Mechanics of nematic shells

Luigi Vergori

Università di Perugia

Nematic liquid crystals are aggregates of rodlike molecules that tend to align parallel to each other along a given direction. Due to their easy response to externally applied electric, magnetic, optical and surface fields, liquid crystals are of greatest potential for scientific and technological applications.
In the last few decades, there has been an increasing interest in soft matter physics on small spherical colloidal particles or droplets coated with a thin layer of nematic liquid crystal. The hope is to build mesoatoms with controllable valence. These coating layers are referred to as *nematic shells*.

When nematic liquid crystals are constrained to a curved surface, the geometry induces a distortion in the molecular orientation. The possibility to have an in-plane order rather than a spatial distribution of the molecules depends on the shell thickness. In ultra-thin shells, the interaction with the colloid surface enforces a sort of degenerate anchoring, i.e., the tendency of the molecules to align parallel to the surface.
Thus, unavoidable defects arise when nematic order is established on a surface with the same topology as that of the sphere.

Most theoretical studies on nematic liquid crystals are framed within the classical director theory. In this setting, the local properties of the nematic liquid crystals are described through a unit vector, the *director*, parallel to the local average molecular direction. However, the director description of a nematic configuration misses a relevant information at the mesoscopic level: the dispersion of the molecules around the average molecular orientation.
The order-tensor theory, developed by the Nobel laureate Pierre-Gilles de Gennes, overcomes this gap by introducing a richer kinematic description.

Within the framework of both the order-vector and order-tensor theories, these lectures aim to derive models for the free energy density of nematic shells from well-established three-dimensional theories for liquid crystals, to introduce suitable dissipation potentials and to develop a rigorous variational approach for studying the statics and dynamics of nematic shells.