Quantum Signatures in a Quadratic Optomechanical Heat Engine with an Atom in a Tapered Trap

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We investigate how the quantum signatures can emerge by simple modifications to the experimentally demonstrated single-atom heat engine setup. The physical system consists of an atom confined in a tapered trap geometry and subject to hot and cold thermal reservoirs. We model the physical system using a quadratic optomechanical model and identify an effective Otto cycle in the system dynamics. We compare the engine performance by evaluating the dissipative power in the quantum and classical regimes by solving the master equation and stochastic Langevin equations. We find that the difference between classical and quantum correlations contributing to the dissipative power increases with the trap asymmetry, enhancing the quantum squeezing effect in the quadratic optomechanical model. We conclude that lowering the temperature per se is not sufficient to make the single-ion engine a profound quantum heat engine. We propose that making the trap more asymmetric is necessary to ensure quantum correlations in the engine can cause a sufficiently remarkable enhancement in the power output relative to its stochastic counterpart.

For more details: https://arxiv.org/abs/2111.12803