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

Quantum thermodynamics defines the ideal quantum thermoelectric, with maximum possible efficiency at finite power output. However, such an ideal thermoelectric has not yet been implemented experimentally. Thus, instead, we consider two thermoelectrics regularly implemented in experiments: (i) a single-level quantum dot and (ii) a potential barrier or quantum point-contact. We model them with Landauer scattering theory as, respectively, (i) Lorentzian transmission or (ii) step transmission. We optimize their efficiencies as heat-engines and refrigerators at given power output. The Lorentzian's efficiency is excellent at vanishing power, but it is found to be 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 outputs. 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 thermoelectrics (potential barriers and point contacts) are also about the best.

Theme

Theme 2. Quantum effects in energy processes and materials

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