

## Discussion session on biaxial nematics

Chaired by N. Mottram, Strathclyde  
Thursday, 15 September 2005, 15:00-17:30

Since 1970, when Marvin Freiser of IBM predicted that long and flat molecules could form a biaxial nematic phase, chemists have been attempting to synthesise such a liquid crystal. Whilst lyotropic and polymer biaxial phases were found, a low molecular weight, thermotropic phase proved more difficult to create. However, in 2004 two groups in America published their studies of bent-core molecules which suggest that their molecules may form the elusive biaxial nematic phase. Since then interest in biaxial phases and bent-core molecules has increased significantly. The discussion session will consider progress in synthesis, characterisation and the mathematical theory of these materials as well as the potential technological advantages of the biaxial nematic phase.

### Contributed talks

#### Potential applications of biaxial nematic liquid crystals

P. D. Brimicombe, Oxford

The recent publication of experimental evidence for the existence of a stable biaxial nematic phase, has produced great interest in potential device applications for such a phase. These applications can be split into two main categories: existing technologies that could be improved by using a biaxial nematic material instead of uniaxial one; and a new set of technologies that require biaxiality for their functionality. The use of biaxial nematic liquid crystals in existing devices and technologies could produce interesting and possibly advantageous effects. Q tensor modelling of defects in nematics has indicated that some biaxiality forms around the defect structure. The use of the biaxial nematic phase in devices that utilise defects, such as the zenithally bistable family of devices, may produce improved switching properties. Another possible application for the biaxial nematic is in optical compensation films. Manufacturers are already producing biaxial compensation films using non-uniform uniaxial nematics, but the same effect could be produced using a uniformly aligned biaxial nematic, possibly with a simpler manufacturing. The existence of a stable biaxial nematic phase could produce an entirely new class of liquid crystal devices. For example, one proposed device [1] is shown in Figure 1. In-plane fields are used to rotate the molecules around the long axis (uniaxial devices rotate the molecules around the short axis). This new device could have a fast response time, since a rotation around the long axis may have a lower viscosity than a rotation about either of the shorter axes because of the molecular shape. Before such devices can be made, however, there are many engineering challenges, not least the question of alignment. Whether or not both the major and minor axes of biaxial nematics can be aligned by simply rubbing the substrates is not known. A combination of applied fields and surface treatment may be needed to produce the required alignment and any such system would make device operation and construction more complicated.

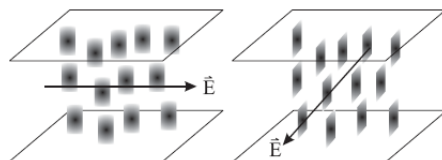


Figure 1: One proposed biaxial nematic device, using in-plane fields to rotate around the long axis of the molecules.

[1] G. R. Luckhurst, Biaxial nematic liquid crystals: fact or fiction?, Thin Solid Films, 393, 40 (2001).

## **Biaxiality connected to the Fredericks transition in a rectangular nematic cell**

**M. Ambrožič, Jožef Stefan Institute**

We study theoretically the Fredericks transition of the nematic liquid crystal in the rectangular cell with a strong uniaxial planar boundary condition. The electric field perpendicular to the plates is applied assuming a definite potential drop across the cell. The Landau-de Gennes theory is used for obtaining equilibrium nematic order parameter tensor together with the potential within the cell. The equilibrium nematic structure is given by minimization of the free energy with imposed boundary conditions and the constraint that divergence of electric displacement vector be zero. Connected with adjustment of the order parameter tensor to the applied field within the cell strong biaxiality appears at some positions. The degree of biaxiality is given by biaxiality parameter which can take values between 0 (uniaxial structures) and 1 (the highest degree of biaxiality).

## **Biaxial phase transitions in nematic liquid crystals**

**G. De Matteis, Strathclyde**

Starting from a general quadrupolar pairwise potential between biaxial molecules (Straley's potential), we consider a simplified model by selecting the free parameters involved. At variance with previous studies, it is not based on the London approximation, the so-called dispersive forces model.

Then, by employing a mean-field approximation, we perform a bifurcation analysis of the equilibrium equations to derive the corresponding phase transitions diagram, eventually contrasting it with Monte Carlo simulations for some model parameters values.

Finally, we show how to extend the model by including a mildly repulsive term and the phase diagram it predicts.

## **Quench driven surface biaxiality**

**S. Kralj, Maribor**

We study the influence of surface memory effects on equilibrium nematic structures within a plane-parallel cell deep in the nematic phase. The confining plates impose isotropic tangential boundary condition. We use Lebwohl-Lasher interaction potential and follow the kinetics via Brownian molecular dynamics. In the simulation we quench the system from the isotropic phase deep into the nematic phase. Due to symmetry breaking and causality a domain pattern is formed. After some time, where the average degree of ordering within the cell is strong enough, we freeze in the orientational ordering of LC molecules at one plate. This freezing mechanism is suggested by several experimental observations. The frozen-in pattern serves afterwards as a boundary condition for the nematic ordering within the cell. We show that by varying the quench rate one can control the degree of surface imposed biaxiality.

## **Attraction and repulsion hidden in biaxial molecular interactions.**

**E. Virga, Pavia**

The general quadrupolar interaction between biaxial molecules, studied by Straley for a specific excluded-volume model, reveals, if appropriately decomposed, both attractive and repulsive components. Whenever a repulsive component is present in an interaction that remains globally attractive—a potential that we call mildly repulsive, the macroscopic phase diagram is likely to present one and the same structure. If time permits, I shall try to justify this conjecture.