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Hydrodynamic diffusion in non-colloidal suspensions: the role of interparticle forces NICHOLAS HOH, ROSEANNA ZIA, Cornell University — Hydrodynamic diffusion in the absence of Brownian motion is studied via active microrheology in the pure hydrodynamic limit, to elucidate the transition from colloidal microrheology to the non-colloidal limit, falling-ball rheometry (FBR). Non-Brownian force-induced diffusion in FBR is strictly hydrodynamic in nature; in contrast, force-induced diffusion in colloids is deeply connected to a diffusive boundary layer even when Brownian motion is weak. To connect these two limits, we derive an expression for the hydrodynamic force-induced diffusion via the Smoluchowski equation, where thermal fluctuations play no role. The diffusion is anisotropic, along and transverse to the line of external force. The latter is zero owing to the fore-aft symmetry of Stokes flow. We find that interparticle forces play a crucial role in the hydrodynamic limit; accounting for this force results in longitudinal force-induced diffusion $D_{\parallel} = 1.26 a U_s \phi$, where a is probe size, U_s the Stokes velocity, and ϕ the volume fraction, in excellent agreement with experiments and theory for macroscopic FBR. This model connects micro- and macro-scale rheology, and provides insight into the role of interparticle forces for diffusion and rheology even in the limit of pure hydrodynamics.

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