Title: Quantum foundations minus probability theory

Date: May 05, 2009 04:00 PM

URL: http://pirsa.org/09050010

Abstract: Researchers in quantum foundations claim (D'Ariano, Fuchs, ...):

Quantum = probability theory + x

and hence:

x = Quantum - probability theory

Guided by the metaphorical analogy:

probability theory / x = flesh / bones

we introduce a notion of quantum measurement within x, which, when flesing it with Hilbert spaces, provides orthodox quantum mechanical probability calculus.

How much QM can we recover without a priori assuming instrumentalist concepts such as measurement and probability but just ‘compoundness’?

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$$\text{quantum} = \text{probability theory} + x$$

and hence:

$$x = \text{quantum} - \text{probability theory}$$

Guided by the metaphorical analogy:

$$\frac{\text{flesh}}{\text{bones}} = \frac{\text{probability}}{\text{x}}$$

We start from x, **(i)** extract (the skeleton of) classicality from it, **(ii)** extract probability from it, **(iii)** extract quantum measurements from it, and **(iv)** describe quantum-classical interaction within it. Flesing it with **FHilb** yields QM probabilistic calculus.

Tue 4:09:01 pm

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Is there a conceptual picture behind this game?

Tue 4:09:17 p

Classicizing quantumness

arXiv:0904.1997

Somewhere out there, in ontic reality, is a world.

That world is called the 'quantum universe'.

We would like to probe that world.

This requires 'classical interfaces'.

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We refer to 'identifiable parts' of it as systems,

and to their 'identifiable changes' as processes.

To joint parts and processes we refer by $-\otimes-$,[1]

and to consecutive processes by $-\circ-$.[1]

[1] One could either think of this as structure of the interface or as structure of the system.

Tue 4:11:10 pm (100%)

Our language := system, process, $\otimes$, $\circ$

(100%) Tue 4:11:13 pr

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Tue 4:11:18 pm (100%)

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What does such a rigid stance buy us?

Why does a tiger have stripes and a lion doesn't?

Tue 4:13:20 pr

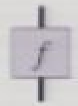
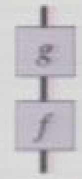
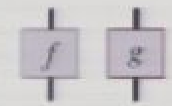
Why does a tiger have stripes and a lion doesn't?

prey $\otimes$ predator $\otimes$ environment

hunt

dead prey $\otimes$ eating predator

Processes and their compositions:

$f \equiv$  $\quad 1_A \equiv$ $\quad g \circ f \equiv$  $\quad f \otimes g \equiv$ 

States and effects for systems, and resulting numbers:

$\mathrm{I} \xrightarrow{\psi} A \equiv$  $\quad A \xrightarrow{\pi} \mathrm{I} \equiv$  $\quad \mathrm{I} \xrightarrow{\pi} \mathrm{I} \equiv$ 

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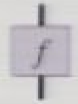
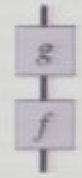
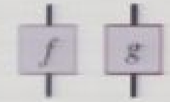
$f \equiv$  $1_A \equiv$ | $g \circ f \equiv$  $f \otimes g \equiv$ 

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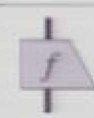
Upside-down flipping i.e. adjoints:

pics:		
cats:	$A \xrightarrow{f} B$	$B \xrightarrow{f^\dagger} A$
FHilb:	linear map	its adjoint

CLASSICAL INTERFACES

An *classical interface* is:

$A \xrightarrow{\delta} A \otimes A =$ 

$A \xrightarrow{\varepsilon} \mathrm{I} =$ 

such that:

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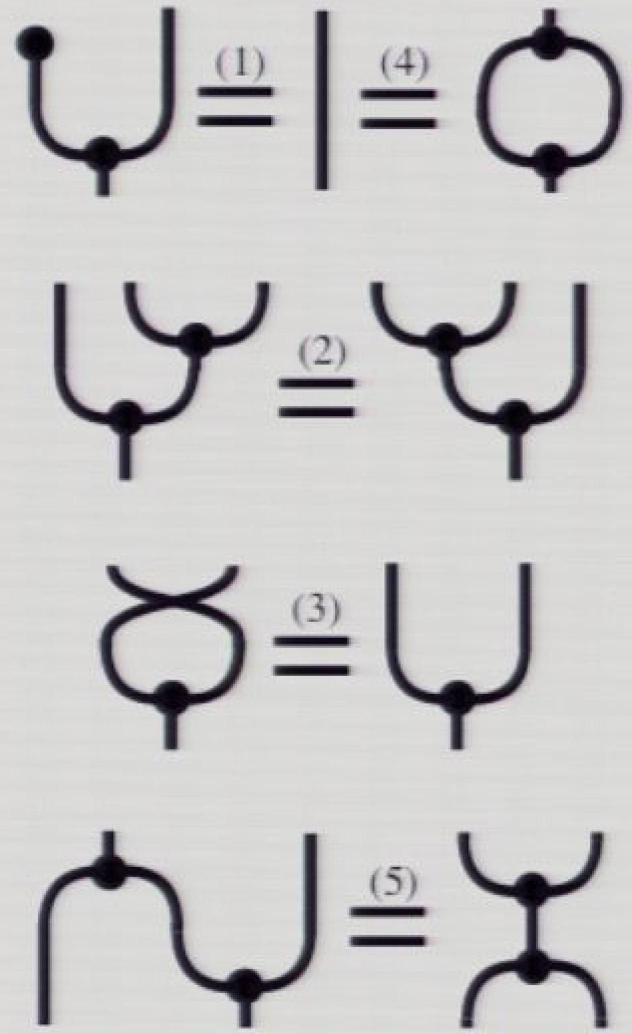

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In **FHilb** we can encode all ONBs as

$$\delta : \mathcal{H} \to \mathcal{H} \otimes \mathcal{H} :: |i\rangle \mapsto |ii\rangle \qquad \varepsilon : \mathcal{H} \to \mathbb{C} :: |i\rangle \mapsto 1\,.$$

Thm. Interfaces (δ, ε) in **FHilb** exactly correspond with orthonormal bases on the underlying Hilbert space.

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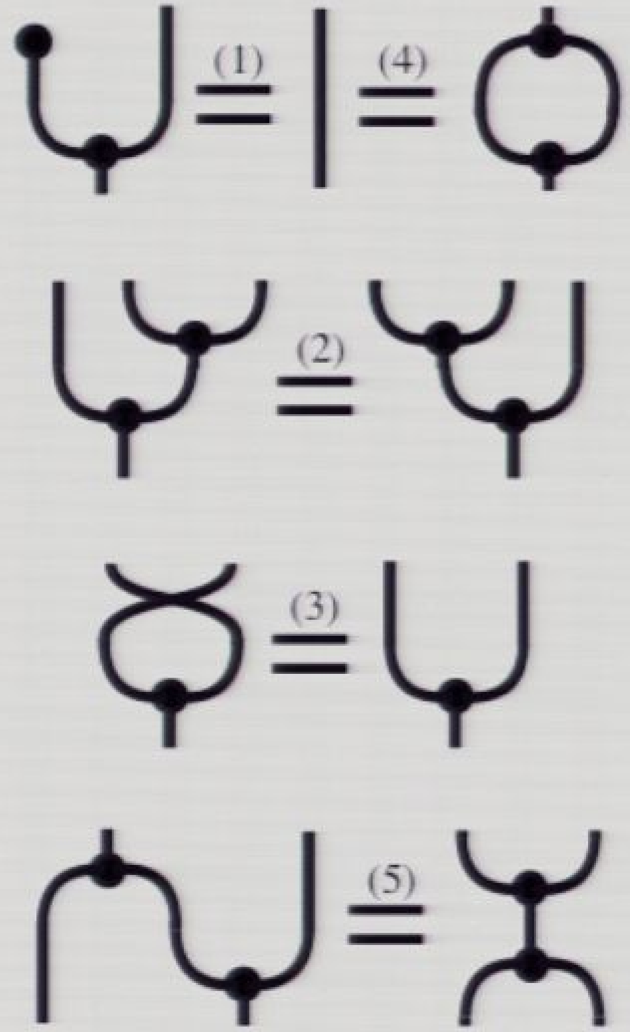

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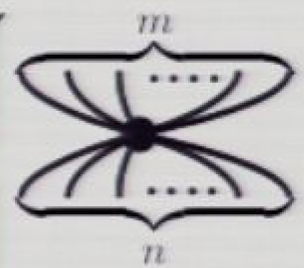
$\Bigg\{$ 

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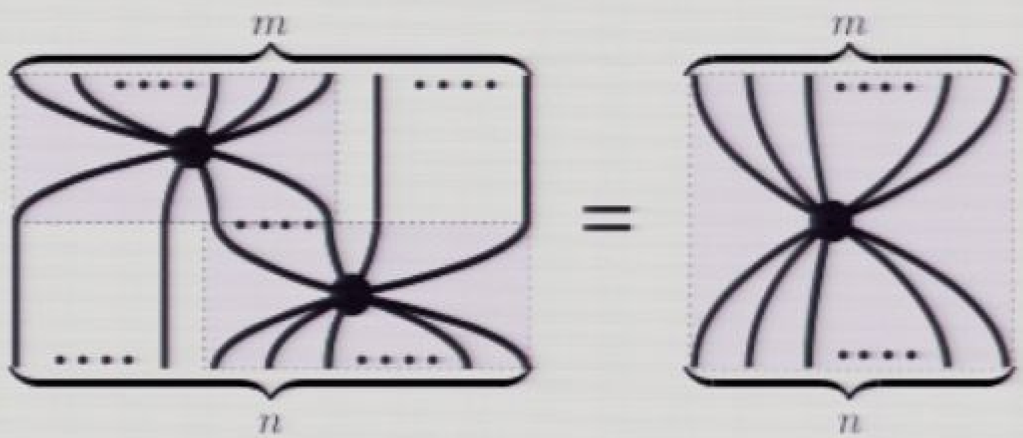

