MECHANICAL INSTABILITIES IN COMPLEX LIQUIDS: LIQUID CRYSTALS AND ROD-LIKE MICELLES

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Flow instabilities in complex fluids often manifest the spatial and temporal self-organization. In liquid crystals, the transient and stationary periodic patterns are formed when the applied (magnetic) field exceeds some critical value, $h > h_c$, where h_c is defined by the certain combination of material parameters of the system [1, 2]. These parameters are twist, bend and splay elastic constants and shear and rotational viscosity coefficients, which control the behavior of anisotropic fluids. We discuss how the selection of material parameters defines the periodic patterns and chaotic states in liquid crystals. For instance, the wavelength of periodic structures diverges in the vicinity of critical field as $l \propto (h - h_c)^{-0.5}$ [1].

Rod-like micellar solutions (liquid hand soap, shampoos, and body wash) represent another class of fluids where flow instabilities occur in a self-organized manner. In this case, above some critical (global) shear rate, the liquid separates into several layers that have different (local) shear rates. For this system, the temporal self-organization occurs as the oscillation of shear stress at constant global shear rate. Using scaling arguments similar to liquid crystals, we found that the stress oscillates between two limits, which are the Hopf bifurcation points [3], i.e. $\Delta = G_0 (t_b |\dot{g} - \dot{g}_c|)^{0.5}$. This equation relates the amplitude Δ of oscillations with the applied shear rate; and the parameters that define the critical shear rate are the elastic constant G_0 and the micellar breaking time t_b. We explore the systems with very different breaking times and elastic constants to prove the universality of this scaling [4]. The possibility of using similar approach to other oscillating systems is discussed.

References

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