BEYOND MANY BODY LOCALIZATION

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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.

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

\[ \eta_- = \sum (-1)^i c_{i\uparrow} c_{i\downarrow} \]
\[ \eta_0 = \frac{1}{2} \left( \hat{N} - L \right) \]
\[ \bar{\eta}^2 = \frac{1}{2} \left( \eta_+ \eta_- + \eta_- \eta_+ \right) + \eta_0^2 \]

\[ [H, \eta_0] = 0 \]
\[ [H, \bar{\eta}^2] = 0 \]

Can prove is at least logarithmically different.

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.
Entanglement

Logarithmically growing entanglement

\[ \text{Entanglement } \propto t^{0.25} \]

Dynamics...

Charge Imbalance

Non-equilibrating charge imbalance

Equilibrating charge imbalance
Conclusions…

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

Probe-able by dynamics

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

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