Mapping repulsive to attractive interaction in driven-dissipative quantum systems

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Outline

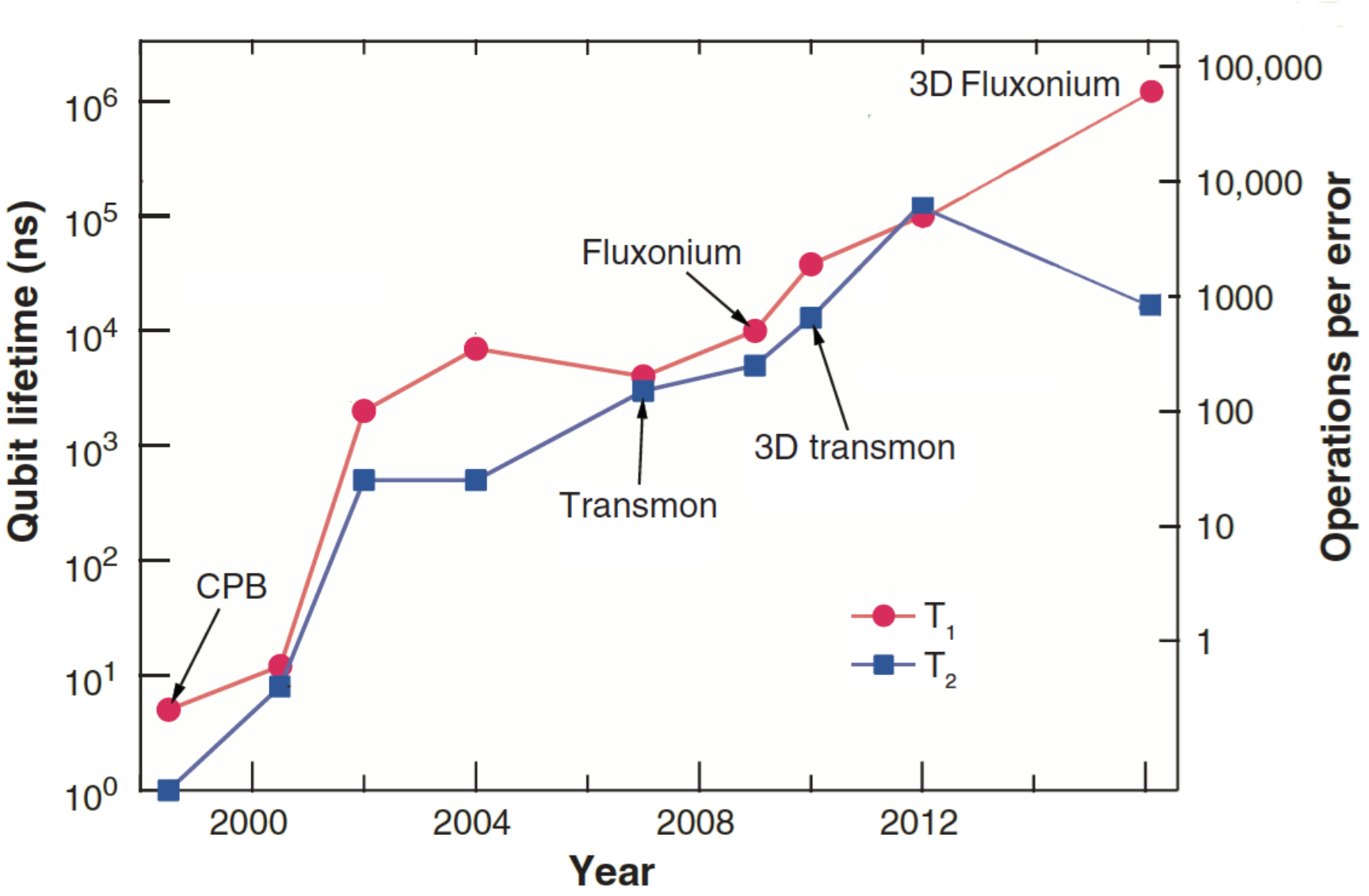
1. Background & motivation

