

Not just cool anymore: Hot Brownian Motion

Scientists venturing into the nanoscopic world find everything in an incessant erratic motion that was first investigated for tiny pollen grains dissolved in water by the botanist Robert Brown in the early 19th century. Albert Einstein later explained this “Brownian motion” as a consequence of the particles being in thermal equilibrium with the solvent molecules. But what if the Brownian particles are much hotter than the solvent — say due to optical absorption? Revisiting Einstein’s seminal paper from 1905, a team of physicists from the University of Leipzig now explains how to extend the common theory to such nonequilibrium conditions [1]. They test their predictions experimentally using gold nanoparticles diffusing in a laser focus. What they find is that the apparent viscosity and temperature conditions effectively “felt” by a hot nanoparticle are not, as some people had suggested, the conditions at its surface. Due to long-ranged correlations in the solvent, the proper effective viscosity and temperature values pertaining to its “hot Brownian motion” need in fact to be calculated by integrating over the whole solvent. This nicely illustrates the general dictum that hydrodynamic boundary conditions should not be confused with the microscopic conditions at the physical boundary. The distinction becomes more important the deeper we delve into the nano-world. Arguably, hot Brownian motion is nowadays becoming a very common thing. Countless experimental techniques used in modern biology and nanotechnology involve optical tracking and trapping of tiny tracer particles that inadvertently heat up due to optical absorption. As a rule, stronger illumination is needed for smaller particles, which thus get hotter. With a reliable analytical theory at hand, one may now make the best of it and exploit the heat-induced increase in the scattering contrast for photothermal particle tracking and correlation spectroscopy techniques. These novel developments allow for a precise and virtually background-free detection of nanoparticles and are now getting into a good position to complement more conventional fluorescence methods in many applications.

[1] D. Rings, R. Schachhoff, M. Selmke, F. Cichos, and K. Kroy, *Physical Review Letters* 105 (2010) 090604.