

Title: Session 2 - Subhayan Sahu

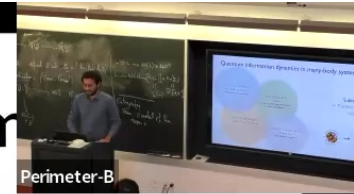
Speakers:

Collection: POSTDOC WELCOME 2022

Date: October 24, 2022 - 11:40 AM

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# Quantum information dynamics in many-body system



Out-of-equilibrium  
scrambling phases  
*Measurement induced phases*

Scrambling and  
Chaos

*OTOCs, Temperature dependence  
of information dynamics*

Quantum information in  
many-body systems

Classical simulation of  
Quantum

*Tensor Network methods*

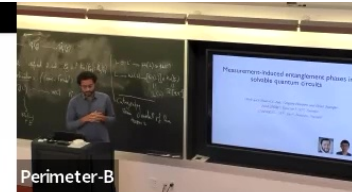
**Subhayan Sahu**

PI Postdoc Welcome!

Oct 24, 2022



# Measurement-induced entanglement phases in solvable quantum circuits



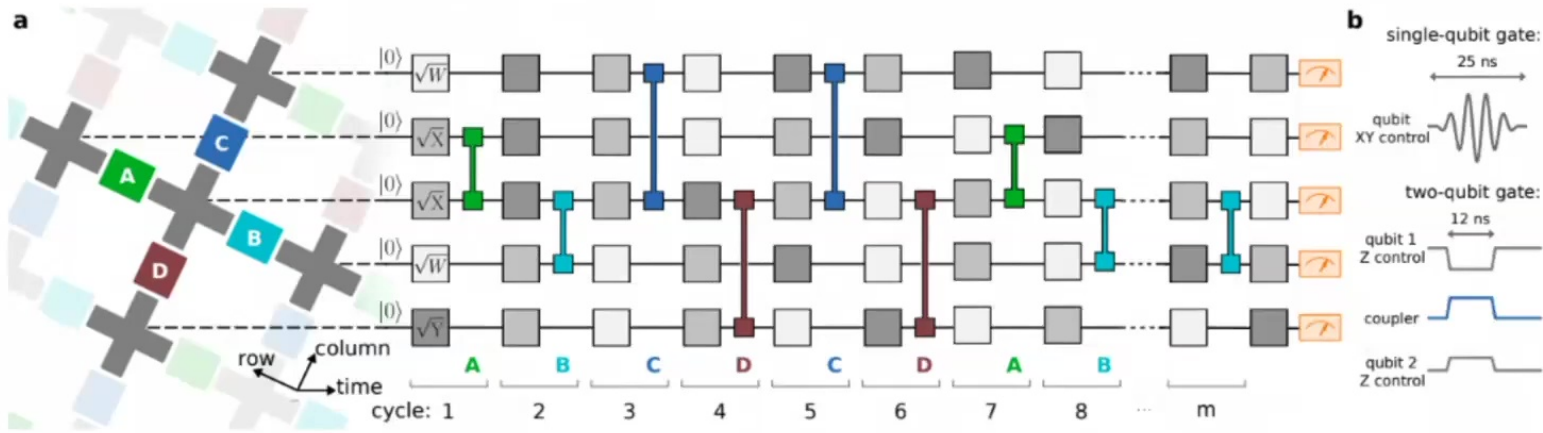
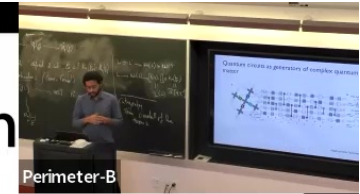
*Work with Shao-Kai Jian, Gregory Bentsen and Brian Swingle*

*2104.07688 – Bentsen\*, SS\*, Swingle*

*2109.00013 – SS\*, Jian\*, Bentsen, Swingle*

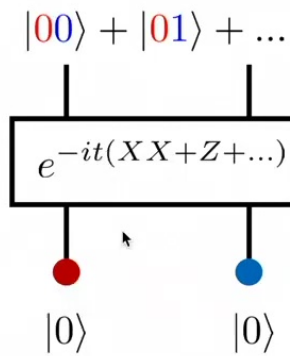
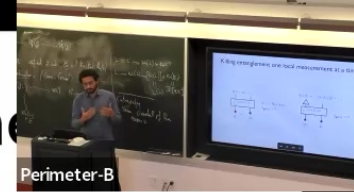


# Quantum circuits as generators of complex quantum matter



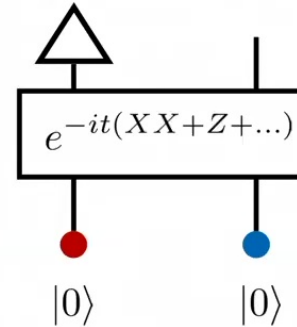
Google's quantum "supremacy" ...

