(Non)linear responses and fluctuations in non-Markovian baths

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Brownian motion of a micron-sized particle in a purely viscous fluid is a paradigmatic stochastic process which is described via a (Markovian) Langevin equation. In contrast, in viscoelastic flu- ids which are characterized by long structural relaxation times on the order of seconds, complex couplings enter, which make a Markovian description no longer possible. With theory and exper- iments we study the response and fluctuations of colloidal particles in such non-Markovian baths, in different driving modes.

When a colloidal particle is driven through a non-Markovian bath, there exist different driving modes, for example moving with velocity or feeling a force. Formally, these modes are described via a friction or mobility kernel, with time-dependencies encoding temporal correlations of the fluid. Studying two observables, the recoil after releasing a probe that was driven through the fluid [1] and the equilibrium mean squared displacement (MSD), we obtain insight into the relation between the two kernels, within the linear regime. While the recoil provides direct access to the mobility kernel, the equilibrium MSD is dominated by the friction kernel. Applying two models, a generic Langevin bath particle model [1-4] and mode coupling theory (MCT), we find a formal Volterra relation between the two kernels, explaining different behaviors in either experiments [2].

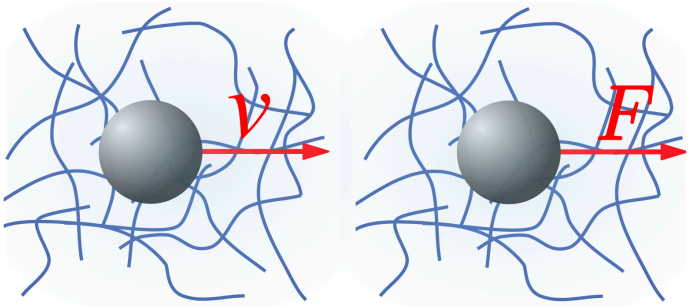

Fig. 1: *A colloidal particle is suspended in a (viscoelastic) wormlike micellar solution and perturbed by a velocity v for a force F. Does the response depend on the type of perturbation?*

Going beyond linear response, it is known that wormlike micellar solutions exhibit a shear-thinning regime where viscosity decreases with driving velocity. Applying path integral techniques, we characterize this regime with higher order memory kernels in both driving modes and find gen- eralized Langevin equations with respectve noise correlations. Theoretically, we analyze these using a stochastic Prandtl-Tomlinson model [4], which allows to find analytical expressions for the respective kernels and to extract them from equilibrium simulations.

References:

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