Quantum coherence and correlations on quantum thermal machines

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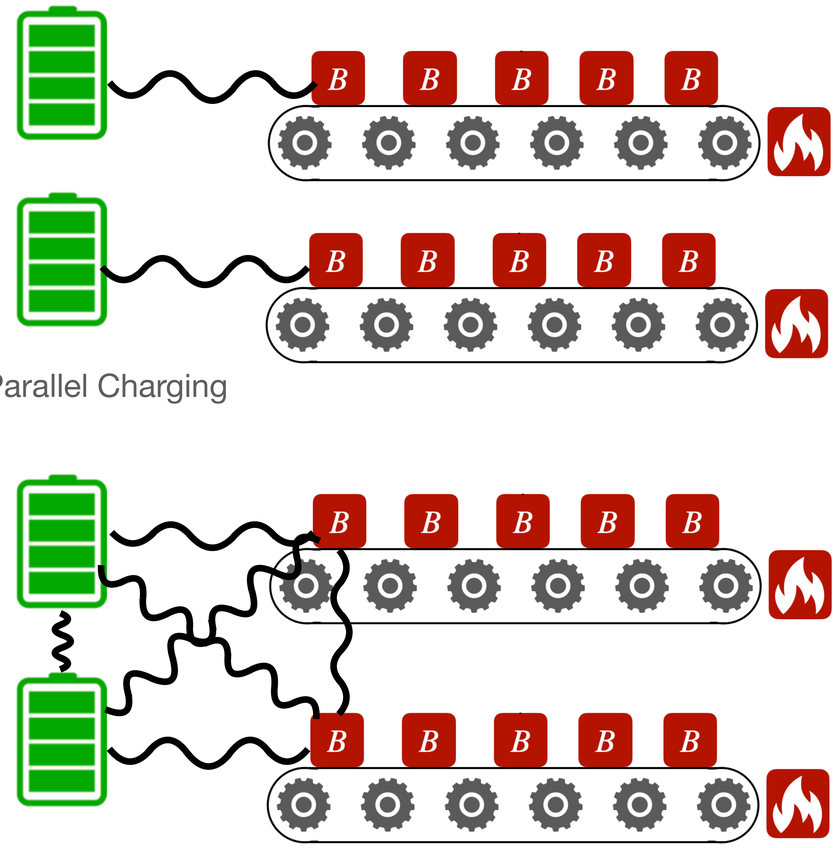
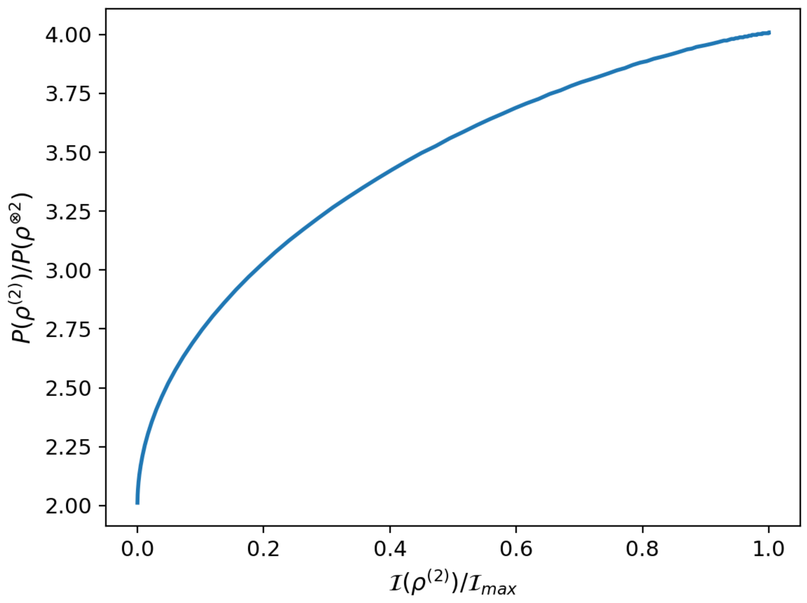
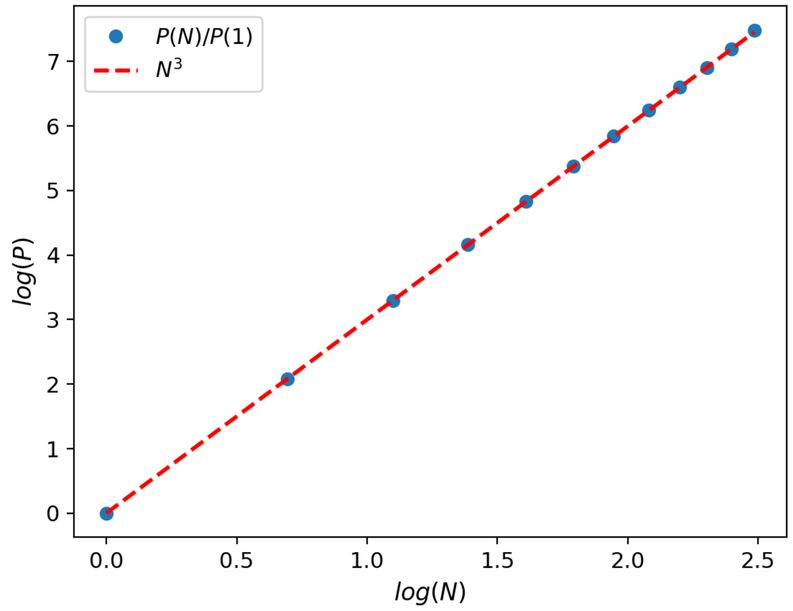
Charging quantum batteries with Correlations



