http://www.comlab.ox.ac.uk/activities/quantum/course/

Tue 1 June 2010

– what's next? (S. Clark)

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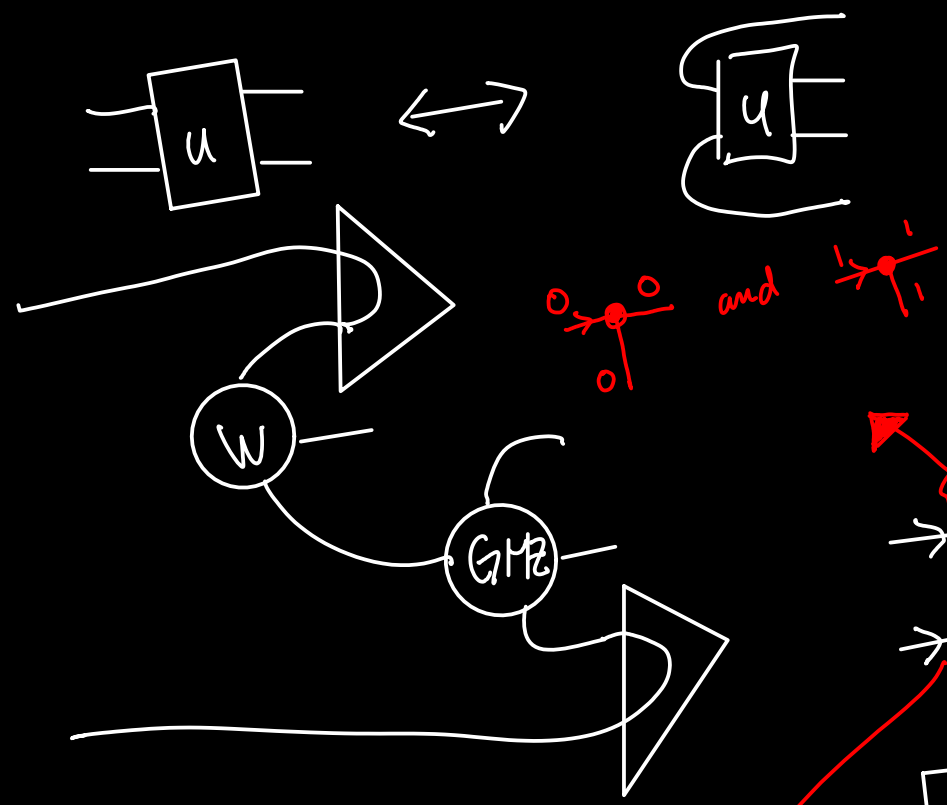
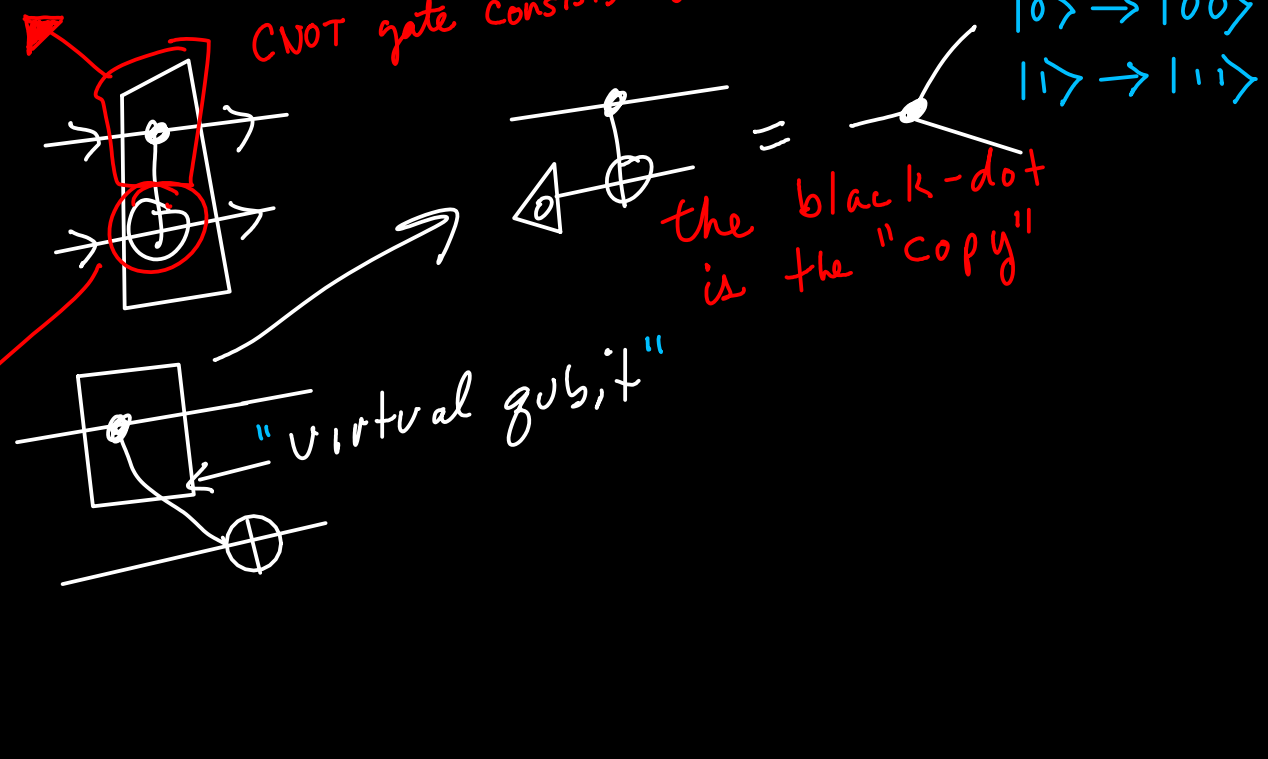
maps ⟷ states