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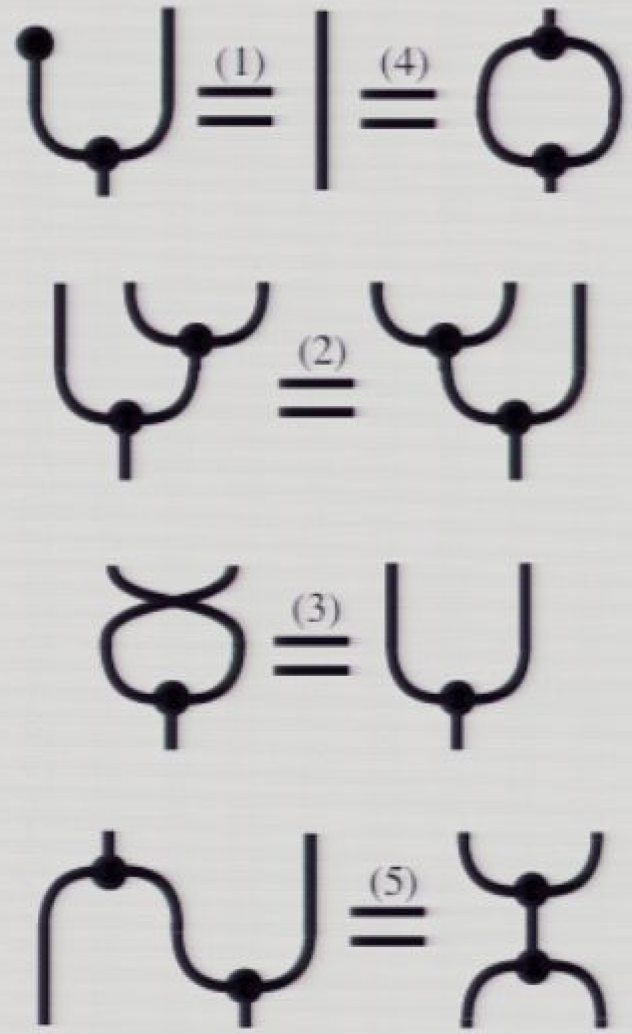

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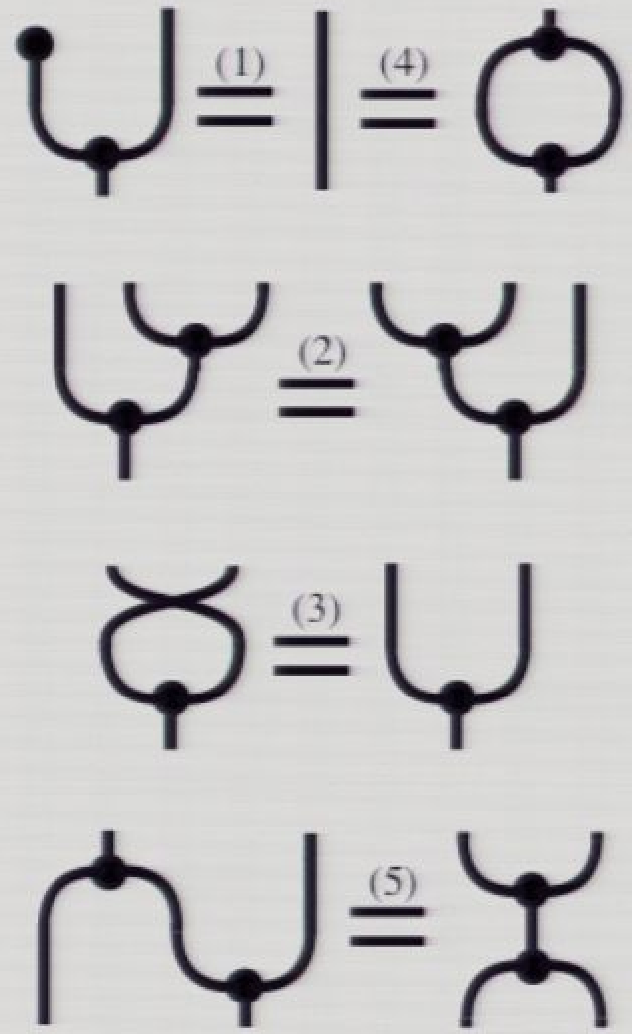

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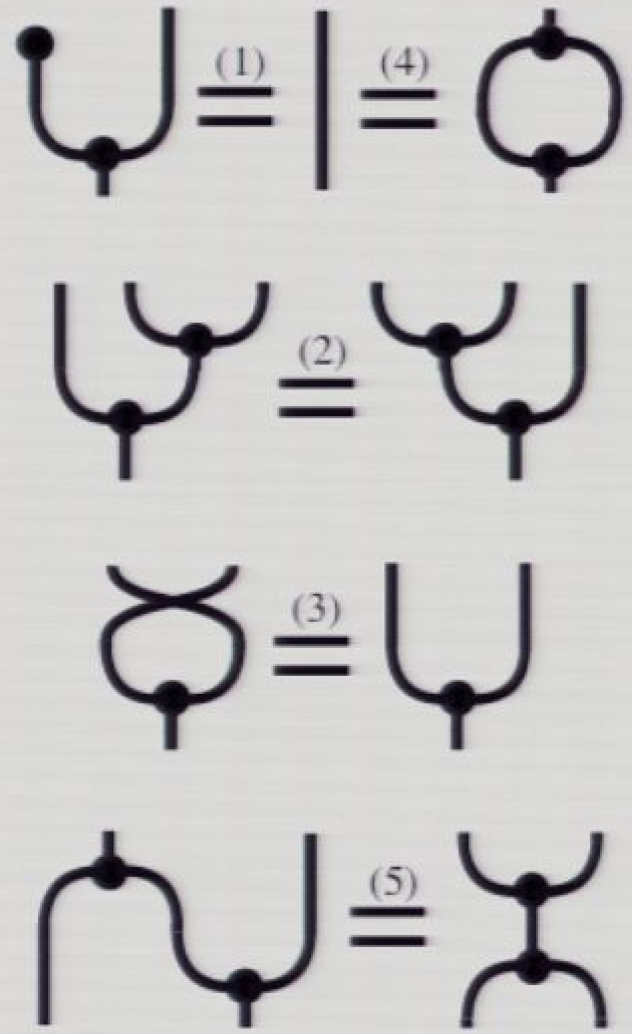

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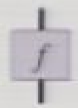
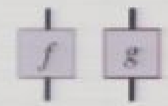
$f \equiv$  $\quad 1_A \equiv$ $\quad g \circ f \equiv$  $\quad f \otimes g \equiv$ 

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Why does a tiger have stripes and a lion doesn't?

prey $\otimes$ predator $\otimes$ environment

↓ hunt

dead prey $\otimes$ eating predator

(100%) Tue 4:31:58 pr

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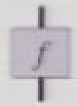
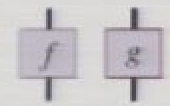
$f \equiv$  $1_A \equiv$ $g \circ f \equiv$  $f \otimes g \equiv$ 

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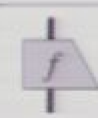
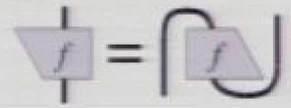
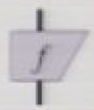
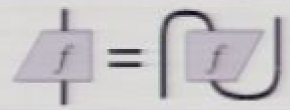
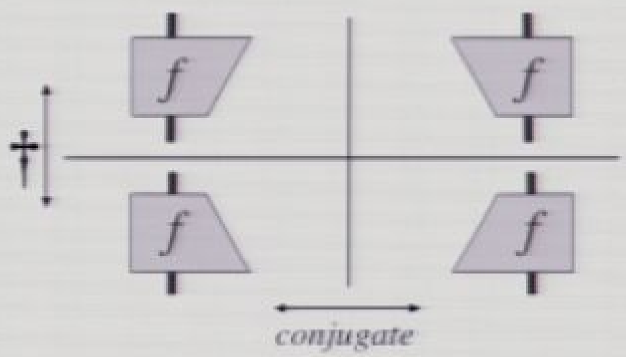
pics:		
cats:	$A \xrightarrow{f} B$	$B \xrightarrow{f^\dagger} A$
FHilb:	linear map	its adjoint

pics:		
cats:	$A \xrightarrow{f} B$	$f^\ddagger = A \xrightarrow{(\epsilon_A \otimes 1_B)\circ(1_A \otimes f^\dagger \otimes 1_B)\circ(1_A \otimes \eta_B)} B$
FHilb:	linear map	its conjugate

pics:		
cats:	$A \xrightarrow{f} B$	$f^* = B \xrightarrow{(\epsilon_B \otimes 1_A)\circ(1_B \otimes f \otimes 1_A)\circ(1_B \otimes \eta_A)} A$
FHilb:	linear map	its transposed