2. Bose-Hubbard dimer

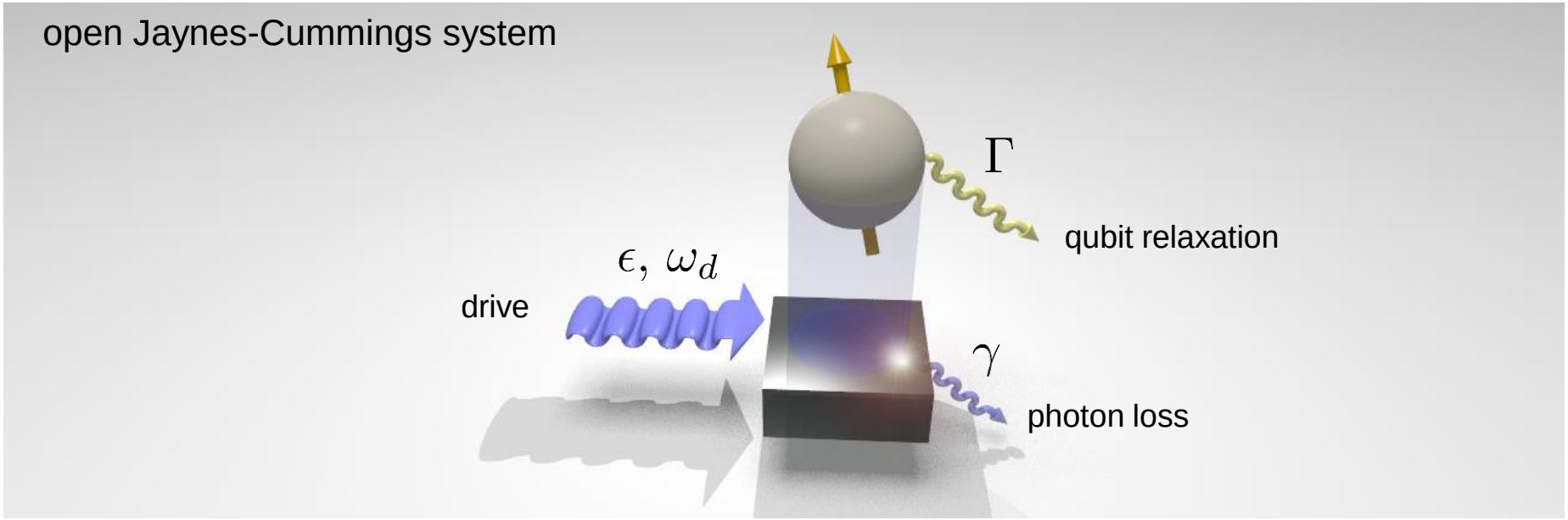
   attraction vs. repulsion
   - in closed system
   - in driven, damped system

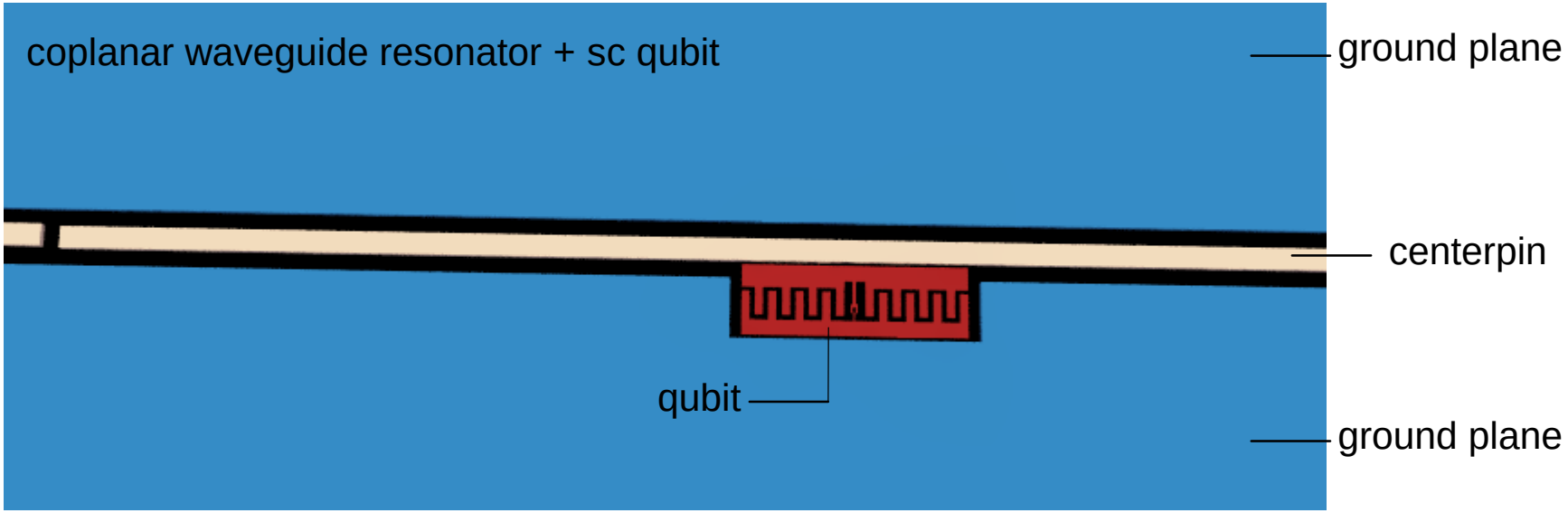
3. General Hamiltonian Sign Inversion mapping

