets of a polar nematic material RM734. The existence of a polar nematic phase was confirmed experimentally recently. The novel phase with reduced symmetry exhibits huge spontaneous polarization, and therefore exceptional sensitivity to electric fields, which makes its discovery important not only from a scientific point of view, but an emergence of new class of liquid crystals promises high potential in applications as well. It will be presented what kind of structures are realized (see some examples in Figure 1) in the studied geometries. We will present a striking, yet unseen dynamic phenomenon as a result of the special director structure and pyroelectricity in the presence of a thermal gradient.

Figure 1: Texture of an RM734 droplet in the normal nematic phase (a), close to the transition to the polar phase (b), and in the polar nematic phase (c).



[1] M.T. Máthé, Á. Buka, P. Salamon, Journal of Molecular Liquids 336, 116074 (2021)
[2] P. Salamon, Z. Karaszi, V. Kenderesi, Á. Buka, A. Jákli, Phys. Rev. Research 2, 023261 (2020)
[3] Z. Karaszi, P. Salamon, Á. Buka, A Jákli, Journal of Molecular Liquids 334, 116085 (2021)