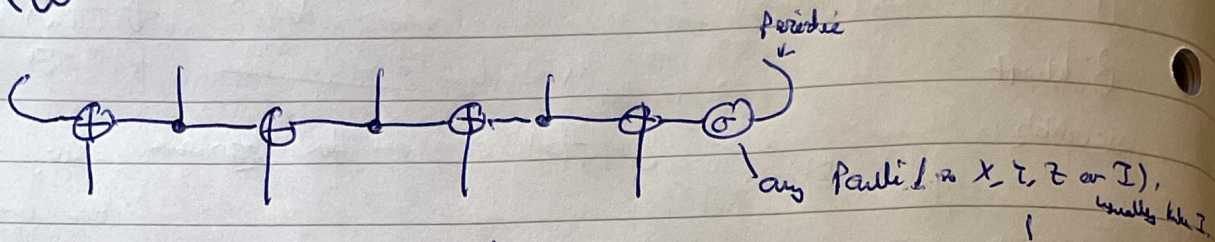


KW

MPO  
dephaser.



where

$$\text{leg} = -Z \text{ leg} = -Z \text{ leg} = \text{leg} = \text{leg}$$

$= |000\rangle + |111\rangle$

$$\text{leg} = -X \text{ leg} = -X \text{ leg} = \text{leg}$$

$= |111\rangle + |---\rangle$

also

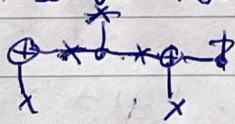
$$-X \text{ leg} = \text{leg}, \quad -Z \text{ leg} = \text{leg}$$

can see by these also that

$$\text{leg} = \text{leg}$$

is symmetric above &  $X^{\otimes N}$ , below &  $Z^{\otimes N}$  (if  $\sigma = I$ )

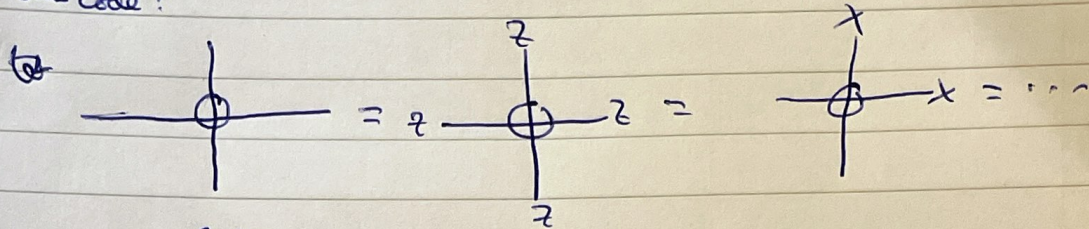
also, see that rule X on top pulls through to two adjacent X on bottom:



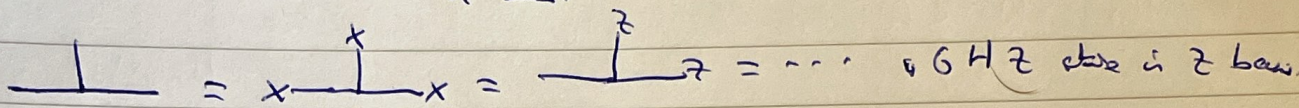
similarly two adjacent Z gates on top pull through to two adjacent Z on bottom.



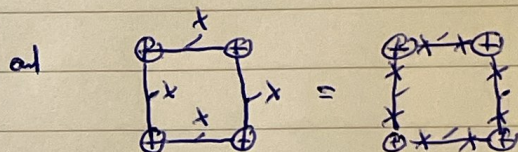
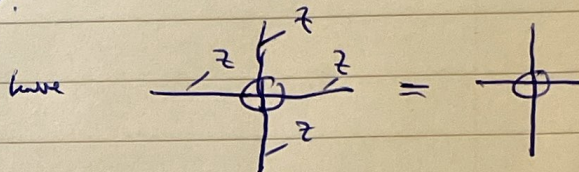
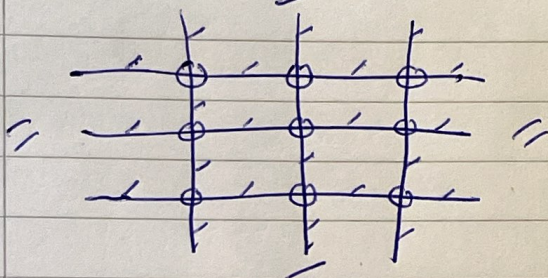
Toric code:



is GHZ state in X basis.



Toric code wave:  $|\psi\rangle =$  identity // all /.



So  $\bigotimes_{i \in V} Z_i |\psi\rangle = |\psi\rangle$

for vertex  $v$

$|\psi\rangle$  is PEPS with bond dimension 2.

and  $\bigotimes_{i \in P} X_i |\psi\rangle = |\psi\rangle$  for plaquette  $p$ .

So Hamiltonian is  $H = - \sum_v \bigotimes_{i \in V} Z_i - \sum_p \bigotimes_{i \in P} X_i$

$|\psi\rangle$  is GS of  $H$  as it is GS of each term.

Have  $\prod_v \bigotimes_{i \in V} Z_i = I = \prod_p \bigotimes_{i \in P} X_i = I$ .