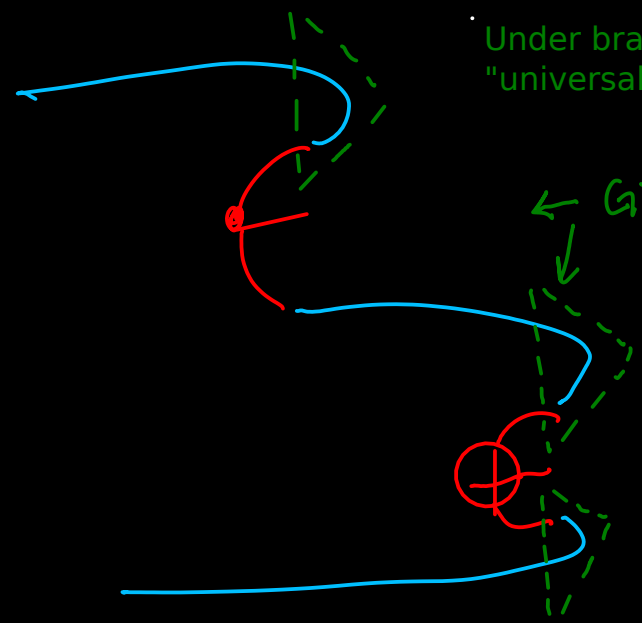


$$M = \sum_i |ii\rangle$$

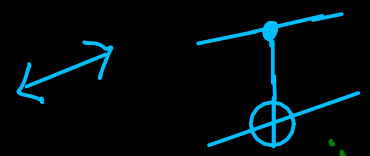
$$\epsilon = \sum_i \langle i| \langle i|$$



Under bra-ket duality, we can now think of "universal sets of states", as compared to "universal sets of gates", in the standard circuit model



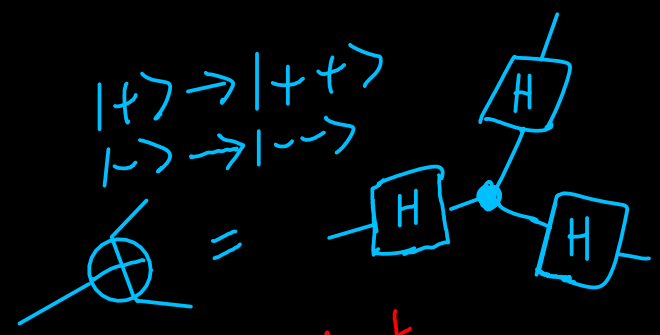
Given these two GHZ-class states, we can "bend wires" to construct a logical CNOT-gate.



Each sub-dot is again a 0/1 or +/- copy machine

$|+\rangle \to |++\rangle$

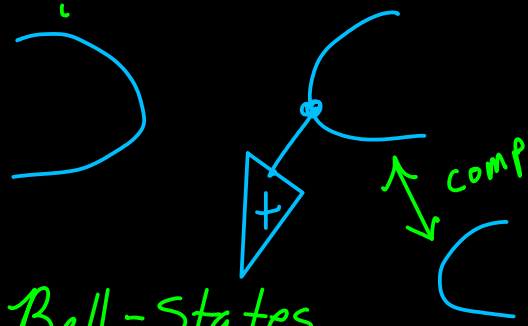
$|-\rangle \to |--\rangle$

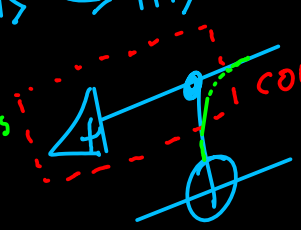


$\epsilon = \sum_i \langle ii|$ $\quad \eta = \sum_i |ii\rangle$

$|0\rangle \to |00\rangle$

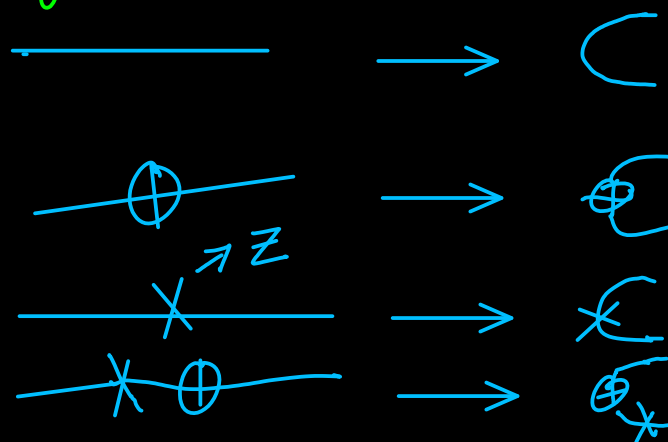
$|1\rangle \to |111\rangle$





compact structure for black-dot is +.

