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Kinematically irreversible particle motion in 2D suspensions due to surface-pressure-dependent surface rheology HARISHANKAR MANIKANTAN, TODD SQUIRES, University of California, Santa Barbara — The surface viscosity of many insoluble surfactants depends strongly on the surface pressure (or surface tension) of that surfactant. Surface pressure gradients naturally arise in interfacial flows, and surface-pressure-dependent surface rheology alters 2D suspension dynamics in significant ways. We use the Lorentz reciprocal theorem to asymptotically quantify the irreversible dynamics that break Newtonian symmetries. We first show that a particle embedded in a surfactant-laden interface and translating parallel to or rotating near an interfacial boundary experiences a force in the direction perpendicular to the boundary. Building on this, we extend the theory to compute the first effects of pressure-dependent surface viscosity on 2D particle pairs in suspension. The fore-aft symmetry of pair trajectories in a Newtonian interface is lost, leading to well-separated (when pressure-thickening) or aggregated (when pressure-thinning) particles. Notably, the relative motion is kinematically irreversible, and pairs steadily evolve toward a particular displacement. Based on these irreversible pair interactions, we hypothesize that pressure-thickening (or -thinning) leads to shear-thinning (or -thickening) in 2D suspensions.

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