Swich metastable dynamics in dissipative quantum system

Ya-Xin Xiang[1], Weibin Li[2], Zhengyang Bai[1], Yu-Qiang Ma[1]

[1]Nanjing University, Nanjing, China, [2]University of Nottingham, Nottingham, UK

Stochastic switching is a central phenomenon in dissipative many-body systems, offering a key probe of metastability across classical and quantum regimes. Here, we unravel the connection between switching dynamics and quantum metastability through the lens of spectral decomposition, quantum-jump simulations, and the large deviation principles. By establishing a direct correspondence between classical fixed points and quantum metastable states, we distinguish the trajectory-level noise-induced metastability from the spectrum-level deterministic metastability in a Markovian open quantum system with bistability. The Liouvillian gap, the steady-state occupation ratio, and the observed switching rates of the metastable states all exhibit exponential scaling with system size, giving rise to a quantum analogue of Arrhenius law, with the inverse system size serving as an effective temperature. These results provide a unified picture of quantum bistability and clarify the relaxation processes of strongly interacting, dissipative quantum systems far from the thermodynamic limit.