Title:	The effective temperature for the thermal fluctuations in hot Brownian motion
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Abstract:	We revisit the effective parameter description of hot Brownian motion—a scenario where a colloidal particle is kept at an elevated temperature than the ambient fluid. Due to the time scale separation between heat diffusion and particle motion, a stationary halo of hot fluid is carried along with the particle resulting in a spatially varying comoving temperature and viscosity profile. The resultant Brownian motion in the overdamped limit can be well described by a Langevin equation with effective parameters such as effective temperature THBM and friction coefficient ζHBM that quantifies the thermal fluctuations and the diffusivity of the particle. These parameters can exactly be calculated using the framework of fluctuating hydrodynamics and require the knowledge of the complete flow field and the temperature field around the particle. Additionally, it was also observed that configurational and kinetic degrees of freedom admit to different effective temperatures, TxHBM and TvHBM, respectively, with the former predicted accurately from fluctuating hydrodynamics. A more rigorous calculation by Falasco et al. [Phys. Rev. E 90, 032131-10 (2014)] extends the overdamped description to a generalized Langevin equation where the effective temperature becomes frequency dependent and consequently, for any temperature measurement from a Brownian trajectory requires the knowledge of this frequency dependence. We use this framework to expand on the earlier work and look at the first order correction to the limiting values in the hydrodynamic limit and the kinetic limit. We use the linearized Stokes equation and a constant viscosity approximation to calculate the dissipation function in the fluid. The effective temperature is calculated from the weighted average of the temperature field with the dissipation function. Further, we provide a closed form analytical result for effective temperature in the small as well as high frequency limit. Since hot Brownian motion can be used to probe the local environment in complex systems, we have also calculated the effective diffusivity of the particle in the small frequency limit. To look into the kinetic temperature, the velocity autocorrelation function is computed from the generalized Langevin equation and the Wiener-Khinchine theorem and numerically integrated to evaluate TvHBM as a function of the ratio of particle density and fluid density ρP/ρ0. The two limiting cases of ρP/ρ0 → 0 and ρP/ρ0 → ∞ is also discussed
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