Comment on "Nonequilibrium Periodic Structures Induced by Rotating and Static Fields in a Lyotropic Nematic Liquid Crystal"

Kuzma[1] reports the observation of magnetic-field–induced transient periodic structures in a nematic liquid crystal composed of disklike micelles. On the basis of the main features of the phenomena, he classifies them with similar effects observed in nematics composed of very long rodlike particles. However, Kuzma's observations are made for the geometry of the bend Fréedericksz transition, a configuration in which stripe patterns are not observed for rodlike nematics. This Comment offers support for Kuzma's general conclusions by presenting physical arguments relating the disklike shape of the micelles to the relative magnitudes of the various viscosities and elastic moduli that control macroscopic phenomena, thus justifying the appearance of stripes in a geometry for which they do not appear for rodlike nematogens.

At the heart of the matter is the simple observation that disks viewed edge on look like rods oriented perpendicular to the director. This means that certain geometric arguments for the relative magnitudes of the elastic moduli and viscosities in rodlike systems[2] can be carried over to the disklike systems, if one interchanges the elastic moduli K_1 and K_3 for splay and bend, the Miesowicz shear viscosities η_b and η_c, and the coupling coefficients α_2 and α_3 relating rotation and shear flow as defined by Lacerda Santos, Galerne, and Durand.[3] For rods, η_c and α_2 are large and η_b and α_3 are small; for disks we have the opposite. The pure rotational viscosity γ_1 is large for both rods and disks. In addition, the twist elastic constant K_2 and the third Miesowicz viscosity η_a, which are small for rods, are large for disks.

Mode selection in these transient phenomena is determined by the criterion that the fastest mode dominates. The appearance of stripes for rodlike particles in the splay geometry is due to a viscosity reduction; the high rotational viscosity γ_1 for uniform rotation is replaced by the low viscosity of a bend wave, $\eta_{\text{bend}} = \gamma_1 - \alpha_2^2/\eta_c$, in which rotation and flow are efficiently coupled. In the bend geometry, for rodlike particles, the viscosity would not be reduced in a periodic structure since γ_1 would be replaced by the splay wave viscosity $\eta_{\text{splay}} = \gamma_1 - \alpha_3^2/\eta_b$, which is also large; therefore uniform rotation is fastest in this case. For disklike particles, these arguments are precisely interchanged. We see this in detail below.

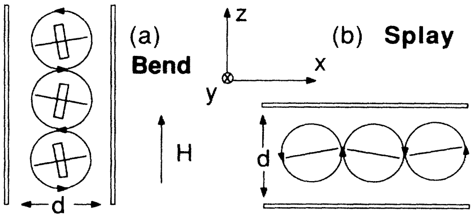

FIG. 1. The director (indicated by a solid line) is initially parallel to x, and $\chi_a > 0$. Periodic reorientation of disks (seen edge on as small rectangles) (a) in the bend geometry produces flows similar to those produced by rods reorienting (b) in the splay geometry.

We consider the splay and bend geometries shown in Fig. 1, with structures invariant in the y direction, and free boundary conditions. The rate of reorientation, s, of the director in both configurations as a function of magnetic field strength, H, is

$$s = (\chi_a H^2 - K_3 q_x^2 - K_1 q_z^2) \times \left[\gamma_1 - \frac{(\alpha_2 q_x^2 - \alpha_3 q_z^2)^2}{\eta_b q_z^4 + N q_z^2 q_x^2 + \eta_c q_x^4} \right]^{-1}$$

χ_a is the absolute value of the anisotropy of the magnetic susceptibility, and N is a particular combination of viscosity coefficients.[4] In the splay geometry the wave vector $q_z = \pi/d$, while the wave vector of the stripes q_x is selected to maximize the rate. In the bend geometry the roles of q_z and q_x are interchanged. If we now replace rods by disks, we also interchange the roles of K_1 and K_3, η_b and η_c, and α_2 and α_3, returning us to the same form of rate equation. Thus the splay geometry for the rod system is both formally and physically equivalent to the bend geometry for the disk system, and the appearance of stripes for disks in the bend geometry is expected. This applies for $\chi_a > 0$ and the field in the plane of the sample, or for the case Kuzma studied, $\chi_a < 0$ and a rotating magnetic field. A corollary to this is that we do not expect a periodic response from disklike nematics in the splay geometry.

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[1] M. R. Kuzma, Phys. Rev. Lett. **57**, 349 (1986).

[2] R. B. Meyer, in *Polymer Liquid Crystals*, edited by A. Ciferri, W. R. Krigbaum, and R. B. Meyer, (Academic, New York, 1982), Chap. 6; N. Kuzuu and M. Doi, J. Phys. Soc. Jpn. **52**, 3486 (1983), and **53**, 1031 (1984).

[3] For another discussion see M. B. Lacerda Santos, Y. Galerne, and G. Durand, J. Phys. (Paris) **46**, 933 (1985).

[4] E. Guyon, R. B. Meyer, and J. Salan, Mol. Cryst. Liq. **54**, 261 (1979).