SC qubits: coherence

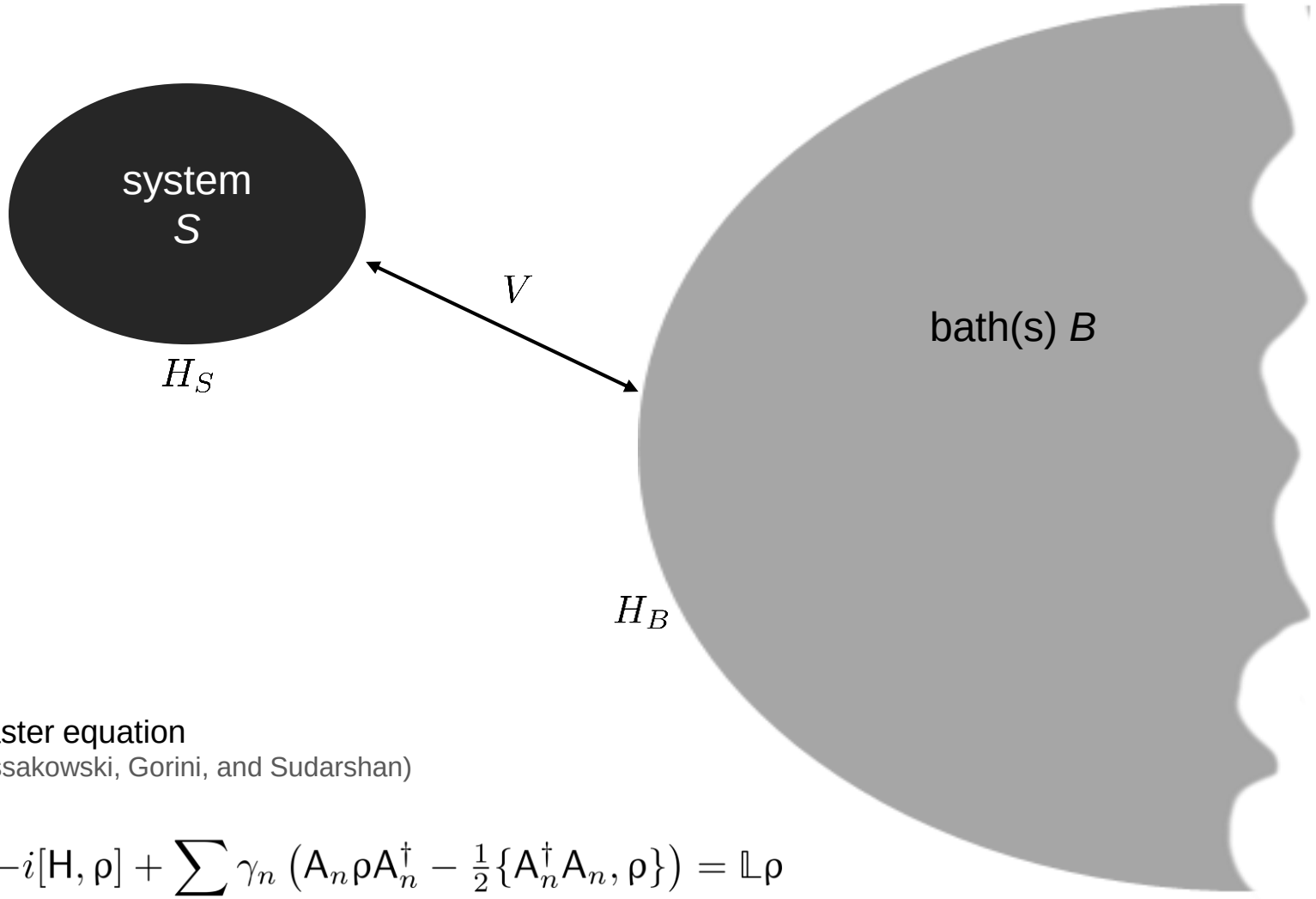


JC building block





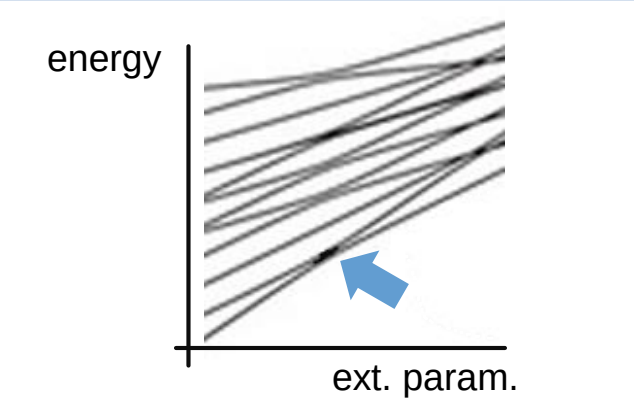
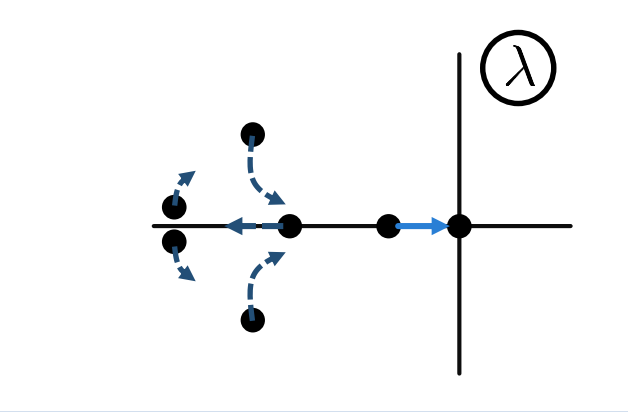
Markovian open quantum systems



Lindblad master equation
(Lindblad, Kossakowski, Gorini, and Sudarshan)

$$\frac{d}{dt}\rho(t) = -i[\mathsf{H},\rho] + \sum_n \gamma_n \left(\mathsf{A}_n \rho \mathsf{A}_n^\dagger - \tfrac{1}{2}\{\mathsf{A}_n^\dagger \mathsf{A}_n, \rho\}\right) = \mathbb{L}\rho$$

