

BEYOND MANY BODY LOCALIZATION

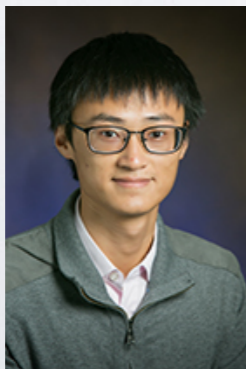
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University of Illinois at Urbana Champaign

APS March Meeting 2019 - Boston

March 6, 2019

<https://arxiv.org/abs/1803.02838>
PRB 98, 115106



Eigenstate phases *sharp changes in properties of finite-energy density eigenstates over transitions.*

Many-Body Localized (MBL)

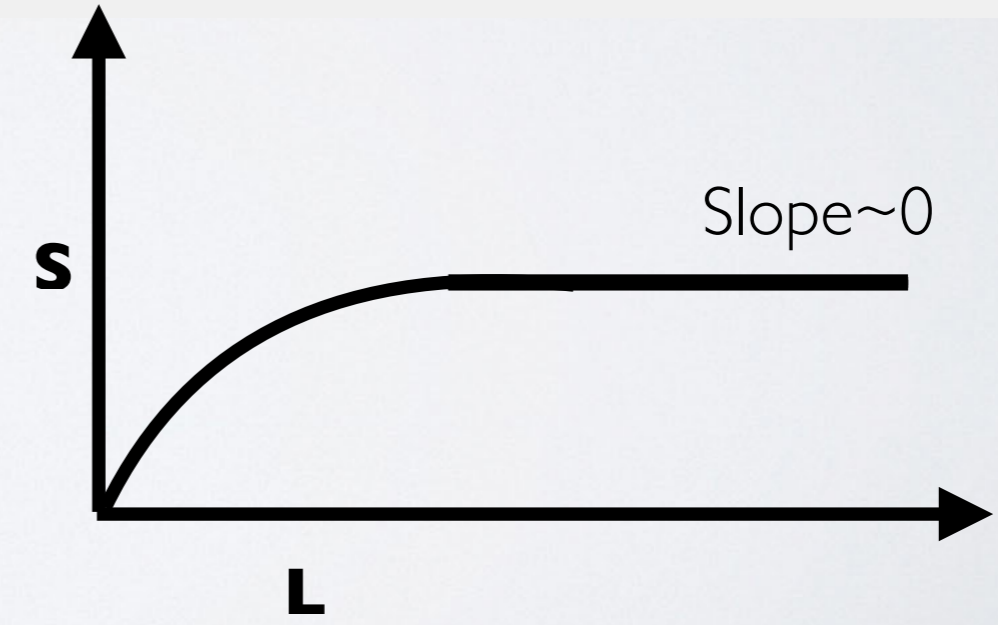
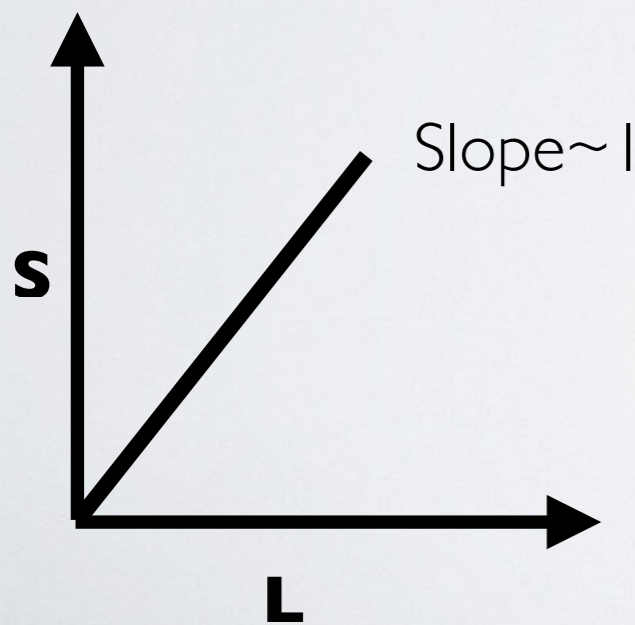
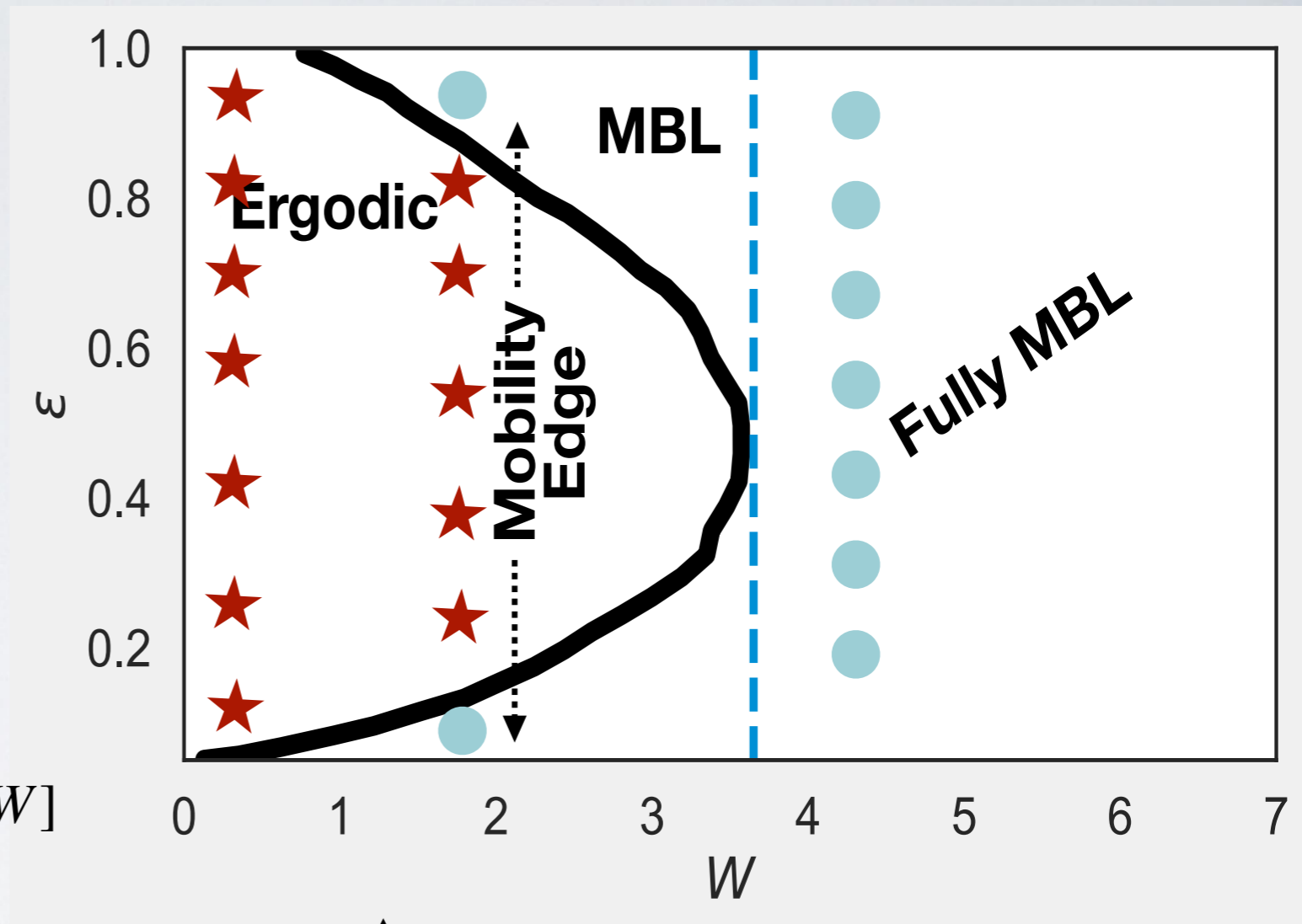
Ergodic

Today: An eigenstate phase beyond the MBL and ergodic phase...

The MBL phase is characterized by the entanglement of its eigenstates...

