Langevin equations for reaction-diffusion processes

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Abstract

Langevin equations are ubiquitous in the modelization of out-of-equilibrium systems and provide a starting point both for numerical simulations and field theory approaches. Most of the time, these equations are derived in a phenomenological way by adding a noise term – which is supposed to modelize the complicated microscopic degrees of freedom of the system – to a deterministic mean-field equation.
However, I will show in my presentation that it is possible for some systems (the reaction-diffusion processes) to start from the microscopic dynamics and, without any approximation, to obtain a Langevin equation that describes the system exactly (Benitez, Duclut et al., PRL 2016).

Obviously, this exact description of the system by a Langevin equation has a cost: The Langevin equation is not stated in terms of a "physical" variable but rather in terms of an "auxiliary" variable. I will however show that with the help of a duality relation, all the physics can be extracted from this auxiliary variable (Doering, Mueller, Smereka, Physica A 2003).
Since these Langevin equations are exact (and real) – in particular in the low density regions – they are the right starting point for numerical and theoretical studies of reaction-diffusion processes (Dornic, Chaté, Muñoz, PRL 2005).

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