STABILIZATION BY DISSIPATION AND RESONANT ACTIVATION IN QUANTUM METASTABLE SYSTEMS

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Common wisdom is that environmental fluctuations always enhance the escape from a quantum metastable state. A critical issue of great importance is whether the dissipation can enhance the stability of a quantum metastable state. 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 and starting from a nonequilibrium initial condition. 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. In particular, the escape dynamics is characterized by a nonmonotonic behavior, with a maximum, as a function of the damping strength: there is an optimal value of the damping strength which maximizes the escape time, producing a stabilizing effect in the quantum system. 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

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time scale of the modulations is the same as the characteristic time scale of
the systems dynamics, essentially determined by dissipation-induced renor-
malization 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 the
system, while at fast modulations the escape dynamics is determined by the
average configuration.

Figure 1: Escape time $\tau$, as a function of both damping $\gamma$ and temperature $T$. The figure shows the presence of a peak in $\tau$ vs $\gamma$, whose height and position depend on the temperature.