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Rheology of colloidal suspensions measured by dragging a probe

XIN DU, Graduate Student, Emory University, PIOTR HABAS, Associate Professor, Saint Joseph's University, ROSEANNA ZIA, Post-doc, Princeton University, ERIC WEEKS, Professor, Emory University — We use active microrheology to study the rheological properties of colloidal suspensions at moderate volume fractions. Traditionally, the rheology of complex fluids is experimentally studied using macroscopic mechanical rheometers. Alternatively, single-particle tracking—microrheology—can be utilized to measure material properties. Microrheology involves the tracking the motion of a probe particle embedded in a complex fluid. In passive microrheology, the motion of the probe particle is driven by thermal fluctuations. Here we study non-equilibrium systems via active microrheology, in which a magnetic probe particle is dragged by a constant external magnetic force through a suspension of colloidal particles. By tracking the mean and mean-square probe motion, the viscosity, diffusivity, and normal stresses are obtained. The effective viscosity of the suspension is determined from the mean velocity of the probe particle. The velocity fluctuations of the probe which are parallel and perpendicular to the mean velocity direction produce force-induced probe diffusion, are measured by the mean-square displacement of the probe. By applying recent theory, the two measurements are combined to understand other rheological properties of the complex fluid such as normal stresses. Our results are in good agreement with macroscopic rheology of similar suspensions, demonstrating that the microscopic technique may be useful for cases when only small sample quantities are available.

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