First passage time distribution of a Brownian particle in a viscoelastic bath

Brandon Alejandro Reyes Ferrer[1], Juan Rubén Gómez-Solano[1]

[1]Instituto de Física, UNAM, Ciudad De México, Mexico

We investigate theoretically and experimentally the first passage-time properties of a spherical Brownian particle that is harmonically trapped at thermal equilibrium in a fluid at constant temperature. By using the overdamped version of the generalized Langevin equation, we derive a general expression for the probability density function of the time that the particle takes to reach for the first time the minimum of the potential starting from an arbitrary position. We show that such a first-passage time distribution can be implicitly expressed in terms of the friction memory kernel that encodes the interaction of the particle with its surroundings, and correctly reduces to previously found expressions in the case of a Markovian viscous bath.

We validate our theoretical results by measuring the first passage time of colloidal beads optically trapped in non-Markovian baths such as viscoelastic polymer and micellar solutions, as well as in a viscous glycerol/water mixture and water, which behave as Markovian media, thereby finding agreement with the derived expressions. In particular, we find that the mean first passage time in a viscoelastic bath can surpass that in a viscous medium of the same zero-shear viscosity due to the emergence of slowly decaying tails in the first-passage time probability density of the former.