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Nonlinear hydrodynamic phenomena in Stokes flow[1] JERZY BLAWZDZIEWICZ, Yale University, ELIGIUSZ WAJNRYB, IPPT Warsaw, Poland, YUAN-NAN YOUNG, NJIT — The inertial term in the Navier–Stokes equations gives rise to numerous nonlinear phenomena, such as flow instabilities, formation of complex convective patterns, and turbulence. In our presentation we will discuss nonlinear behavior of a fluid under Stokes flow conditions, i.e., with no inertial forces. The fluid-dynamics equations are thus linear—the nonlinearity of the system stems entirely from the boundary conditions. We will consider (a) the dynamics of a highly viscous drop in 2D linear flows with rotation and (b) the motion of regular particle arrays in Poiseuille flow in a parallel-wall channel. We show that the drop response to quasistatic vorticity change is hysteretic, and at higher frequencies of the external forcing, the system undergoes a cascade of period-doubling bifurcations leading to chaos. We also demonstrate that the evolution of regular particle arrays in parallel-wall channels leads to emergence of complex patters that include separation of double rows of particles from the main body of the array, coexistence of ordered and disordered regions, rearrangements of regular particle lattice along dislocation lines, and fingering instabilities.

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