

Kent State University

Physics Colloquium

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Statistical Physics of Modulated Phases in Nematic Liquid Crystals

Abstract

Nematic liquid crystals are the state of the matter in which there is no positional order like crystals but it has orientational order of the constituent molecules. In the conventional nematics, the long axes of the rod-like molecules tend to align up or down uniformly along a director n . If the constituent molecules are chiral, they tend to form a modulated structure in one of the space dimensions. They are called the chiral nematics. If the chirality is strong enough we get the modulated structures in all three dimensions called the chiral blue phase. On the other hand, if the molecules are achiral, but an additional polar dipole is attached to the molecules, they also tend to form a modulated structure. In these types of materials we observe an important physical effect called flexoelectric effect, in which the polar order is linearly coupled to the director gradients. This dissertation work presents analytical and simulation studies of that modulated structures using the flexoelectric mechanism. Classic work by R. B. Meyer and further studies by I. Dozov predicted two possible structures, known as twist-bend and splay-bend. One of these predictions, the twist-bend phase, has recently been identified in experiments on bent-shaped liquid crystals. In this recently discovered twist-bend nematic phase the modulation is along one of the space dimensions. If this flexoelectric coupling is strong enough, in addition to twist-bend and splay-bend, here we predict the formation of polar analog of chiral blue phases (in both 2D and 3D) made of achiral polar liquid crystal materials by using Elastic continuum theory-based numerical calculations and computer simulations. This dissertation work also presents the coarse-grained theory of twist-bend phase. This theory predicts normal modes of fluctuation in both sides of nematic to twist-bend transition, which then compared with light scattering experiments. Macroscopic elastic and electric properties of twist-bend nematics can be realized using this coarse-grained description.

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