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The impact of hydrodynamics on stress formation, relaxation, and memory in colloidal dispersions: Transient, nonlinear microrheology RITESH P. MOHANTY, ROSEANNA N. ZIA, Cornell University — In active microrheology, a probe is driven through a complex medium. Most work thus far has focused on steady behavior and established the relationship between the microstructure, probe speed, and rheology. But important information about structural development and relaxation are captured by startup and cessation of flows in the non-linear regime, where the structure is driven far from equilibrium. Here we study theoretically the rate of stress formation and relaxation under non-linear microrheological forcing of hydrodynamically interacting colloids. We study the behavior analytically in the dual limits of weak and strong probe forcing and weak and strong hydrodynamic interactions and numerically in between. To elucidate the detailed role of hydrodynamic, Brownian, and interparticle forces in stress formation and relaxation, we employ an excluded annulus model to introduce each systematically, and study the rheological and structural response for arbitrary forcing and strength of hydrodynamic interactions. Hydrodynamics introduce an additional mode of dissipation, which manifests as a reduction in the rate of stress formation during startup. While this non-equilibrium contribution vanishes instantly upon flow shutoff, a delicate interplay between Brownian and interparticle forces influences relaxation, revealing multiple relaxation modes. The recovery of entropically stored energy is studied.

Ritesh Mohanty
Cornell University

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