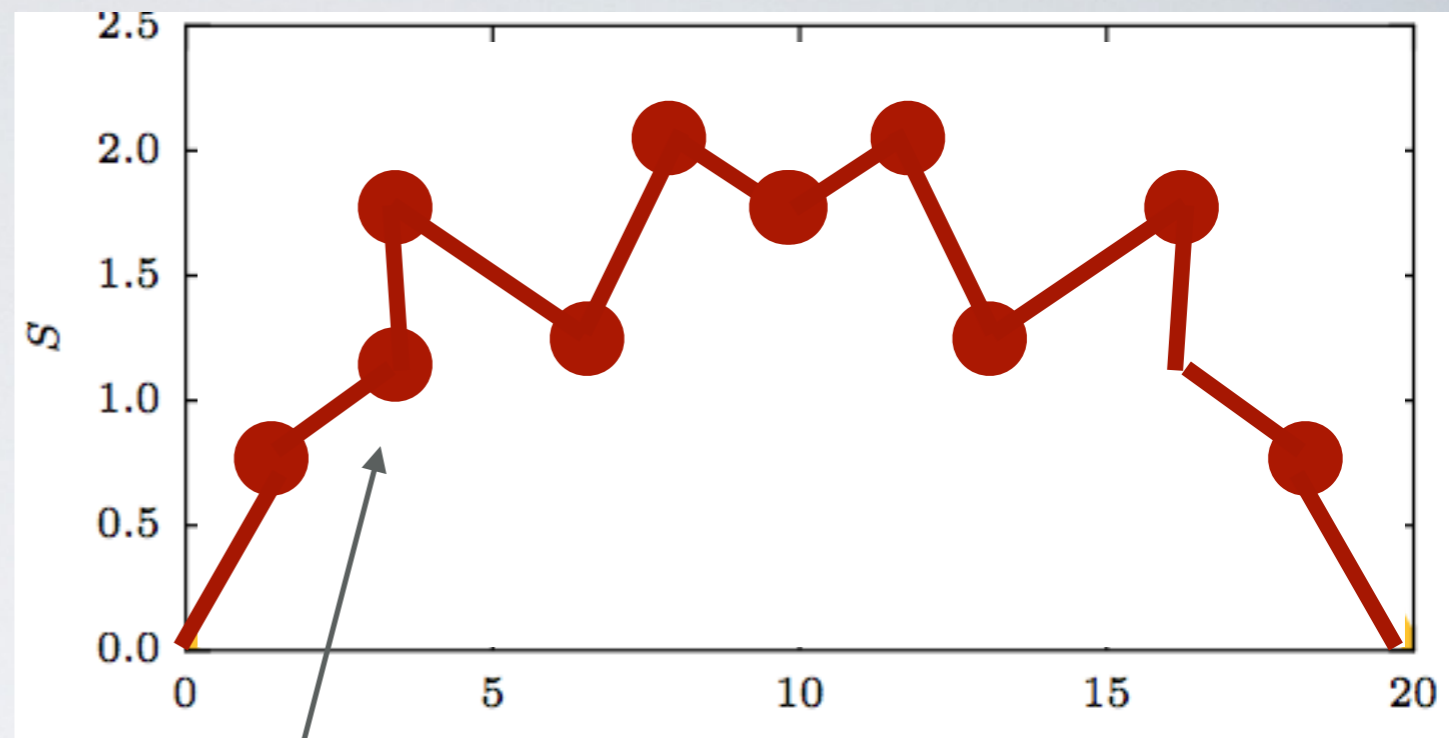
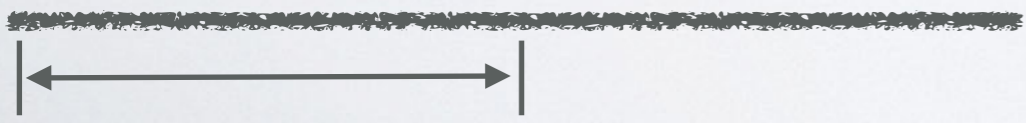
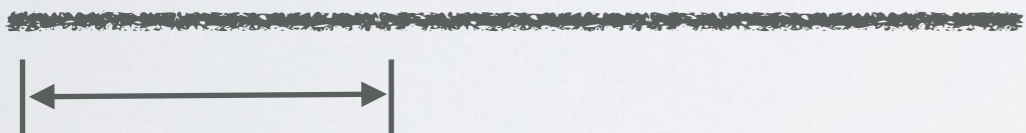
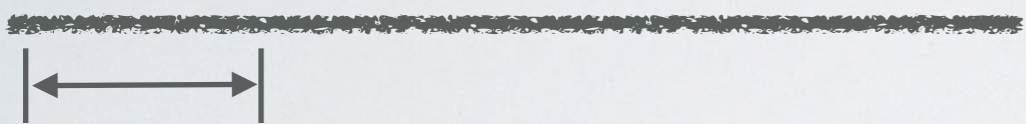
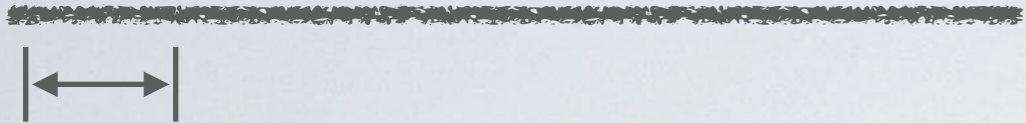
- Fully MBL: *Area Law*
- Ergodic: *Volume Law*
- Mobility Edge: *Both volume and area law but separated by energy.*

$$H = \sum_{i=1}^L S_i \cdot S_{i+1} + h_i S_i^z, h_i \in [-W, W]$$



★ Volume Law

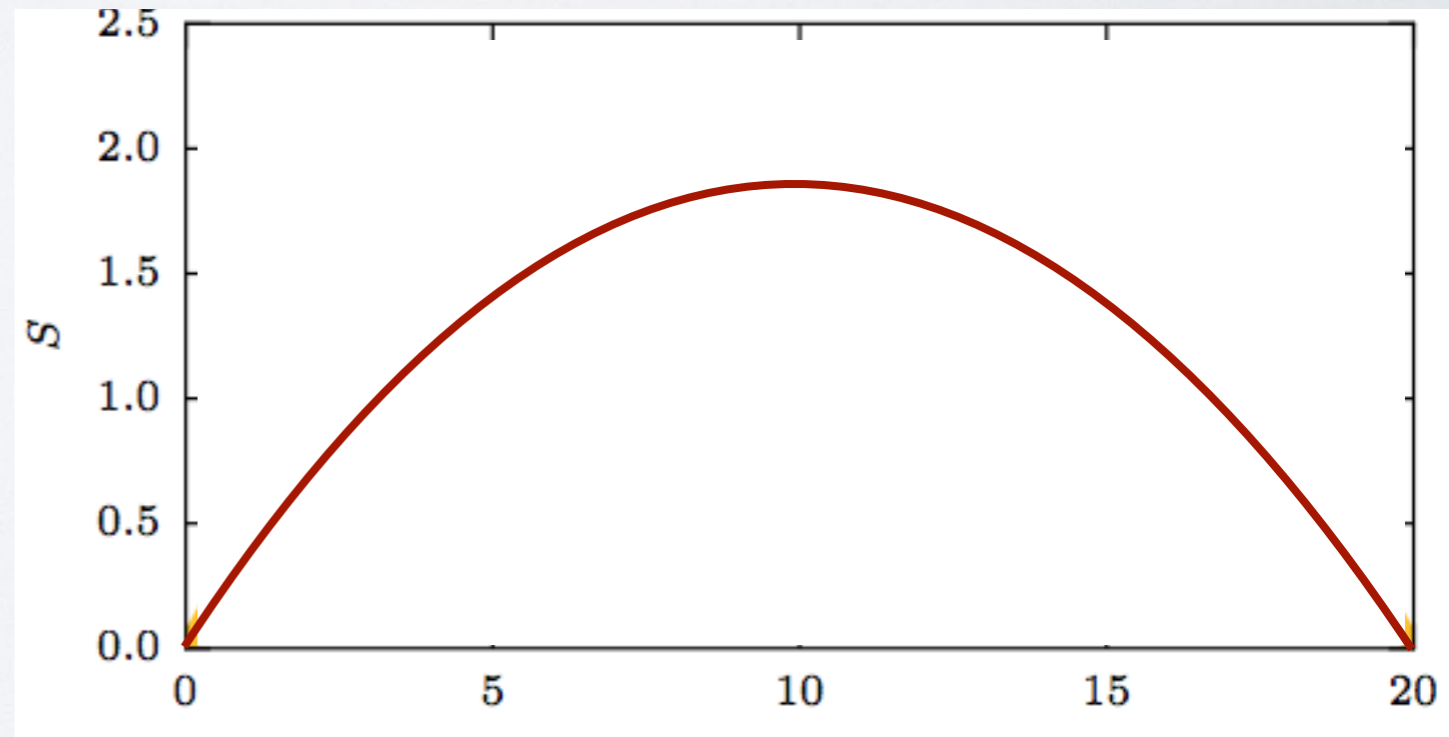
● Area Law



slope?



