Quantum interaction quench in the presence of a long-range order

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Quantum interaction quench is a fundamental problem of interest that concerns dynamics after an abrupt change of the interaction parameter for an isolated quantum system. It is most easily realized in experiments on cold atomic gases, which allow precise control of the interaction parameter with very well isolation from environment. The main question there is whether and how the system thermalizes from unitary evolution. For the normal phase of fermionic systems, it shows "prethermalization", i.e., local quantities quickly arrives at thermal values whereas the momentum distribution is trapped to a nonthermal quasi-stationary distribution.

Here we study the quantum interaction quench problem for the fermionic Hubbard model in the presence of a long-range order [1][2][3], which can be antiferromagnetism for the repulsive interaction, or superconductivity for the attractive interaction. The time evolution is obtained by the nonequilibrium dynamical mean-field theory. We show that, contrary to the case in the normal phase, the order parameter (which is a local quantity) does not immediately decay after the quench but stays to be a nonthermal finite value for a relatively long time even when the effective temperature exceeds the thermal critical temperature. It turns out that the dynamics of the order parameter (e.g., the Higgs mode) is governed a "nonthermal critical point", rather than the thermal critical point. Around the nonthermal critical point, there emerges a universality that characterizes the nonequilibrium phase transition.

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