Optimizing energy conversion in quantum devices exploiting non-thermal resources

Elsa Danielsson
Janine Splettstoesser, Henning Kirchberg

Chalmers University of Technology, Department of Microtechnology and Nanoscience, Gothenburg, Sweden

elsad@chalmers.se

In quantum transport, one investigates particle currents through quantum devices coupled to multiple reservoirs, which are defined by their chemical potentials and temperatures. Recently, there has been a large interest in studying the energy conversion processes in these devices, making the quantum thermodynamical aspects of them relevant. For example, one could imagine using dissipated heat from regular processes as a resource to cool critical components on nanochips. However, when reaching the nanoscale, particles might no longer equilibrate with their thermal surroundings. Consequently, to investigate energy conversion processes, non-thermal distributions become highly relevant descriptors of the particles' environment. I will present how a non-thermal resource can be exploited to generate power or cool another reservoir, and how to maximize the efficiency for these processes. Utilizing coherent electron scattering, the optimization is made by adjusting the transmission probabilities of electrons at different energies. Importantly, we also address the issue of how to define an efficiency as the energy current cannot be neatly divided into heat and work, due to the presence of a non-thermal resource. Based on this, we show that for either a fixed input or output current, the optimal transmission function is a series of band-passes in the energy spectrum, depending on the shape of the non-thermal distribution.

References

[1] E. Danielsson, H. Kirchberg, J. Splettstoesser. In preparation.
[2] R.S. Whitney, Phys. Rev. B, 91 (2015) 115425
[3] L. Tesser, R.S. Whitney, J. Splettstoesser, Phys. Rev. Appl., 19 (2023) 044038
[4] M. Accai et al., Phys. Rev. B, 109 (2024) 075405

Figures

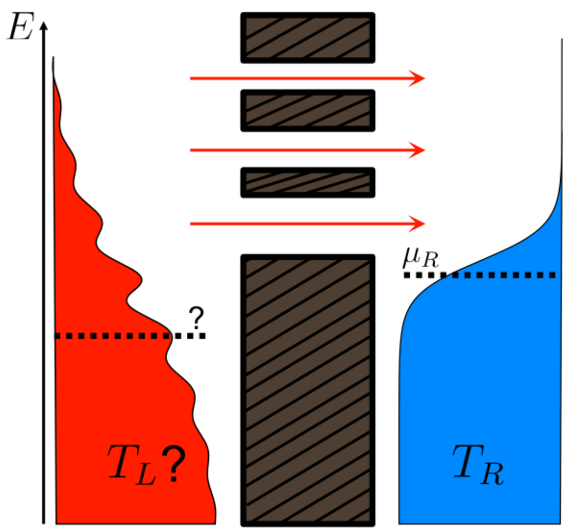

Figure 1: A non-thermal electron distribution on the left exchanging energy and particles with a thermal distribution on the right. The brown wall blocks all electrons, while the gaps allow them to flow freely. This type of transmission function gives the highest efficiency for a given input or output.