Diagramatic Bell-States



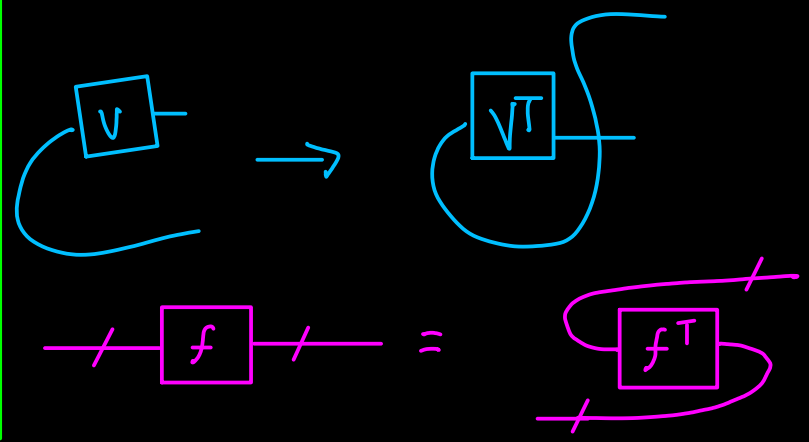
$|00\rangle + |11\rangle$

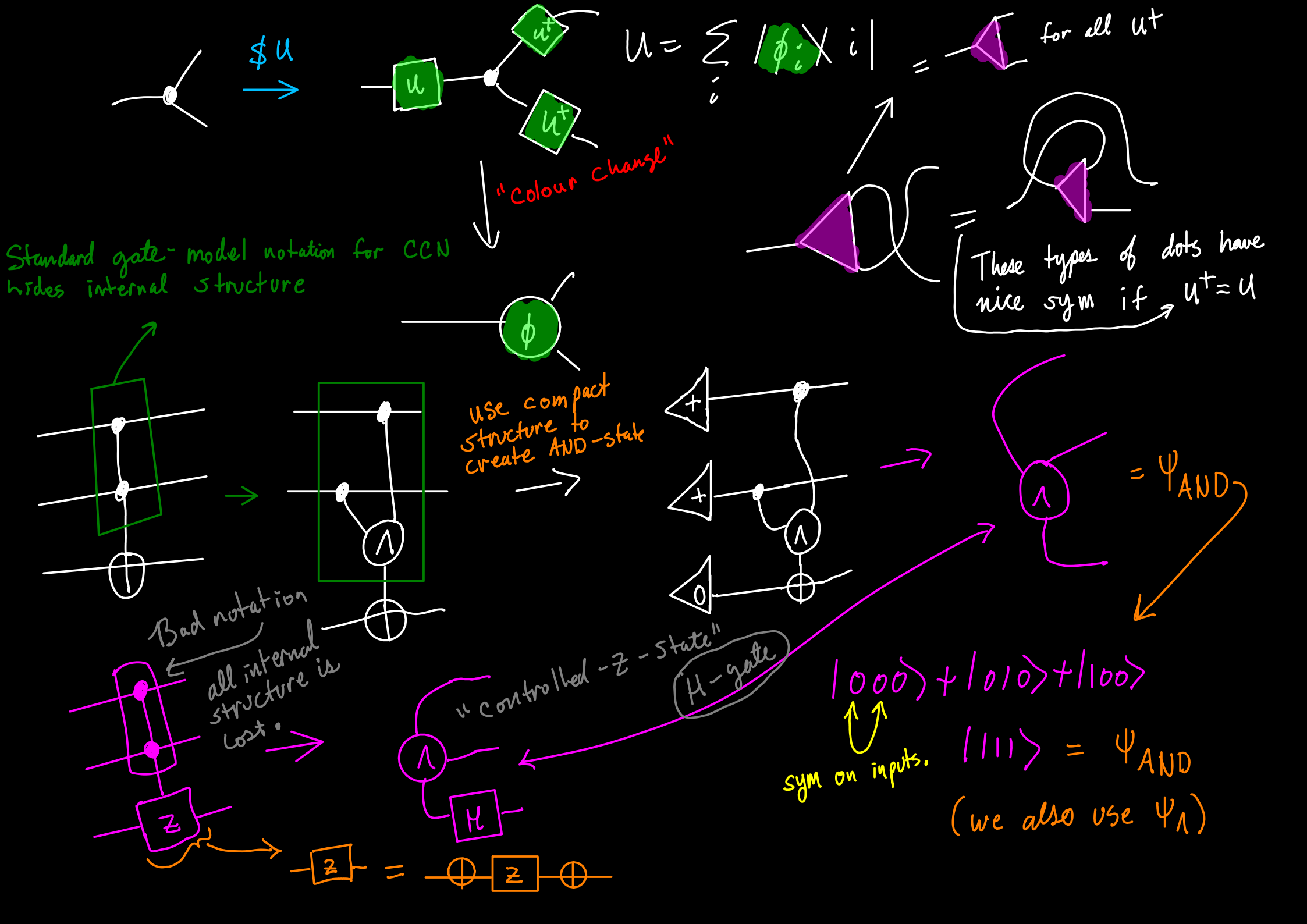
$|01\rangle + |10\rangle$

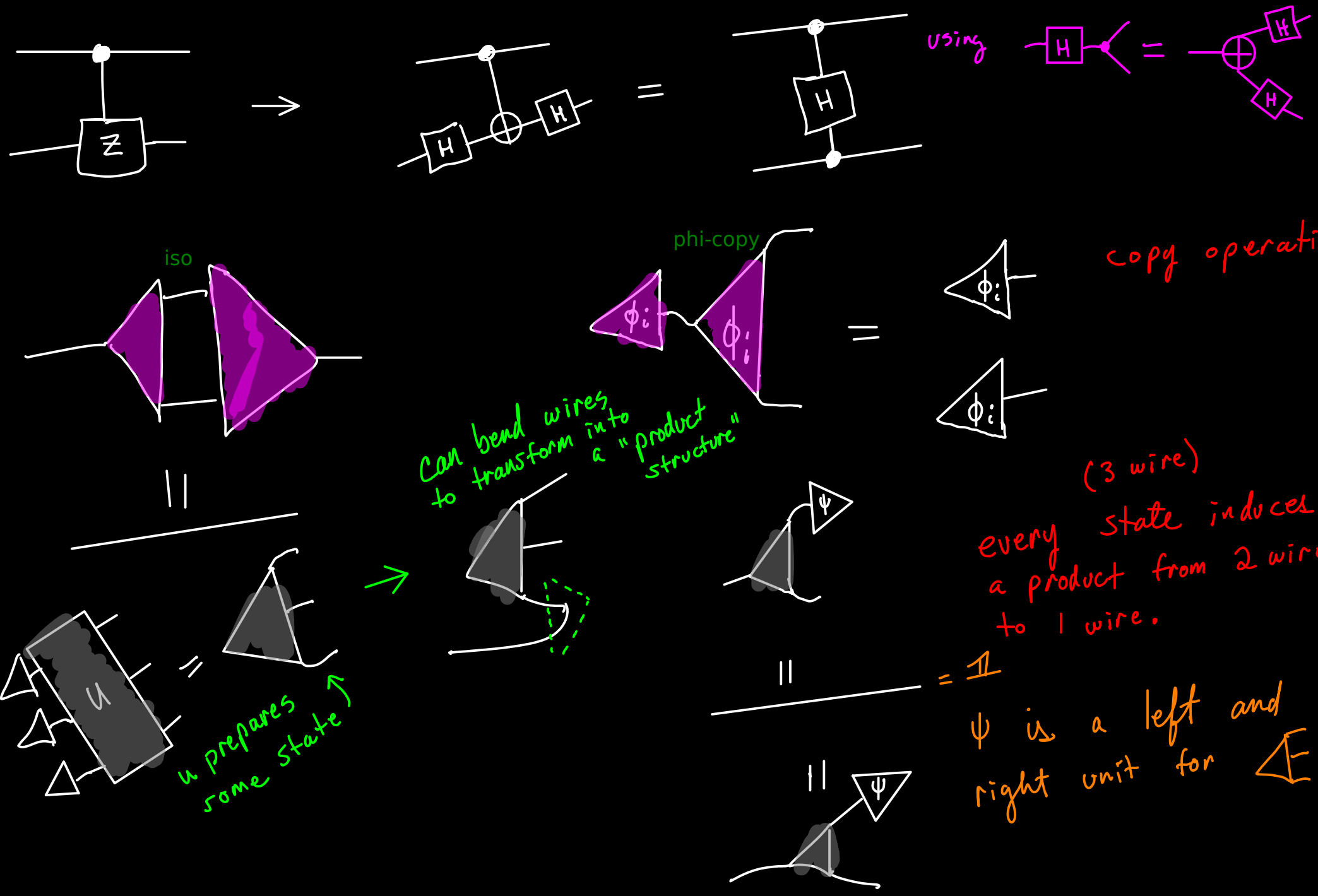
$|00\rangle - |11\rangle$

$|01\rangle - |10\rangle$

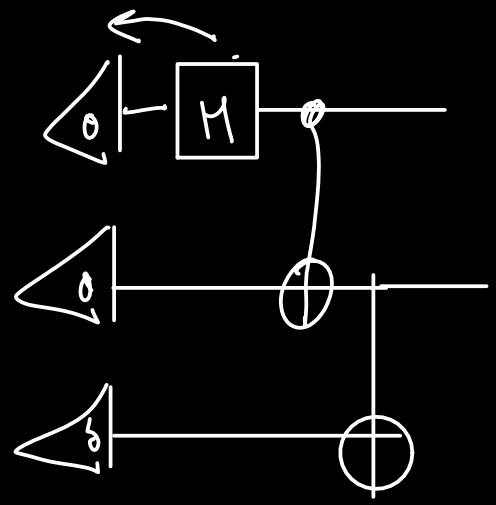
Bending wires to take transpose

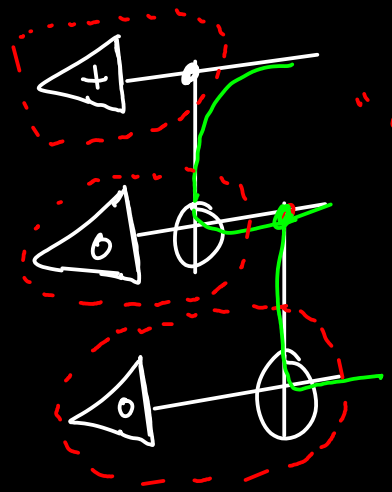



$U
U
U+
U+
"colour change"
U = Σ_i |φ_i⟩⟨i|
= for all U+
