THERMODYNAMICS OF A MINIMAL ALGORITHMIC COOLING REFRIGERATOR

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↳ Setup

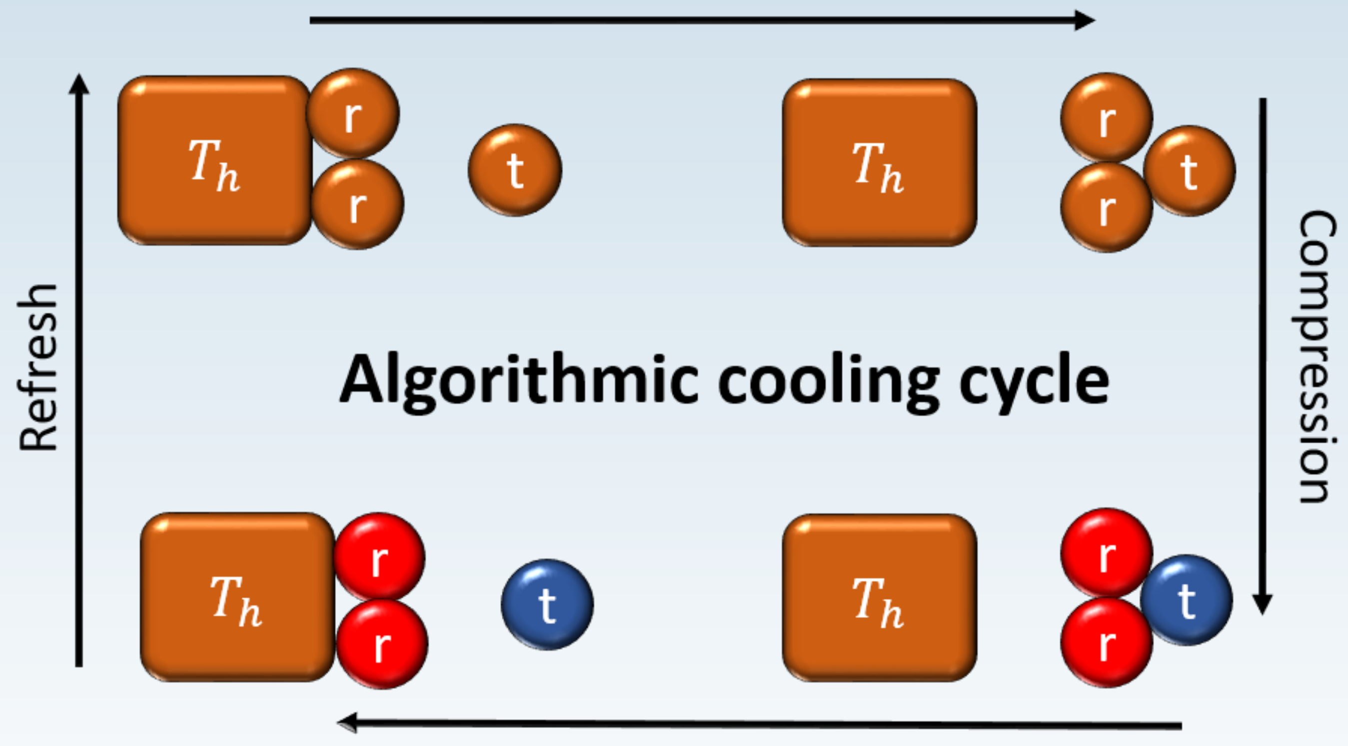
NV Center in Diamond

t: ^{14}N nuclear spin

r: ^{13}C nuclear spins

