Symposium Micromachines (SYMM)

jointly organized by
the Atomic Physics Division (A) and
the Quantum Optics and Photonics Division (Q)

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There has recently been a surge of experimental and theoretical research devoted to the realization of micro and nanoscale machines, from heat engines to refrigerators. The main topic of this symposium is to present a detailed overview of the latest achievements in the field. It will cover a large variety of experimental platforms and theoretical models used to analyze the performance and the influence of both thermal and quantum effects.

Overview of Invited Talks and Sessions

(Lecture room RW HS)

Invited Talks

SYMM 1.1	Fri	13:30–14:00	RW HS	**Some experimental contributions to the study of thermodynamics in quantum systems.** — •Ian Walmsley
SYMM 1.2	Fri	14:00–14:30	RW HS	**Levitated Nanoparticle Micromachines** — •Nikolai Kiesel
SYMM 1.3	Fri	14:30–15:00	RW HS	**Autonomous quantum machines and timekeeping** — •Marcus Huber
SYMM 1.4	Fri	15:00–15:30	RW HS	**An autonomous thermal machine for amplification of coherence** — •Juan MR Parrondo, Gonzalo Manzano, Ralph Silva

Sessions

SYMM 1.1–1.4	Fri	13:30–15:30	RW HS	**Micromachines**

SYMM 1: Micromachines

Time: Friday 13:30–15:30 Location: RW HS

Invited Talk SYMM 1.1 Fri 13:30 RW HS
Some experimental contributions to the study of thermodynamics in quantum systems. — •Ian Walmsley — University of Oxford, Oxford, UK

The nature of work and information in systems where quantum mechanics is palpably operative opens new questions about the connections between macroscopic and microscopic characteristics of such systems, as well as opening the possibility for machines that use quantum principles to deliver work.

Here we report recent experiments that explore and exploit the connections between work and information and identify clear quantum signatures for the operation of heat engines. Two platforms exhibiting quantum features at room temperature provide different options for the working fluid: light and electron spins.

Using these platforms we show (i) a measurement at the few-photon level followed by a feed-forward operation allows the extraction of work from intense thermal light into an electric circuit and (ii) direct experimental evidence of quantum effects in heat engines.

Invited Talk SYMM 1.2 Fri 14:00 RW HS
Levitated Nanoparticle Micromachines — •Nikolai Kiesel — VCQ, Faculty of Physics, University of Vienna, Austria

Optical traps for nano- and microparticles are useful tools in a large number of applications. Amongst these are recent demonstrations of micromachines that operate in an overdamped environment.

Decoupling such particles from their environment is a versatile approach to operate such machines in the less explored underdamped regime. In addition, cavity optomechanics allows to taylor a new, controlled environment with prospects to approach the quantum regime.

Here, I first briefly review thermodynamic processes that have been demonstrated experimentally in the underdamped regime with a focus on levitation. Optimal protocols for the operation of micromachines in this regime have recently been found. I will demonstrate how levitated cavity-optomechanics enables the implementation of such optimal protocols and report our experimental steps towards their realization. We will conclude with an outlook on future developments the all-optical control of nanoparticles may enable.

Invited Talk SYMM 1.3 Fri 14:30 RW HS
Autonomous quantum machines and timekeeping — •Marcus Huber — Boltzmanngasse 3, Vienna, Austria

We introduce the concept of an autonomous quantum clock, which represents a minimal model of a quantum clock that is both complete and self-contained. It allows us to elucidate the fundamental limitations in the process of timekeeping without implicitly assuming unaccounted-for resources through external control. We focus on the case where the out-of-thermal-equilibrium resource powering the clock is a hot thermal bath. We show that the clock's accuracy and resolution, i.e. it's performance, are intimately related to the power the clock dissipates. In other words, measuring time results in an increase in entropy. This finding provides a quantitative basis for the intuitive connection between the second law of thermodynamics and the arrow of time. On the practical side the findings complement resource theoretic approaches to quantum thermodynamics by unveiling a hidden cost of timing machine cycles.

Invited Talk SYMM 1.4 Fri 15:00 RW HS
An autonomous thermal machine for amplification of coherence — •Juan MR Parrondo[1], Gonzalo Manzano[2], and Ralph Silva[3] — [1]Universidad Complutense de Madrid (Spain) — [2]IFISC (Spain) — [3]Université de Genève (Switzerland)

A common belief is that any contact of a quantum system with thermal baths implies the vanishing of any coherence in the energy eigenbasis. Here we present a model that questions this idea: an autonomous quantum thermal machine that is capable of amplifying the coherence in a non-degenerate system by using only thermal resources. The model illustrates new possibilities of interconversion between energy, both work and heat, and coherence, and opens up new possibilities in the generation and manipulation of coherence by autonomous thermal machines.