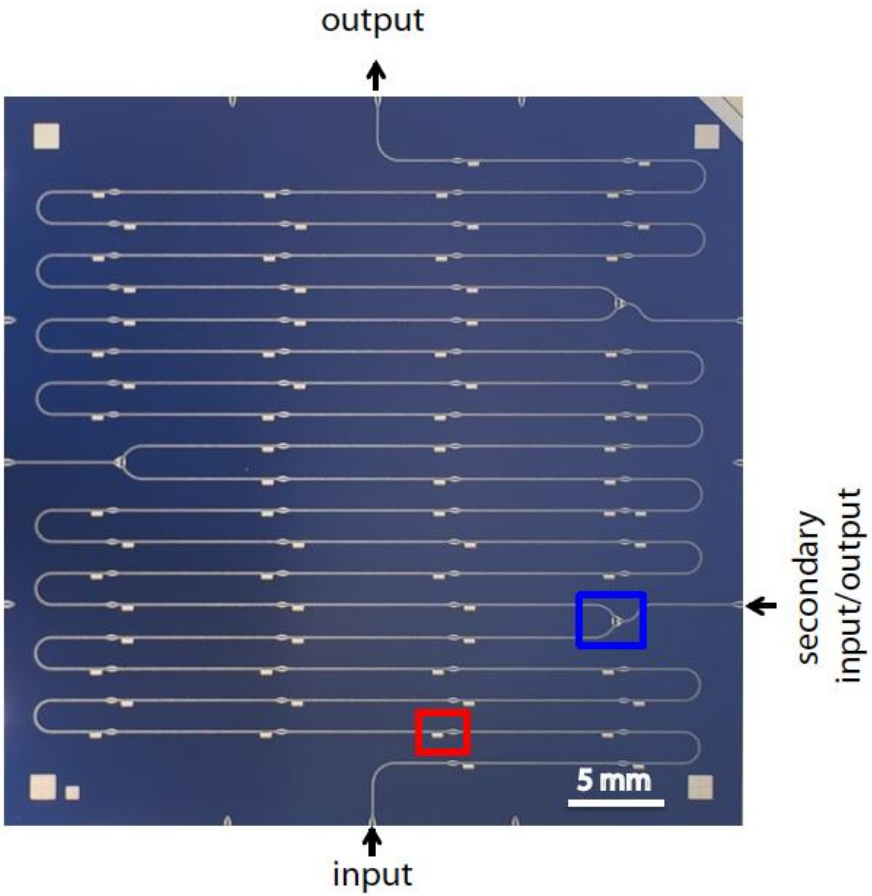
Observables: $\langle \mathsf{M} \rangle = \mathrm{tr}\,(\mathsf{M}\,\rho_s)$

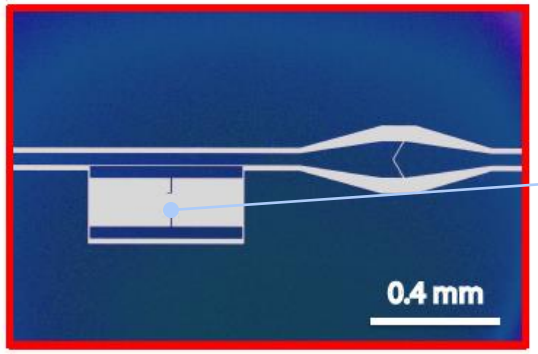
	Quantum Phase Transition	Dissipative Phase Transition
System Operator	Hamiltonian $H = H^\dagger$	Liouville superoperator $\mathbb{L} \neq \mathbb{L}^\dagger$
State	ground state	steady state
Transition	switch to different ground state 	switch to different steady state 

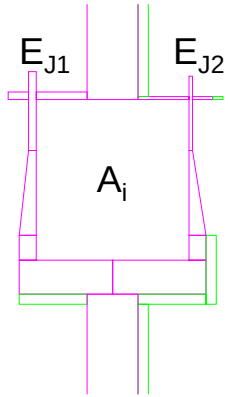
based on:
E.M. Kessler et al.,
PRA 86, 012116 (2012)