(100%) Tue 4:32:04 pr

MEASUREMENT $\leftrightarrow$ NO-SIGNALING

Tue 4:32:08 pr

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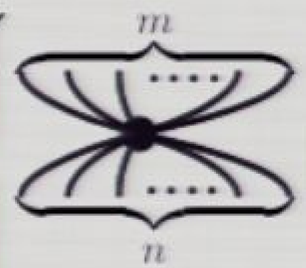
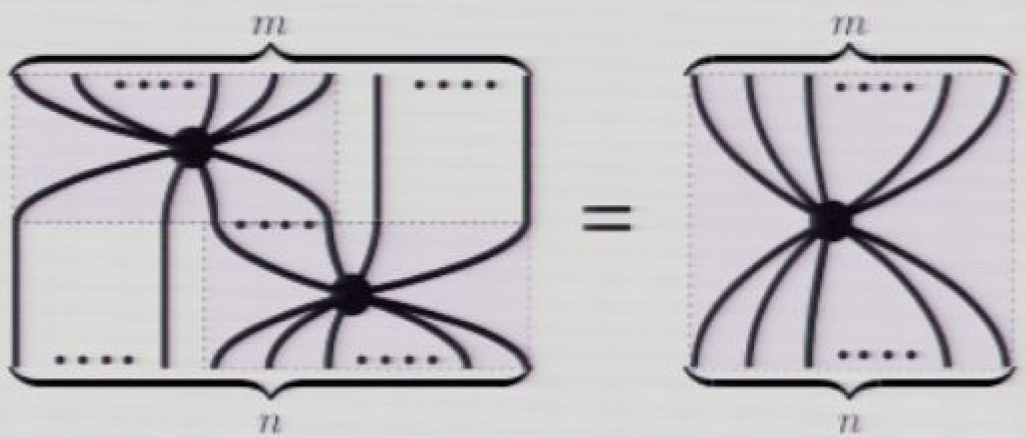
{ 

| $n, m \in \mathbb{N}$ }

invariant under flipping and swapping, and such that:



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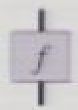
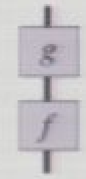
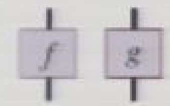
$f \equiv$  $1_A \equiv$ $g \circ f \equiv$  $f \otimes g \equiv$ 

States and effects for systems, and resulting numbers:

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Upside-down flipping i.e. adjoints:

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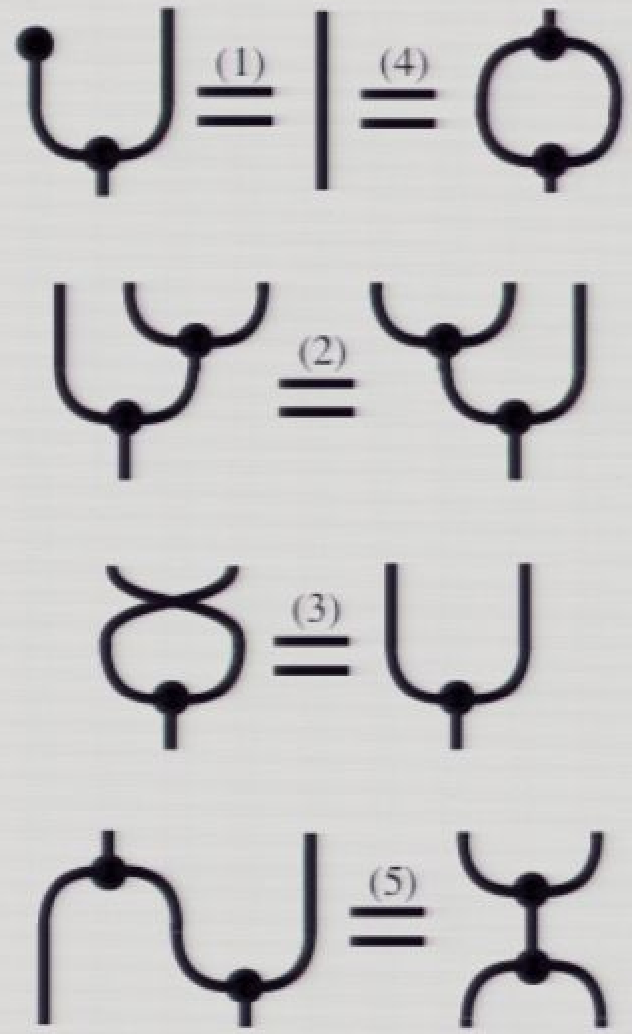

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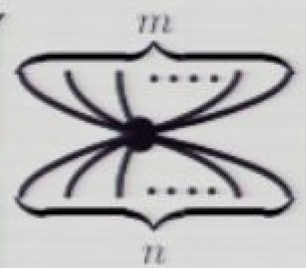

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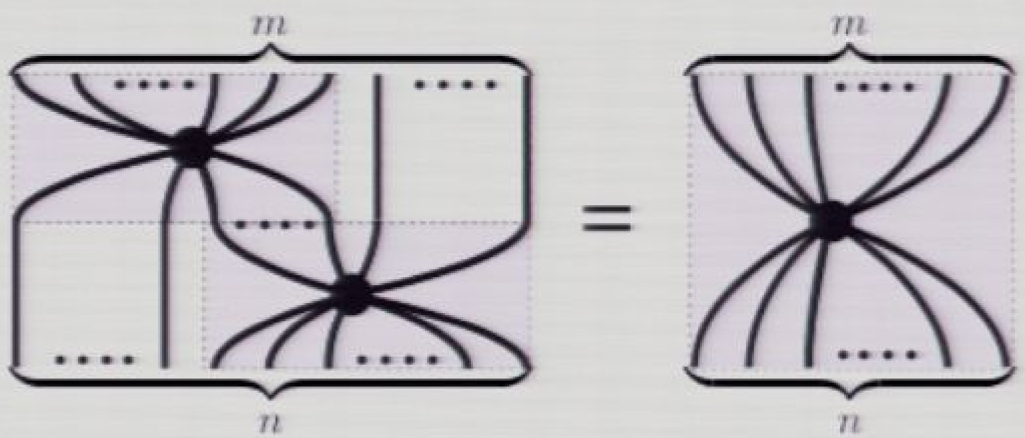

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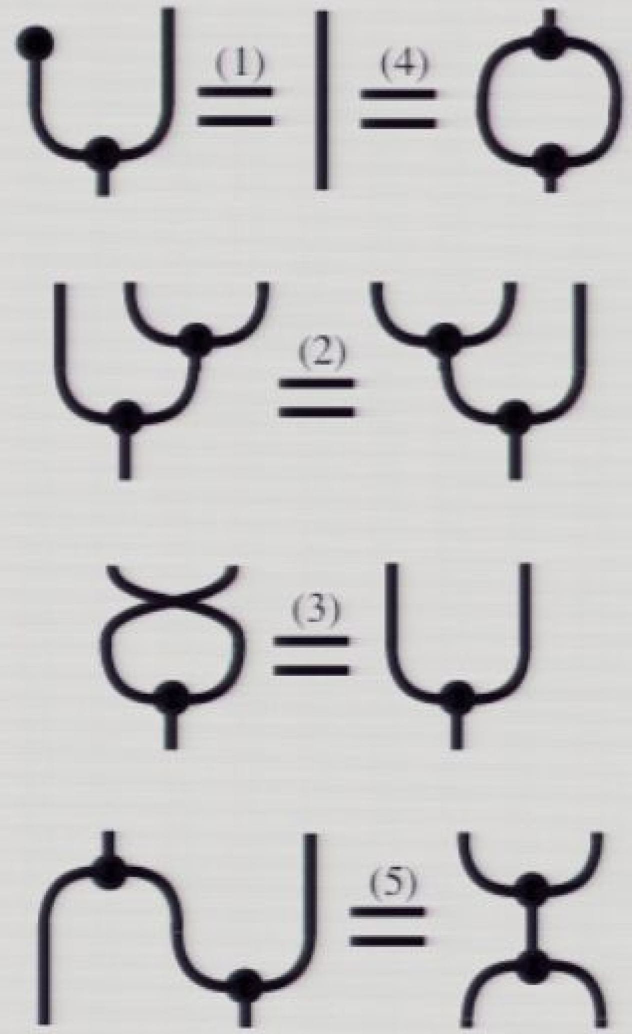

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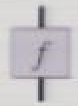
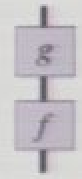
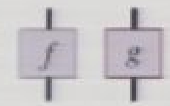
$f \equiv$  $\quad 1_A \equiv$ | $\quad g \circ f \equiv$  $\quad f \otimes g \equiv$ 

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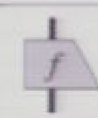
pics:		
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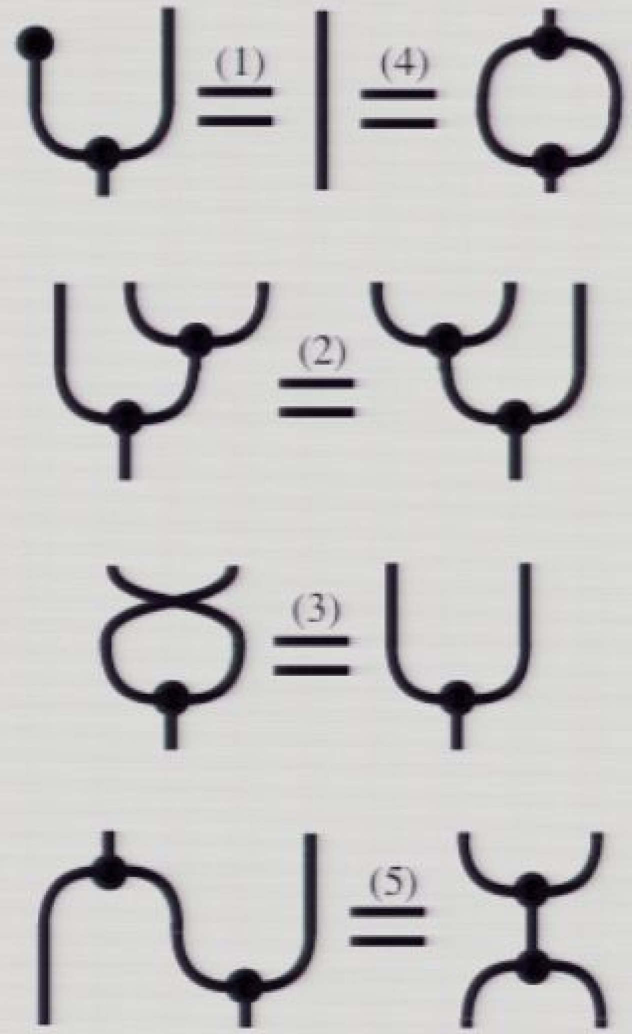

