F. COMPLEX FLUIDS

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Synthesis – A derivative of the methyl red azo-dye has been prepared for non-linear optical investigations. Different bent-core monomers and their mixtures have been prepared which were used in composite materials with magnetic nanoparticles. Reactive linear and bent core liquid crystals have been also synthesized for polymerization and preparation of liquid crystal elastomers.

Electric field driven pattern formation – A detailed theoretical analysis of the flexoelectric instability of a planar nematic layer has been carried out in the presence of an alternating electric field of frequency f, which leads to stripe patterns (flexo-domains). This equilibrium transition is governed by the free energy of the nematic, which describes the elasticity with respect to the orientational degrees of freedom as well as the electric interactions. Surprisingly the limit $f \rightarrow 0$ is highly singular. In distinct contrast to the dc case, where the patterns are stationary and time independent, they appear at low f periodically in time as short flashes. Flexo-domains are in competition with the intensively studied electro-hydrodynamic instability in nematics, which represents a non-equilibrium dissipative transition. It has been demonstrated that f is a very convenient control parameter to tune between flexo-domains and convection patterns, which are clearly distinguished by the orientation of their stripes.

The temporal evolution of the spatially periodic electroconvection (EC) patterns has been studied within the period of the driving ac voltage by monitoring the light intensity diffracted from the pattern. Measurements have been carried out on a variety of nematic systems, including those with negative dielectric and positive conductivity anisotropy, exhibiting “standard EC” (s-EC), those with both anisotropies negative exhibiting “nonstandard EC” (ns-EC), as well as those with the two anisotropies positive. Theoretical predictions have been confirmed for stationary s-EC and ns-EC patterns. Transitions with Hopf bifurcation have also been studied. While traveling had no effect on the temporal evolution of dielectric s-EC, traveling conductive s-EC and ns-EC patterns exhibited a substantially altered temporal behavior with a dependence on the Hopf frequency. It has also been shown that in nematics with both anisotropies positive, the pattern develops and decays within an interval much shorter than the period, even at relatively large driving frequencies.

Liquid crystal composite materials – The influence of dodecanethiol functionalized gold nanoparticles (with diameter 3–5 nm) on the structural transitions has been investigated in a nematic liquid crystal 4-(trans-4’-n-hexylcyclohexyl)-isothiocyanatobenzene (6CHBT). It has been shown that the inclusion of gold nanoparticles increases the sensitivity of 6CHBT to the imposed external magnetic fields. Stable colloidal suspensions of net and magnetite-labeled single-walled carbon nanotubes in 6CHBT have also been prepared. The morphology and the size distribution of the nanotubes have been determined by transmission electron microscopy. For the magnetite labeled nanotubes a significant increase of the saturation magnetization has been

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detected by a SQUID magnetometer. By measurements in electric and magnetic fields, the density of the anchoring energy at the nematic–magnetic particle boundary has been found higher for the liquid crystal doped with magnetite labeled nanotubes than that for suspension with net nanotubes. The nematic to isotropic phase transition temperature of 6CHBT doped with magnetic nanoparticles of different shape has been monitored by precise capacitance measurements in external magnetic fields up to 12 T. A magnetic-field induced shift in the transition temperature has first been observed in a calamitic liquid crystal doped with rod-like magnetic particles.

Interactions at liquid crystal surfaces – Optically induced instabilities were observed in nematic liquid crystals sandwiched between a photosensitive layer and a reference plate. The instabilities occurred when the light entered the cell from the reference plate and its polarization was parallel to the director alignment at the entrance face. Two kinds of patterns were detected: a static and a dynamic one. The underlying mechanism of these pattern formations is the coupling between the director orientation on the photosensitive plate and the polarization direction of the light on the same plate.

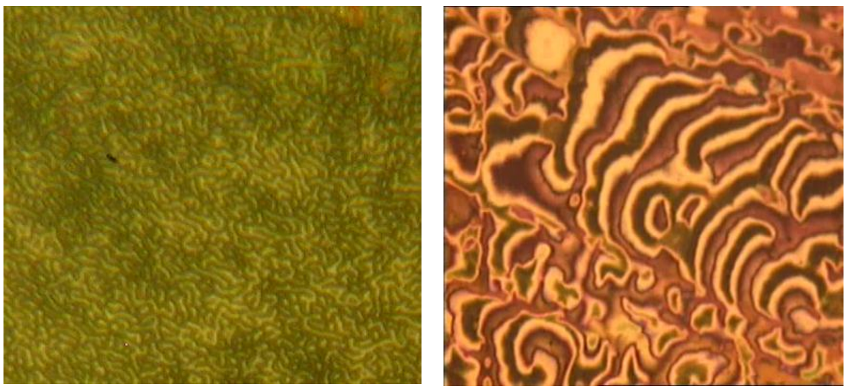

Fig. 1. Optically induced static (left panel) and dynamic (right panel) patterns.

Granular dynamics – A block of granular material consisting of two horizontal layers with different friction was deformed by moving the bottom wall of the container (see Fig. 2). The deformation zone finds an optimal path in the material by escaping the lower (high friction) layer and staying in the low friction layer near the layer boundary (Fig. 2.c). The formalism describing the selection of the optimal path is very similar to that of light propagation through inhomogeneous media.

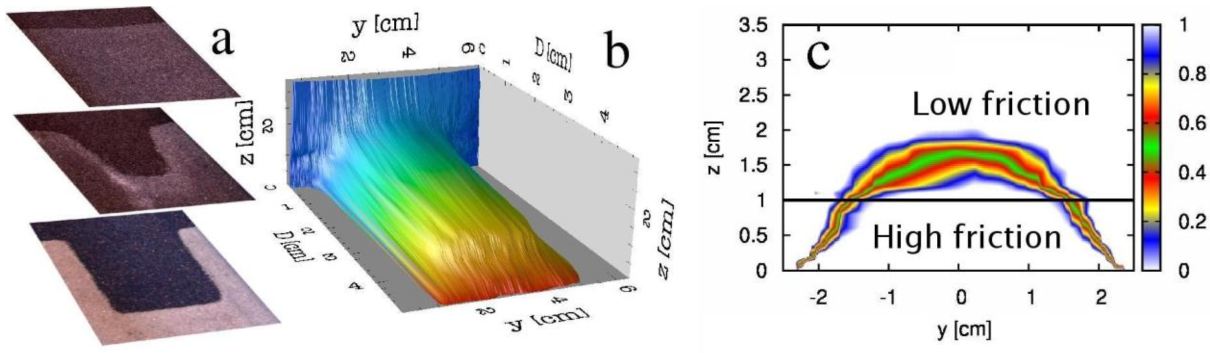

Fig. 2 A layered granular material is deformed by moving the bottom wall of the container. (a-b) The displacement is visualized by using colored samples and excavating the material layer by layer. The deformation zone (see panel c) does not remain at the bottom of the cell (this would be the shortest way connecting its two ends) but escapes the high friction layer and stays in the low friction layer near the layer boundary (horizontal black line).

Resonant silo discharge - called silo music - has been investigated experimentally. Grain motion has been detected with high speed imaging, while the systems resonance was monitored with a microphone and piezoelectric accelerometers. It was found that the grains do not oscillate in phase at neighbouring vertical locations; rather information propagates upward in this system in the form of sound waves. It was shown that the wave velocity is not constant throughout the silo; it considerably increases toward the lower end of the system, suggesting increased pressure in this region, where the flow changes from cylindrical to converging flow. Grain oscillations exhibit a stick-slip character only in the upper part of the silo.