Potential barriers make quantum thermoelectrics with nearly ideal efficiency at finite power output

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Abstract

Quantum thermodynamics defines the ideal quantum thermoelectric, with maximum possible effi ciency at finite power output. However, such an ideal thermoelectric has not yet been implemented experimentally. Thus, instead, we consider two types of thermoelectrics regularly implemented in experiments: (i) finite-height potential barriers or quantum point contacts, and (ii) double-barrier structures or single-level quantum dots. We model them with Landauer scattering theory as re spectively (i) step transmission or (ii) Lorentzian transmission. We optimize their efficiencies as heat-engines and refrigerators at given power output. The Lorentzian's efficiency is excellent at vanishing power, but we find that it is poor at the finite powers of practical interest. In contrast, the step transmission is remarkably close to ideal efficiency (typically within 15%) at all power out puts. The step transmission is also close to ideal in the presence of phonons and other heat-leaks, for which the Lorentzian performs very poorly. Thus, the simplest nanoscale thermoelectric (the potential barrier) are also almost the best.