UNIVERSITÄT DUISBURG ESSEN

Offen im Denken

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Engines, Batteries, and Demons in the Quantum World

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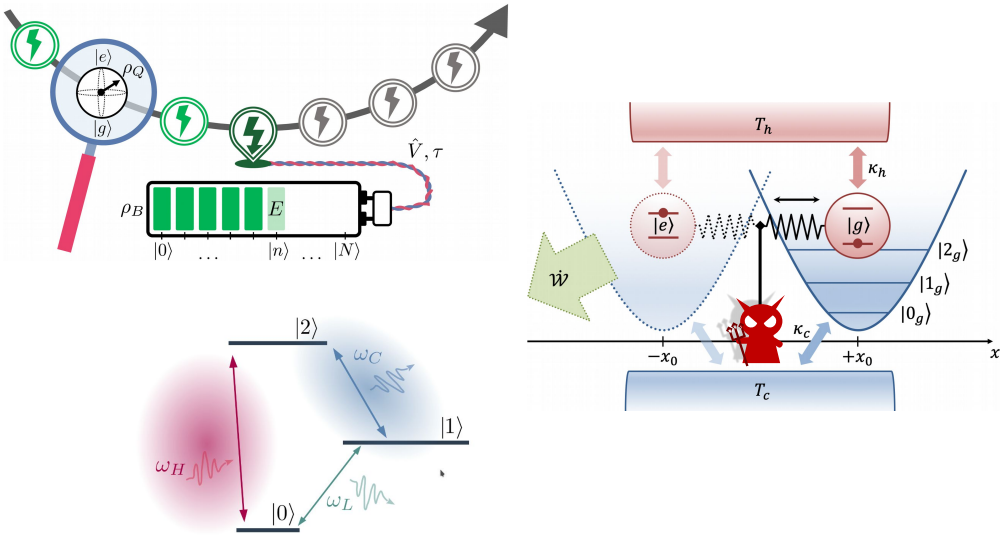

What happens if we miniaturize the thermal devices from our everyday world -- engines, refrigerators, batteries, thermometers -- down to the quantum scale? Will their performance simply be ruined by strong quantum fluctuations, or can we harness nonclassical phenomena such as energy quantization, coherence, and entanglement to boost it instead? This question is at the heart of quantum thermodynamics, a research field that bridges the gap between statistical physics and quantum information theory, reformulating the laws of thermodynamics for small open quantum systems under external control.

For example, a quantum optical system can serve as the working medium of a continuous or cyclic control protocol that converts thermal resources (heat) into useful energy (work), also known as an engine. Depending on the setting, quantum effects may be detrimental or beneficial to the engine efficiency, and they may even enable engine operation in the first place. Likewise, when storing work in a battery, one can make use of quantum coherence to speed up the charging process. Finally, quantum measurement-feedback channels can be used to design so-called Maxwell demon engines that extract work from heat via continuous observation of the working medium, putting Landauer's erasure principle into practice. I will present theoretical case studies that illustrate various aspects of quantum behavior in thermodynamic tasks. These examples may be toy models at this point, but experimental demonstrations on diverse physical platforms are growing in number.