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

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Introduction

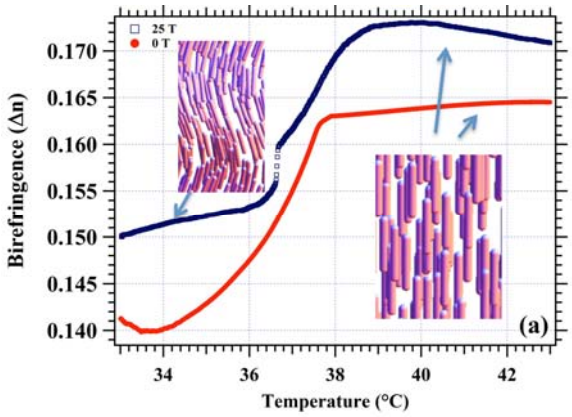
High magnetic fields are a particularly powerful technique for the study of ordered, fluid materials, such as liquid crystals. This technique can give insight into the propensity of these materials to spontaneously break their symmetry. Furthermore, high fields give the experimenter a powerful tool to control the principal axes within inherently anisotropic fluid materials. In 2013, using one week of magnet time in the Split Helix, we obtained especially revealing results on three very different types of exotic, mesogenic materials: two thermotropic liquid crystals, the “blue fog” phase and the brand-new “twist-bend” nematic, as well as a isothermal material comprised of a suspension of anisotropic, benzimidazolone pigment particles. The latter is the basis of a nascent collaboration with Universität Otto von Guericke in Magdeburg.

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 2013 we performed two different classes of magneto-optical measurements: measurement of the intensity of depolarized, scattered light, and measurement of optical anisotropy; both techniques were used on samples subject to high magnetic fields.

Results and Discussion

The effective optical anisotropy of a new class of liquid crystalline materials, the so-called twist-bend nematics is shown at left. This figure reveals numerous surprising results. A 25T field not only markedly suppresses the twist-bend phase transition temperature, it also renders it second order (it is first order in zero field). This large field also strongly quenches twist-bend fluctuations. Although not shown here, we have also demonstrated that a large field can remove the optical stripes that are the twist-bend nematics most visible feature, even though that state is still present.



Effective optical anisotropy vs temperature at two different fields. The transition to TB phase goes from second order at zero field to first order at 25T. Insets are proposed structures for the TB morphology in the two cases.

Acknowledgements

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