Born's Dynamical Quantum Phase Transition

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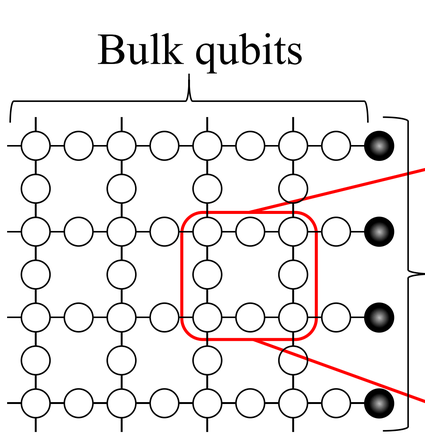
Protocol: Boundary state after bulk decoherence

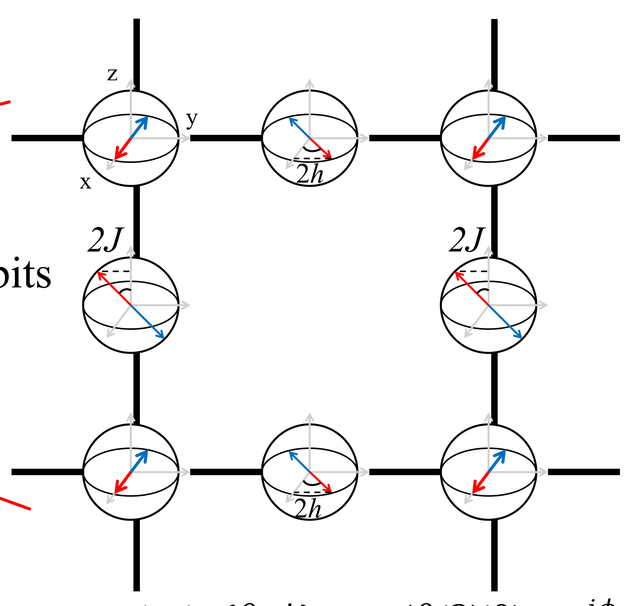
Dynamical quantum phase transition in circuit sampling or decohered state

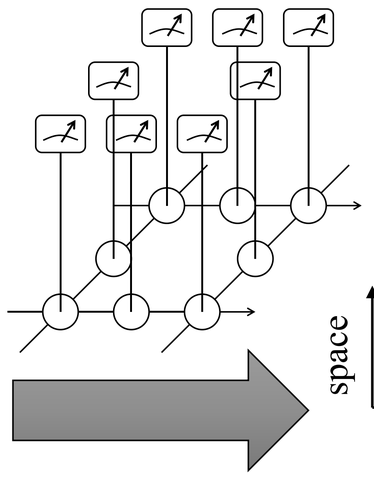
Decoherence-induced mixed states

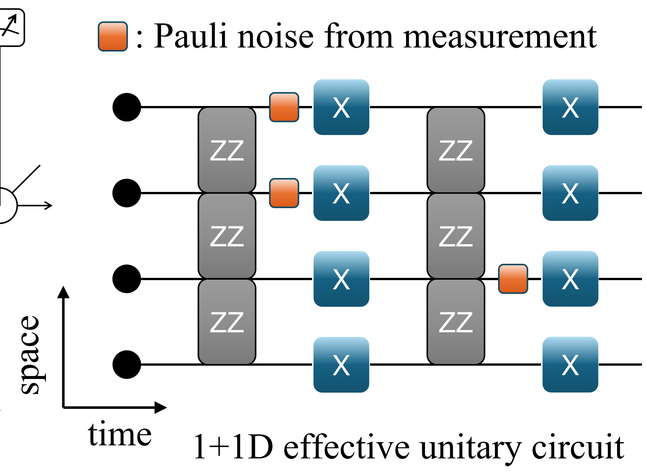
Dynamical quantum phase transition

Measurement based quantum computation









1. Entangle qubits by CZ gates
2. Bulk decoherence in specific basis
3. Leave boundary uncollapsed qubits

Measurement basis: $\{\theta, \phi\}$: $\cos(\theta/2)|0\rangle + e^{i\phi}\sin(\theta/2)|1\rangle$

Measurement pattern in a plaquette

Measurement based dynamical transition shown by 1D bitstring distribution

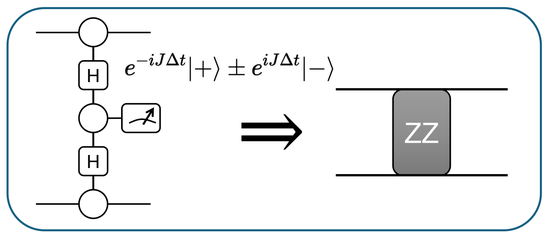
Measurement based computation

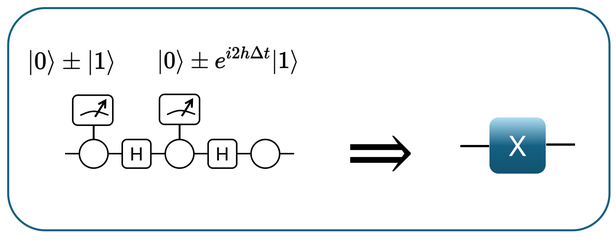
1D Transverse-Field Ising model : $H = -J\sum_j Z_j Z_{j+1} - h\sum_j X_j$

$$\Rightarrow \quad U(t) = U_X U_{ZZ} = e^{ihXt} e^{iJZZt}$$

Cluster state : $|\Psi\rangle = \prod_{ij\in\text{graph}} CZ_{ij}|+\rangle^{\otimes N}$