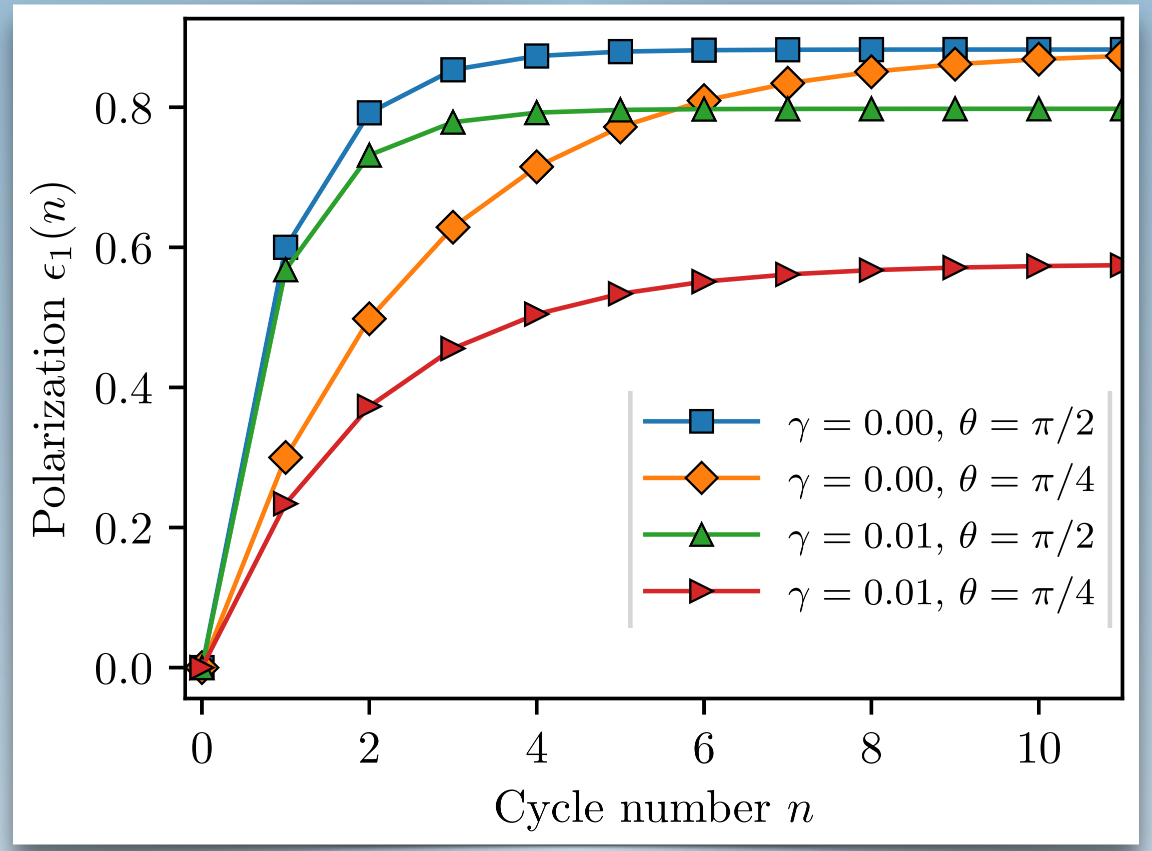
Processes:

Central electron spin acts as thermal bath in the Refresh step, and as the interaction mediator in Compression ($|100\rangle \rightleftarrows |011\rangle$) step.