These types of dots have nice sym if U+ = U
Standard gate-model notation for CCN hides internal structure
φ
use compact structure to create AND-state
+
+
0
Λ
= ψ_AND
Bad notation
all internal structure is lost.
Z
"controlled-Z-state"
H-gate
H
|000⟩ + |010⟩ + |100⟩
sym on inputs.
|111⟩ = ψ_AND
(we also use ψ_Λ)

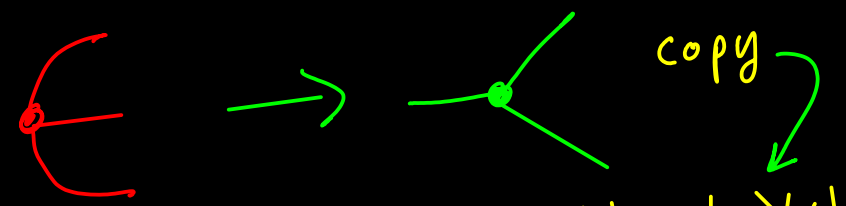


States induce products, and products have units
this unit is some state psi





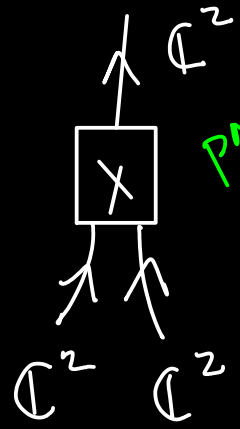
"compactness"



GHZ-state

$|000\rangle + |111\rangle$

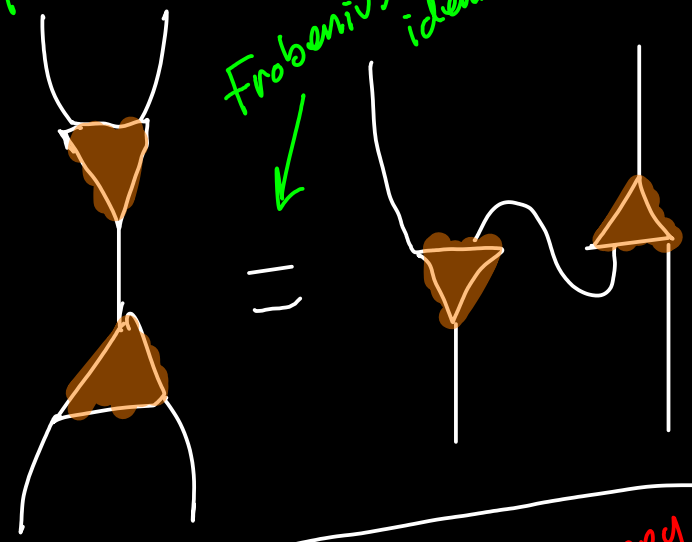
$|00\rangle\langle 0| + |11\rangle\langle 11|$

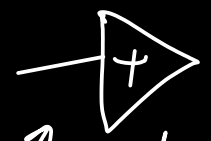


products can be written as string diagrams

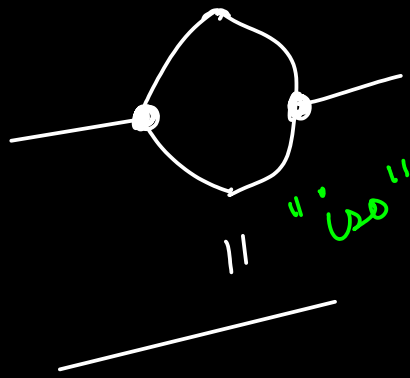
"GHZ-product"

The phi-dots we consider are Frobenius with units U|+>, etc.



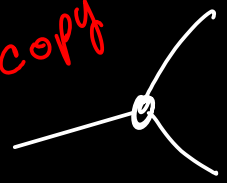


unit for copy



= "iso"

