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A new effective theory for stochastic relativistic hydrodynamics

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Thermal fluctuations are a fundamental feature of dissipative systems that are essential for understanding physics near the expected critical point of QCD and in small systems. Such fluctuations can be modeled by including a stochastic source in the standard hydrodynamics equations. However, when this is done naively strange features can appear such as negative self-correlation functions [1–3]. We construct an effective theory for nonlinear stochastic relativistic hydrodynamics that ensure a well-posed mathematical formulation. Using Crooks fluctuation theorem [4], we derive a symmetry of the effective action that incorporates fluctuations through a suitable free energy functional [5]. For divergence type theories [6], the action can then be fully specified using a single vector generating current. This generating current is related to the free energy, which allows for a systematic understanding the stability properties of the system. The equations of motion obtained using this procedure are guaranteed to be flux conservative and symmetric hyperbolic. This ensures that these equations are well-posed (for suitable initial data) and are in a form that can easily be simulated, including with Metropolis techniques [7].

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Category

Theory

Collaboration (if applicable)

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