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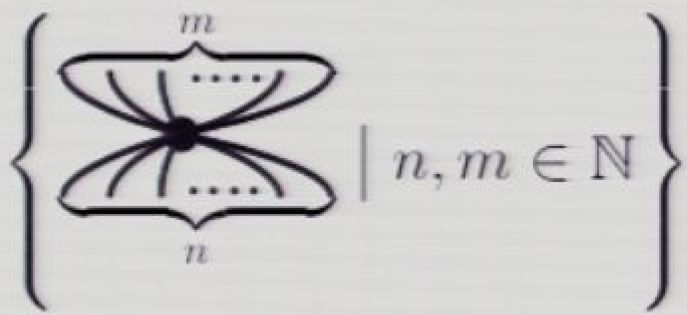

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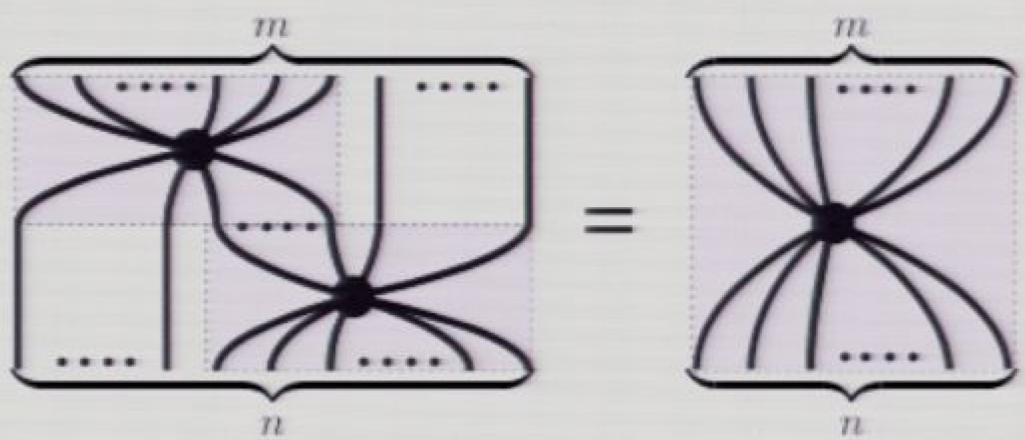

Tue 4:37:32 pm

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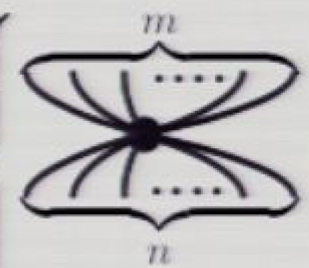

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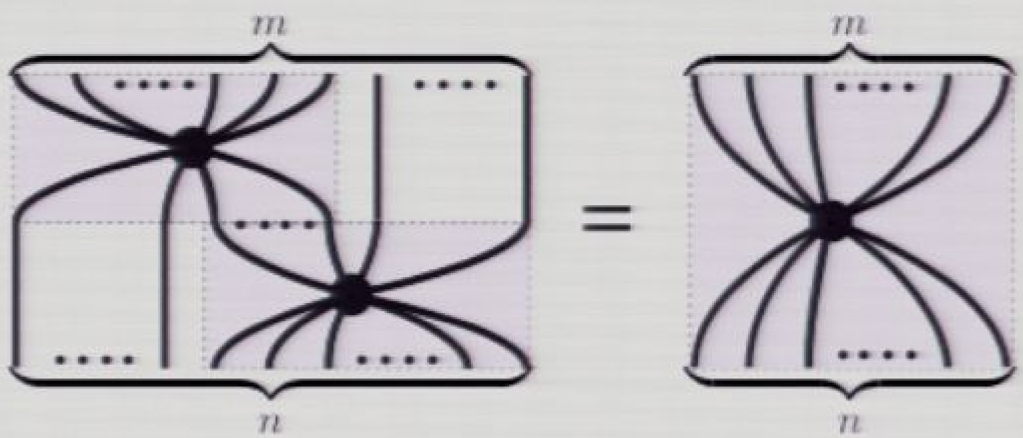

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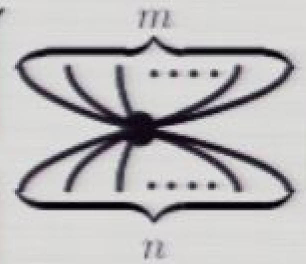
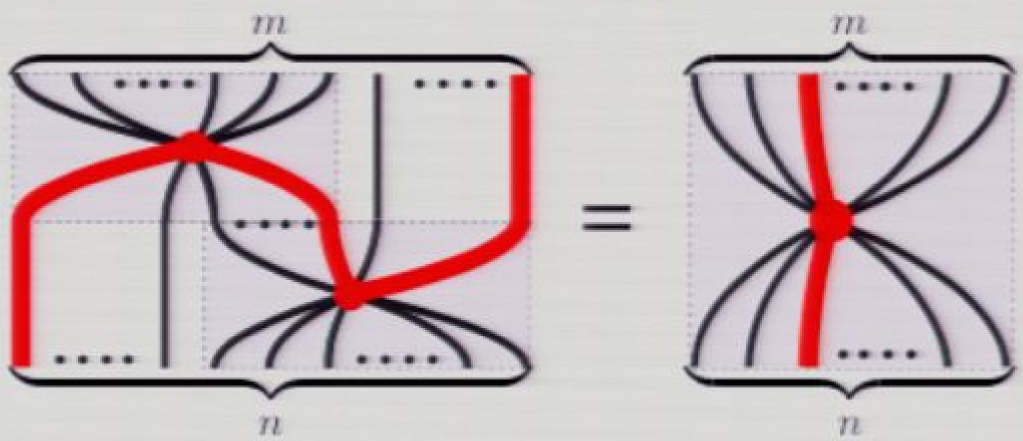
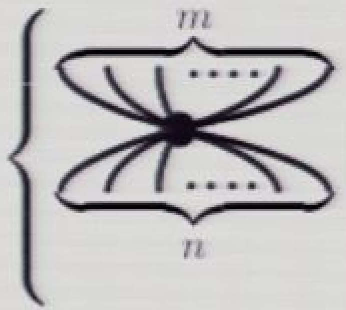
$\Bigg\{$  $\Big|\ n, m \in \mathbb{N} \Bigg\}$

invariant under flipping and swapping, and such that:



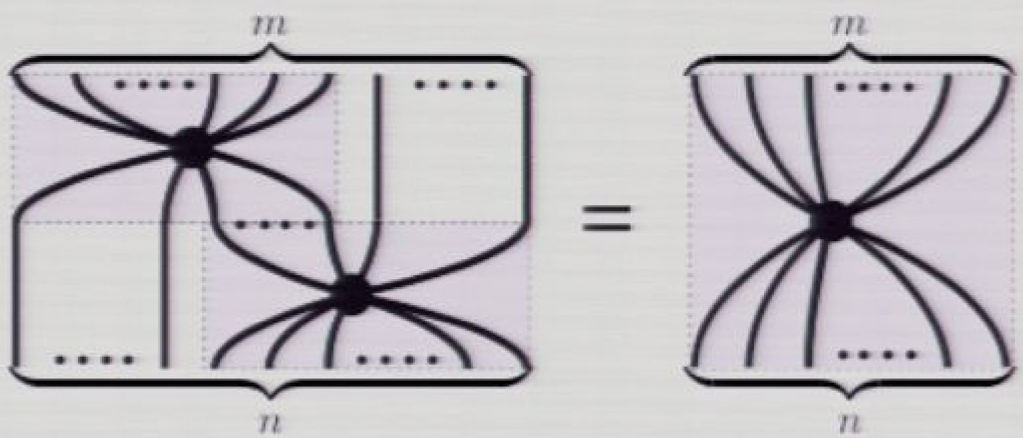
for instances $\delta_0^2 =$  and $\delta_2^0 =$ .

A *classical interface* is:

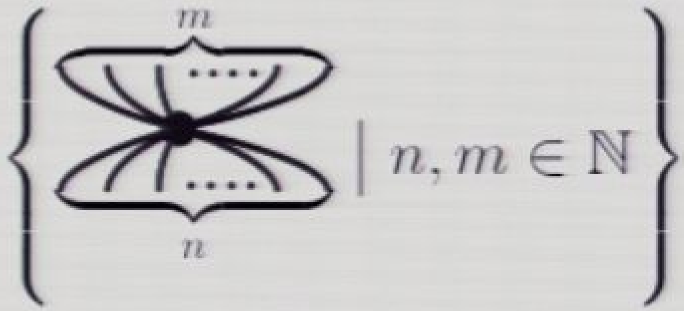


$\Big|\, n, m \in \mathbb{N} \Big\}$

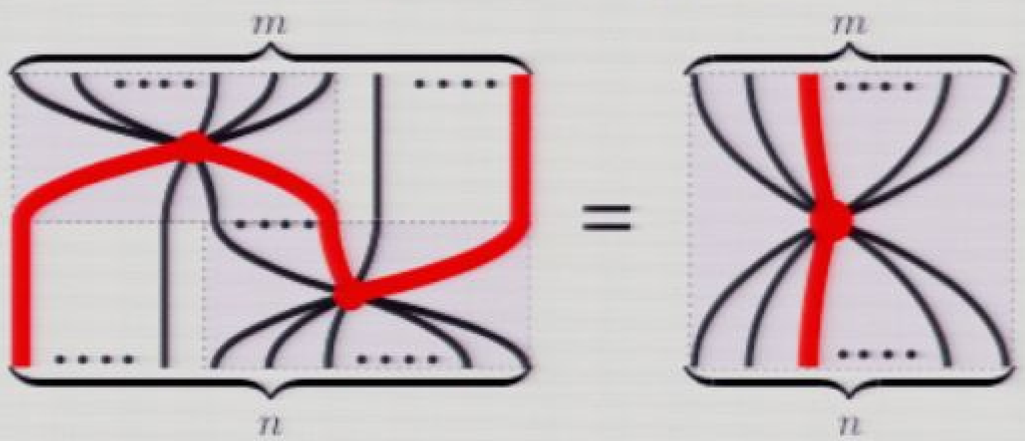
invariant under flipping and swapping, and such that:



A *classical interface* is:



invariant under flipping and swapping, and such that:



for instances $\delta_0^2 =$  and $\delta_2^0 =$ .