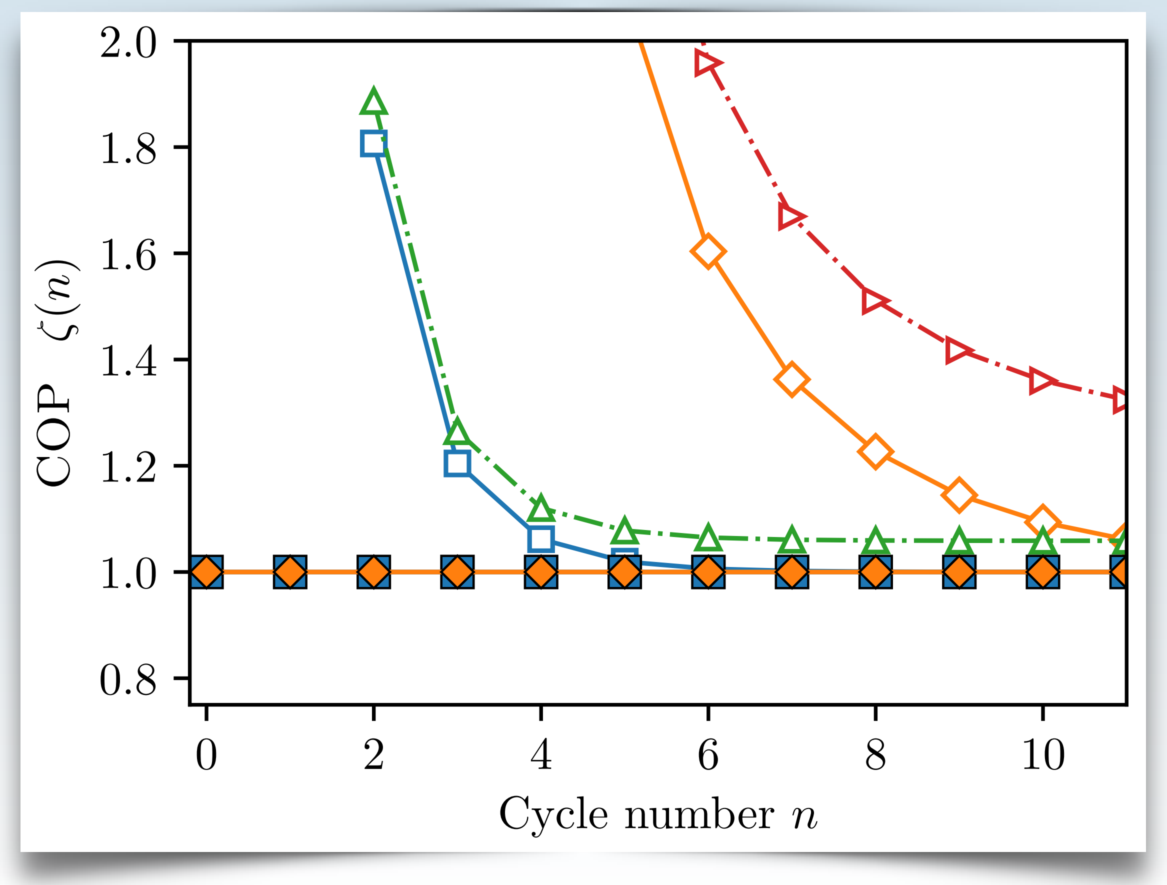
npj Quantum Inf doi.org/gmztvr

Refrigerator

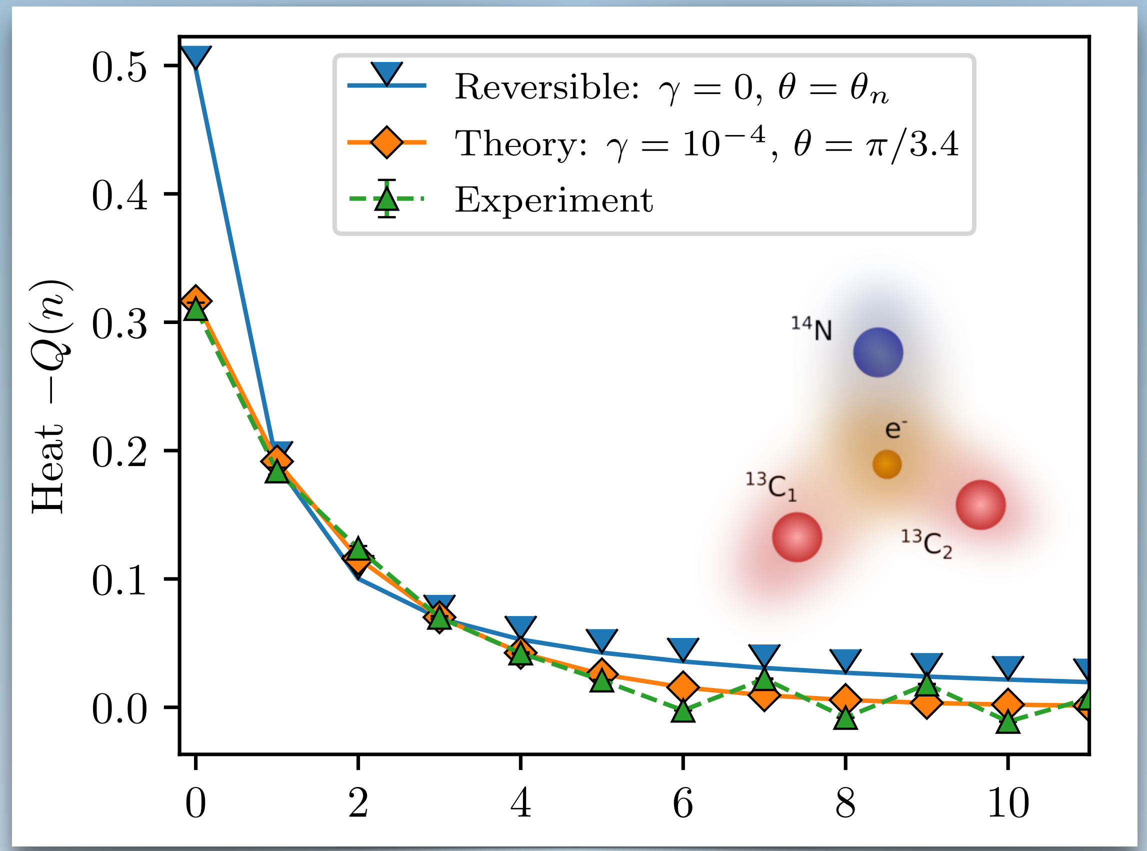


1a) Cooling above reset temperatures $\epsilon_1 = \epsilon_2 = 0.6$.

