Entanglement in Featureless Mott Insulators

Brayden Ware

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Outline

Motivation

Featureless insulators

Definition of 'Featureless Insulator'

- Gapped
- Symmetric
- No topological order

- Unique ground state:
  $E_1 - E_0 \geq const.$

Alternate Definition

- Unique ground state on any boundary-less system
- Possibly with 'features' localized to edge of system

Fundamental Result

- Integer charge per unit cell
  - (Lieb, Schultz, Mattis)

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- Gapless modes:
  $E_1 - E_0 \sim \frac{1}{L^\nu}$

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- Spontaneous symmetry breaking: $E_1 - E_0 = 0$

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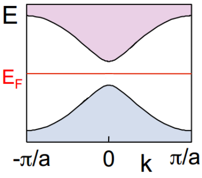
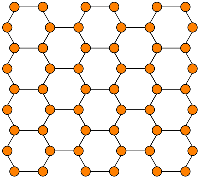
Examples of Featureless Insulators

Classical Insulators

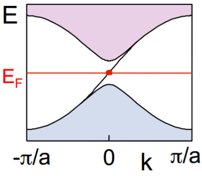


Free fermion band insulator



Bosonic Mott insulator

Topological Insulators



Band insulator with chiral edge [1]

Examples of Featureless Insulators

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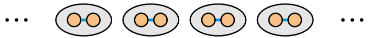
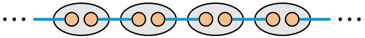


1D Trivial Chain Caricature

Topological Insulators



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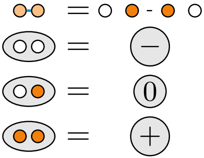
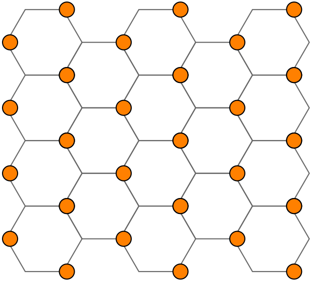


Entangled pairs and projectors for AKLT state

Honeycomb Bosonic Mott Insulators

Does there exist a featureless bosonic insulator with filling m=1 on the honeycomb?



Breaks point group symmetry D_6 to D_3

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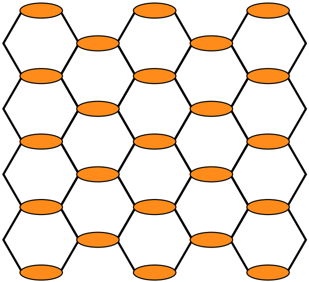

Breaks rotational symmetry

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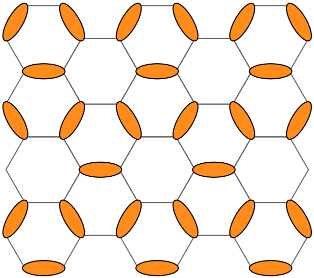
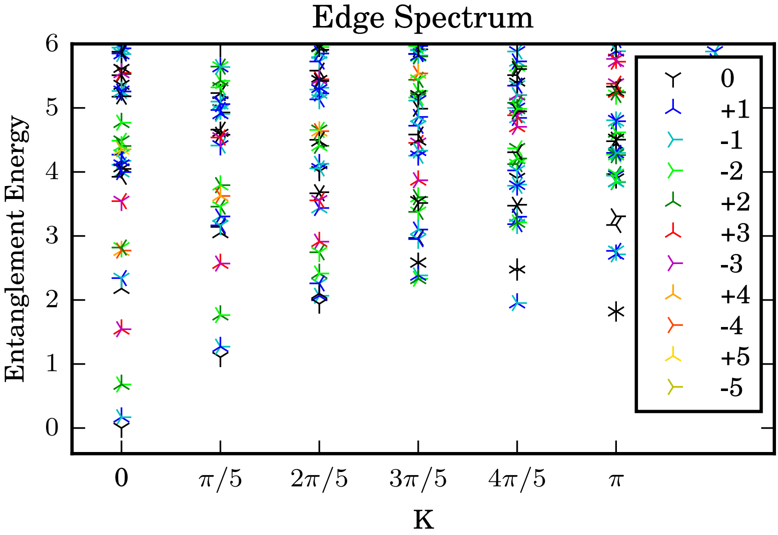


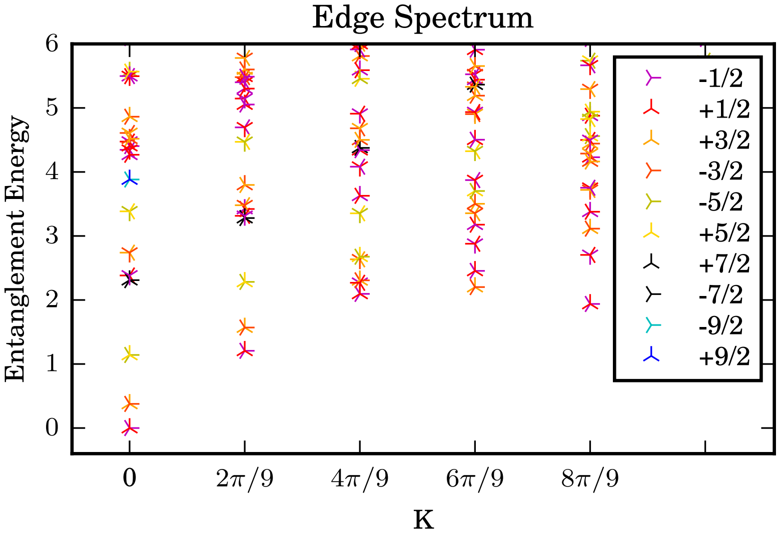
Breaks translationally symmetry, unit cell is 3 times larger

