Topological transformations in shells of nematic liquid crystal

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When nematic liquid crystals are confined to thin spherical shells, complex defects structures emerge (1). These structures are characterized by a varying number of point defects and disclination lines, depending on the elastic energy of the liquid crystal, the thickness of the shell, and the boundary conditions for the director ***n*** at the confining spheres. Topology establishes restrictions that must be fulfilled, but it is energy minimization what determines the final state of the system. Here, we investigate how a defect structure evolves after changing (i) the boundary conditions for ***n*** at one of the confining surfaces, and (ii) after the size and thickness of the shell is either increased or decreased via osmotic pressure.

We enforce planar boundary conditions for ***n*** at the bounding surfaces; this is our starting point. In this situation, we observe shells with four defects of topological charge s = +1/2, Fig 1a, shells with two defects s = +1/2 and one s = + 1, Fig 1b, and shells with two s = + 1 defects, Fig 1c; the total charge is always +2 in either bounding surface, as imposed by the Poincaré theorem. We, then, add a concentrate solution of SDS to the continuous phase to impose normal boundary conditions for ***n*** at the outer surface. In this hybrid configuration, the system evolves to a new configuration characterized by only two defects s = +1 at the inner sphere. The route towards equilibrium depends on the initial defect configuration of the shell and involves fascinating topological transformations, including the creation of transient disclination lines or the coalescence of defects with the same topological charge (2). We find that the kinetics of the process greatly depends on the size and thickness of the shell.

We can also induce changes in the original defect structure by immersing the shells in a continuous phase with a high osmotic pressure; this thickens the shell resulting in transitions between the different configurations.

References

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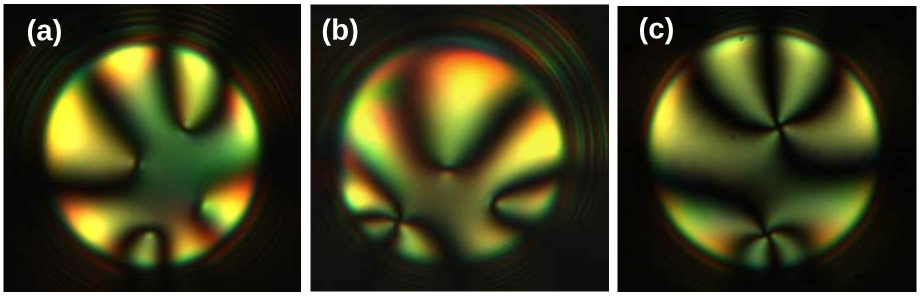

Figure 1. Three different defect structures observed in nematic liquid crystal shells under planar boundary conditions. They are characterized by different number and type of defects: (a) four s = +1/2 defects, (b) two s = +1/2 defects and one s = +1defect, and (c) two s = +1 defects.