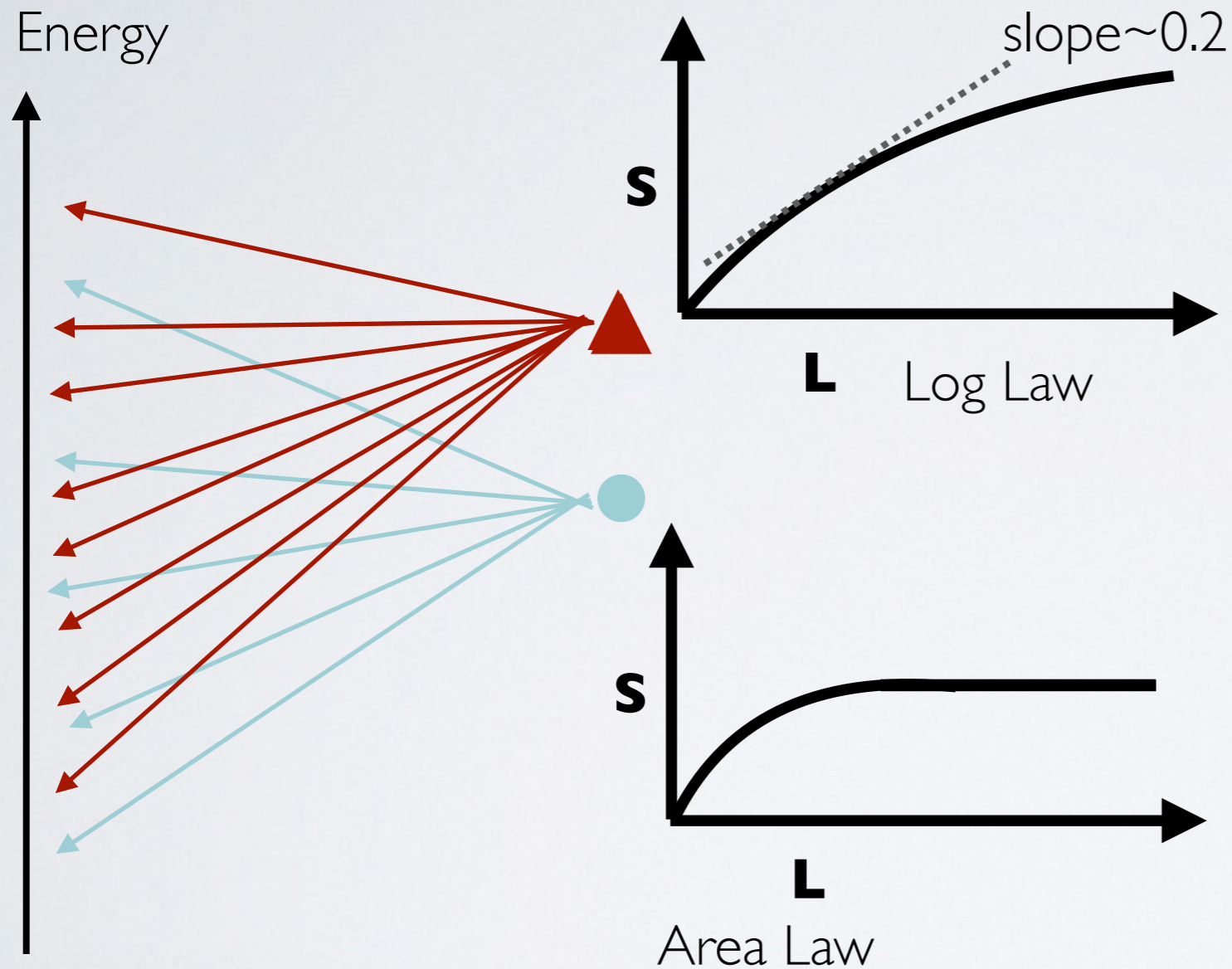
SCAEE



Are there other options for entanglement?

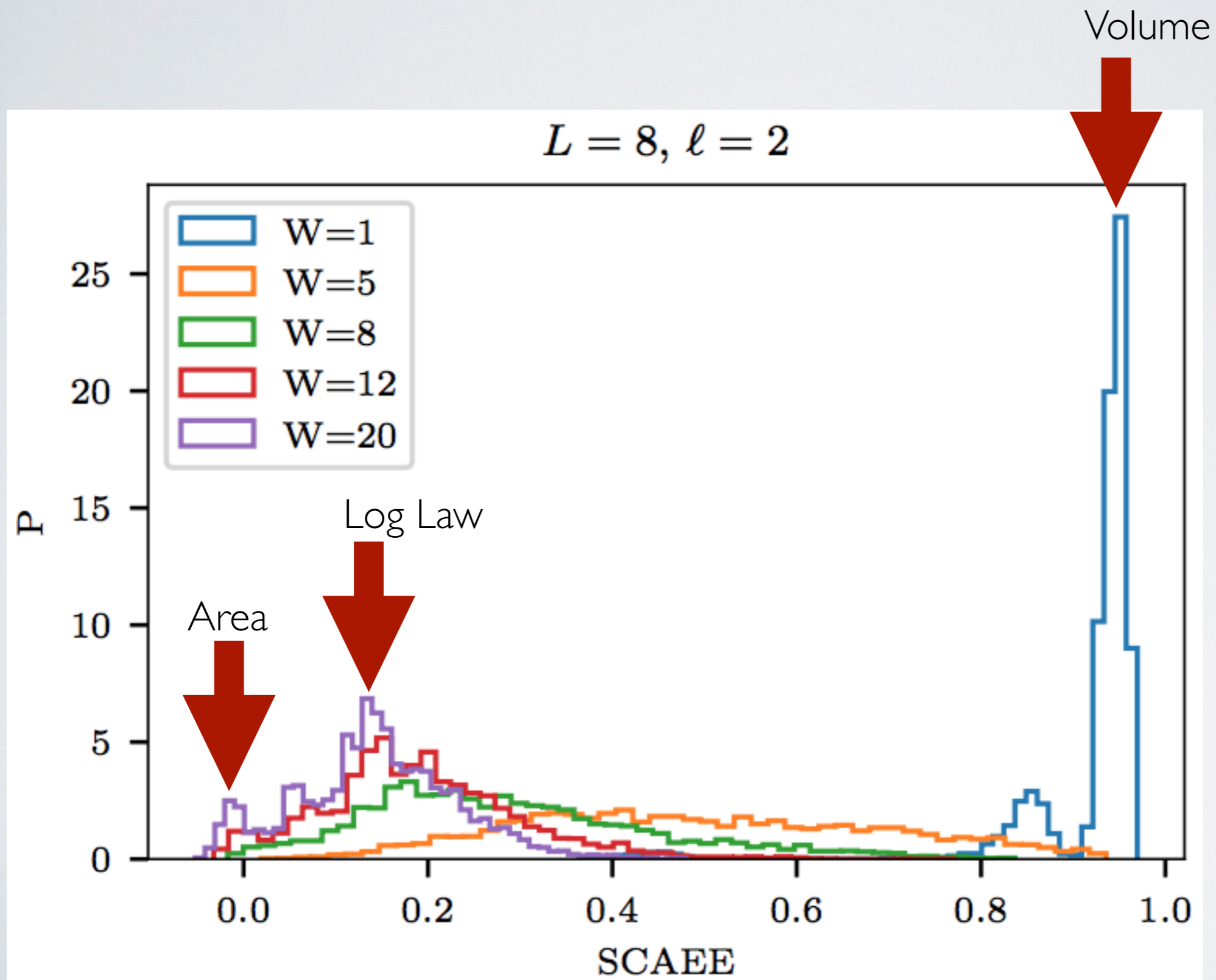
Spin Disordered Hubbard Model

$$H = -t \sum_{i\sigma} \left(c_{i\sigma}^\dagger c_{i+1\sigma} \right) + \sum_i U n_{i\uparrow} n_{i\downarrow} + \sum_i h_i S_i^z$$



An interspersed mixture of
an exponential number of log law
an exponential number of area law

How do we know?



