Quantum themodynamics in cavity QED

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In my talk, I will present our latest results on quantum thermodynamics experiments realized in a cavity QED system. First, I will introduce our flexible cavity QED setup. We use two high-quality microwave cavities as "batteries" or "reservoirs", whose charge or temperature can be measured by a sequence of circular Rydberg atoms adjusted to measure the number of stored photons in a quantum non-demolition way. The batteries can be prepared either in a coherent or thermal state by means of an external microwave source with the controllable phase. Resonant atoms, crossing both cavities, are used to transfer heat from one cavity to the other. Depending on the experimental sequences, they can serve us as thermal reservoirs with variable temperature. The experimental apparatus allows us for the auxiliary manipulation of atoms at different moments during the experiment, eg before, in between and after the cavities. Atomic states are finally detected with high precision.

Our first experiment aims on realizing a variant of a "Maxwell's demon", where the heat from the colder reservoir is transferred to the hotter one by using demon's information on quantum fluctuations. The simplest scheme uses an autonomous demon – a resonant atom transferring a photon from cavity 1 to cavity 2 if and only if it carries a photon. Otherwise, it is transferred to an atomic level not coupled to the cavity 2 thus keeping the cavity-2 temperature unchanged without absorbing already present heat. In this way, we can unbalance the two cavity temperatures. The careful measurement of the transfers of energy, entropy and information between simple quantum entities, provides us an entropy budget in accordance with the second law. More generally, we target to derive and measure generalized fluctuation theorems in this new scenery, bringing new quantitative evidences of the energetic and entropic footprints associated to classical and quantum correlations.