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*Langevin dynamics with a nonlinear thermal bath: basics and applications to motors*

Conventional Langevin models of stochastic dynamics assume that the system of interest is weakly coupled to a thermal bath which is linear in the sense that it produces a dissipative force linear in the system velocity. With the notable exception of harmonic oscillator baths, the assumption of a linear bath can be justified only as an approximation of the lowest order in a relevant small weak coupling parameter  $\lambda$  characterizing the intensity of the system-bath interaction. To higher orders in  $\lambda$  the Langevin equation contains additional dissipative terms which are nonlinear in the system velocity and described by additional fluctuation-dissipation relations. We discuss the structure of these nonlinear fluctuation-dissipation relations, show that they guarantee thermalization of the system to a Maxwell equilibrium distribution to any order in  $\lambda$ , and emphasize the non-Gaussian nature of corresponding random forces.

While nonlinear dissipation forces (being of higher order in  $\lambda$ ) are usually much smaller than the linear one, they may give rise to important physical effects which do not show up in the linear bath approximation. Among other examples, we consider intrinsic ratchets: a family of Brownian motors archetyped by an asymmetric Brownian particle subjected to an external unbiased (e.g. harmonic or noisy) time-dependent force. Directional motion of an intrinsic ratchet is a nonlinear effect of order  $\lambda^3$ , and the approximation of a linear bath (of order  $\lambda^2$ ) is not sufficient for its description.