How do we know?

eta-pairing:

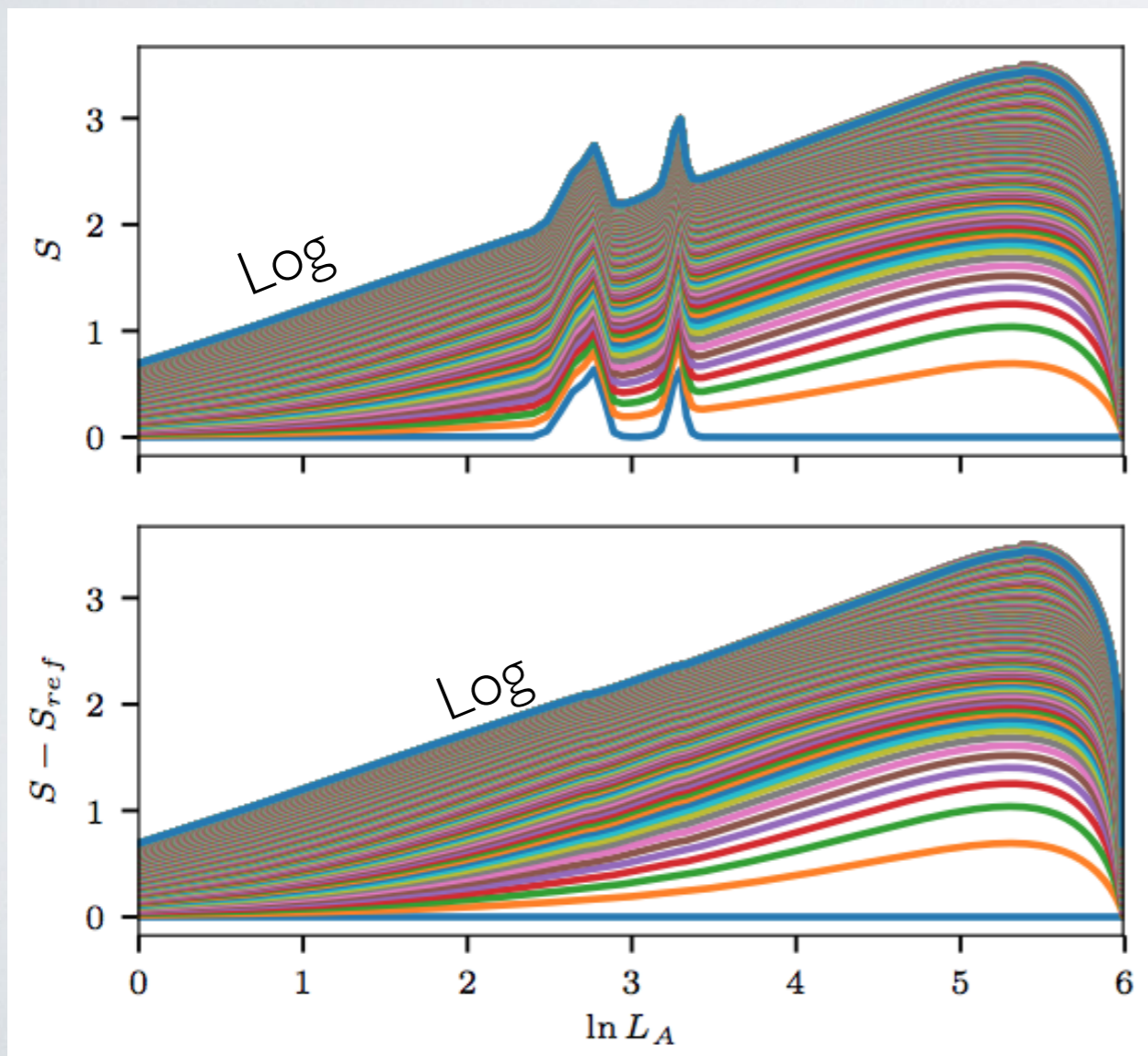
$$\eta_- = \sum (-1)^i c_{i\uparrow} c_{i\downarrow}$$

$$\eta_0 = \frac{1}{2} (\hat{N} - L)$$

$$\vec{\eta}^2 = \frac{1}{2} (\eta_+ \eta_- + \eta_- \eta_+) + \eta_0^2$$

$$[H, \eta_0] = 0$$

$$[H, \vec{\eta}^2] = 0$$



η_+
↑
Log
Area

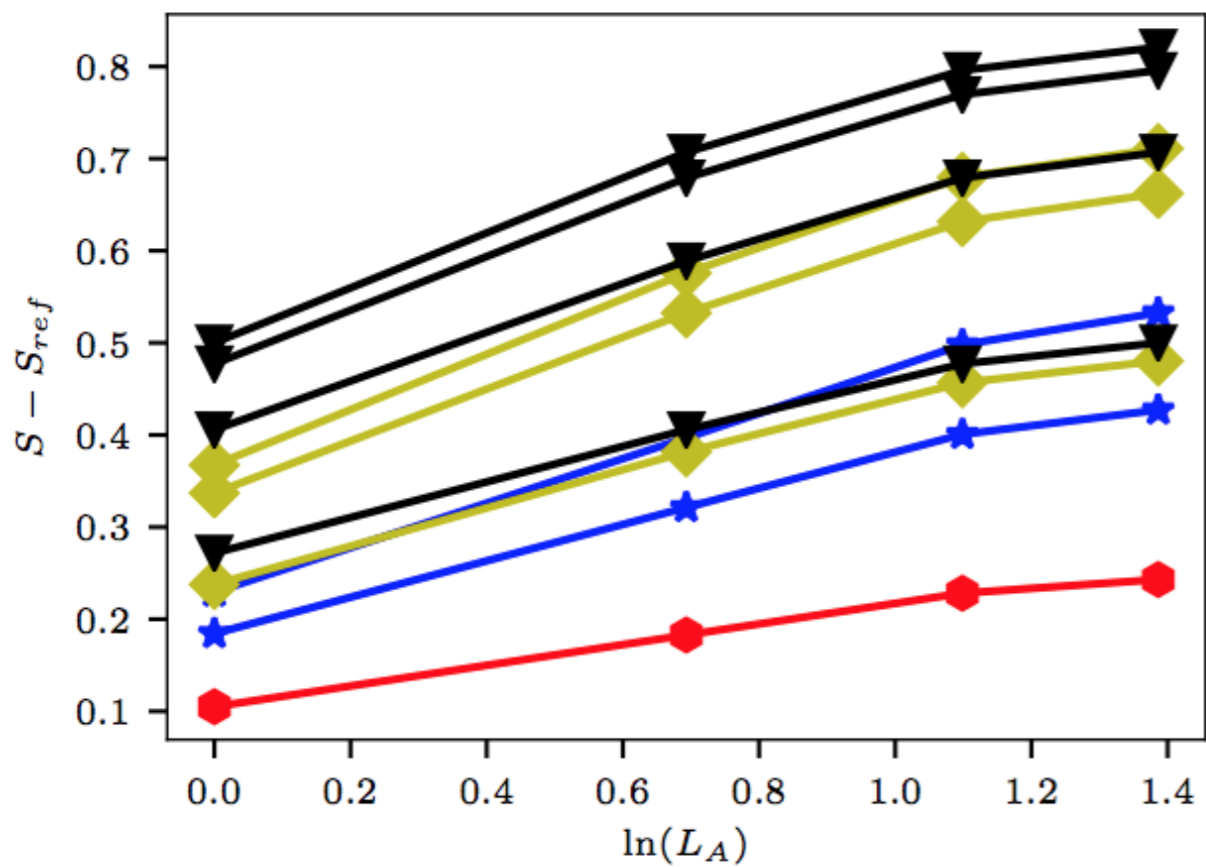
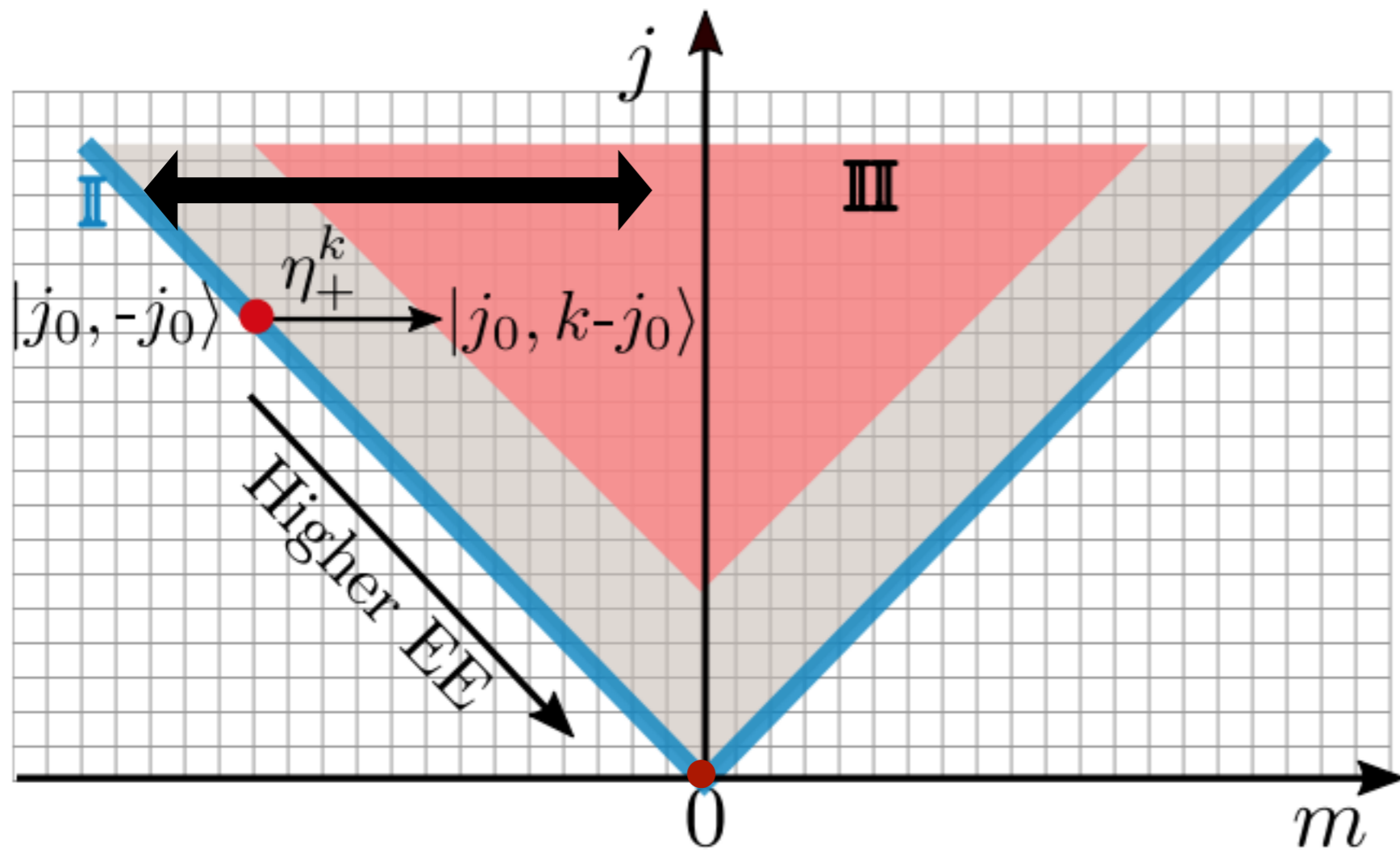
Can prove is at least logarithmically different.