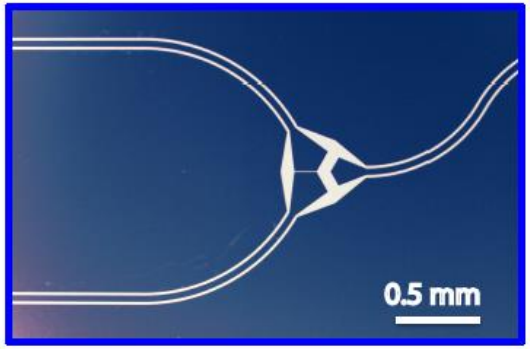
Houck lab (Princeton): cQED chain

72 resonators and qubits



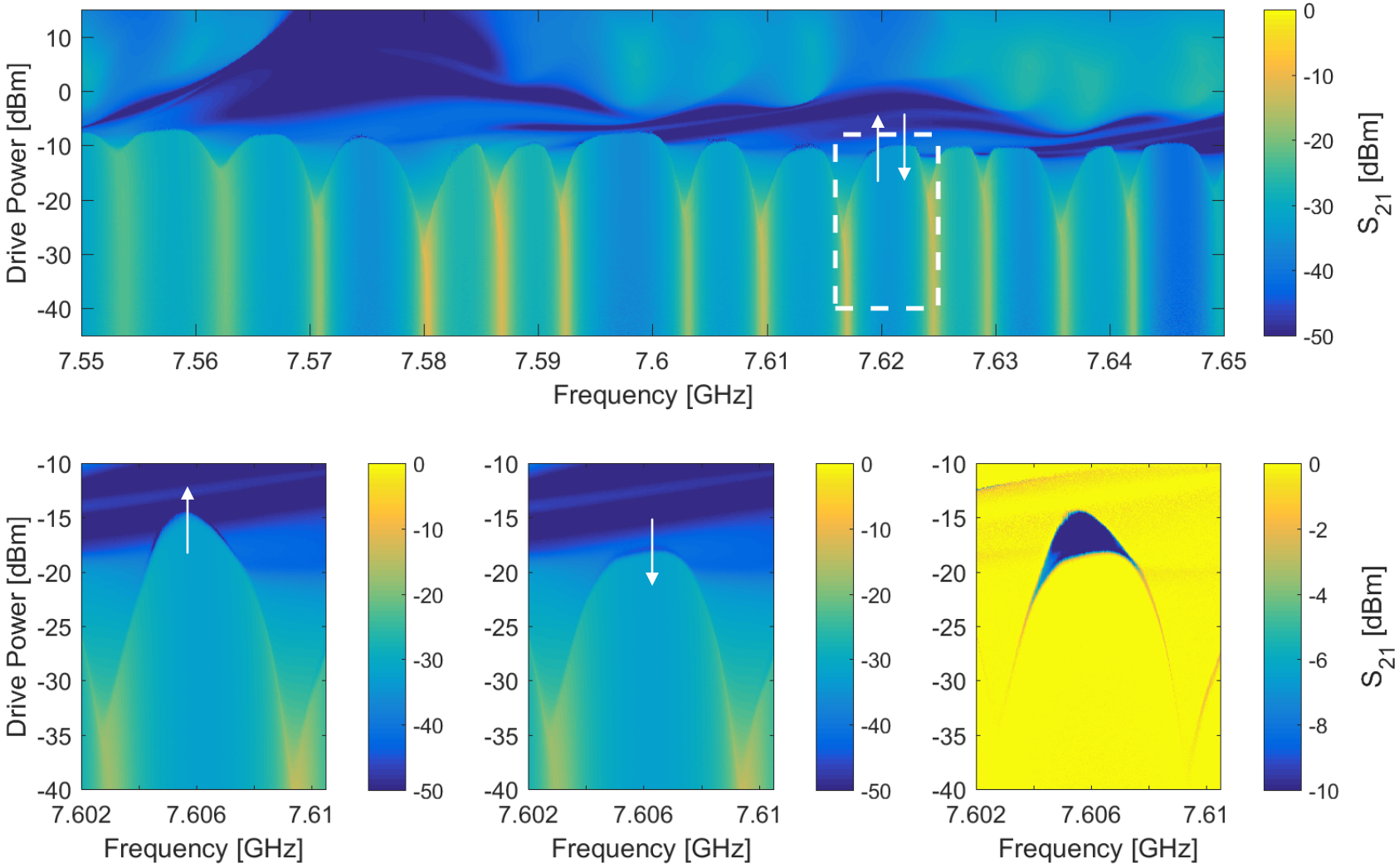






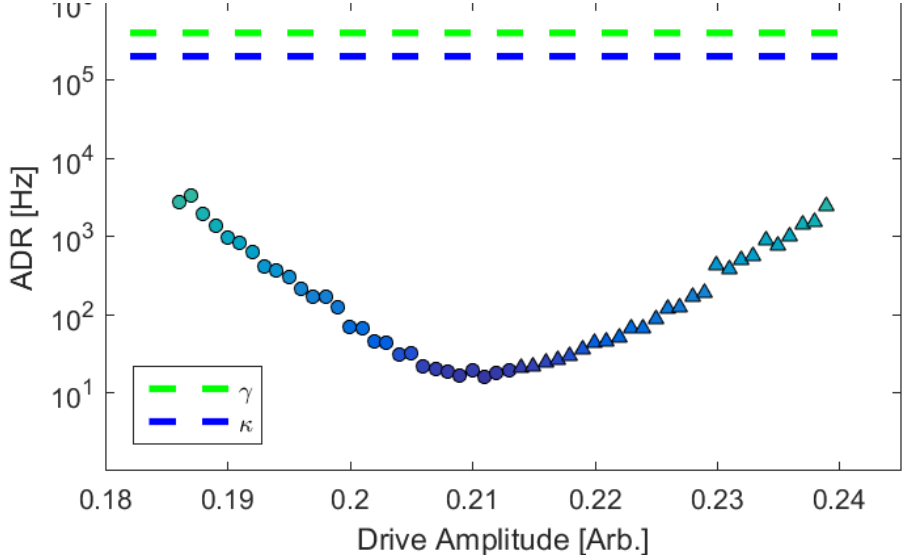
Fitzpatrick et al., PRX 7, 011016 (2017)