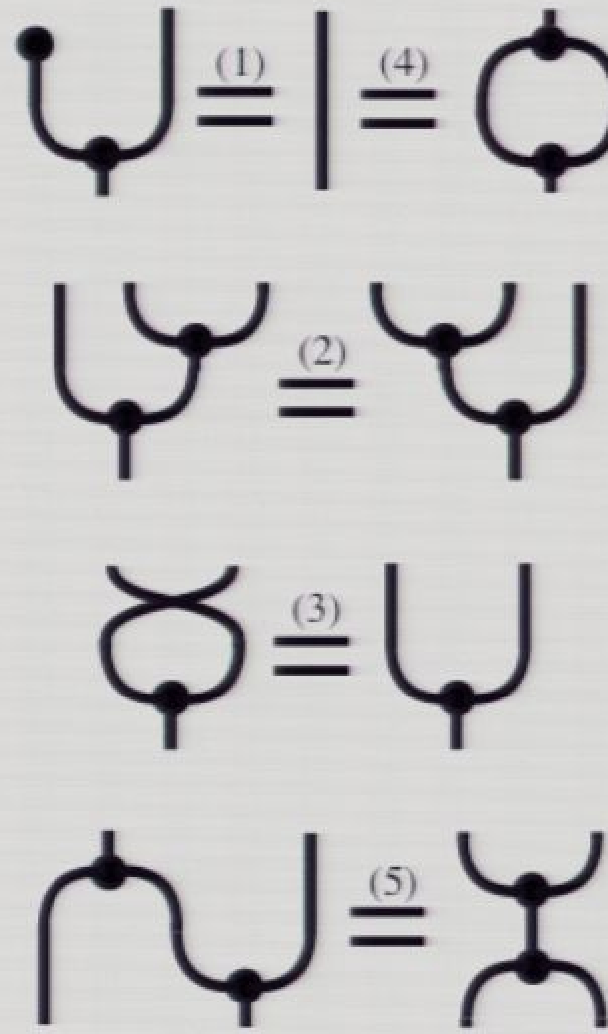
An *classical interface* is:

$A \xrightarrow{\delta} A \otimes A =$ 

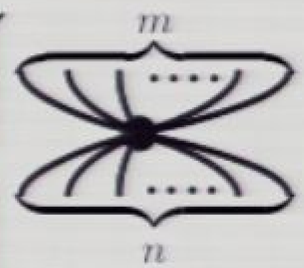
$A \xrightarrow{\varepsilon} \mathrm{I} =$ 

such that:

1. ε is a *unit* for δ ;
2. δ is *coassociative* ;
3. δ is *cocommutative* ;
4. δ is *isometry* ;
5. δ is *Frobenius*.

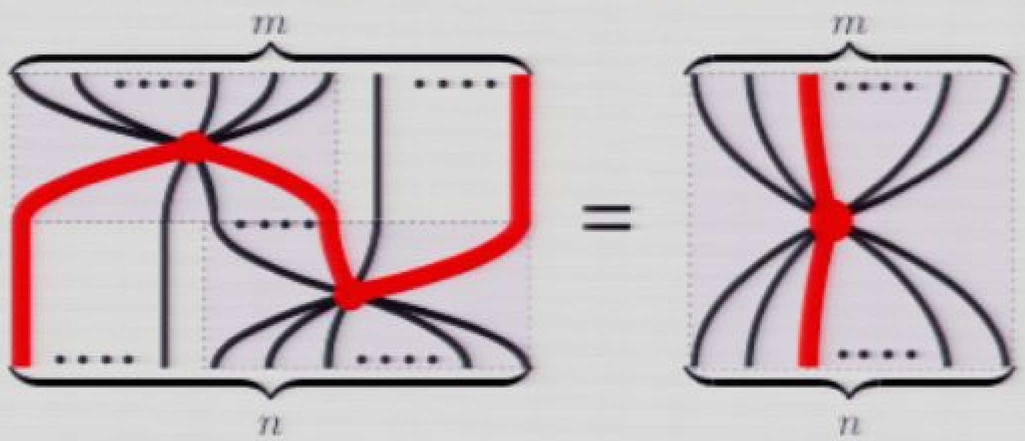


A *classical interface* is:

$\Bigg\{$ 

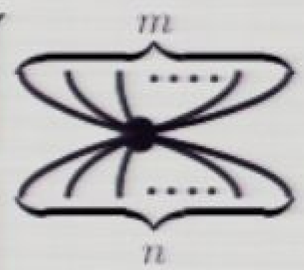
$\Big|\ n, m \in \mathbb{N} \Bigg\}$

invariant under flipping and swapping, and such that:



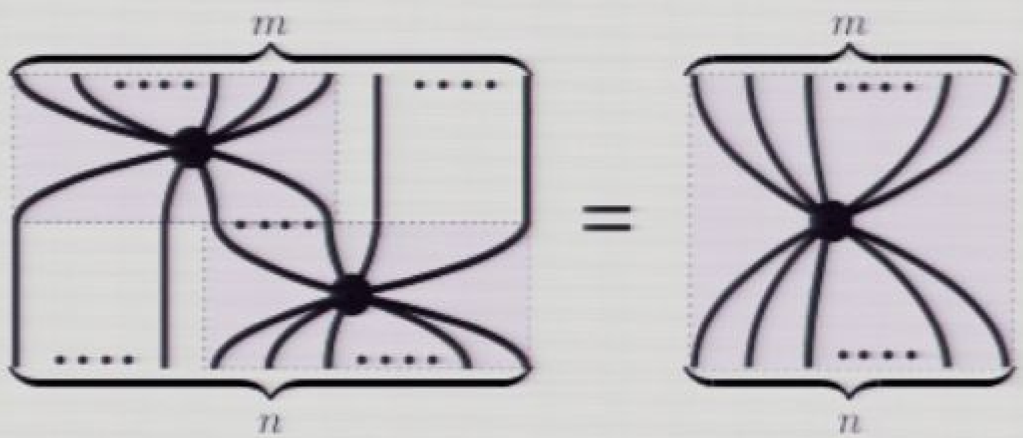
for instances $\delta_0^2 =$  and $\delta_2^0 =$ .

A *classical interface* is:

$\Bigg\{$ 

$\Big|\ n, m \in \mathbb{N} \Bigg\}$

invariant under flipping and swapping, and such that:



Tue 4:40:36 pm

An *classical interface* is:

$A \xrightarrow{\delta} A \otimes A =$ 

$A \xrightarrow{\varepsilon} \mathrm{I} =$ 

such that:

1. ε is a *unit* for δ ;
2. δ is *coassociative* ;
3. δ is *cocommutative* ;
4. δ is *isometry* ;
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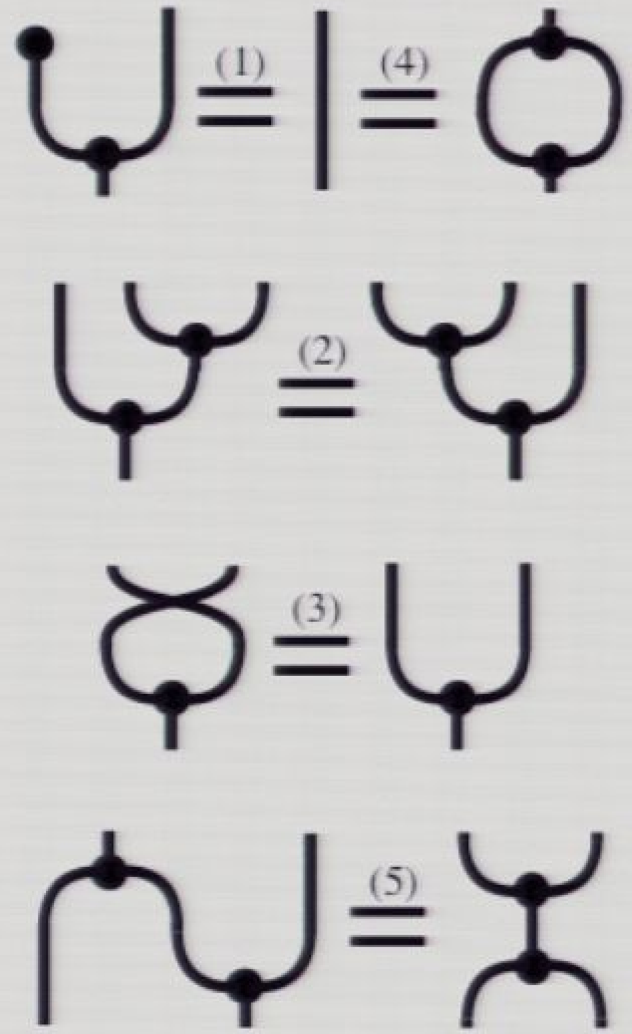
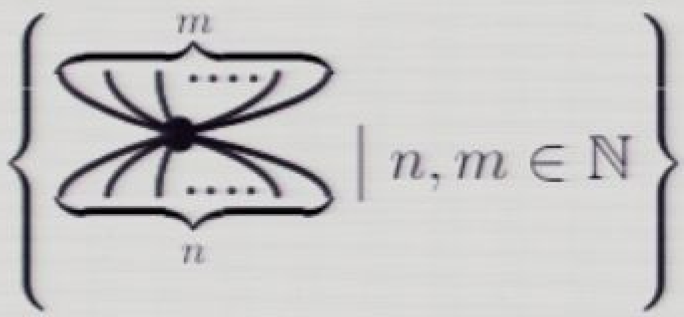
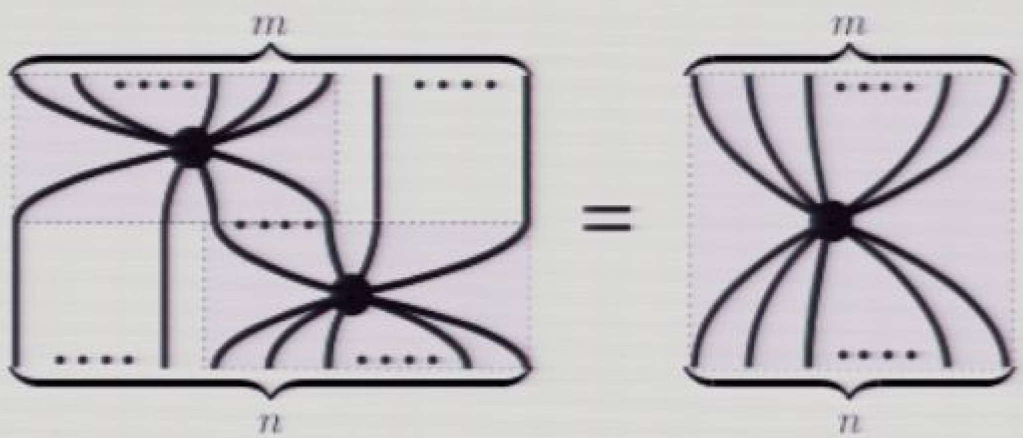


