Thermodynamics of the generalized Langevin equation and its applications

The generalized Langevin equation (GLE) is the non-Markovian extension of the equation introduced by Langevin to study the Brownian motion of particles immersed in a simple fluid. Indeed, if the particle is immersed in a solution containing for example long and complex polymers, a net separation of time scales relative to the colloidal particle and the fluid is not possible and memory effects occur. These effects are characteristic of viscoelastic fluids and, in this context, the GLE emerges as a very effective model to describe such kind of systems. Furthermore, the GLE can be used to model the motion of a reaction coordinate in a free energy landscape describing, for example, the zipping/unzipping dynamic of a DNA hairpin. By introducing a new method to deal with the large time behaviour of the solutions of the linear GLE, we will be able to highlight the differences as well as the similarities between the GLE and the Markovian Langevin equations in the context of stochastic thermodynamics. We will also show how some care must be taken when the non-Markovian extension of the overdamped Langevin equation is considered. The discussion will be also complemented by simple but at the same time relevant examples stemming from the field of biological Physics