Example: Qubits





- Power grows with the amount of correlations
- Power scales as N^3 (N = number of batteries)

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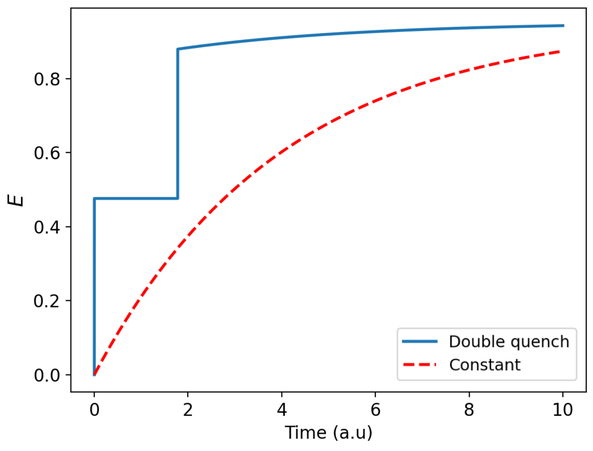
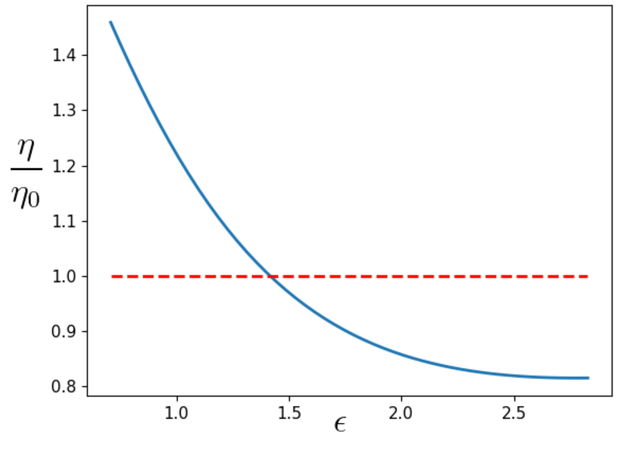
Charging quantum batteries generating coherence