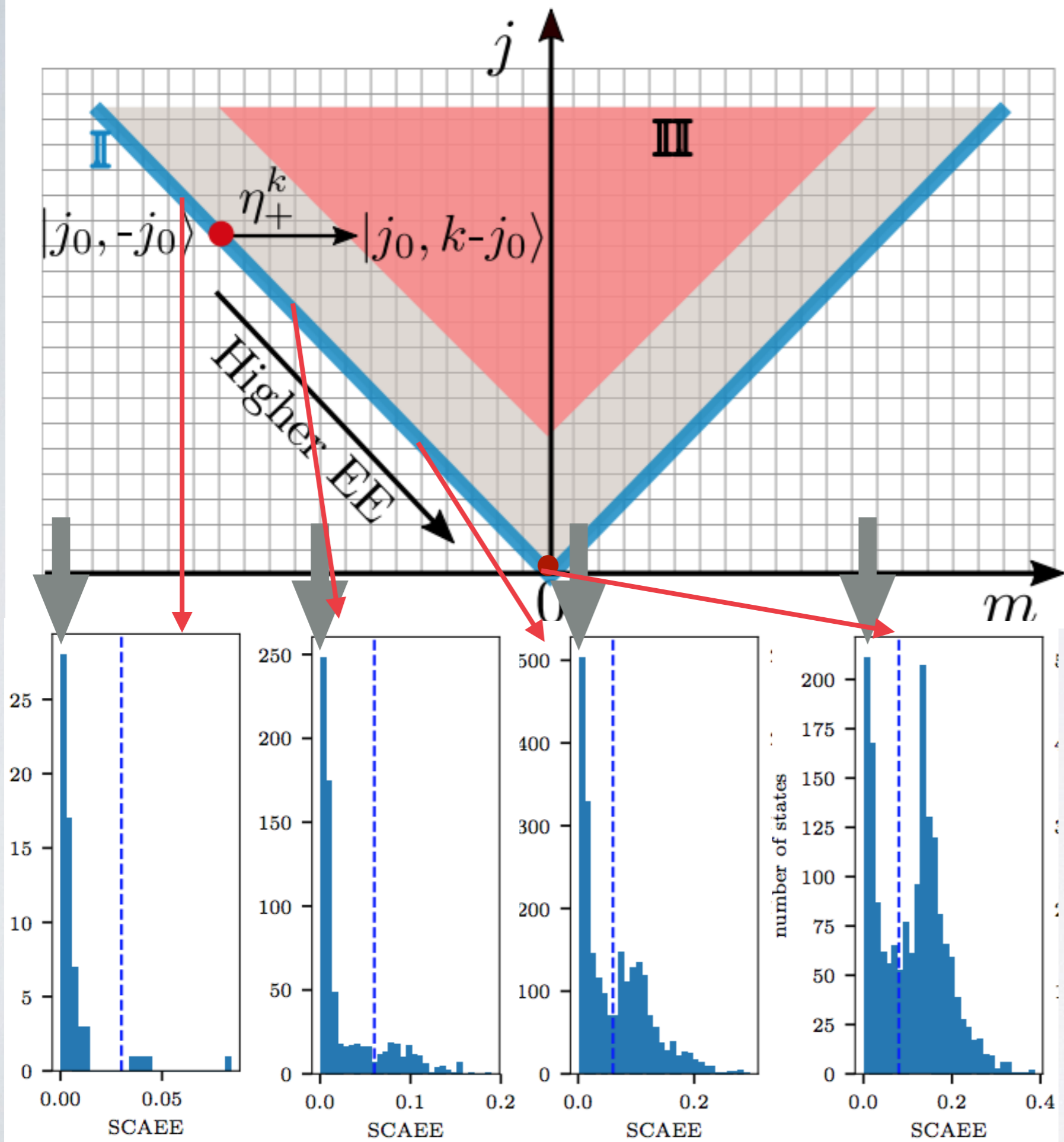
η_+
↑

Effect of SU(2)