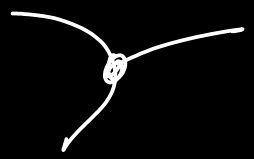
copy



+

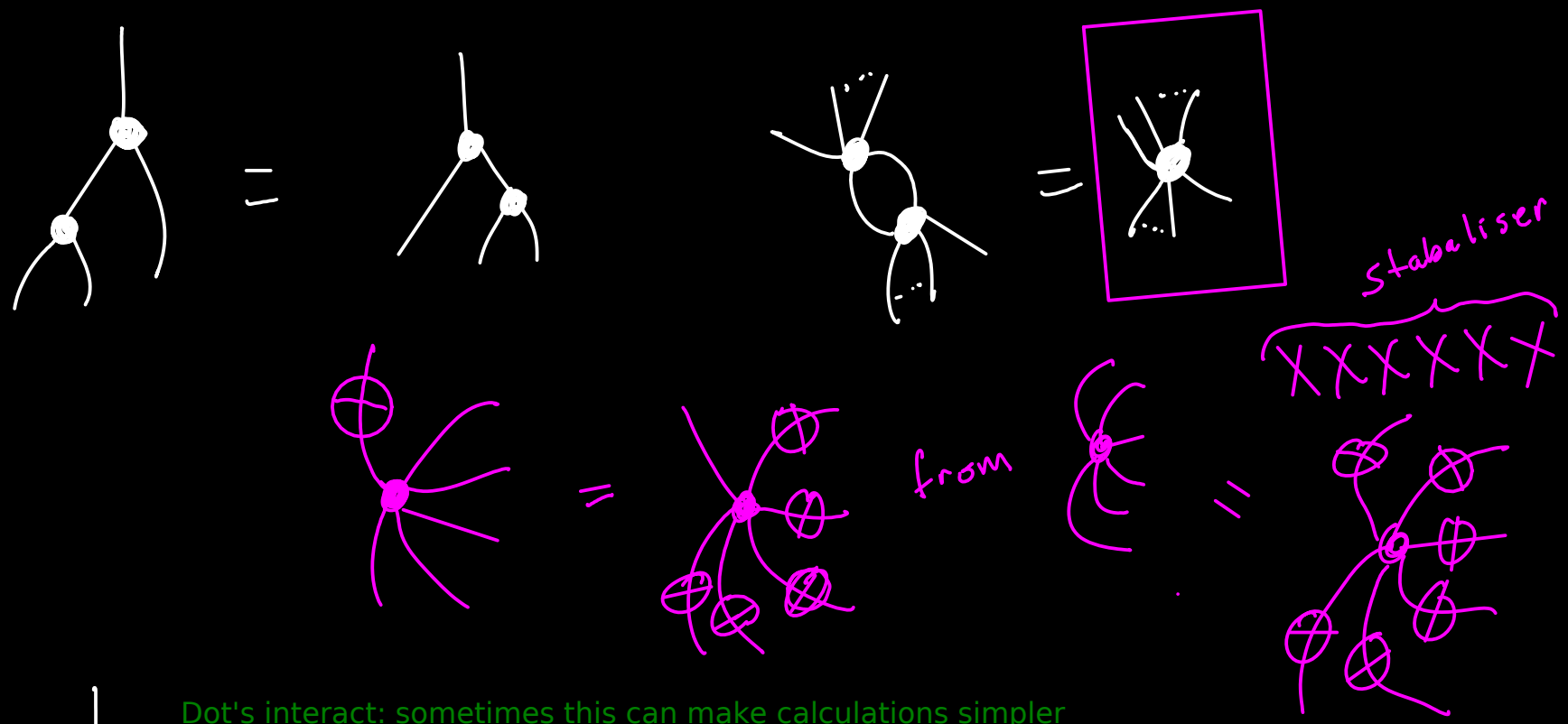
dual under the dagger

co-copy

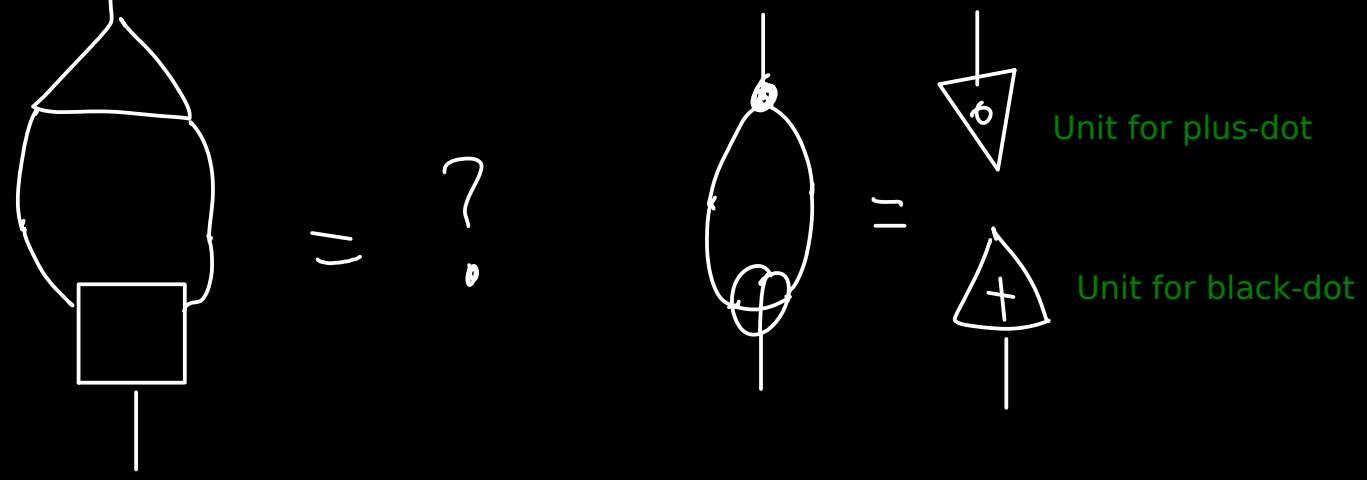


$(\mathcal{H}, \otimes, 1)$

