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Coherent Charging of Quantum Batteries by an Incoherent Source

The transfer of energy from a coherent source (e.g. a laser) to a quantum battery is of significant technological importance. However, a bounded transfer of energy from an incoherent source (e.g. a thermal bath) to a quantum battery, and its storage in a coherent form (active states) is also possible. In this study, we propose a novel approach for using thermal reservoirs for battery charging. Our method involves utilizing a system of non-interacting two-level fermions as the fundamental units of the quantum battery, interacting collectively with a shared reservoir.

Using algebra of angular momentum, we provide analytic formulas for a stationary state of the system of N fermions that interact with a shared reservoir of a given temperature. The nonergodicity of the evolution plays a crucial role in enforcing the second law of thermodynamics, limiting maximal ergotropy one can extract from a single bath. Furthermore, we observe that, with increasing the number of cells in the battery, a linear increase in the extracted ergotropy can be observed, with a fixed gap between the ergotropy and the energy. Our analysis reveals that the charging power of the battery experiences an enhancement with an increase in the temperature of the reservoir. Exploring evolution dependence on the initial state, we show that for the most experimentally friendly initializations of fermions in a product of Gibbs states, the ergotropy extracted per battery cell is a monotonic function of temperature difference between local baths preparing the state and the shared reservoir, and that for finite temperatures it achieves its maximum at a specific size N of the system.

With possible implementations of the scheme in the current state-of-the-art quantum photonic systems or microwave superconducting circuits, the invesigated setup may be of practical interest for exraction and processing energy in the nano- and microscale.

Theme

Theme 2. Quantum effects in energy processes and materials

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