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Spatiotemporal patterns and hysteresis in colloidal suspensions under shear

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Shearing a fluid is a paradigmatic example of driving a soft-matter system out of equilibrium. Indeed, it is now well established that shear flow can induce a variety of complex dynamical effects such as spatial symmetry–breaking in polymeric and colloidal systems, spontaneous oscillations in systems of anisotropic particles, and even chaotic states. Understanding and controlling these effects is not only of strong fundamental interest, but also crucial for many applications. Here we focus on soft–matter systems under the combined influence of shear flow and restricted geometry. We first consider confined suspensions of interacting spherical colloids, analyzed by many-particle computer simulations and effective single-particles models. By varying the externally applied shear rate these colloidal films can display sequences of states characterized by pinning, shear-induced melting, laning, and moving crystalline order with synchronized oscillations of the particles. The transitions between these states are accompanied by pronounced nonlinearities and hysteresis in the corresponding flow curve. We also discuss the appearance of moving density heterogeneities (kinks and antikinks). In the second part, we discuss the nonlinear flow-behavior and the emergence of shear-bands in systems of anisotropic particles. Based on a continuum model involving the (five-dimensional) orientational order parameter and the flow profile we explore systems with different boundary conditions and different spatial correlation lengths. Our results reveal new types of shear-banded states characterized by coexistence of oscillatory motion and steady states.