

# Potential barriers are nearly-ideal quantum thermoelectrics at finite power output

Chaimae Chrirou,<sup>1, 2</sup> Abderrahim El Allati,<sup>2</sup> and Robert S. Whitney<sup>1</sup>

<sup>1</sup>Université Grenoble Alpes, CNRS, LPMMC, 38000 Grenoble, France.

<sup>2</sup>Laboratory of R&D in Engineering Sciences, Faculty of Sciences and Techniques Al-Hoceima, Abdelmalek Essaadi University, Tetouan, Morocco

*(Dated: July 20, 2025)*

Quantum thermodynamics defines the ideal quantum thermoelectric, with maximum possible efficiency at finite power output. However, such an ideal thermoelectric is challenging to implement experimentally. Instead, here 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 (i) step transmissions and (ii) Lorentzian transmissions. We optimize their thermodynamic efficiency for any given power output, when they are used as thermoelectric heat-engines or refrigerators. 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 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, a simple nanoscale thermoelectric — made with a potential barrier or quantum point contact — is almost as efficient as an ideal thermoelectric.