To generate coherence (in the energy basis) in the battery we need $[H_S(t), H_S(t')] \neq 0$

$$H_S(t) = \frac{\hbar\omega_0}{2}\left[\alpha(t)\sigma_x + (1-\alpha(t)\sigma_z)\right] \ , \ \alpha(t) \in [0,1]$$

$\alpha(t)$ is chosen optimizing power



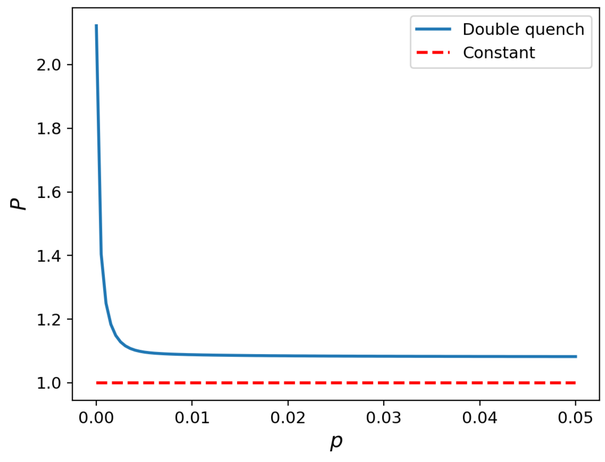


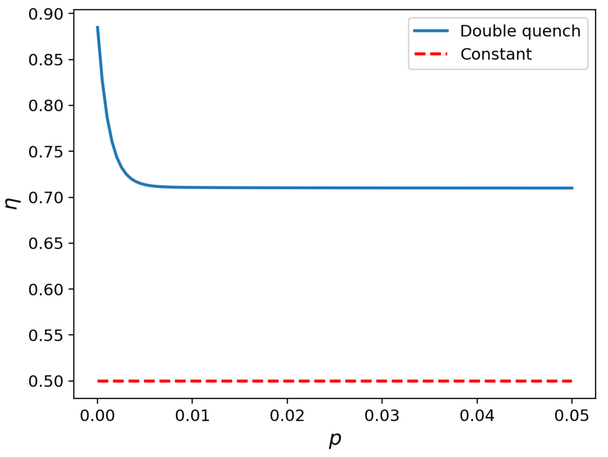
- Time dependent (with coherence) charging is faster.
- The process is more efficient for weak coupling ($\eta = E/W_{ext}$).

What happens if we remove coherence?

Dephasing noise:

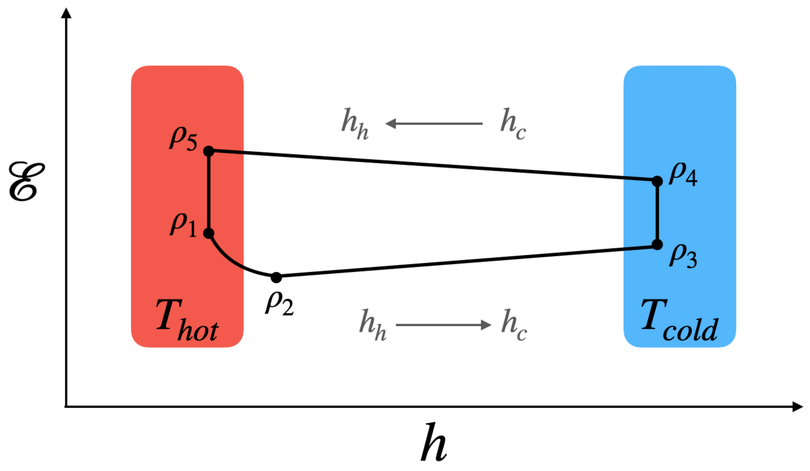
$$\mathscr{E}(\rho) = (1-\frac{p}{2})\rho + \frac{p}{2}\sigma_z\rho\sigma_z$$



