Memory Effects in Micro and Nanoscale Systems

Kay Brandner
School of Physics and Astronomy
University of Nottingham
Nottingham NG7 2RD
United Kingdom

Memory effects are ubiquitous in small-scale systems. They emerge from interactions between accessible and inaccessible degrees of freedom and give rise to evolution equations that are non-local in time. If the characteristic time scales of accessible and inaccessible degrees of freedom are strongly separated, locality can be restored through the standard Markov approximation. Here, we show that this approach can be rigorously extended to a precisely defined weak-memory regime, where the relevant time scales can be of comparable order of magnitude. We provide explicit bounds on the error of the local approximation and a perturbative scheme for its systematic construction. Our theory is applicable to any non-local time evolution equation that is autonomous and linear in the observables of interest and provides a general framework to treat memory effects beyond the Markov approximation.