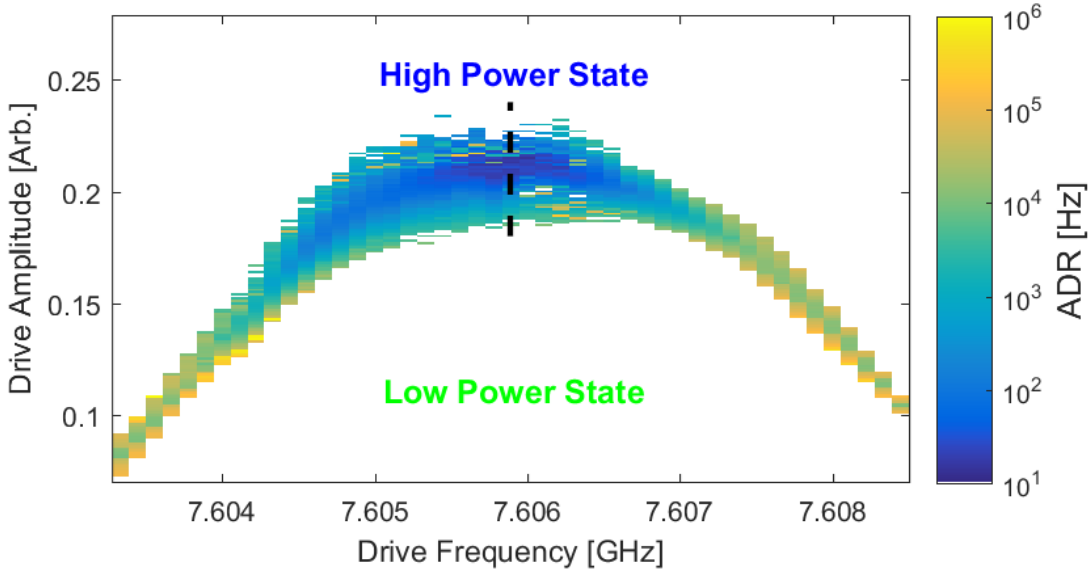
Hysteresis in transmission



Fitzpatrick et al., PRX 7, 011016 (2017)

