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

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Introduction

Bent core nematic 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 an important tool in furthering our understanding of what mesogenic states of matter are possible. We have expanded upon our initial project, which was the search for liquid crystals having a new symmetry class, that of a tetrahedron, to include the study of a technologically important class of mesogenic materials, liquid crystalline gels. The key question concerning the latter is whether high magnetic fields can produce sufficient orientational order above the liquid crystal-isotropic transition temperature to cause gelation. This has important consequences not only for understanding the process of gel formation in anisotropic liquids, but also for developing new material processing techniques exploiting magnetic field induced order.

Experimental

The principal tool for studying liquid crystal material science has always been optics using polarized light. Deploying this tool in NHMFL resistive magnets is a logistical challenge. To that end, during our run in May, 2007 we commissioned and tested a second generation oven, constructed at KSU, for use in Cell 5 (31.5 T). Our previous results were obtained in Cell 4 (19.5 T), which allows much easier optical access but has substantially weaker field. Since the sought after effect depends on the square of the magnetic field strength, moving from Cell 4 to Cell 5 gives us almost 2½ times as much signal. The photo at right shows the oven; visible about halfway up on the left and right sides are two right-angle prisms which direct the laser beam up from below the bore, through the liquid crystal (perpendicular to the magnetic field), and then back down the bore to the optics below. This arrangement, which is the only geometry possible with vertically oriented solenoids, is particularly challenging to align and then compensate for stray birefringence.

Results and Discussion

Preliminary results using this new oven at high fields are extremely intriguing yet somewhat ambiguous and hence not yet ready for publication. The intriguing aspect is that we observed concrete indications that the sought after effect, magnetic field induced gel formation, was indeed present. The ambiguity stems from two sources: during our shakedown run with this new oven, we encountered unexpected contributions in the optical signal which had to be understood, accounted and corrected before reliable results were possible, and second, we suffered a serious setback in our schedule for magnet time. The initial plan was to fully test this oven during November, 2006. Unfortunately, due to delays associated with the power supply upgrades, we receive no magnet time at all during this week, and subsequently were pushed back to the following May.

Conclusions

Conclusions remain pending, as the work is not yet complete.

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