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Quantum thermodynamics and thermal quantum information transfer

Considerable research efforts were devoted to study the quantum thermodynamic behaviour of nanoscale structures with the aim of utilization for finite-temperature quantum information processing. Emphasis is on the question as to which extent the quantum nature of the system, and in particular the entanglement, can be exploited to enhance the performance of quantum heat engines. Motivated by the fact that entanglement entails mixedness and correlation, we investigated theoretically correlated many body systems. We focus on the low-energy excitations that can be captured by an effective quantum spin model, possibly with a topologically non-trivial spin order. Thermodynamic quantities are formulated in a way as to trace the role of entanglement. For instance, we find that an efficient spin-dependent Otto heat engine can be constructed with the working substance being Ni_2 dimer driven by non-resonant THz field. As evidenced by full ab-initio calculations the entanglement enhances the cycle efficiency. The same applies to quantum spin systems with non-collinear magnetic order. In particular, we studied quantum heat engines with a working substance being a helical multiferroic structure, meaning a system which is susceptible to external electric and magnetic fields allowing to perform electro-magnetic work. We will discuss how to exploit the inherent spin non-collinearity to enhance the thermodynamic cycle efficiency. Practical applications such as the entanglement-assisted thermal pumping of spin currents will be presented.

Recent Publications

1. A Dechant, et al. (2015) All-optical nanomechanical heat engine. Phys. Rev. Lett. 114: 183602.
2. F G S L Brandao, et al. (2015) The second laws of quantum thermodynamics. PNAS 112:3275.
3. M Azimi, et al. (2014) Quantum Otto heat engine based on a multiferroic chain working substance. New J. Phys. 16:063018.
4. M Azimi, et al. (2014) Helical multiferroics for electric field controlled quantum information processing Phys. Rev. B 89:024424.
5. P Skrzypczyk, et al. (2014) Work extraction and thermodynamics for individual quantum systems. Nat. Commun. 5:4185.

Biography

J Berakdar is a Theoretical Physicist with research interests in various aspects of electronic many-body systems with emphasis on time and spin-dependent processes and their utilization in nanoelectronics and quantum information.

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