Non-equilibrium steady-states in a tilted periodic potential

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We report our recent experimental and theoretical studies on the non-equilibrium steady-state (NESS) dynamics of the diffusing colloids over a tilted periodic potential, in which detailed balance is broken due to the presence of a steady particle flux. A tilted two-layer colloidal system is constructed for this study. The periodic potential is provided by the bottom layer colloidal spheres forming a fixed crystalline pattern on a glass substrate[1]. The corrugated surface of the bottom colloidal crystal provides a gravitational potential field for the top layer diffusing particles. The measured mean drift velocity v(F,Eb) and diffusion coefficient D(F,Eb) of the particles as a function of F and energy barrier height Eb agree well with the exact solution of the one-dimensional Langevin equation[2]. From the exact results we show analytically and verify experimentally that there exists a scaling region, in which v(F,Eb) and D(F,Eb) both scale as ν'(F)exp[-Eb*(F)/kT], where the Arrhenius pre-factor ν'(F) and effective barrier height Eb*(F) are both modified by F. The Stoke-Einstein relation is shown to be violated to a different extend, depending on the driving or how far away from equilibrium[2]. Furthermore, the NESS probability distribution Pss is obtained exactly for the 1D case and compared well with the experimental results[3]. From the obtained exact solution of the 1D Smoluchowski equation, we develop an analytical method to accurately extract the 1D potential from the measured Pss(x). The experimental results are compared with the exact solution of the one-dimensional (1D) Smoluchowski equation and the numerical results of the 2D Smoluchowski equation.

References

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