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Séminaire AXE 1 - Sciences et Matériaux Quantiques

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Active quantum reservoir engineering - Using a qubit to manipulate its environment

Quantum reservoir engineering leverages dissipative processes to achieve desired behavior, with applications ranging from entanglement generation to quantum error correction. Thereby, a structured environment thereby acts as an entropy sink for the system and no time-dependent control over the system is required. In this work, we focus on an active approach to reservoir engineering, where time-dependent control over a quantum system is used to manipulate its environment. In this case, the system may act as an entropy sink for the environment. We develop a theoretical description for active reservoir engineering that captures the dynamical interplay between system and environment, and provides an intuitive picture of how finite-size effects and system-environment correlations allow for manipulating the environment by repeated initialization of the quantum system. We illustrate our results with two examples: a superconducting qubit coupled to an environment of two-level systems and a semiconducting quantum dot coupled to nuclear spins. In both scenarios, we find qualitative agreement with previous experimental results. By providing a theoretical framework for active reservoir engineering, our work opens new avenues to control open quantum systems.

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