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Zeno polaron induced by driven-dissipative background medium

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The study of open quantum systems subjected to driven-dissipation is a long-lasting yet less-tackled problem. Conceptually, all physically relevant systems must interact with another system or an external bath to exchange energy or information. However, an open quantum system is practically more complicated because the energy is no longer a conserved quantity, thereby compromising nearly all familiar theoretical tools within closed systems. This difficulty is devastating in the study of interacting many-body systems, where a well-behaved quasiparticle lies at the center of almost all theories to reduce the problem to noninteracting limits. However, an open quantum system can gain an advantage from its coupling with external parties to reach a special status, which is unattainable in closed systems.

As a famous example of a quasiparticle, a polaron is defined as a dressed state formed by a mobile impurity interacting with a medium. First proposed by Landau [1] and Pekar [2] over half a century ago to describe the dressing effect of impurities by the elementary excitations of a medium, polaron has attracted considerable attention and has become a fundamental problem in condensed matter physics, primarily because it plays an essential role in understanding more complex many-body phenomena [3]. Depending on whether the host particle excitations obey Bose or Fermi statistics, a polaron can be classified as a Bose or Fermi polaron, respectively. While the Bose polaron has been studied extensively in the context of electron-phonon systems, a Fermi polaron has been reported to behave quite differently because the impurity may undergo a polaron-molecule transition and effectively change its statistics by binding fermions from the background.

Recently, Cao and Zhou [4] investigated an interesting configuration of Fermi polarons, i.e., an impurity particle interacting with a driven-dissipative Fermi background. With the nonequilibrium Green's function formalism, they obtained spectrum responses of molecular and polaron states, as well as quasiparticle parameters. Consequently, they determined when and where there are polaron or molecular-bound states in the open background medium. Based on the literature, frequent measurements of a quantum system will result in the Zeno effect, as verified in this work by demonstrating that the resonance peaks of the molecular-bound and polaron states first diffuse and converge with the increase in dissipation. Their calculation of quasiparticle parameters also highlighted that dissipation can be used as a control method to adjust quasiparticle properties. Their results set a solid benchmark for further investigation of the polaron problem in open systems.

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