A *classical interface* is:



invariant under flipping and swapping, and such that:



An *classical interface* is:

$A \xrightarrow{\delta} A \otimes A =$ 

$A \xrightarrow{\varepsilon} \mathrm{I} =$ 

such that:

1. ε is a *unit* for δ ;
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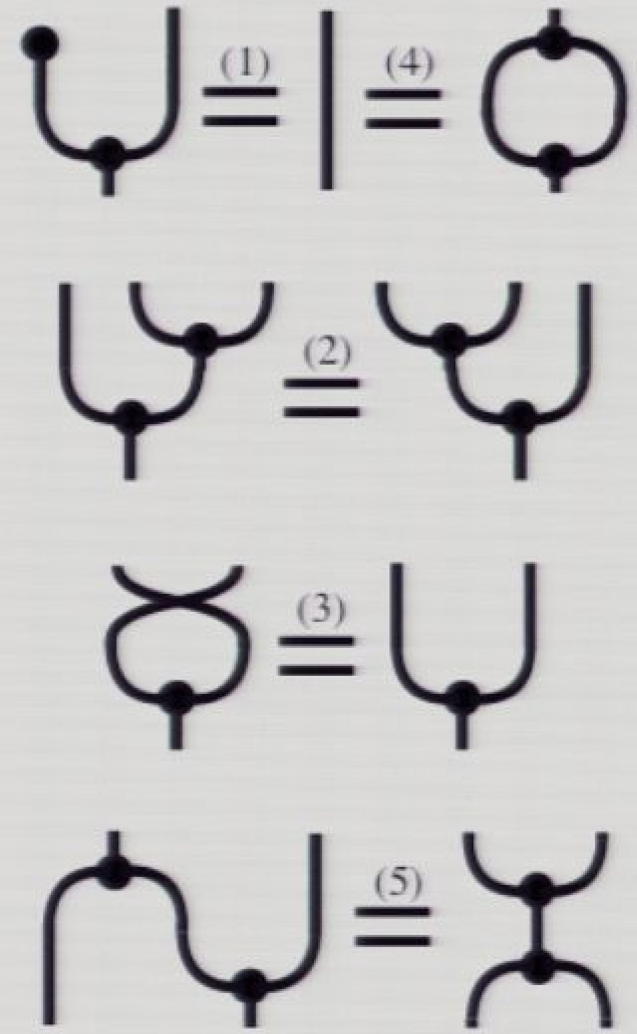
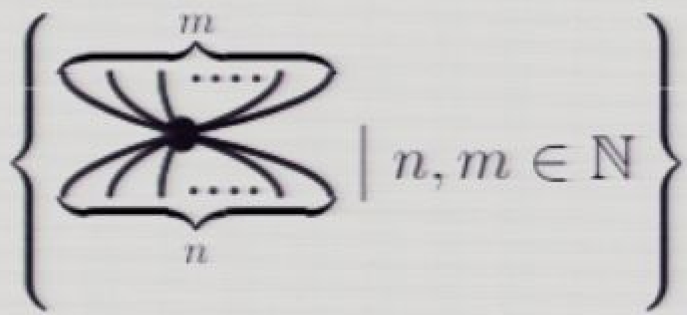
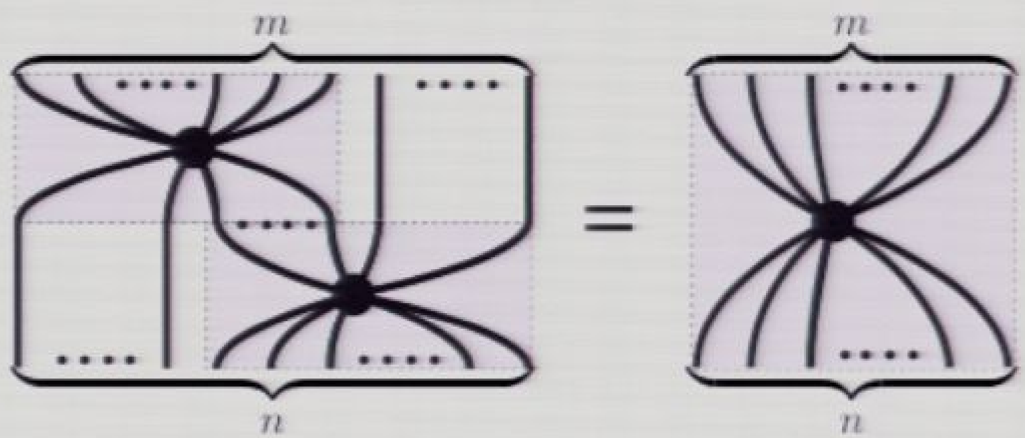


A *classical interface* is:



invariant under flipping and swapping, and such that:



An *classical interface* is:

$A \xrightarrow{\delta} A \otimes A =$ 

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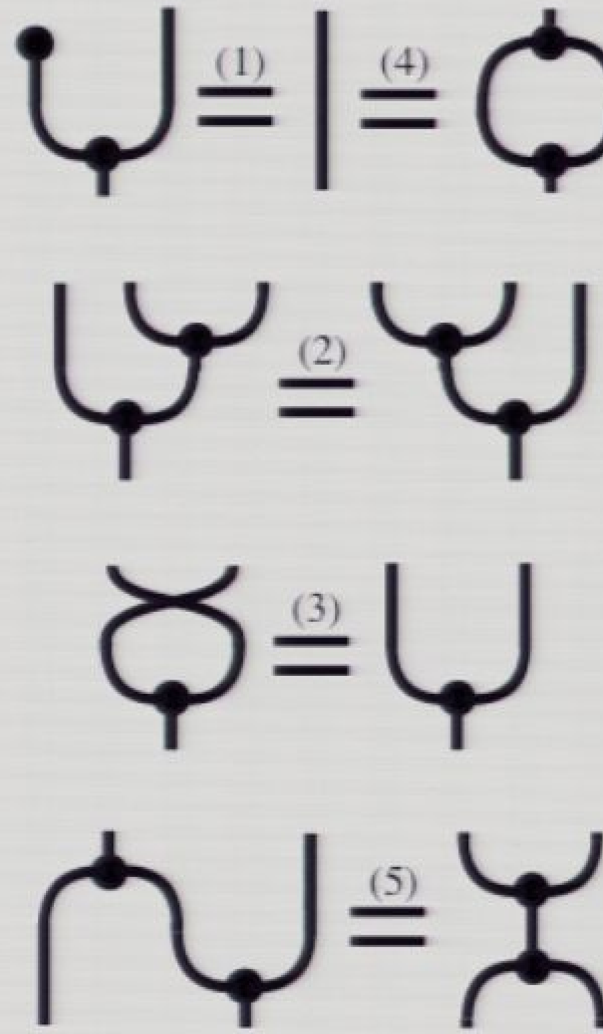
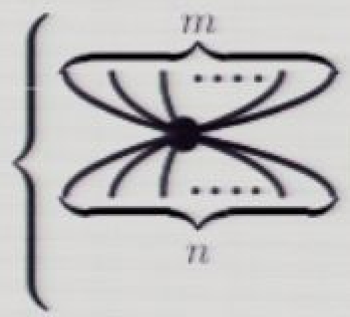
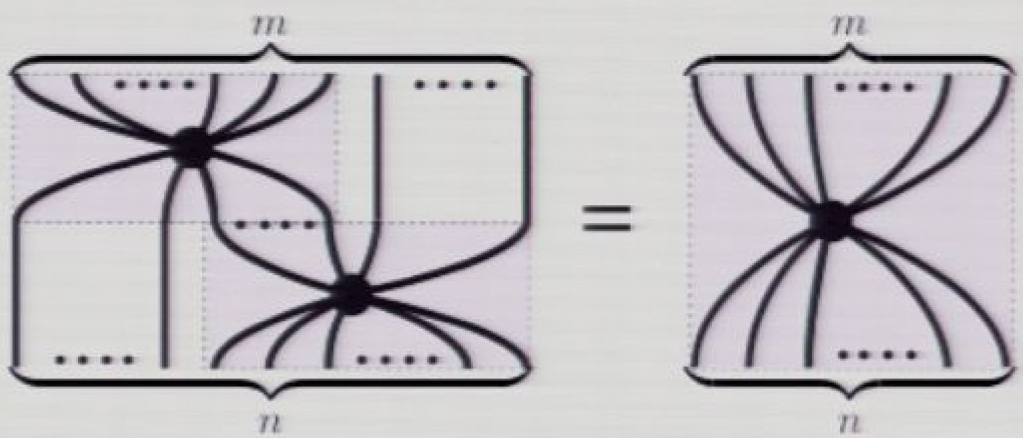


