Quantum Heat Engine Simulated on Superconducting Qubits
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Classical vs. Quantum Heat Engines

Classical Otto Engine Cycle (Internal Combustion)
[Quantum heat engine.](http://www.nist.gov/itl/metrology/quantum/)

Many Body Localization (MBL) Engine Cycle

Bose Hubbard Model

Multilevel Hamiltonian
\[ H = -J \sum_i \langle \beta_j | \hat{a}_j \rangle + \text{h.c.} \]
\[ + \sum_i (\delta_i - \mu_i) n_i + \frac{U}{2} \sum_i n_i (n_i + 1) \]

Disordered Phase

Mott Insulator Phase

Superfluid Phase

Hardware Mapping

Coupled Transmon Qubits
- Implements Bose Hubbard Model
- Defaults to Mott Insulator (\( J < U \))
- External flux tuning can access the disordered phase, control \( h(t) \)

Experimental Device

Simulation of Adiabatic Strokes

- Generate disorder realizations \( h(t) \)
- Exact diagonalization of ETH and disordered (DIS) Hamiltonians

Disorder Realizations

Annealing Schedules

Results

Model Parameters
\[ J/2\pi = 10 \text{ MHz}, \ U/2\pi = 250 \text{ MHz}, \ h = [-10J, 10J] \]

Expansion Stroke \( \tau^+ \sim \tau \)

Compression Stroke \( \tau^- \sim \tau^0 \)

Future Work

- Repeat the analysis using the transverse field Ising model as the base Hamiltonian and adding disorder to \( J, h \)
- Compute the heat and extract the work done by the engine using the density matrix and Hamiltonian expressions
- Discuss details of simulating the heat engine on superconducting qubits / quantum annealers with experimental collaborators

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