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Coupling of orientation and shear flow in freely suspended liquid-crystal films

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Hydrodynamic phenomena observed in liquid crystalline materials are far more complex than those in conventional Newtonian fluids. The reason lies in the coupling of macroscopic translational motions to inner degrees of freedom, created by broken symmetries. So far, a direct quantitative observation of shear flow coupling to the local orientation of the fluid has been reported only in very few situations.

We present an experimental and theoretical study of one of the simplest non-trivial geometries in anisotropic fluid dynamics [1]. Freely suspended smectic films represent quasi-twodimensional systems with in-plane anisotropy. We show that vortex flow in these films can be induced entirely by elastic distortions of the orientational director field. By means of a rotating external electric field, a periodically deformed director pattern is prepared, which, after the field is switched off, relaxes into a homogeneous state. Macroscopic flow is induced by this director reorientation. We visualize it by means of tracer particles posed on the film surface. The flow field in turn drives the relaxation of the elastic distortions.

Continuum theory is applied for the description of the observed dynamic phenomena. We discuss the experimental results and and compare them to the predictions of theoretical models developed for different configurations of the director field. It is shown that the presence or absence of topologicals defects in the center of the vortex has essential influence on the relaxation dynamics of flow and director fields. The experiments provide access to quantitative measurements of shear viscosities [2].

In configurations with a central defect of topological strength +1 in the director field, flow is absent and a characteristic stick-slip dynamics is observed. This can be explained with the assumption of an anisotropy of the orientational elasticity of the material [3].

[1] D.R. Link, L. Radzihovsky, G. Natale, J.E. Maclennan, N.A. Clark, M. Walsh, S.S. Keast, and M.E. Neubert *Phys. Rev. Lett.* **84** 5772 (2000).

[2] R. Stannarius, C. Bohley and A. Eremin, *submitted* (2006)

[3] A. Eremin, R. Stannarius, and C. Bohley, *submitted* (2006)