Entanglement Edge of Honeycomb Insulators

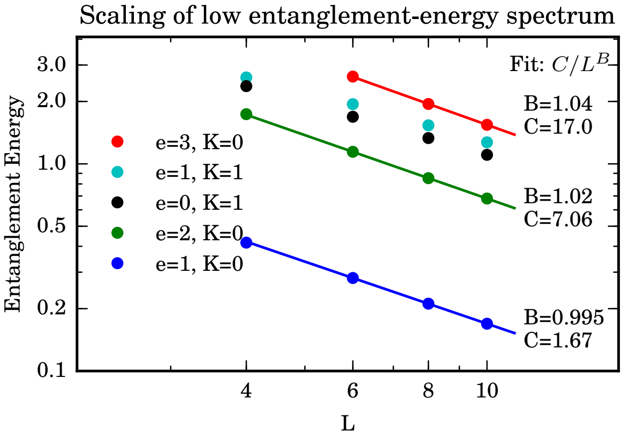
Entanglement Spectrum



Entanglement Spectrum



Finite Size Analysis of Entanglement Spectra



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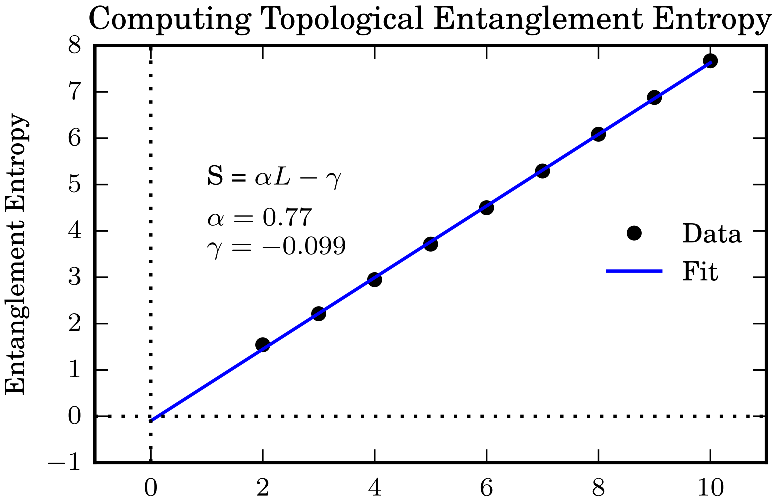
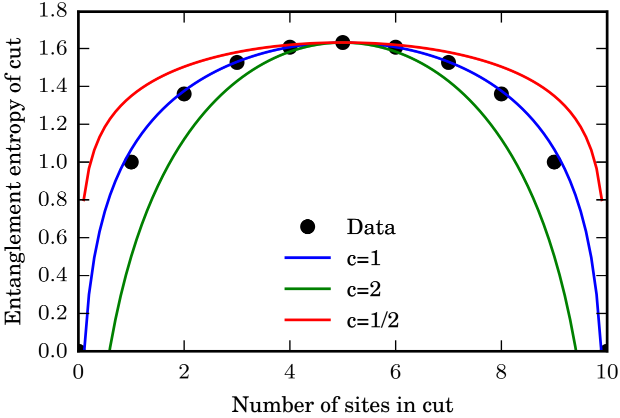


Identification of Edge CFT

Conformal Charge



$$\boxed{c = 1}$$

Identification of Edge CFT

Conformal Weights

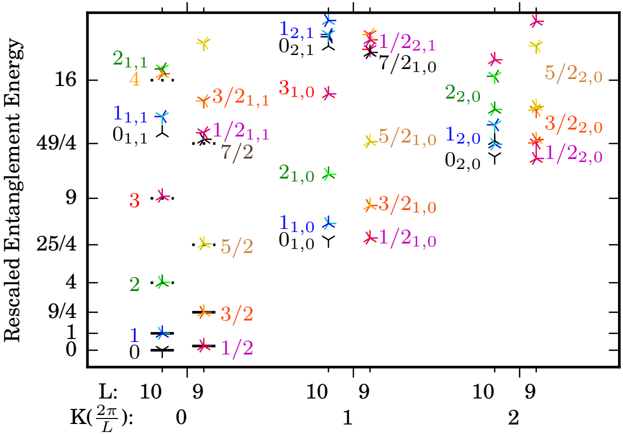
We can match the rescaled entanglement energies to the conformal weights of a free bosonic CFT.

$$\mathbf{P} = \frac{2\pi}{L}(\mathbf{L_0} - \mathbf{\bar{L}_0}) = \frac{2\pi}{L}(em + n - \bar{n})$$
$$\mathbf{H} = \frac{2\pi}{L}(\mathbf{L_0} + \mathbf{\bar{L}_0}) = \frac{2\pi}{L}(\frac{\kappa e^2}{2} + \frac{m^2}{2\kappa} + \frac{n + \bar{n}}{2})$$

$$\boxed{\mathbf{H} \propto e^2 + \frac{m^2}{\kappa^2} + \frac{1}{\kappa}(n + \bar{n})}$$

Identification of Edge CFT

Conformal primary identification in entanglement spectra



Future Work

- Entanglement properties in different geometries
  - Cylinders with different edges
  - Finite size clusters
- Relation to 'MPO Injectivity'
  -
- Numerical testing of parent Hamiltonians
  -

Resources

Hasan, M. Z. and Kane, C. L. (2010). *Colloquium*: Topological insulators. *Reviews of modern physics*, 82(4):3045–3067.

Questions?

Brayden Ware
brayden@physics.ucsb.edu

Bonus slides