Driven quantum metastable states: stabilization by dissipation and resonant activation

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Normally, quantum fluctuations enhance the escape from metastable states in the presence of dissipation. We show first that dissipation can enhance the stability of a quantum metastable system, consisting of a particle moving in a strongly asymmetric double well potential, interacting with a thermal bath. We find that the escape time from the metastable region has a nonmonotonic behavior versus the system-bath coupling and the temperature, producing a stabilizing effect. We also find that the behavior of the escape time versus the temperature is nonmonotonic, and in particular is characterized by the presence of a minimum. Therefore, as the temperature increases, an enhancement of the escape time is observed, increasing the stability of the metastable state. These results shed new light on the role of the environmental fluctuations in stabilizing quantum metastable systems.
We investigate then, how the combined effects of strong Ohmic dissipation and monochromatic driving affect the stability of a quantum system with a metastable state. We find that, by increasing the coupling with the environment, the escape time makes a transition from a regime in which it is substantially controlled by the driving, displaying resonant peaks and dips, to a regime of frequency-independent escape time with a peak followed by a steep fall off. The quantum noise enhanced stability phenomenon is observed in the system investigated.
Thirdly, we analyze the resonantly activated escape from a quantum metastable state by tunneling in the spin-boson model at strong Ohmic dissipation in the presence of fluctuating and periodical driving fields. Resonant activation, the presence of a minimum in the mean escape time, occurs when the time scale of the modulations is the same as the characteristic time scale of the systems dynamics, essentially determined by dissipation-induced renormalization of the bare tunneling amplitude. The simple quantum system considered displays as well the general features that at slow modulations the mean escape time is dominated by the slowest configuration assumed by he system, while at fast modulations the escape dynamics is determined by the average configuration.

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