1b) Fundamental bounds determined (e.g. Carnot coefficient of performance $\zeta_C(n)$).

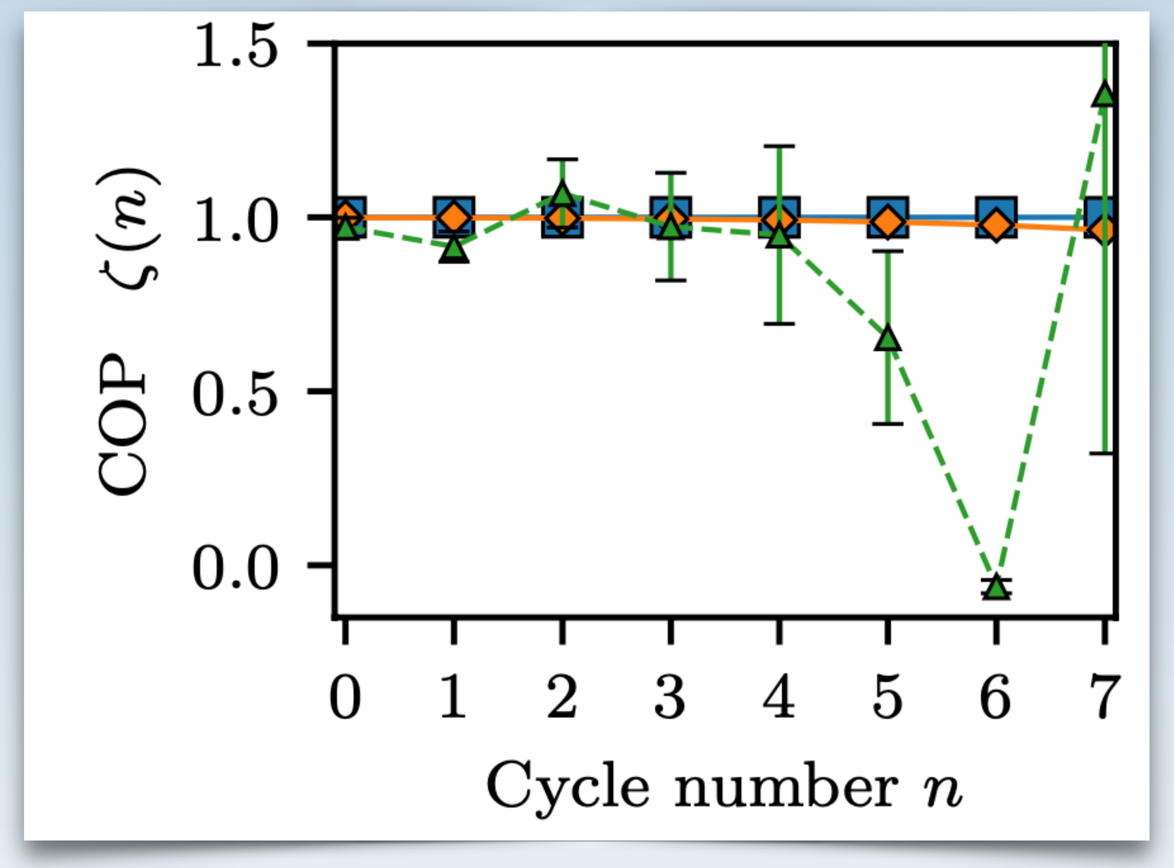


Theory vs Experiment



2a) Full theoretical solution available. Reproduces experimental performance of thermodynamic variables at imperfect compression (θ) and with target qubit relaxation (γ).

2b) Experimental performance achieves upper bounds near vanishing relaxation ($\gamma \to 0$), after a few cycles.



$$\varepsilon_{1,\max}(n \to \infty) = \frac{\epsilon_2 + \epsilon_3}{1 + \epsilon_2 \epsilon_3}$$

ϵ_2, ϵ_3: ^{13}C spin polarization

2c) Asymptotic target polarization agrees with previous works in the literature. Corresponds to lowest possible temperature achievable.