Quantum coherence and thermodynamics of non-equilibrium transport

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Nano-scale systems often display an intriguing quantum mechanical effect due to system-bath couplings, i.e. polaron effect. We demonstrate this non-trivial effect using the non-equilibrium spin-boson model [1-3] and three-level heat engine model [4-5]. Our analysis will shed light on the coherent nature in quantum transport and will be relevant for the design and control of nano-scale quantum devices. To carry out the above analysis, we adopt the polaron transformation [6] as a non-perturbative method for treating open quantum systems. In the polaron frame, the equilibrium distribution presents a deviation from the canonical distribution. Our polaron transformed Redfield equation (PTRE) bridges smoothly between the Redfield-Bloch equation in the weak coupling limit or Fermi's golden rule in the strong coupling limit, and provides a reliable and analytical method to calculate the non-equilibrium steady state [1-4].

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