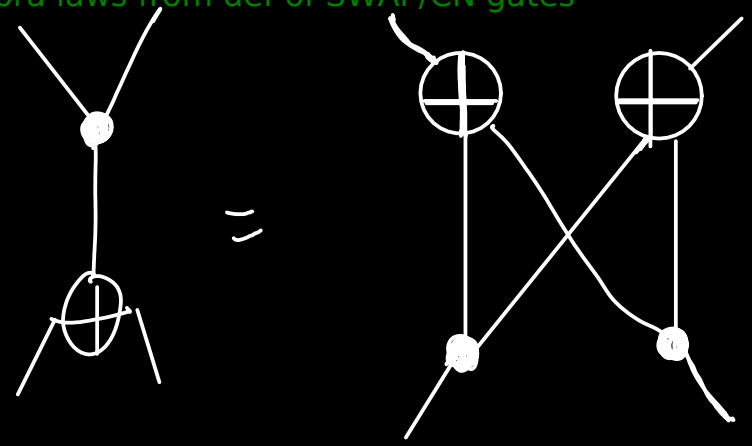
The monoid of Hilbert space

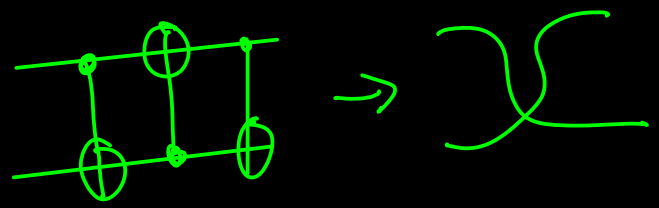


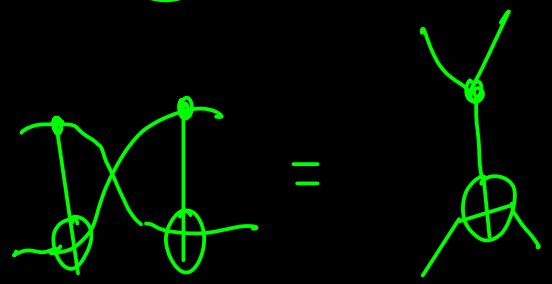
Dot's interact: sometimes this can make calculations simpler

