PHYS 447 Physics of Liquid Crystals

Bulletin Description
This course is intended to provide a grounding in the physics of liquid crystals and introduce concepts associated with liquid crystals that can be applied to other systems. Topics include:. Molecule interactions; order parameters; electrical, optical, and magnetic properties of the hematic phase; phase transitions; elastic and viscous properties; biaxiality; lyotropic phases; the role of chirality; defects in liquid crystals; interactions at interfaces; smeptic order and smeptic polymorphism; ferroelectricity, antiferroelectricity, and ferrielectricity; phases associated with complex molecular architectures; free-standing films and quasi 2D behavior; experimental techniques, including nanomanipulation; and liquid crystal devices.

Syllabus

Goal: To provide a firm grounding in the physics of liquid crystals and introduce concepts associated with liquid crystals that can be applied to other systems.

Textbook: P.G. DeGennes and J. Prost, *The Physics of Liquid Crystals* (Clarendon, Oxford, 1994). This book covers the fundamental concepts. More recent topics will be covered by readings from the literature.

Topics:
Structure of simple molecules that display liquid crystallizing
Order parameters and symmetry
Phase transition from isotropic to hematic phase
Theoretical models (c.g., hard rod, Maier-Saupe, Landau)
Experimental results from NMR, light scattering, ellipsometry
Behavior at the phase transition
Biaxiality and the Landau point
Elastic properties of nematics, torques, flexoelectricity
Anisotropy and optical, electrical, and magnetic properties of nematic liquid crystals
The Fredericks transition
Fluctuations and light scattering from collective Goldstone modes Interfacial properties
Anchoring and anchoring transitions
Control of the surface, including nanomanipulation
Electrical polarizations at interfaces
Defects in liquid crystal alignment
Types and classification of defects
Disclination lines and points
The behavior of walls
Viscous behavior in liquid crystals: Theory and experimental technique
The role of choral symmetry
The cholesteric phase and pitch
Optical rotatory power and its behavior near the phase transition

Optical properties of twisted nematics
Smectic phages and smeptic polymorphism
The hematic - smectic-A phase transition: Theory and experimental results The absence of long-range order in the smectic-A phase: The Landau-peierls instability and x-ray scattering
Elastic behavior in the smectic-A phase
The tilted smectic-c phase, including the smectic-A - smectic-c phase transition
Chiral smectic-c phase and ferroelectricity
Relationship among ferroelectric, antiferroelectric, and ferroelectric phases Phases and phase transitions
Broken symmetry modes, including optic and acoustic modes in antiferroelectrics
Quasi 2D behavior and crossover from 3D; free-standing films
Liquid crystal phase transitions in confined geometries (when the pore size is smaller than the correlation length)
Overview of other liquid crystalline systems:
Lyotropic LCs
Dendrimeric LCs
Bent-core molecules and their phases
Lamellar liquid crystals
Polymer LCs
Elastomers
Liquid crystal devices
The twisted hematic display
Optical compensation plates for the TN display
Beam steering devices

Homework:
Problem sets will be topic-based, and therefore will be handed out sporadically (approximately six times) during the semester. Additionally, students will be required to do a literature-based research project and presentation on a topic chosen by the student and approved by the instructor.

Exams:
A midterm and a final exam are planned. The letter grade will be based approximately on the formula: midterm and final exams 30% each, research project 20%, and homework 20%.