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Ultraviolet divergences in classical field equations with noise: the dynamics of the chiral phase transition in QCD

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Abstract content

The dynamics of the time evolution of an order parameter towards equilibrium is a much-studied problem in nonequilibrium statistical mechanics. Typically, when a system consisting of a two-phase mixture in a homogeneous phase is rapidly driven across the critical coexistence temperature into a nonequilibrium state, fluctuations around the initial homogeneous state will develop; the system will break into domains of different phases in space, and ultimately will reach a new equilibrium state. If the order parameter that characterizes the phases of the system is not a conserved quantity, its time evolution can be described by nonlinear Ginzburg-Landau (GL) type of equations – relevant e.g. for studies of the QCD phase transition. Environmental effects of random nature (e.g. of thermal origin) are usually taken into account by noise sources, turning GL equations into stochastic differential equations, which we name generically as Ginzburg-Landau-Langevin (GLL) equations. Analytic solutions of GLL equations are achievable only in very special circumstances, like when linearization on the effective potential are made, which in general are valid only at short times. Extensive numerical simulations are necessary, usually by discretizing the equations on a space lattice. However, a not much appreciated feature is that due to the noise sources, ultraviolet divergences appear, which are reflected in lattice-spacing dependence of the solutions. The divergences are related to the well-known Rayleigh-Jeans ultraviolet catastrophe in classical field theory. In the present talk we present a systematic method to regularize and renormalize GLL equations on a lattice, which leads to results independent of the lattice spacing. We discuss the implementation of the method for the full GLL equation in the context of the chiral phase transition of QCD and consider the nonequilibrium evolution of the chiral condensate during the hydrodynamic flow of the quark-gluon plasma.

Summary

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