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The thermodynamics of reversible thermoelectric nanomaterials

TAMMY HUMPHREY, University of Wollongong, HEINER LINKE, University of Oregon — Irreversible effects in thermoelectric materials limit their efficiency and economy for applications in power generation and refrigeration. While electron transport is unavoidably irreversible in bulk materials, here we derive conditions under which reversible diffusive electron transport can be achieved in nanostructured thermoelectric materials via the same physical mechanism utilized in the three-level amplifier (thermally pumped laser) and idealized thermophotovoltaic and thermionic devices. From a broader physical perspective, the most interesting aspect of this work is that it suggests that all of the above-mentioned solid-state devices may be unified as a single 'type' of heat engine which achieves reversibility when heat transfer via particle exchange between reservoirs is isentropic (but non-isothermal), in contrast to heat engines such as Carnot, Otto or Brayton cycles, which achieve reversibility when heat transfer between the working gas and heat reservoirs is isothermal.

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