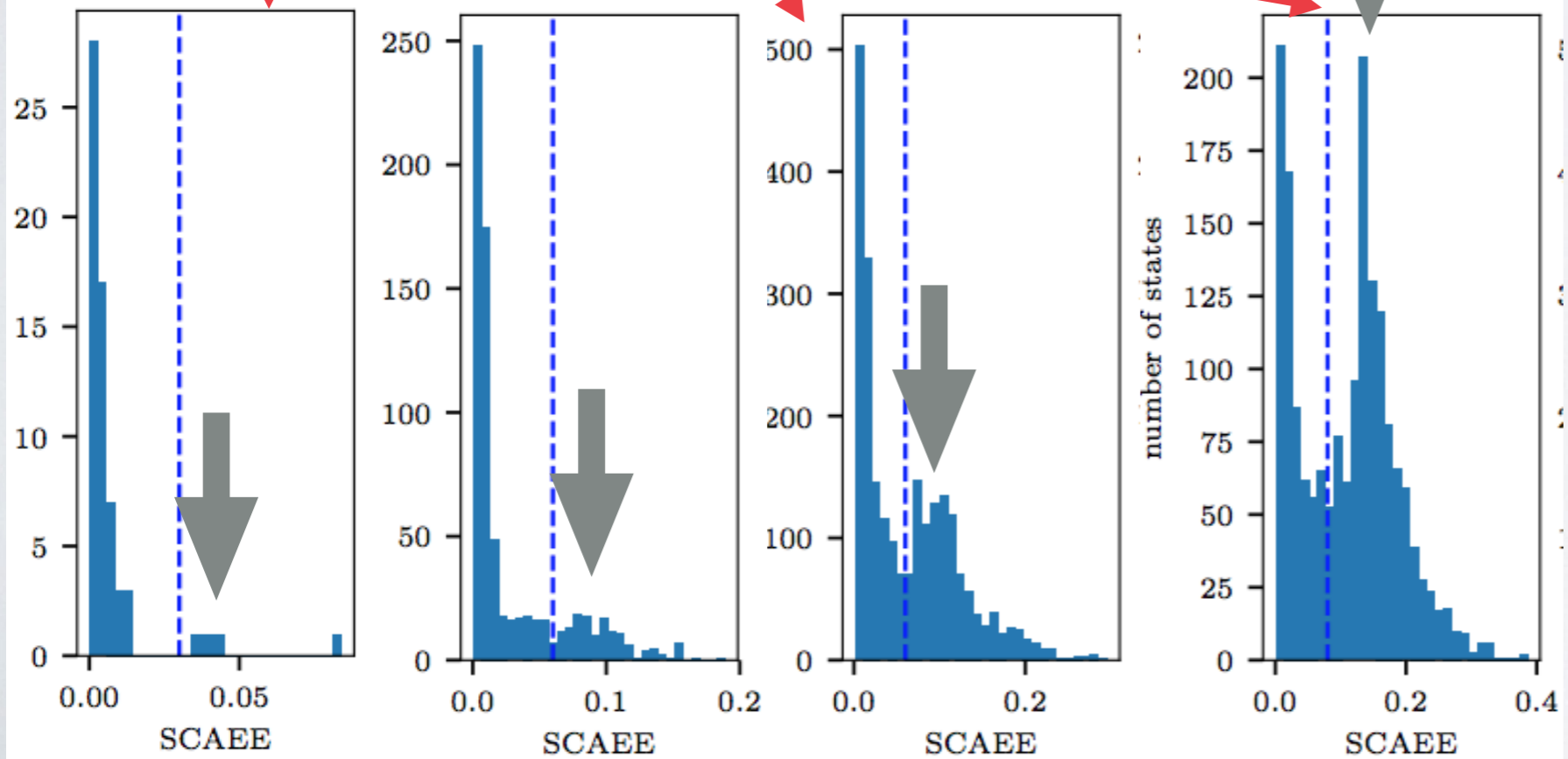
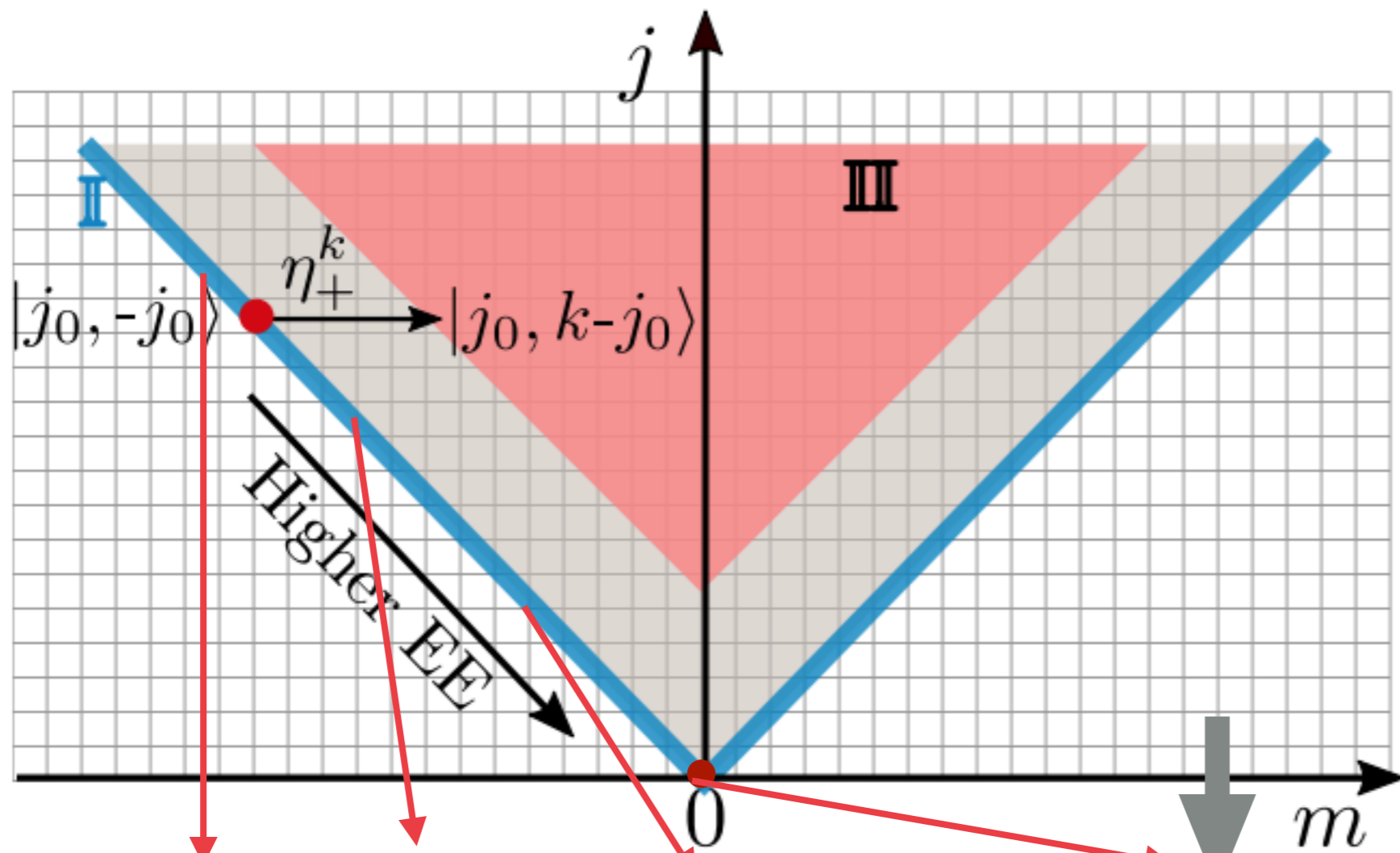
Protopopov, Ho, Abanin – Effect of SU(2) symmetry on many-body localization and thermalization

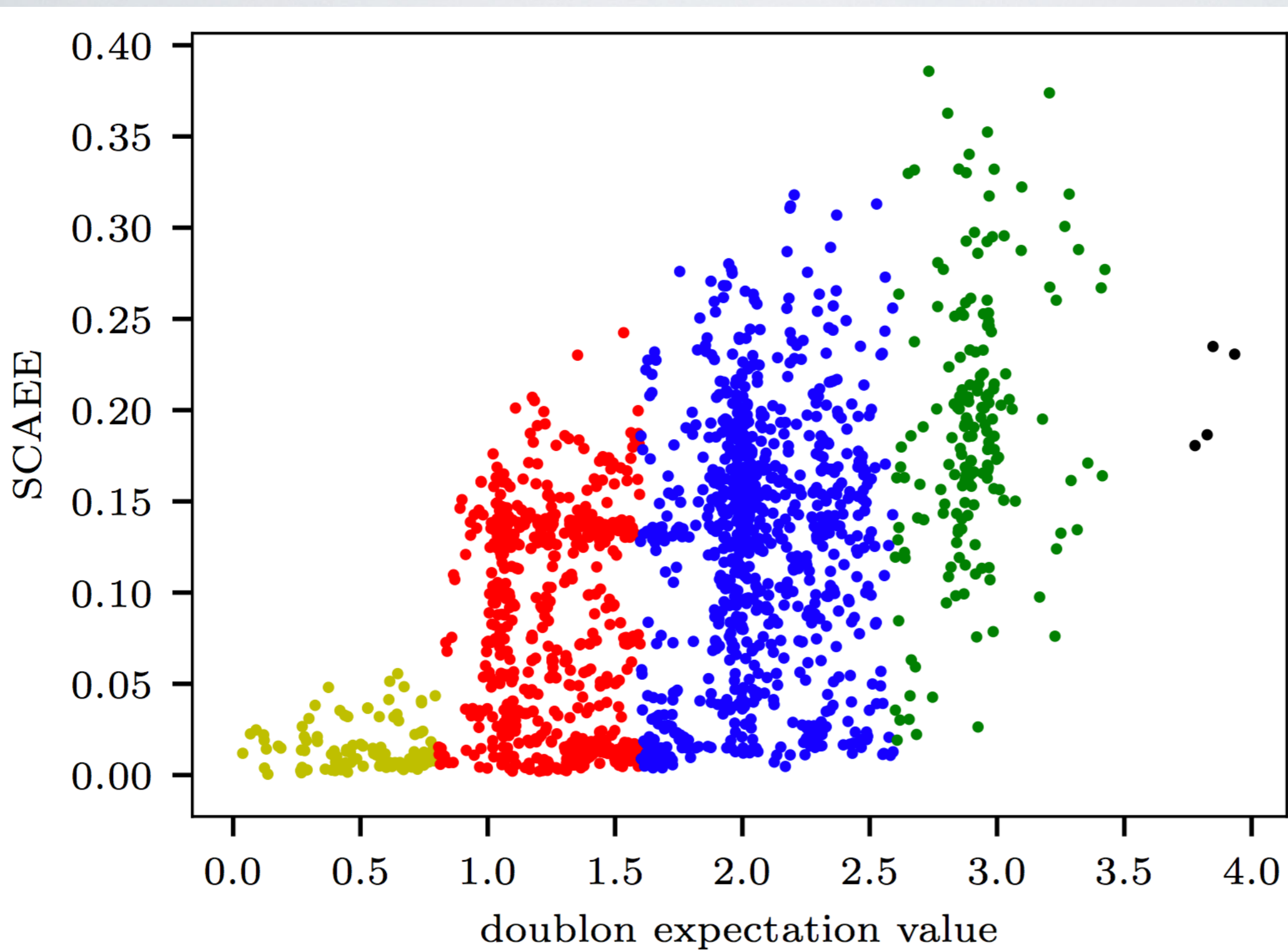
Potter and Vasseur – Symmetry constraints on many-body localization Phys. Rev. B 94, 224206





