

Generalized Keldysh formalism for nonequilibrium correlation functions and its application to fluctuation dynamics

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Time-resolved Raman scattering and resonant inelastic X-ray scattering now resolve the time evolution of low-energy charge, spin, and phonon excitations in materials. Beyond the spectra themselves, they have recently been shown to give access to higher-order quantities such as the quantum Fisher information, which are attracting interest as novel diagnostics of nonequilibrium states [1].

Theoretically, both the spectra and these quantities are expressed in terms of nonequilibrium two-particle correlation functions. Their time evolution can in principle be obtained from the nonequilibrium Bethe–Salpeter equation, but at prohibitive computational and memory costs. Conventional approaches therefore neglect vertex corrections, thereby omitting collective effects.

To overcome this, we propose an approach that naturally incorporates vertex corrections, based on the generalized Keldysh formalism [2] applied to a Hamiltonian with a virtual external probe field [3]. We derive a linear integral equation for the correlation functions and develop an efficient solver for it based on quantics tensor trains [4], a tensor network technique [5].

In this poster, we outline the formalism and apply it to the fluctuation dynamics of nonequilibrium antiferromagnetic states in the Hubbard model. We show that vertex corrections qualitatively change the dynamics, and that fluctuations are enhanced near a nonthermal critical point [6].

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