# Killing entanglement one local measurement at a time



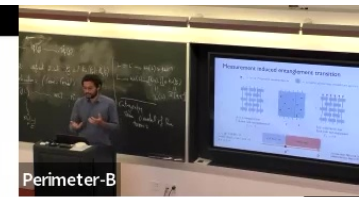
$$S = -\text{Tr}(\rho \ln \rho)$$
$$S_{\text{final}} > 0$$

$|0\rangle (|0\rangle + \dots)$  or  $|1\rangle (|0\rangle + \dots)$



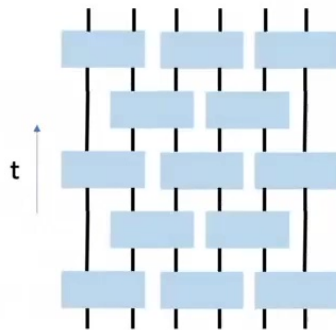
$$S_{\text{final}} = 0$$



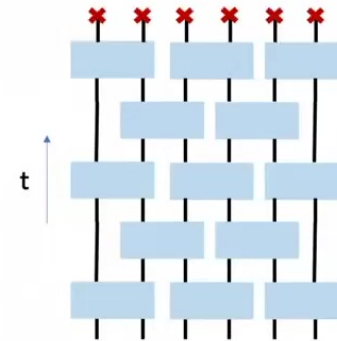
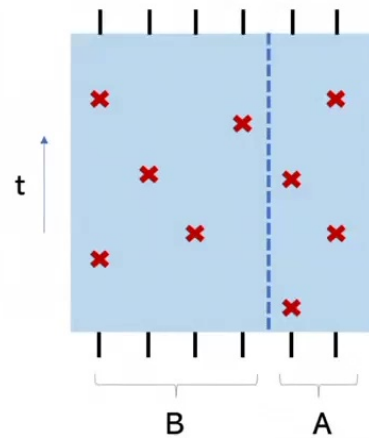


# Measurement induced entanglement transition

✗ = Local Projective measurements     = Locality preserving scrambling unitary

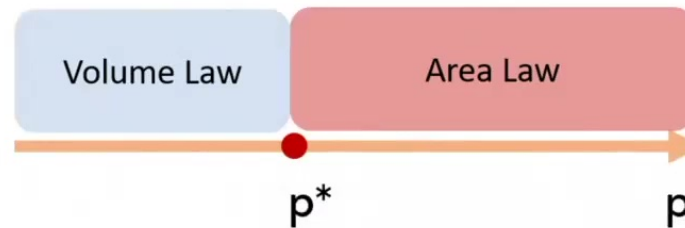


Any subregion has  
Volume law entanglement  
 $S_A \sim A$

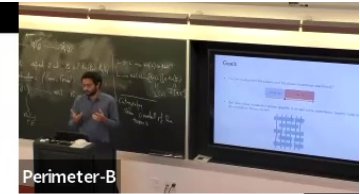


Any subregion has  
Area law entanglement  
 $S_A \sim \partial A$

$p$  = probability of  
measuring in one layer of  
the circuit

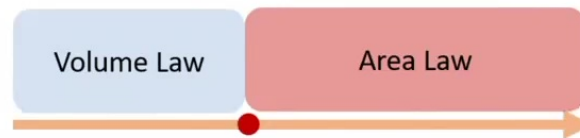


[Li, Chen, Fisher PRB 2018, 2019]  
[Skinner, Ruhman, Nahum PRX 2019] ...

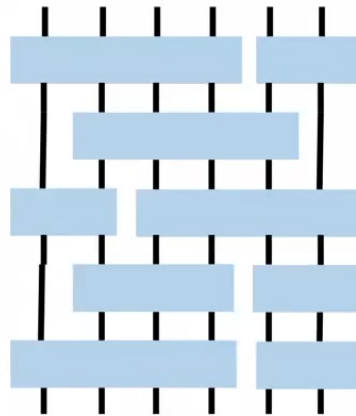


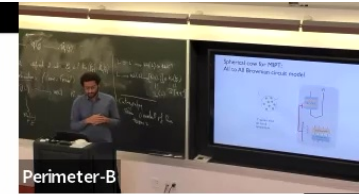
# Goals

- Can we understand the phases and the phase transitions analytically?

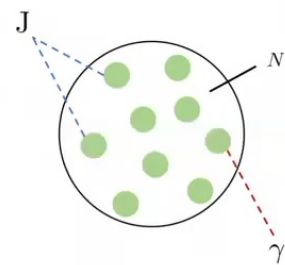


- Are there other dynamical phases possible if we add more ingredients, namely long-range interactions in the unitaries?

