Quantum field thermal machines

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Abstract

Recent years have enjoyed an overwhelming interest in quantum thermodynamics, a field of research aimed at understanding thermodynamic tasks performed in the quantum regime. In this work, we introduce a blueprint of quantum field machines. Concretely, we provide a proposal on how to realize a thermal machine in one-dimensional ultra-cold atomic gases, where the working fluids of the machine are quantum fields. We identify several building blocks of the machine, which we call thermodynamic primitives, and study them numerically with the Tomonaga-Luttinger liquid model. Essentially, these primitives model the compression/decompression of a piston, and the coupling to a bath which gives rise to a valve controlling phononic heat flow. By concatenating the primitives, we design a complete thermodynamic cycle that cools the gas. The active cooling achieved in this way would operate in regimes where existing cooling methods may become ineffective. The building of such a machine, and its operation in parameter regimes where quantum effects become significant, will allow for the exploration of open questions in quantum thermodynamics, in particular the interplay of quantum information and energy in complex many-body quantum systems.

Short Biography

Nelly received her B.Sc.(Hons) from the physics department of SPMS, Nanyang Technological University in 2012. She then worked as a research assistant at the Centre for Quantum Technologies for a few years. In 2017, she received her PhD on the study of quantum information theory and thermodynamics from Delft University of Technology, under the supervision of Prof. Stephanie Wehner. During her PhD, her main research focus was to develop the resource-theoretic framework of describing thermodynamic interactions at a fundamental level, in particular to address fundamental limits on how well one can prepare and control quantum systems in the presence of their immediate environment - known as the second laws of quantum thermodynamics. She is also in particular known for studying the effects of catalysts in quantum thermodynamics.

Since November 2017, Nelly is hosted by the group of Prof. Jens Eisert at the Free University of Berlin, first as an Alexander von Humboldt Research Fellow, and subsequently employed as a postdoctoral fellow. Her research interests consist of further developing the tools of quantum information in the context of probing problems in many-body physics, such as conditions on equilibration and localization, and designing quantum thermal machines with cold atomic gases.

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