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The effect of shear flow on the rotational diffusivity of a single axisymmetric particle BRIAN LEAHY, Department of Physics, Cornell University, DONALD KOCH, Chemical and Biomolecular Engineering, Cornell University, ITAI COHEN, Department of Physics, Cornell University — Colloidal suspensions of nonspherical particles abound in the world around us, from red blood cells in arteries to kaolinite discs in clay. Understanding the orientation dynamics of these particles is important for suspension rheology and particle self-assembly. However, even for the simplest case of dilute suspensions in simple shear flow, the orientation dynamics of Brownian nonspherical particles are poorly understood at large shear rates. Here, we analytically calculate the time-dependent orientation distributions of particles confined to the flow-gradient plane when the rotary diffusion is small but nonzero. For both startup and oscillatory shear flows, we find a coordinate change that maps the convection-diffusion equation to a simple diffusion equation with an enhanced diffusion constant, simplifying the orientation dynamics. For oscillatory shear, this enhanced diffusion drastically alters the quasi-steady orientation distributions. Our theory of the unsteady orientation dynamics provides an understanding of a nonspherical particle suspension's rheology for a large class of unsteady flows. For particles with aspect ratio 10 under oscillatory shear, the rotary diffusion and intrinsic viscosity vary with amplitude by a factor of ≈ 40 and ≈ 2, respectively.

Brian Leahy
Department of Physics, Cornell University

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