Measurement pattern:





Average free energy

Dynamical quantum phase transitions are defined by the nonanalyticities in dynamical free energy :

$$f(\sigma = +++\ldots) = \lim_{N\to\infty} -\frac{1}{N}\log(|\langle +|U|+\rangle|^2)$$

Equal to the zeros of partition function $P(\sigma)$ (Loschmidt echo) into the complex plane :

$$P(\sigma) = |\langle\sigma|e^{-iHt}|+\rangle|^2 = |\langle\sigma|U|+\rangle|^2$$

n-th moment Average free energy f_n over all bitstring σ:

$$f_n = -\frac{1}{N}\frac{\sum_\sigma P^n(\sigma)\log P(\sigma)}{\sum_\sigma P^n(\sigma)}$$

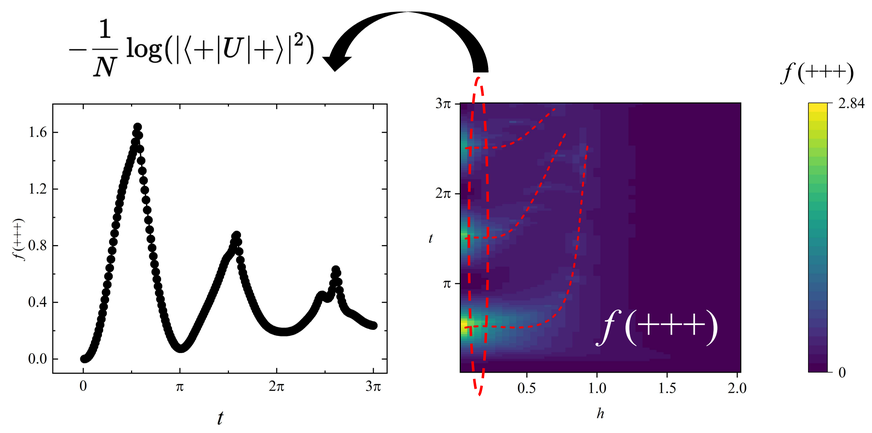
f_0 shows average $f(\sigma)$ with equal weights :

$$f_0 = -\frac{1}{N}\frac{\sum_\sigma \log P(\sigma)}{2^N} = \frac{1}{2^N}\sum_\sigma f(\sigma)$$

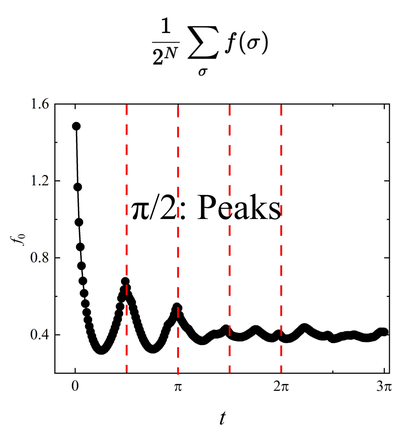
f_1 shows Shannon Entropy of bitstring distribution :

$$f_1 = -\frac{1}{N}\sum_\sigma P(\sigma)\log P(\sigma) = \mathbb{E}_{P(\sigma)}[f(\sigma)]$$

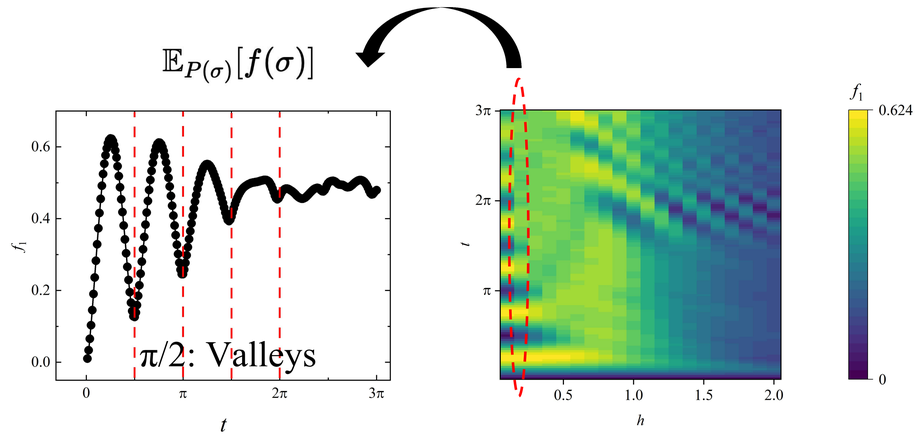
Numerical results



Original DQPT in Ising model
Nonanalyticities move to critial point h=1



Existing DQPT in finite systems
⇒ Direct average



Smoother crossover
⇒ Born average

Reference

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