Master 2 Internship Proposal

Quantum thermodynamics
with Rydberg atoms and microwave cavities

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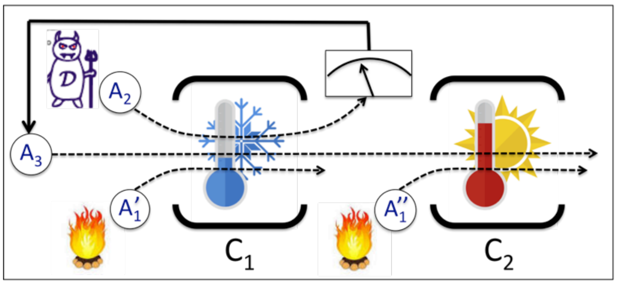
Thesis possibility after internship: **MAYBE**
Funding: **NO**

Scientific context:

For the long time the experimental work of our team has been devoted to better understand limits of quantum properties of light and matter in the context of cavity quantum electrodynamics (cavity QED). We study fundamental quantum effects of light trapped in a high-quality superconducting microwave cavity and then probed by individual, highly excited Rydberg atoms interacting with the light and then detected one by one.



Two high-quality superconducting cavities C_1 and C_2 store microwave field for several tens of microseconds. Circular Rydberg atoms A cross the cavities one-by-one. Precise real-time control of their interaction with the cavity fields allows us to realize different thermodynamical components, like reservoirs, batteries, Maxwell's daemon, etc. and perform on them heat transfer and work.

We plan, by using our two-cavities setup, to enter a new field of research – quantum thermodynamics, which deals with quantum work and quantum heat transfer obeying rules of quantum micro-world. Here, our cavities can be treated as "quantum reservoirs". Coupling to the external thermal microwave field or stream of "thermal" atoms realizes well controllable thermal environment to the reservoirs. By shaping the individual atom-cavity interaction, atoms can play role of ***quantum Maxwell's daemons***, measuring the reservoirs' state and deciding upon the following evolution. In this way, in the planned Maxwell's demon experiment we aim to investigate the impact of information extraction on the second law of thermodynamics.

Internship:

The goal of the internship will be to develop and implement experimental protocols realizing different regimes of a quantum thermodynamical system. Analysis of the conducted experiments, both initial numerical simulations and posterior data treatment, will be as well a part of the internship activity. The ultimate goal is to realize a Maxwell daemon providing heat transfer from a colder to a hotter energy reservoir. During his internship in the group, the intern student will participate to the preparation and conducting of the experiment and will learn different experimental technics, like cryogenics and ultra-high vacuum, laser excitation and microwave spectroscopy of Rydberg atoms, real-time data acquisition and control of the experiment, etc. Besides, he/she will be introduced into the fundamentals of quantum optics necessary to understand the underlying physics.