A *classical interface* is:

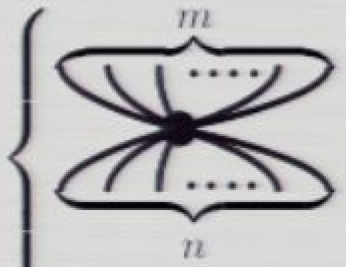


$\Big| \; n, m \in \mathbb{N}$

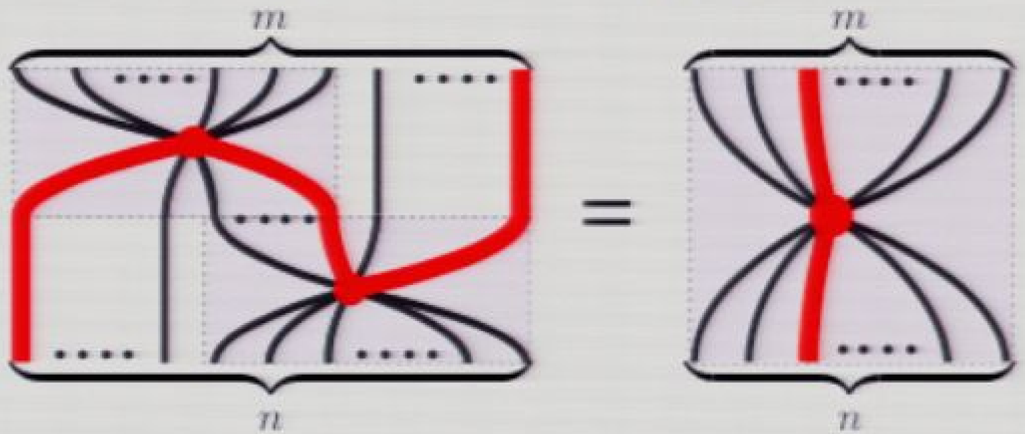
invariant under flipping and swapping, and such that:



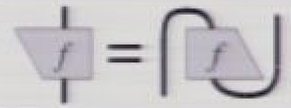
A *classical interface* is:

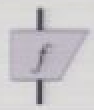
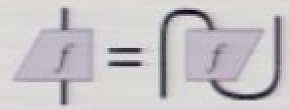
$$\left\{ \right.$$  $\left| \; n, m \in \mathbb{N} \right\}$

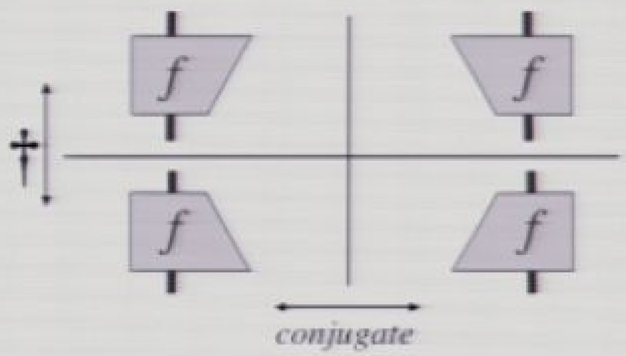
invariant under flipping and swapping, and such that:



for instances $\delta_0^2 =$  and $\delta_2^0 =$ .

pics:		
cats:	$A \xrightarrow{f} B$	$f^{\ddagger} = A \xrightarrow{(\epsilon_A \otimes 1_B)\circ(1_A \otimes f^{\dagger} \otimes 1_B)\circ(1_A \otimes \eta_B)} B$
FHilb:	linear map	its conjugate

pics:		
cats:	$A \xrightarrow{f} B$	$f^{*} = B \xrightarrow{(\epsilon_B \otimes 1_A)\circ(1_B \otimes f \otimes 1_A)\circ(1_B \otimes \eta_A)} A$
FHilb:	linear map	its transposed



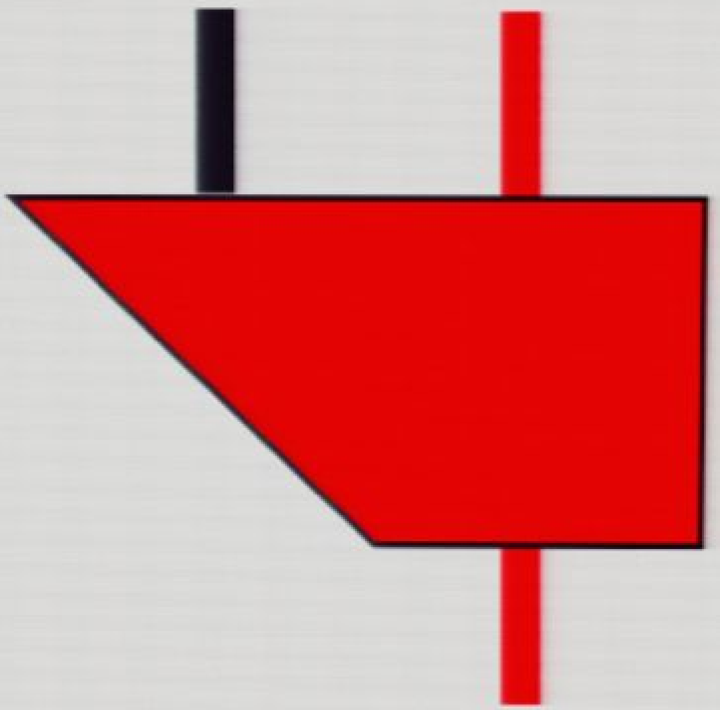
Tue 4:43:53 pm

MEASUREMENT $\leftrightarrow$ NO-SIGNALING

Tue 4:45:07 pm

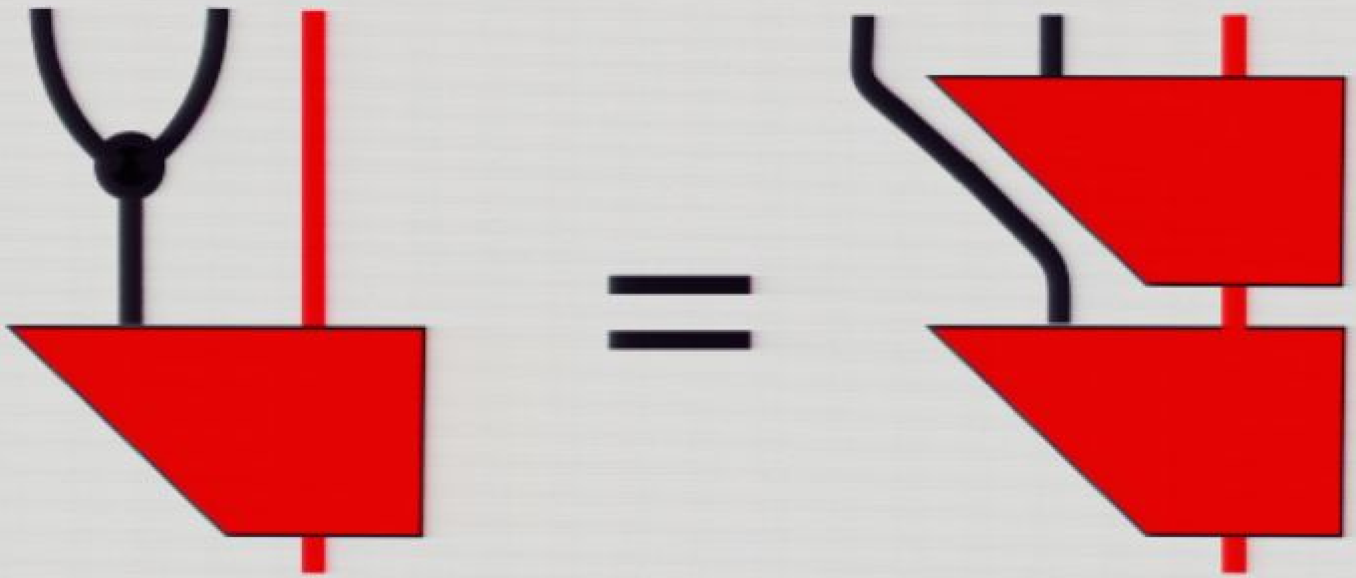
Quantum measurement:

$$\mathcal{M} : A \to X \otimes A$$



Quantum measurement:

