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Fluctuation, dissipation, and a non-equilibrium "equation of state" via nonlinear microrheology of hydrodynamically interacting colloids HENRY CHU, ROSEANNA ZIA, Cornell University — In our recently developed non-equilibrium Stokes-Einstein relation for microrheology, we showed that, in the absence of hydrodynamic interactions, the stress in a suspension is given by a balance between fluctuation and dissipation. Here we generalize our theory to develop a simple analytical relation connecting diffusive fluctuation, viscous dissipation and suspension stress in systems of hydrodynamically interacting colloids. In active microrheology, a Brownian probe is driven through a complex medium. The strength of probe forcing compared to the entropic restoring force defines a Peclet number, Pe. In the absence of hydrodynamics, normal stress differences scale as Pe^4 and Pe for weak and strong probe forcing, respectively. But as hydrodynamics become important, interparticle forces give way to lubrication interactions and the normal stresses scale as Pe^2 and $Pe^\delta ln(Pe)$, where $0.773 \leq \delta \leq 1$ as hydrodynamics vary from strong to weak. The new phenomenological theory is shown to agree with standard micromechanical definitions of the stress. A connection is made between the stress and an effective temperature of the medium, prompting the interpretation of the particle stress as the energy density, and the expression for osmotic pressure as a "non-equilibrium equation of state."

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