Quantum heat engine enhanced by coherence: Efficiency at maximum power and Chambadal-Novikov-Curzon-Ahlborn limit

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Various quantum effects have been observed in the thermodynamic of small systems. For instance understanding the microscopic origin of the quantum coherence and its role in the energy and charge transfer processes along with thermodynamics characteristics of the small systems is a key problem in both thermodynamics and quantum mechanics. We had investigated the possible role of quantum coherence and interference on steady state and transient behavior of the quantum heat engines (QHE), e.g lasers, photovoltaic cells, photosynthetic reaction centers, and nanoplasmonic devices. We showed that the maximum power of a QHE that converts incoherent thermal energy into coherent cavity photons could be enhanced by manipulating quantum coherences. We demonstrated that in both artificial (solar cells) and natural (photosynthesis) light harvesting coherence affects the same population–coherence coupling term which is induced by bath (e.g. phonons), does not require coherent light, and will therefore work for incoherent excitation under natural conditions of solar excitation. We further investigate a novel model of the three-level laser QHE where lasing occurs between two closely spaced metastable states and the ground stated. Engine operates by transferring energy from hot bath to cold bath via nonequilibrium coherence assisted process. Coherence has two sources: first is due to quantum interference generated via hot bath and second is due to the lasing field coupled to both metastable states. The resulting efficiency at maximum power may be improved due to interplay between these two coherence contributions. Various parameter regimes are considered.

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