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Wave propagation, diffusive relaxation, and fragmentation instabilities in flow-driven drop chains under quasi-2D confinement[1]

SAGNIK SINGHA, Texas Tech University, Lubbock, Texas, USA, ABHILASH REDDY MALIPEDDI, George Washington University, Washington D.C., USA, MAURICIO ZURITA-GOTOR, Universidad Loyola Andalucia, Seville, Spain, KAUSIK SARKAR, George Washington University, Washington D.C., USA, JERZY BLAWZDZIEWICZ, Texas Tech University, Lubbock, Texas, USA — Drop chains can spontaneously emerge in confined emulsion flows and are frequently present in microfluidic systems. Here we discuss the dependence of the drop-chain dynamics on flow symmetries. For an antisymmetric incident flow (Poiseuille flow) the leading-order interparticle hydrodynamic interactions occur via Hele–Shaw flow dipoles. The vector-like symmetry of these interactions results in density wave propagation in the direction of the dipole orientation. For a symmetric incident flow (Couette flow), the leading-order interparticle interactions are quadrupolar. Due to the fore–aft symmetry of Hele–Shaw quadrupoles, the macroscopic chain dynamics is diffusive, because there in no first-order spatial derivative in the evolution equation. The sign of the diffusion constant depends on the balance between the quadrupolar interactions and near-field hydrodynamic repulsion (the repulsion stems from the swapping-trajectory effect and drop deformation). Density perturbations decay for a positive diffusion constant; for a negative value they grow, eventually leading to the decomposition of a chain into stable chain fragments with a uniform drop spacing.

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