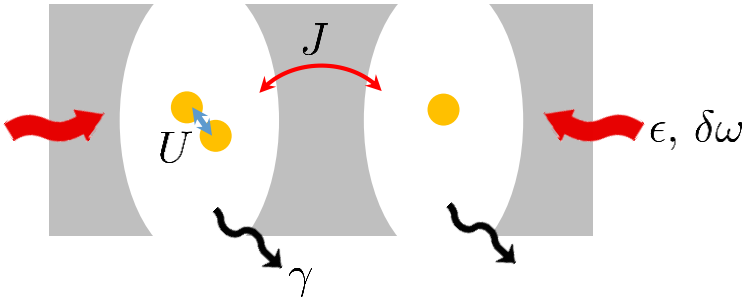
Asymptotic Decay Rates

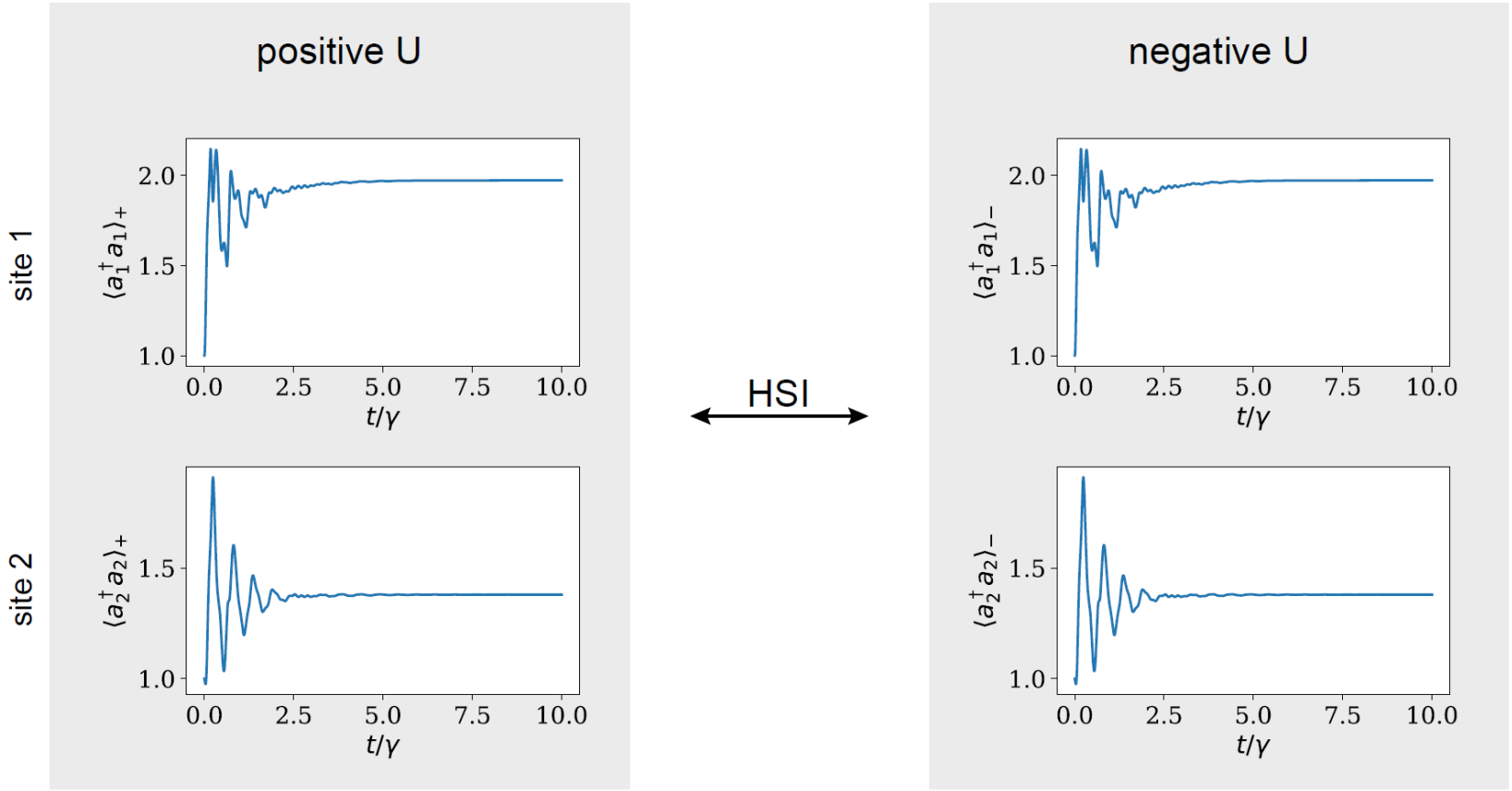




- discussion on blackboard -

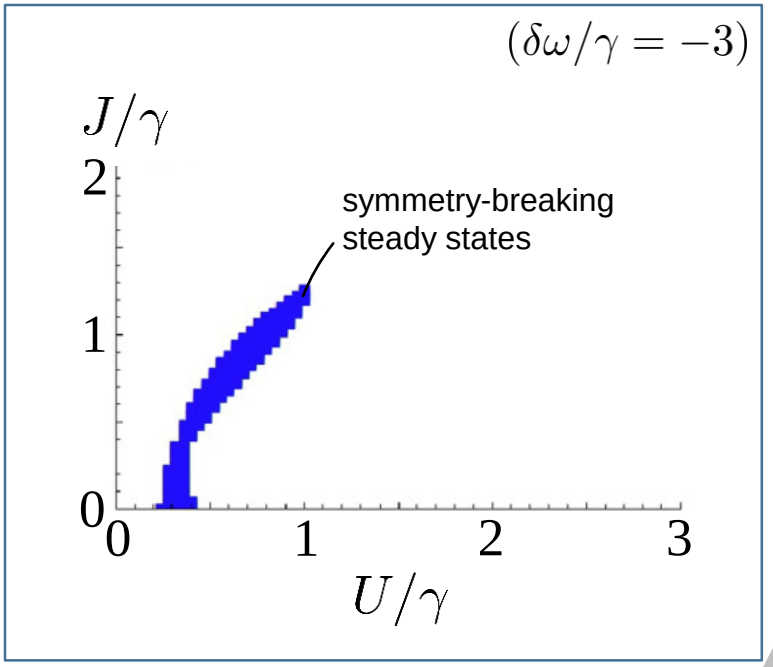
BH dimer: dynamics

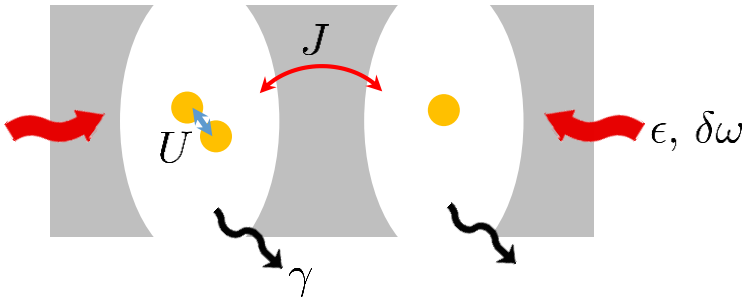


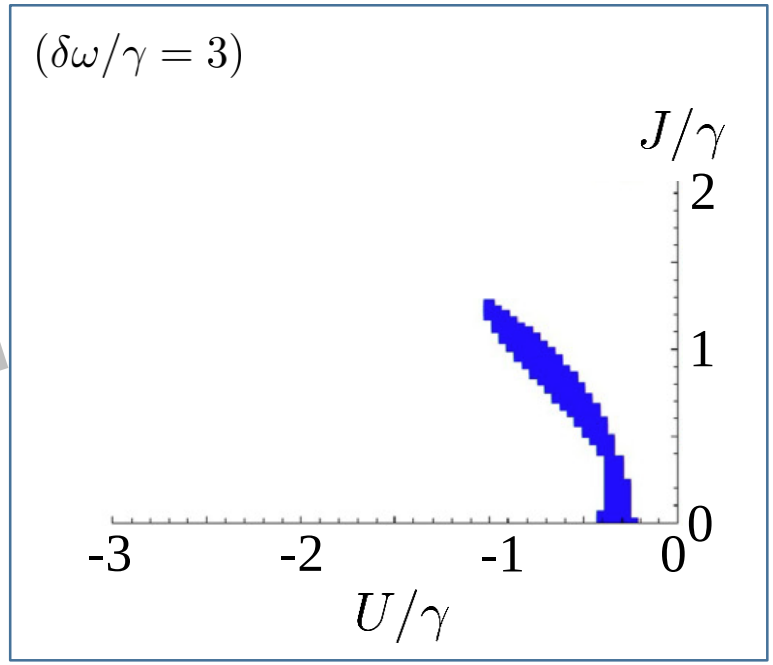


Symmetry-breaking steady states in BH dimer

Cao, Mahmod & Hafezi, PRA 94, 063805 (2016)