* Here we don't have an analytical handle so we can't completely rule out something surprising happens at large L or other intermediate W phases exist.





Dynamics....



Logarithmically growing entanglement



Entanglement $\propto t^{0.25}$

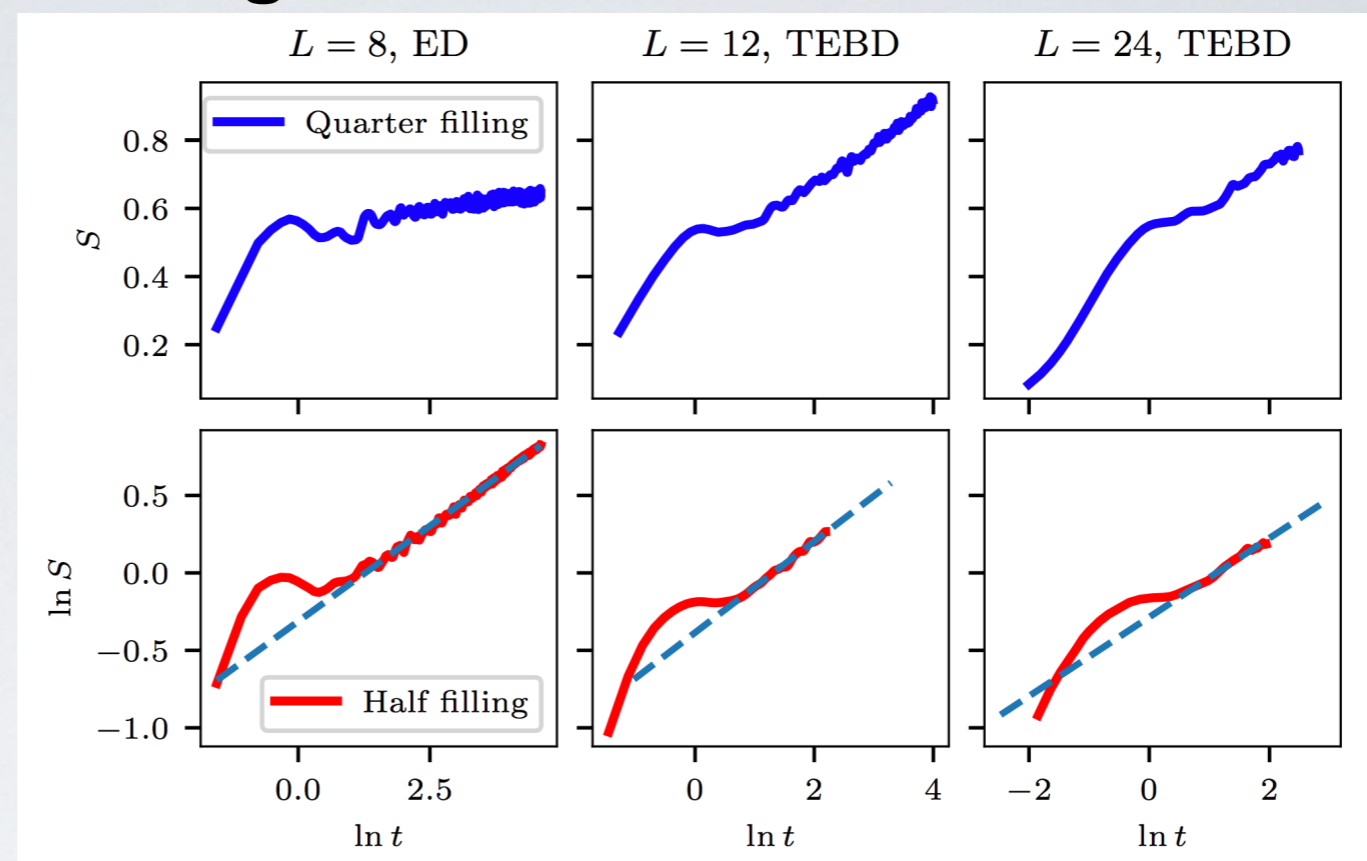


Non-equilibrating charge imbalance

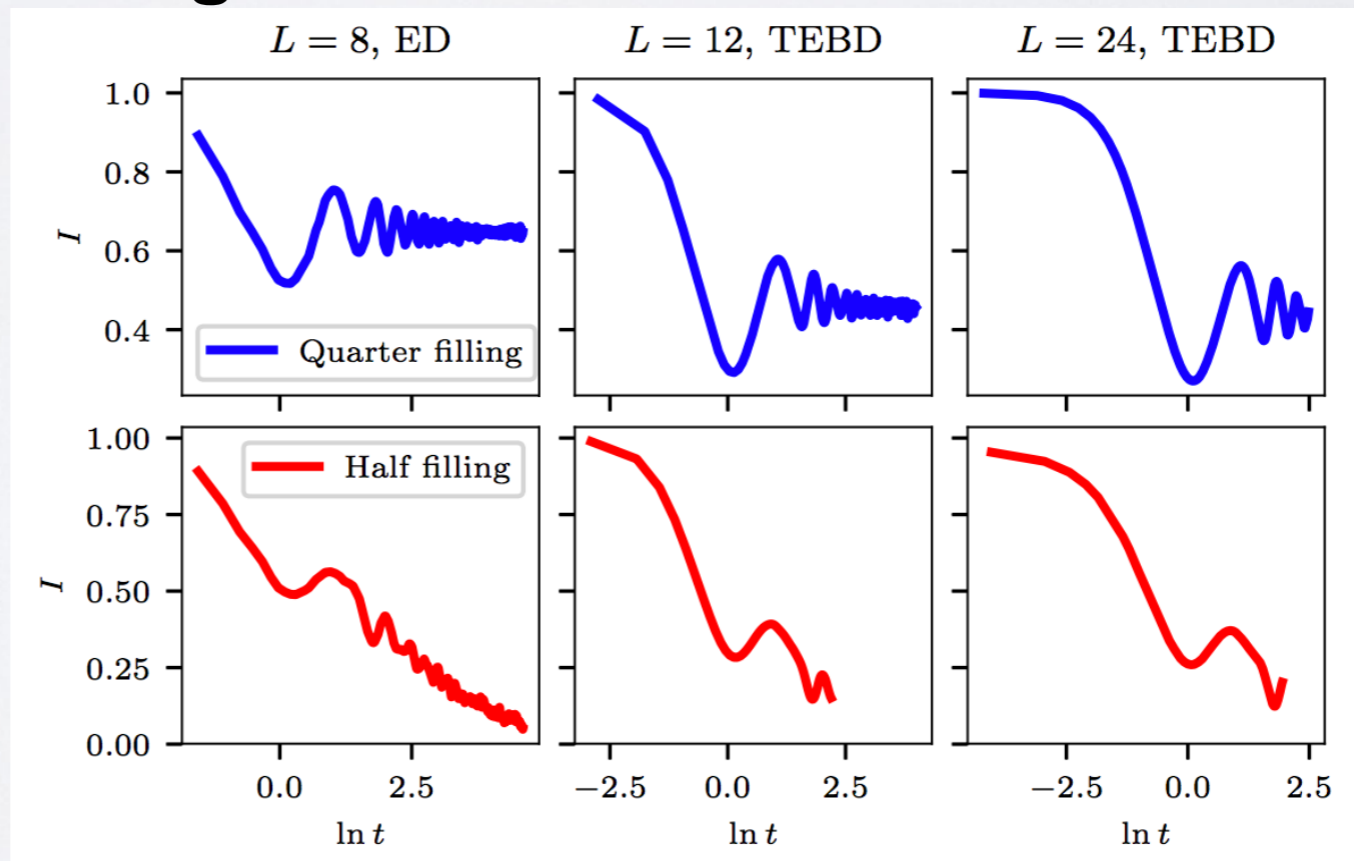


Equilibrating charge imbalance

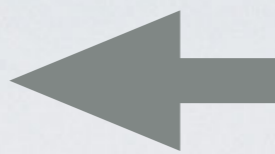
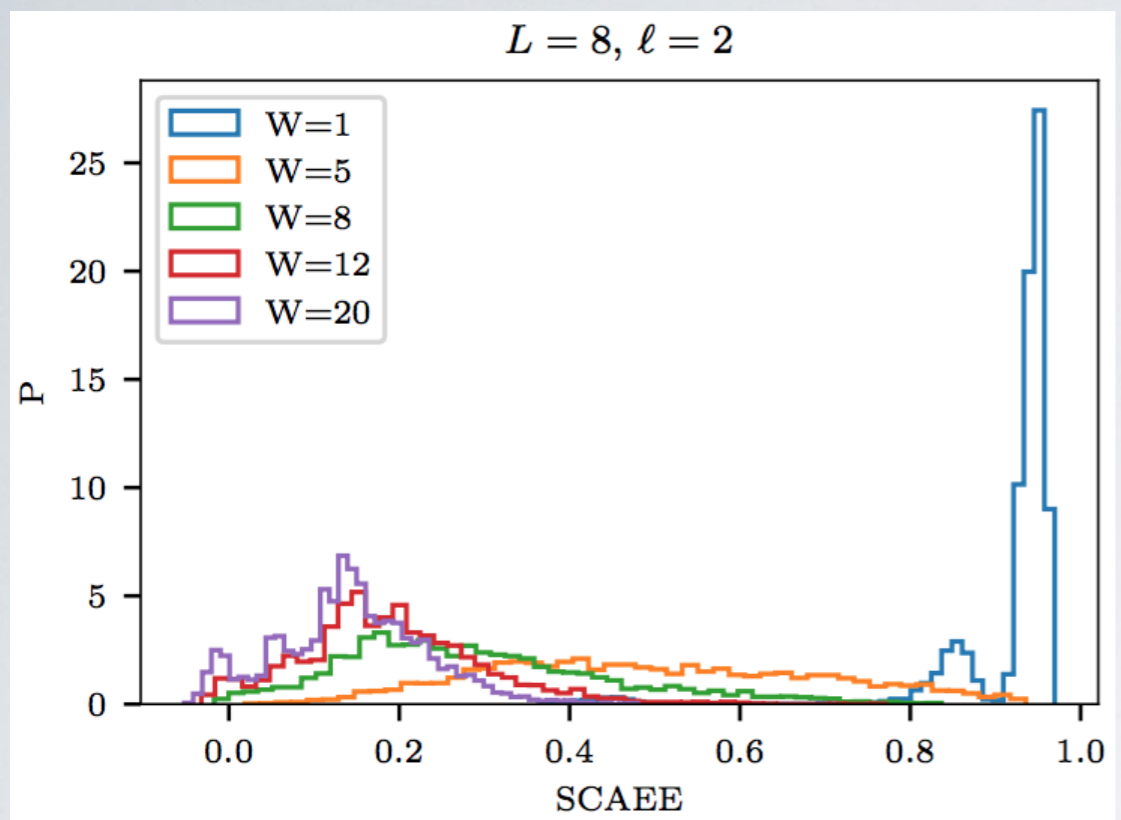