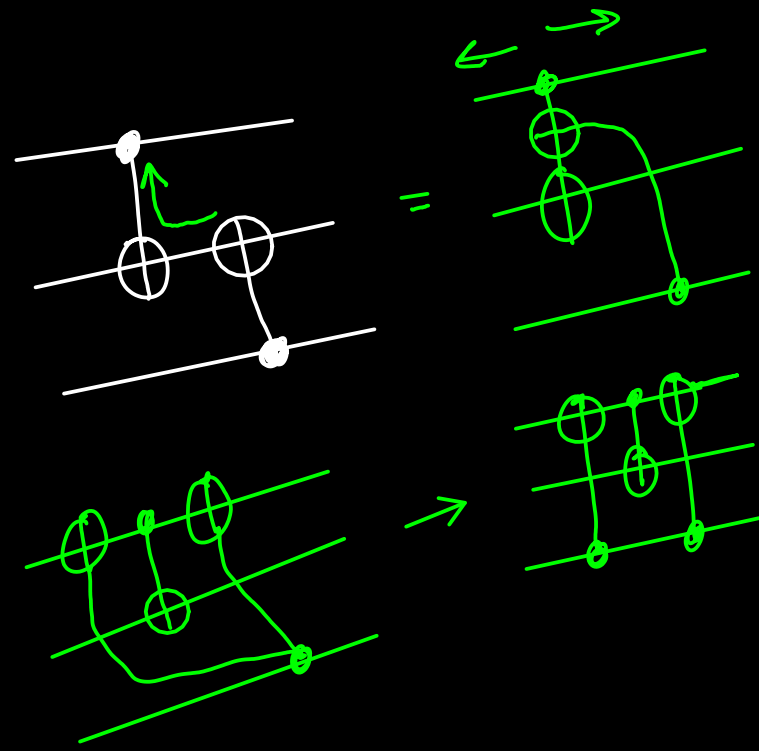


Bi-algebra laws from def of SWAP/CN gates



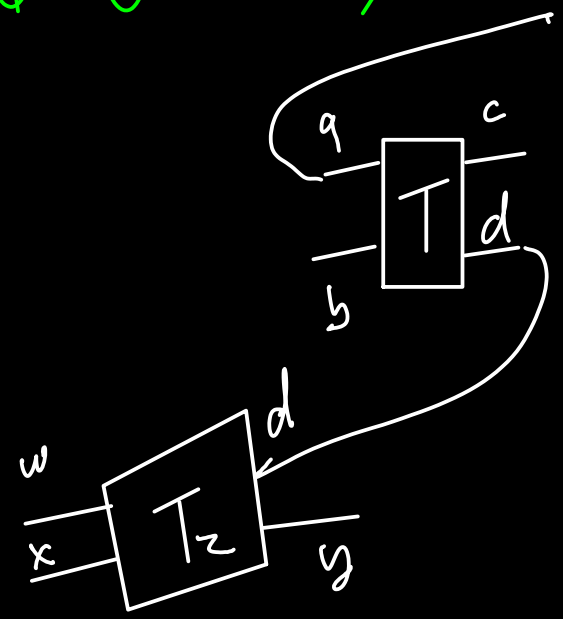


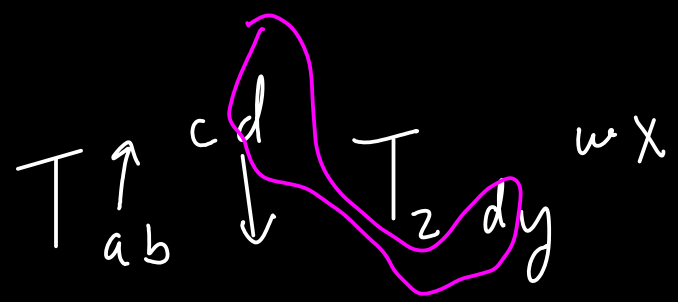




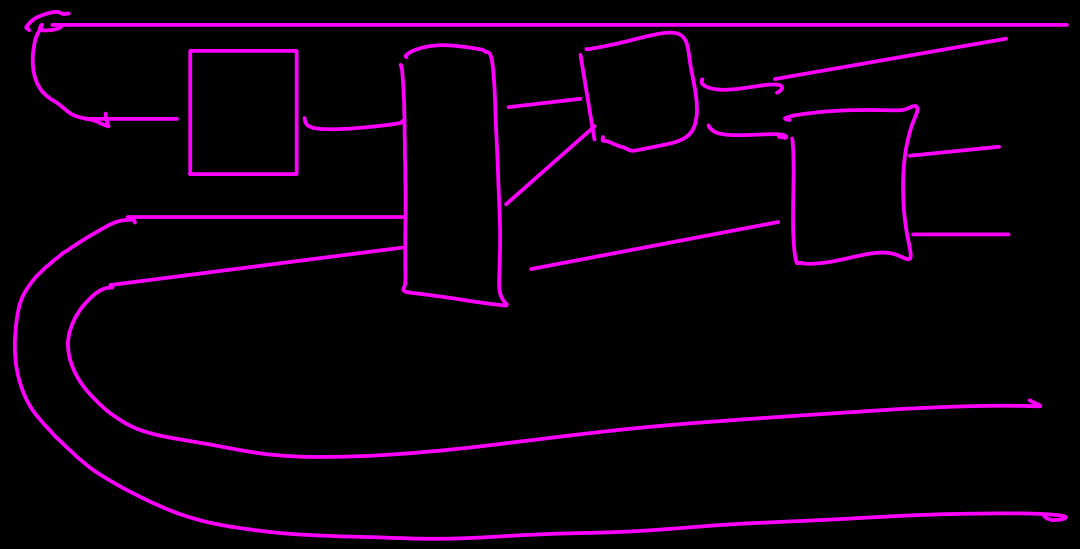
This new rule is GATE-COPY

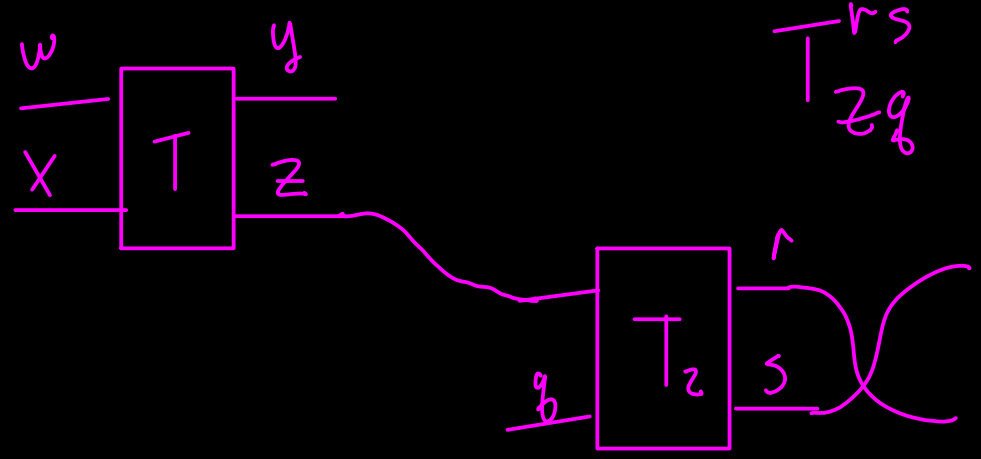
Works for both controlls and targets



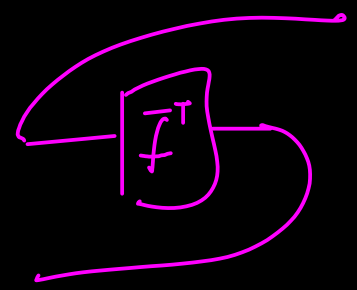


We have been considering toy models and talking about Categorical Quantum Circuits, but really we have been talking about Tensors at the same time!





T_{zq}^{rs}



$T_{wx}^{yz} \, T_{zq}^{rs}$