Tunneling in nearly integrable systems with a non-hermitian perturbation

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We study the tunneling effect in nearly integrable systems with a non-hermitian perturbation. In the integrable system such as a particle moving in the one-dimensional double well potential, the energy splitting ΔE caused by quantum tunneling is evaluated as

$$\Delta E \underset{\hbar \to 0}{\sim} e^{-S/\hbar}, \tag{1}$$

by the semiclassical (WKB) approximation, where the action S is determined by the classical quantity [1, 2]. On the other hand, in the systems under the periodic perturbation, the corresponding classical system becomes non-integrable. If one plots the energy splitting as a function of $1/\hbar$, it exhibits persistent enhancement from the prediction (1) accompanying spikes.

The spike can be interpreted as energetic resonance with excited states by photon absorption in the language of quantum dynamics, but it may be reinterpreted by the language of classical dynamics. The theory of resonance-assisted tunneling (RAT) have discussed the relation between the appearance of the spikes and the classical non-linear resonances, and then it claimed that the classical non-linear resonances create a bunch of spikes, which brings the enhancement of tunneling probability [3, 4].

The appearance of the spikes in the energy splitting has been considered as the origin of the enhancement of tunneling probability, but to make clear this issue, we introduce a weak non-hermitian perturbation which pushes the resonant states to the complex domain. By applying this perturbation, we found the spikes and the persistent enhancement have the different origin, and it was unveiled that the staircase-like structure is hidden in the energy splitting curve as a function of $1/\hbar$ [5].

References

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