Experimental verification of a modified fluctuation-dissipation theorem for a Brownian particle in a non-equilibrium steady state

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A modified fluctuation-dissipation theorem (MFDT) has been recently found for simple Langevin dynamics close to non-equilibrium steady states (NESS) with non-vanishing probability currents [1]. In this work we verify experimentally MFDT for fluctuations of a micron-sized silica particle immersed in water moving in a periodic potential and subjected to a non-conservative constant force. A NESS is implemented by means of a toroidal optical trap created by a rotating laser beam with intensity modulation which confines the motion of the particle on a circle [2,3]. We measure the autocorrelation function of an observable related to the angular position of the particle, the corresponding integrated response function due to a small perturbation of the amplitude of the periodic potential, and a corrective term given by the constant probability current. We find that the correlation minus the corrective term times the inverse temperature of the surrounding water is equal to the integrated response, as shown theoretically by [1]. The results can be interpreted as an equilibrium-like fluctuation-dissipation relation in the Lagrangian frame moving at the mean local velocity of the particle determined by the probability current.

Références

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