Universality in nonequilibrium quantum dynamics

Gesualdo Delfino
SISSA and INFN, Trieste, Italy

A quantum quench dynamically generates a nonequilibrium state that in the proximity of a critical point yields a time evolution exhibiting universal properties. We show how to solve the key problem of determining the nonequilibrium state for the different universality classes, and then analytically determine the behavior of local observables at large times. One result of the theory is that, for systems with interacting excitation modes, the order parameter can exhibit oscillations that stay undamped in time. In particular, this is predicted to occur for a quench of the transverse field within the ferromagnetic phase of the Ising model in more than one spatial dimension, a case previously unaccessible to analytic treatment. If the quench is performed only in a subregion of the whole d-dimensional space occupied by the system, the time evolution occurs inside a light cone spreading away from the boundary of the quenched region. In this case, the additional condition for undamped oscillations is that the volume of the quenched region is extensive in all dimensions. We also address analytically for the first time the central issue of the dependence on initial conditions in nonequilibrium quantum dynamics considering the one-dimensional ferromagnets in the regime of spontaneously broken symmetry, for the infinite-dimensional space of initial conditions of domain wall type. At large times the time evolution takes place inside a light cone produced by the spatial inhomogeneity of the initial condition. While the global limit shape in the variable x/t changes with the initial condition, the form of the space-time dependence in the innermost part of the light cone is universal. In systems with more than two ground states the tuning of an interaction parameter can induce a transition which is the nonequilibrium quantum analog of the interfacial wetting transition occurring in classical systems at equilibrium. We illustrate the general results through the examples of the quantum Ising, Potts and Ashkin-Teller models.

References

[1] G. Delfino, M. Sorba, Persistent oscillations after quantum quenches in d dimensions, Nucl. Phys. B, 974, 115643 (2022).
[2] G. Delfino, M. Sorba, Space of initial conditions and universality in nonequilibrium quantum dynamics, Nucl. Phys. B, 983, 115910 (2022).