High Field Magneto-Optical Studies of Liquid Crystals and Complex Fluids

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Introduction

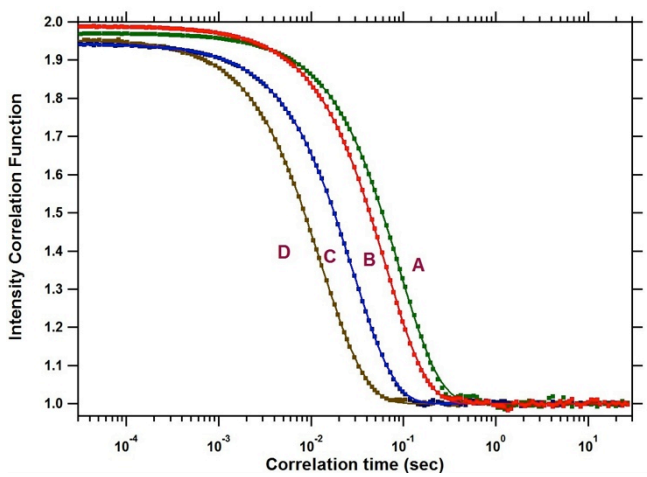
New categories of liquid crystals bring exciting opportunities for both new technological applications and fundamental science. High magnetic fields enable exploration of otherwise inaccessible regions of the phase diagram, and so are important tools in furthering our understanding of what mesogenic states of matter are possible. Over the past year, in addition to obtaining some rather surprising results using our traditional techniques on new materials, we have also continued our program of performing dynamic light scattering (DLS) measurements exploiting all the capabilities made possible by the Split Helix.

Experimental

Optics using polarized, visible light has always been the most important probe to study mesogenic (liquid crystalline) matter because the symmetry axis is so strongly coupled to the optical axis. Moreover, this axis is easily controlled using external fields, especially magnetic fields. During 2012 we performed two measurements in Cell 7: i) continuing the search for spontaneous biaxiality in liquid crystal compounds having exotic shapes, and ii) using high fields to unwind the helical axis of a liquid crystalline “blue” phase. For the first experiment, we measure the birefringence in direction perpendicular to the magnetic field (Faraday geometry); we employ a photo-elastic modulator and phase-sensitive detection to eliminate contributions from unwanted effects such as Faraday rotation and vibration. For the second, we attempt to measure the change in absorption of polarized, blue light as the field is increased. Here, further improvements are necessary to eliminate the contribution of Faraday rotation. DLS measurements in the Split had to be fully reconfigured after the optical tables were installed. Nonetheless, we were able to obtain data on several new compounds.

Results and Discussion

Dynamic light scattering studies on high field on a bent-core shaped liquid crystal are shown at left. These reveal that as the magnetic field is increased, fluctuations become substantially stiffer (and hence faster) and so exhibit a large decrease in the characteristic correlation decay time. The decrease with magnetic field is as one would expect based upon standard hydrodynamics and elasticity theory of nematic liquid crystals. This latter observation is surprising in that complementary small-angle x-ray scattering measurements on the same compound reveal a surprising (and persistent) degree of “cybotaxis” – that is persistent, short-range structures exhibiting a greater degree of order than the macroscopic liquid crystalline phase.



Intensity correlation functions obtained on ClPbis10BB at $T_{IN} - T = 6.5°C$ and θ_s = 10° for various magnetic fields A (5.9T), B (8.3T), C (14.4T), and D (22T). Dots are the correlation data and lines correspond to fits described in the text.

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