Title:	The effective temperature for the thermal fluctuations in hot Brownian motion
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Abstract:	Brownian motion corresponds to the irregular motion of large particles suspended in fluids. It allows us to investigate microscopic processes based on macroscopic observation. It is an important conceptual and methodological example to work out the theory of stochastic processes and to study non-equilibrium processes. One way to study Brownian motion is to consider a Brownian particle coupled by boundary conditions to a fluid governed by fluctuating hydrodynamics and then proceed to contract the description to the level of the dynamical variables of the Brownian particle alone through boundary conditions. However, in the classical Markovian description, the fluctuating force acting on Brownian particle is assumed to be white noise and through delta correlation related to solvent parameters like temperature and viscosity. This approximation ignores retardation effects in the solvent backflow around a moving Brownian particle that gives rise to long-time tails. Nonetheless, these complications can be disregarded for many applications and even for some non-equilibrium generalisations of Brownian motion involving external forces or time or space-dependent temperature fields. Thus the simple Markovian descriptions work as a starting point for more elaborate theories. Hot Brownian motion is one of them. It is a non-equilibrium scenario of equilibrium phenomena. The colloidal particle is heated and thus has a different temperature than the surrounding fluid. The effects of the solvent inhomogeneities caused by heat emission from the Brownian particle are incorporated into the Markovian model of Hot Brownian motion that generalises the equilibrium Langevin equation. In the thesis, we revisit the effective parameter description of hot Brownian motion. We consider a spherical colloidal particle for simplicity, but more irregular shapes are expected to yield similar results. Also, the symmetry of the particle is used to decouple the translational and rotational motion of the particle. As the colloidal particle is kept at an elevated temperature than the ambient solvent and there is time scale separation between heat diffusion and particle motion, we have radially symmetric temperature and viscosity profiles in the co-moving frame of the particle. In this frame, fluid is locally in equilibrium with the particle. All these assumptions used to describe the motion can be put as non-equilibrium steady state Brownian motion. In our calculation, we start with an incompressible solvent. As ΔT is the temperature difference between ambient temperature T0 and the solvent temperature at the particle's surface, it is observed that to first order in ΔT, the viscosity and thermal conductivity temperature dependence do not enter into the picture. Hence a Langevin equation can well describe 3the resultant Brownian motion in the overdamped limit with effective parameters. It has been shown earlier that there are two effective temperatures corresponding to different degrees of freedom of particle motion. One governs the long-time limits of the particle motion and exhibits diffusive behaviour, and the other comes from short- time kinetic behaviour. The former is called the effective positional temperature T x and later the kinetic temperature T v . The expression of T x is obtained up to first in ω from the low frequency limit of the frequency dependent temperature T (ω). As observed in the simulations, the distribution of the momentun of the particle is Gaussian and width of the distribution is determined by a different temperature T v . The local thermal equilibrium and the structure of the solution of the Stokes equation would imply that the width of distribution is determined by an effective temperature that is possibly an average of the temperature field over a narrow shell around the colloid. Further, the high-frequency behaviour (the short time regime) of T (ω) is constant, we define T v by assuming that the particle's velocity obeys Maxwell Boltzmann distribution. Thus the kinetic temperature T v depends on the ratio of densities of particle and fluid, ρρP0 . We discuss the effect of two extreme limits ρρP0 → 0 and ∞ on the behaviour of T v . Later, we also define the effective diffusion coefficient for Brownian particle and calculate its form up to first order in ω. In this thesis, we have worked the detailed calculation of T x and T v , expanding the earlier works by Rings et. al. and Falasco et. al. and explicitly calculated the first order correction in frequency to T x and T v . This significance of the work lies in the fact that in experiments there is always a finite time resolution δt. Consequently, the data is collected at frequency ω ∼ 1/δt. Hence all effective temperature measurements would be frequency depedent. Therefore, the derived expressions in the limit T x (ω → 0) and T v would provide an easy reference for data fitting.
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