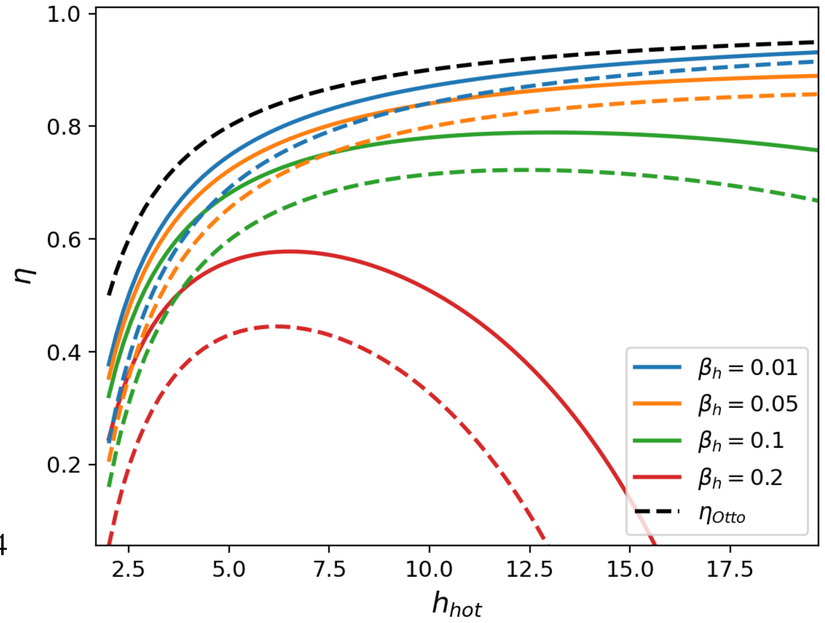


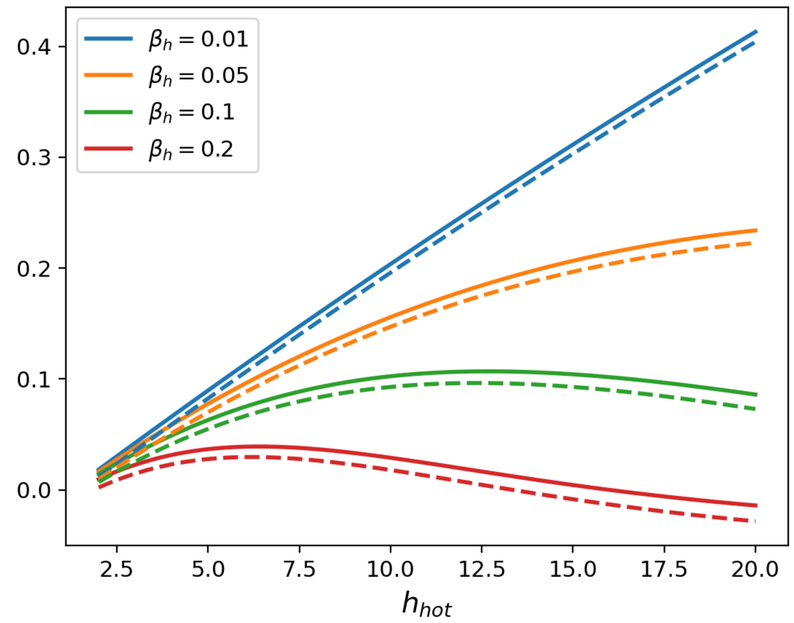
- Performance deteriorates quickly as we remove coherence in the energy basis.

Heat engine with coherence generation



Battery charging process takes place in $\rho_3 \rightarrow \rho_4$





- Efficiency and power of the engine are greater in the process that generates coherence in the energy basis (solid lines) when compared to the dephased process.
- This enhancement appears for short cycles as well.

Sumary:

- In collective battery charging power grows with correlations, and it scales with the number of batteries as N^3.
- Charging a battery generating coherence in its energy basis improves both power and efficiency.
- We designed a heat engine whose performance is related to quantum coherence by incorporating the battery charging as a cycle stroke