Quantum Heat across Capacitively Coupled Quantum Dots

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Thermal transport in the quantum coherent regime has attracted significant attention, particularly in studies of various quantum heat engines [1,2] and measurement processes [3]. While most heat carriers are bosonic excitations, purely electronic heat currents in the absence of charge currents remain relatively unexplored. Theoretical studies have examined capacitively coupled quantum dots (QDs), each tunnel-coupled to a reservoir in local thermal equilibrium [4-7]. Most of these results can be understood without invoking quantum coherence.

In this work, we extend this model to investigate quantum effects on heat transport in a capacitively coupled QD system. Our system consists of three QDs: two arranged in parallel, each tunnel-coupled to a left reservoir, and a third QD tunnel-coupled to a right reservoir. The left and right QDs are capacitively coupled without direct tunneling. We evaluate the heat current using non-equilibrium Green's functions with the equation-of-motion method as a function of the temperature difference, for various values of the energy-level difference δ between the two left QDs. The capacitive coupling energy between the left QDs and the right QD is set to U.

If the two left QDs are closely spaced and their energy difference δ is smaller than the level broadening Γ, indirect quantum coherence via the left reservoir can be established [8]. We phenomenologically characterize the strength of this coherence using a parameter α. This coherence is suppressed by increasing δ or by introducing asymmetry in the capacitive coupling energies to the right QD, which can be interpreted as an effective measurement of the left QDs by the right QD.

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