Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

The study of nonequilibrium dissipative quantum dynamics

By

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Nonequilibrium quantum physics is of fundamental importance and interest. It is still an extremely hard issue even in today's theoretical physics because of the lack of the knowledge on the basic theories, like the nonequilibrium quantum statistical mechanics. The recent advances on theory and experiments reveal the essentiality of nonequilibrium quantum dynamics on explaining as well as understanding many interesting phenomenon, i.e., the ultrafast energy transfer & long-survived quantum coherence in organic molecules, quantum phase transition and the novel transport properties of superfluid gas at low temperature. Here we will focus on the nonequilibrium quantum dynamics relaxing towards the steady state breaking the detailed balance, since this still remains elusive especially at far-from-equilibrium regime.

Firstly we establish a theoretical framework in terms of curl quantum flux to uncover and profoundly understand the intrinsic relation between quantum coherence in systems and nonequilibriumness. This provides the microscopic explanation for the enhancement of coherence in molecular junctions at far-from-equilibrium. Secondly we explore the dynamical relaxation process towards the nonequilibrium steady state and study the important contribution of coherence to the dephasing time scale as well as dynamical energy transport. Moreover we also uncover the mechanism to explain long-lived coherence by effective field theory: the discrete molecular vibrations effectively weaken the exciton-environment interaction, due to the polaron effect. This subsequently demonstrates the role of vibrational coherence which greatly contributes to long-lived feature of the excitonic coherence observed in femtosecond experiments.

As inspired by the quantum information process, we finally study the dynamics of spin arrays coupled to nuclear spin environments via the hyperfine interaction. This uncovers the rapid coherent oscillations of coherence and entanglement under detailed-balance-breaking, which has never been observed before, i.e., Overhauser noise.

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