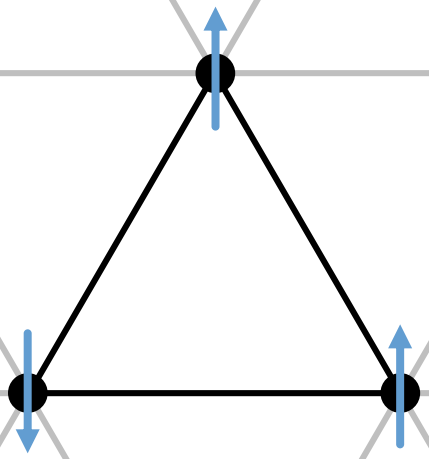






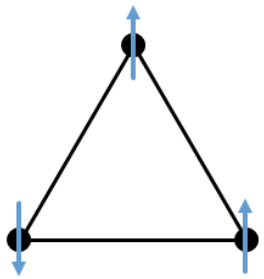
- discussion on blackboard -

Spin lattice example



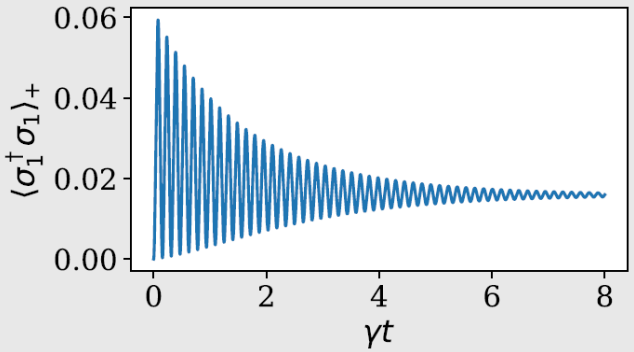
$$H = \sum_j \frac{\delta\omega}{2}\sigma_j^z + JJ\sum_{\langle j,j'\rangle}\sigma_j^z\sigma_{j'}^z + \sum_j \epsilon(\sigma_j^+ + \sigma_j^-) + (\text{damping})$$

Triangular Ising plaquette: dynamics



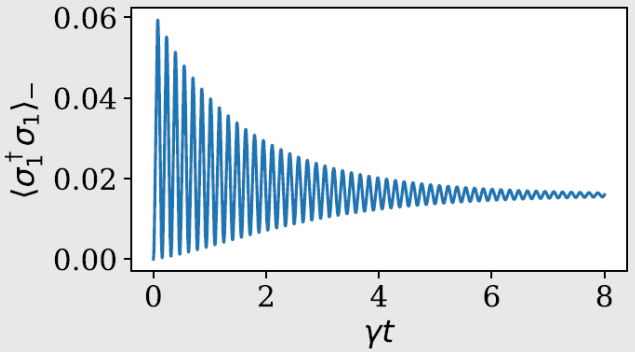
$$H = \sum_j \frac{\delta\omega}{2}\sigma_j^z + J\sum_{\langle j,j'\rangle}\sigma_j^z\sigma_{j'}^z + \sum_j \epsilon(\sigma_j^+ + \sigma_j^-) + (\text{damping})$$

positive J (frustrated AFM)



HSI

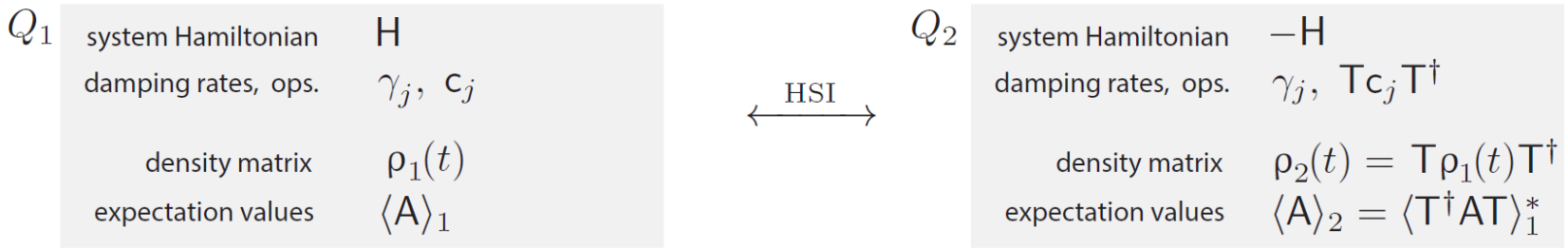
negative J (FM)



Summary

- non-equilibrium dynamics:
  no distinction between attraction/repulsion for BH lattice

- example of general Hamiltonian Sign Inversion mapping



- applications:
  exploring nonequilibrium phase diagrams, …