Robustness of a topological phase of the cluster Ising model against random interactions

PSB-10

Takumi Ohta, Keisuke Totsuka

YITP, Kyoto Univ.

One-dimensional cluster Ising model

$$H = -\sum_i \sigma^x_{i-1}\sigma^z_i\sigma^x_{i+1} + \lambda_y \sum_i \sigma^y_i\sigma^y_{i+1} + \lambda_1 \sum_i \sigma^y_{i-1}\sigma^z_i\sigma^y_{i+1}$$

(XZX in short)

Motivations

☆ entanglement properties of topological phases
☆ effects of randomness in interactions

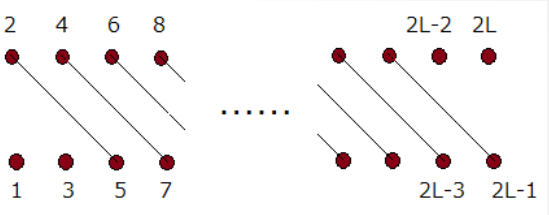
Interaction effects

$$H = -\sum_i \sigma^x_{i-1}\sigma^z_i\sigma^x_{i+1} + \lambda_y \sum_i \sigma^y_i \sigma^y_{i+1}$$

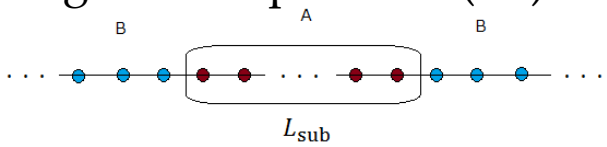
- ground state (cluster phase, C phase)
- Majorana fermion representation

Two free Majorana fermion at each edge

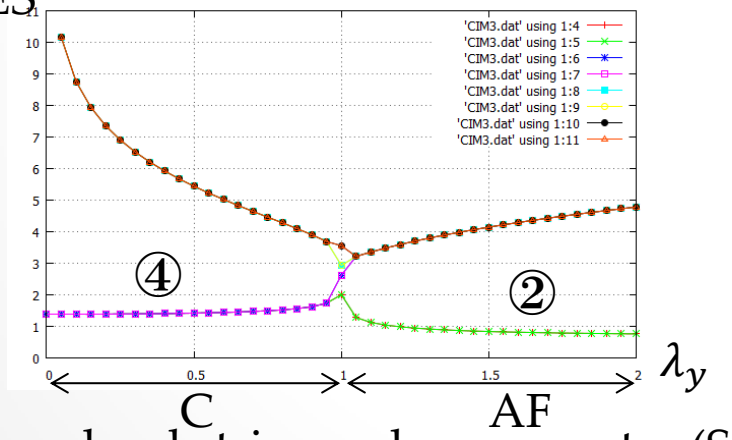
⇒ ground state is 2×2-fold degeneracy



- entanglement spectrum (ES)

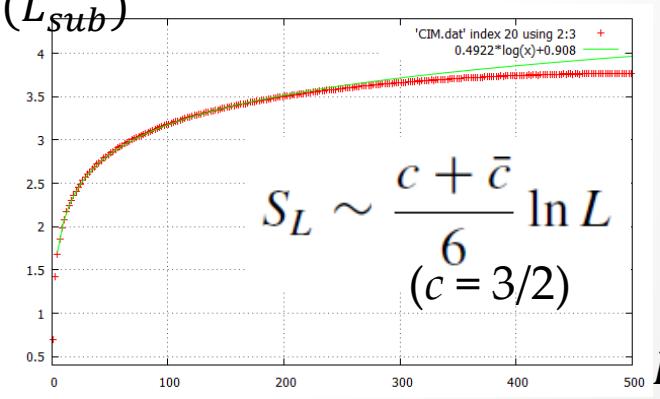


ES



- entanglement entropy at critical point @ $\lambda_y = 1$

$S_{EE}(L_{sub})$



- non-local string order parameter (SO)

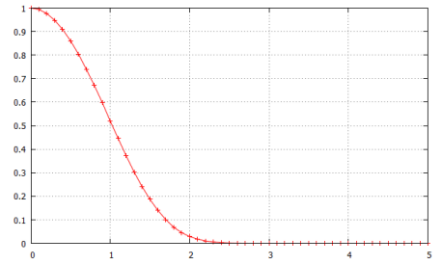
$$O_z = \lim_{N\to\infty} (-1)^N \left\langle \sigma^x_1\sigma^y_2 \left(\prod_{k=3}^{N-2} \sigma^z_k\right) \sigma^y_{N-1}\sigma^x_N \right\rangle$$

Effects of randomness

$$H = -\sum_i \sigma_{i-1}^x \sigma_i^z \sigma_{i+1}^x + \lambda_1 \sum_i \sigma_{i-1}^y \sigma_i^z \sigma_{i+1}^y$$

$\lambda_{1,i} \in [0, W]$ i : site number

Random averaged SO

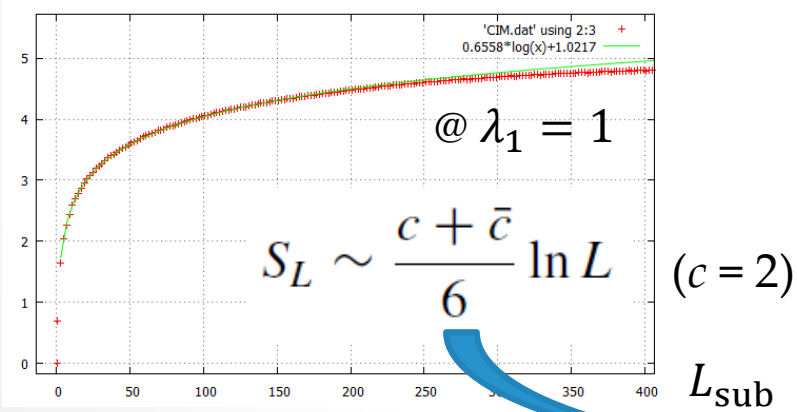


W

- entanglement entropy at critical point

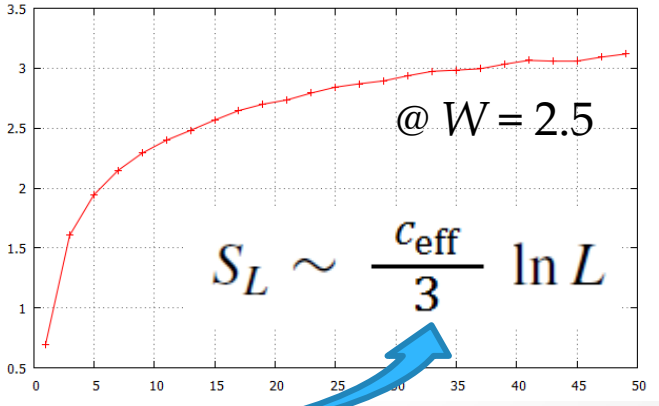
1. Clean case

$S_{EE}(L_{sub})$



2. Random case

$S_{EE}(L_{sub})$



λ_1 random