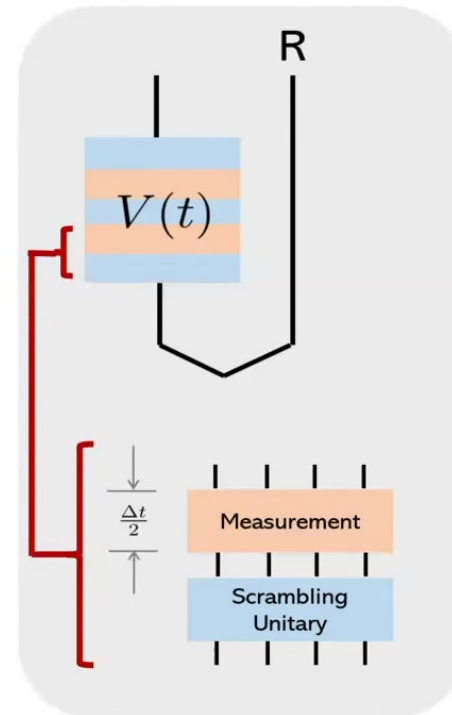




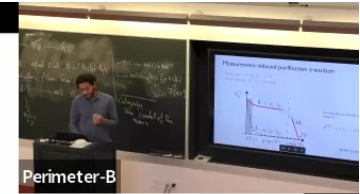
# Spherical cow for MIPT: All to All Brownian circuit model



$N$  qubits with  
all-to-all  
interaction



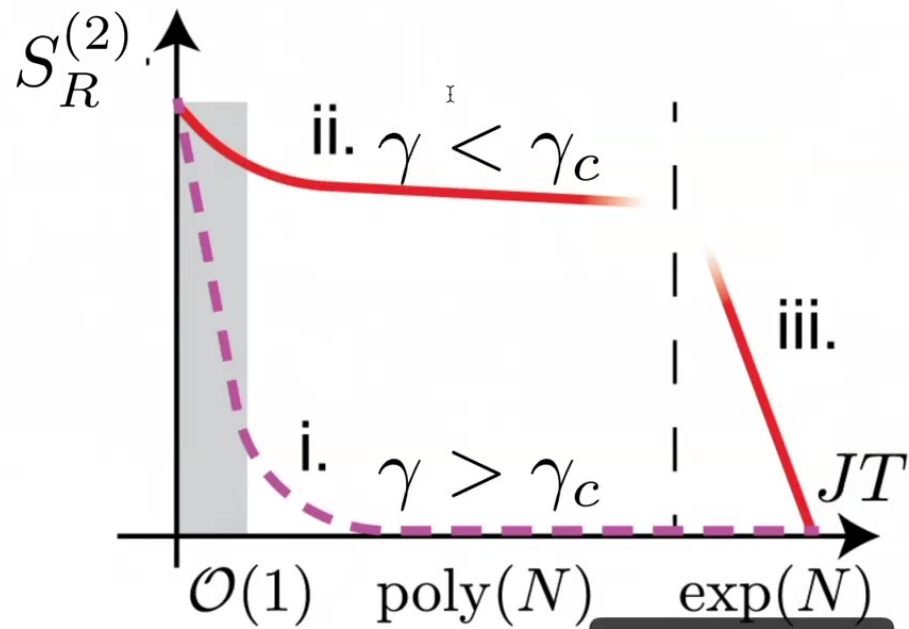




# Measurement induced purification transition

$$\text{Purity}_R(t) = \text{Tr}(\rho_R^2(t)) = e^{-S_R^{(2)}}$$

$$\text{Rényi entropy: } S_R^{(n)} = \frac{1}{1-n} \ln \text{Tr} \rho_R^n$$



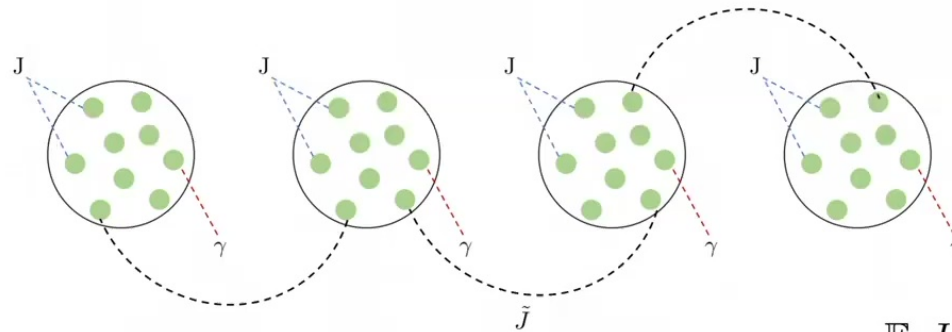
Analytically accessible critical behavior