Entanglement



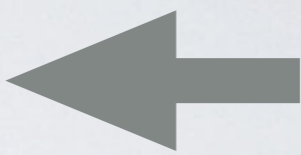
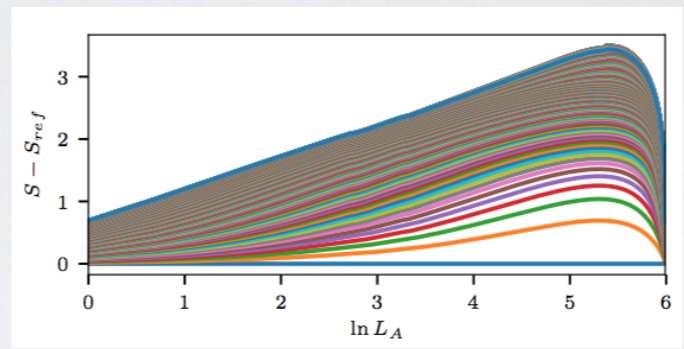
Charge Imbalance



Conclusions...

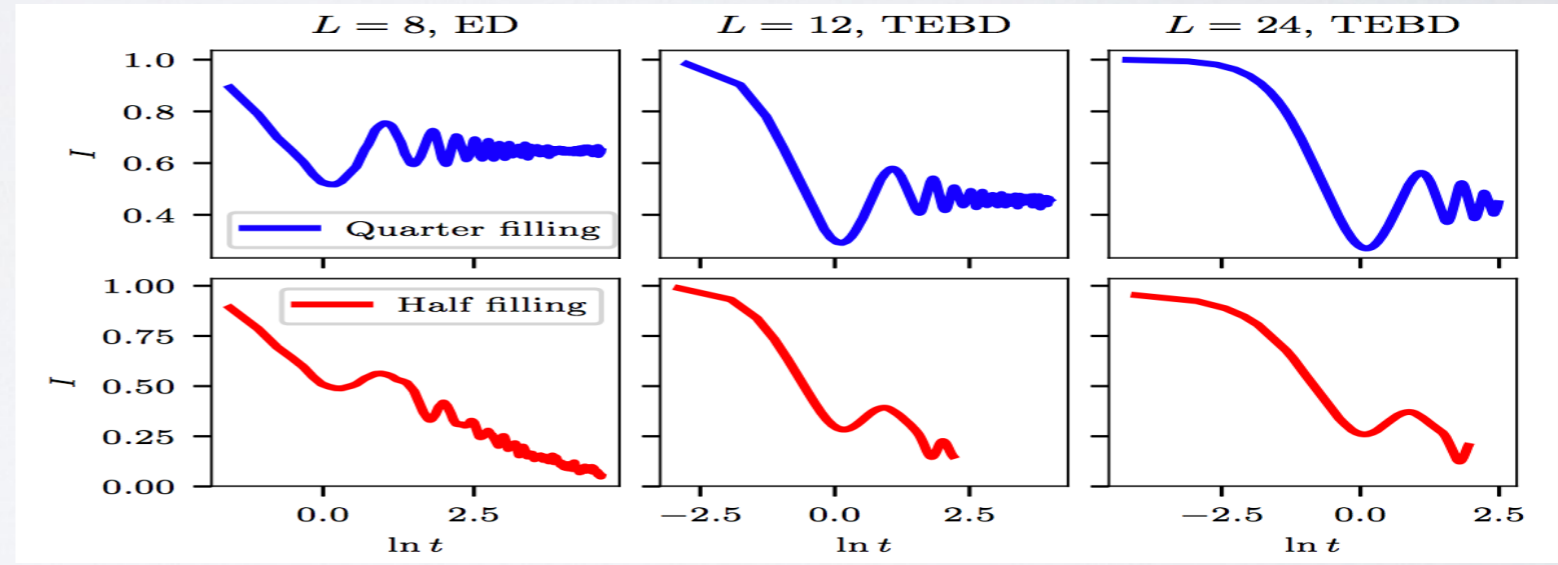
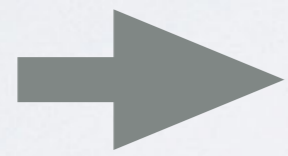


The spin-disordered Hubbard model has intermixed in energy log-law, area-law states. (for small systems)



At least some log-law states out to 400 sites.

Probe-able by dynamics



The SCAEE really improves our ability to do these types of studies.

