Nematic and Smectic Shells

Teresa Lopez-Leon[1,2], Alberto Fernandez-Nieves[2], Maurizio Nobili[1] and Christophe Blanc[1]

[1] *Laboratoire des Colloïdes, des Verres et des Nano-matériaux, Université Montpellier II 34095 Montpellier, France*

[2] *Georgia Institute of Technology, School of Physics, 837 State St. NW, 30332 Atlanta GA,United States*

e-mail: Teresa.Lopez-Leon@univ-montp2.fr

Confinement and curvature have dramatic effects in liquid crystals. For instance, when a nematic is confined between two spherical surfaces, complex defect structures arise [1]. These defect structures stem from the unavoidable topological constraints associated to the curvature of the confining space. The total topological charge of the system is fixed by the boundary conditions for the director ***n*** at the two confining spheres; however, the number and type of defects depend on energetical considerations. While changing the boundary conditions has been shown to induce fascinating transitions between different defect structures [2], the effect of changing the elastical properties of the liquid crystal has not been explored yet, despite the richness of behavior expected.

In this work, we study the structural transitions undergone by a nematic shell when the ratio between the bend (K_{33}) and splay (K_{11}) elastic constants is changed. To produce the shells, we employ a coaxial microfluidic device, where a liquid crystal and two aqueous phases are combined to produce double emulsions [3]. The middle phase is a liquid crystal, 4-n-octyl-4-cyanobiphenyl (8CB), and the aqueous phases contain poly-vynil-alcohol (PVA), which stabilizes the double emulsions and enforces planar boundary conditions at the two interfaces. We use temperature to change the K_{33}/K_{11} ratio. In the nematic phase, 40°C < T < 33°C, the energy associated to bend and splay distorsions is similar (K_{33} and K_{11} have similar values). In this situation, we observe the three defect structures typically observed with pentyl-cyano-biphenyl (5CB) [1]. However, those structures are no longer stable near the nematic-smectic transition temperature, T ~ 33°C, where K_{33} diverges and bend distorsions become energetically prohibited [4]. At this temperature, the system undergoes a transition in which the defects repel each other and relocate along a great circle of the sphere, corroborating existing predictions [5,6]. The topological charge and nature of the defects play a key role in this transiton. Finally, novel defect structures never reported before were observed in the smectic phase at T < 33°C.

References

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