$$\hat{S}^{(2)} \sim (\gamma_c - \gamma)^{3/2}$$

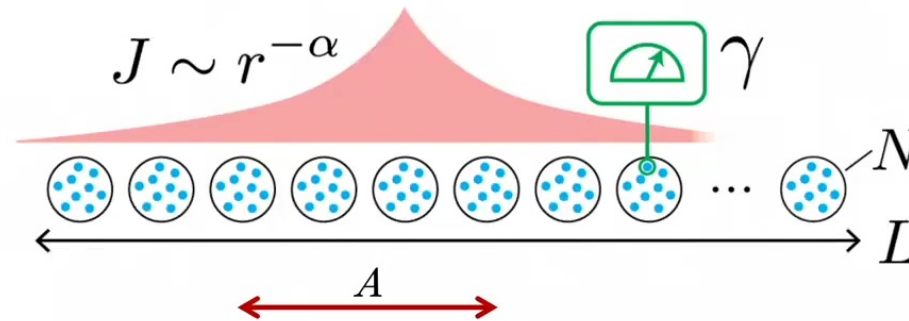
Bentsen, SS, Swingle 2021



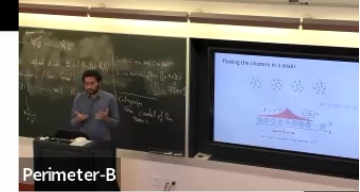
# Putting the clusters in a chain



$$\mathbb{E} J_r(t) J_s(t') \sim |r - s|^{-2\alpha} \delta_{tt'}$$



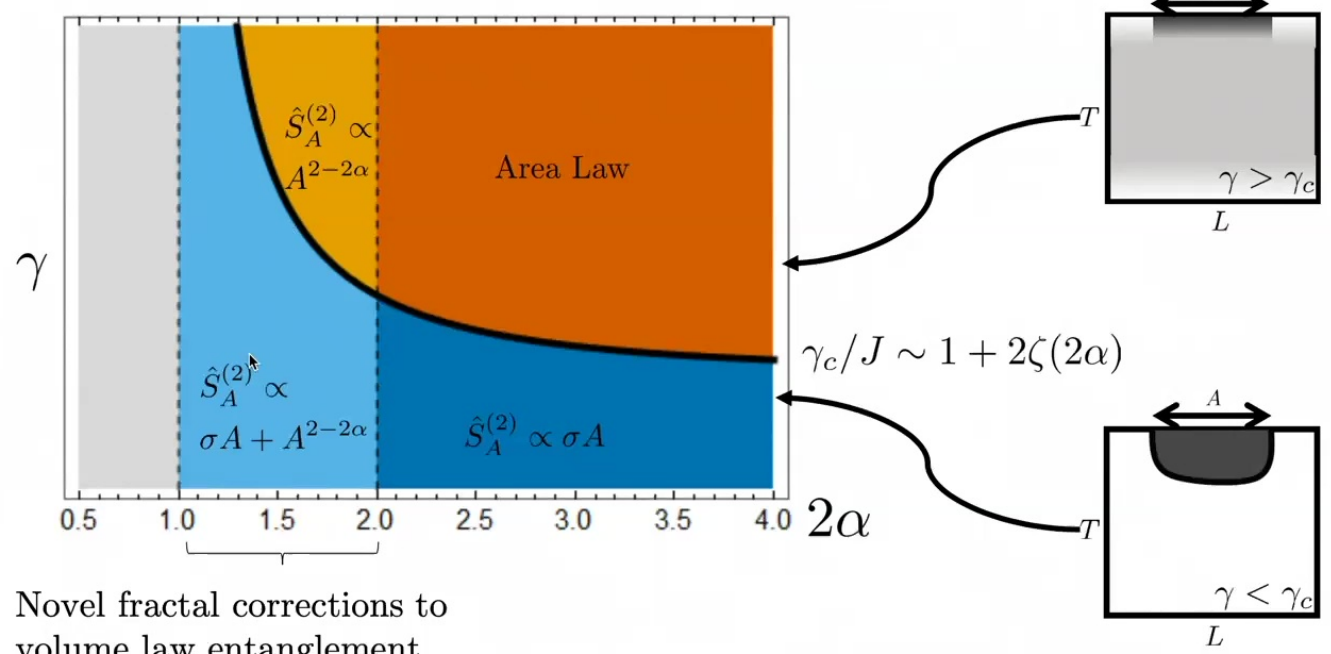
We want to measure the entropy  $\hat{S}_A^{(2)}$





# Entanglement phase diagram

$$I \sim \int_{t,r} \left[ -\phi \partial_t^2 \phi - \int_s \phi_r \phi_s |r-s|^{-2\alpha} - (\gamma_c - \gamma) \phi^2 / 2 + \phi^4 / 4 \right]$$



Novel fractal corrections to volume law entanglement

Fractal corrections to the entropy due to the long-range interaction on domain wall