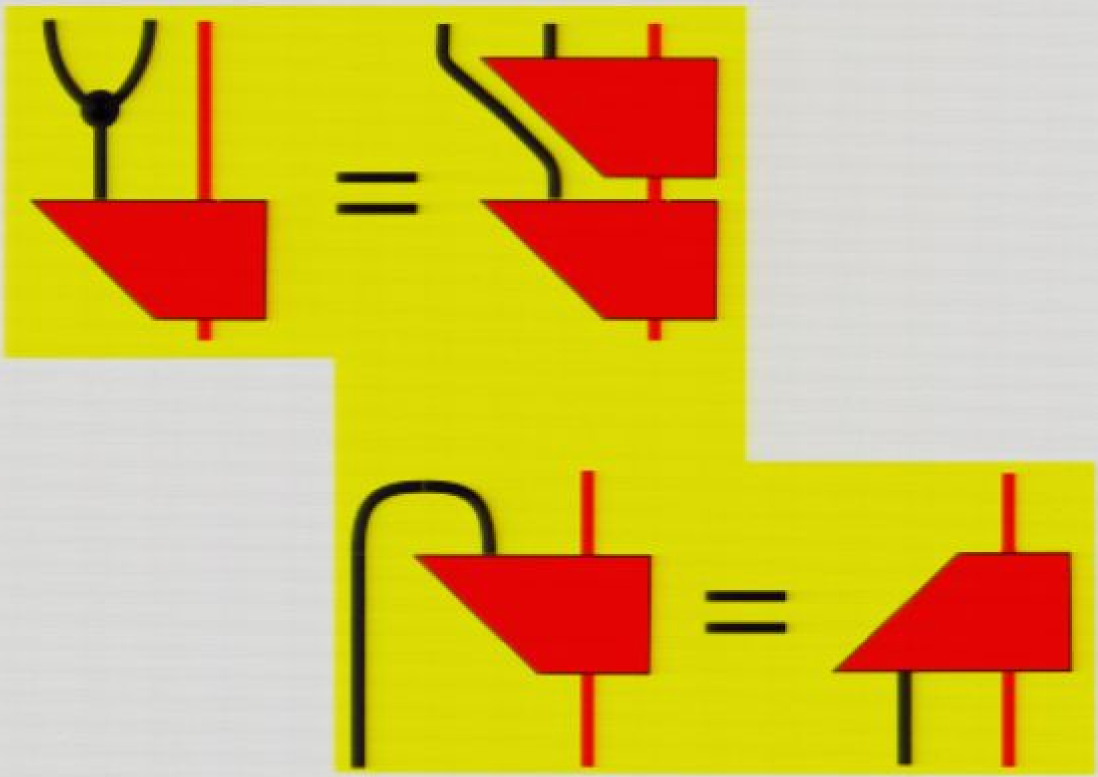
$$\mathcal{M} : A \to X \otimes A$$



$\Rightarrow$ **von Neumann projection postulate.**

Tue 4:46:42 pm

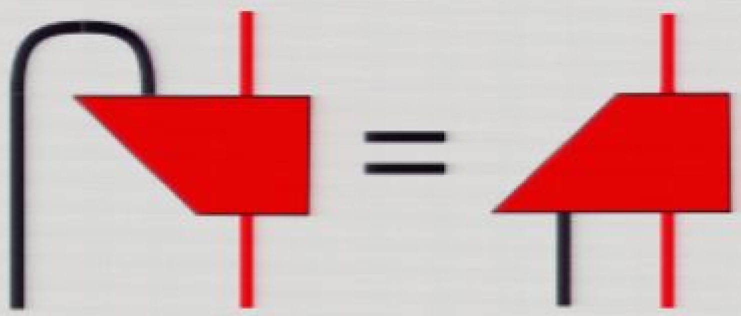
Quantum measurement:



Minimal requirements for reasonable notion of measurement

Tue 4:50:51 pm

Quantum measurement:



Asserts *no-signaling*

Tue 4:50:55 p

Thm. In **FHilb** the above rules yield exactly all projector spectra arising from self-adjoint operators.

proof.

Projection postulate $\Rightarrow$

idempotence $\quad \mathrm{P}_i^2 = \mathrm{P}_i$

mutual orthogonality $\quad \mathrm{P}_i \circ \mathrm{P}_{j \neq i} = \mathbf{0}$

No signaling $\Rightarrow$

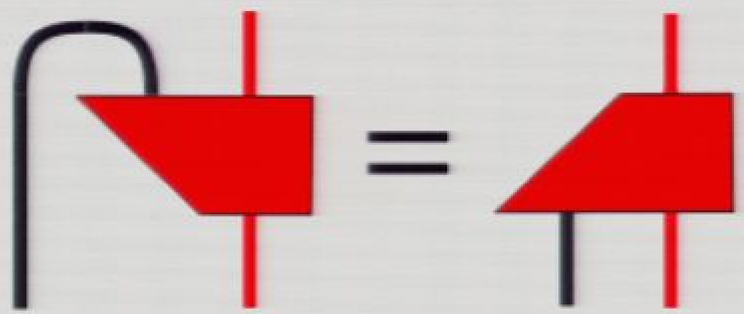
Completeness of spectrum $\quad \sum_i \mathrm{P}_i = 1_{\mathcal{H}}$

Minimal requirement II $\Rightarrow$

Orthogonality of projectors $\quad \mathrm{P}_i^\dagger = \mathrm{P}_i$

PROJECTOR SPECTRUM

Quantum measurement:



Asserts *no-signaling*

Tue 4:51:52 pm

Thm. In **FHilb** the above rules yield exactly all projector spectra arising from self-adjoint operators.

proof.

Projection postulate $\Rightarrow$

idempotence $\mathrm{P}_i^2 = \mathrm{P}_i$

mutual orthogonality $\mathrm{P}_i \circ \mathrm{P}_{j \neq i} = \mathbf{0}$

No signaling $\Rightarrow$

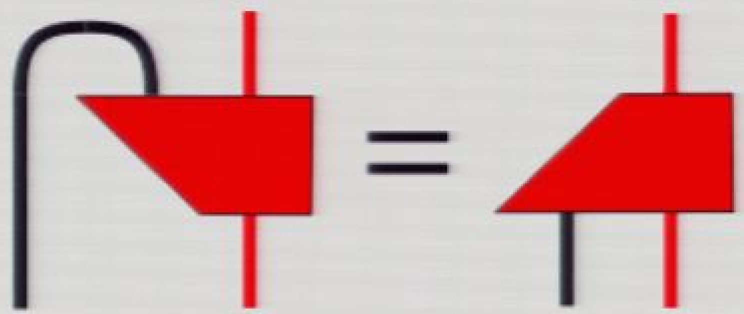
Completeness of spectrum $\sum_i \mathrm{P}_i = 1_{\mathcal{H}}$

Minimal requirement II $\Rightarrow$

Orthogonality of projectors $\mathrm{P}_i^\dagger = \mathrm{P}_i$

PROJECTOR SPECTRUM

Quantum measurement:



Asserts *no-signaling*

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Completeness of spectrum $\quad \sum_i \mathrm{P}_i = 1_{\mathcal{H}}$

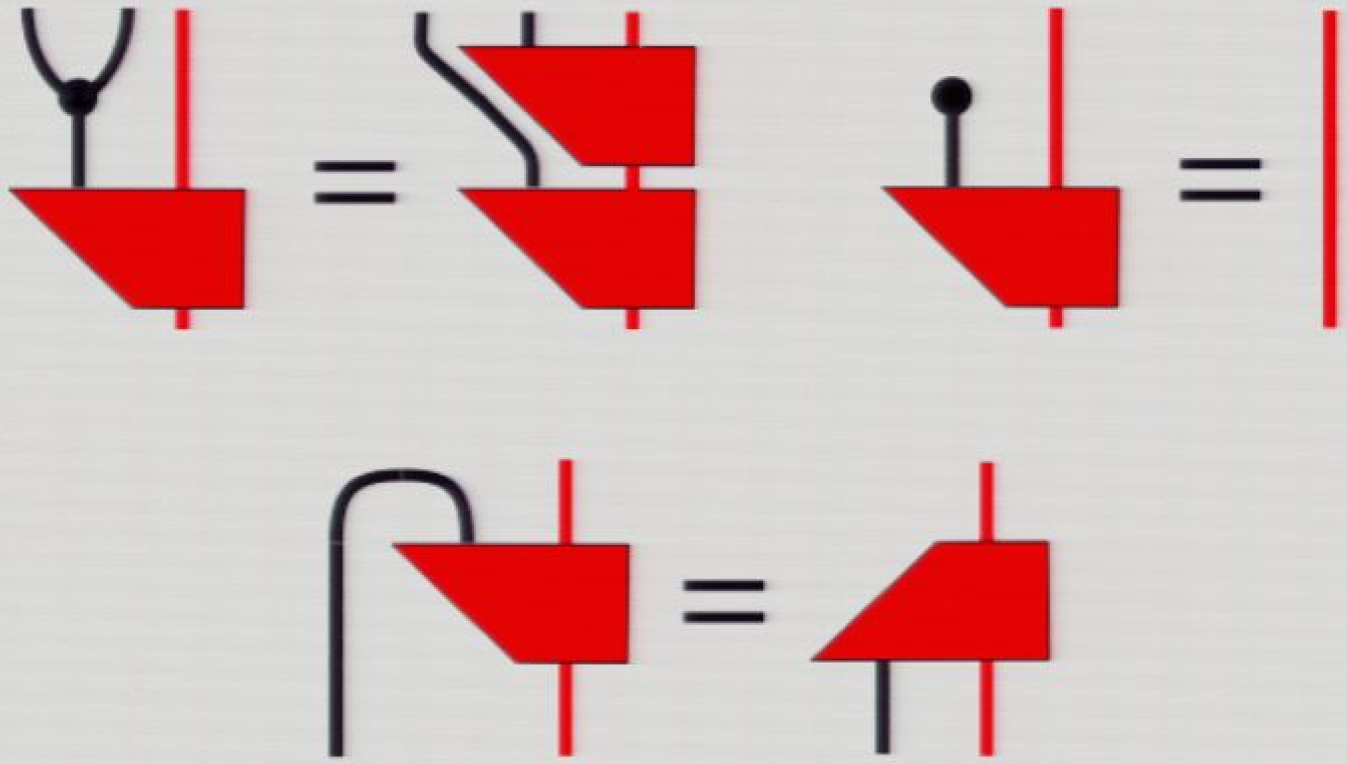
Minimal requirement II $\Rightarrow$

Orthogonality of projectors $\quad \mathrm{P}_i^\dagger = \mathrm{P}_i$

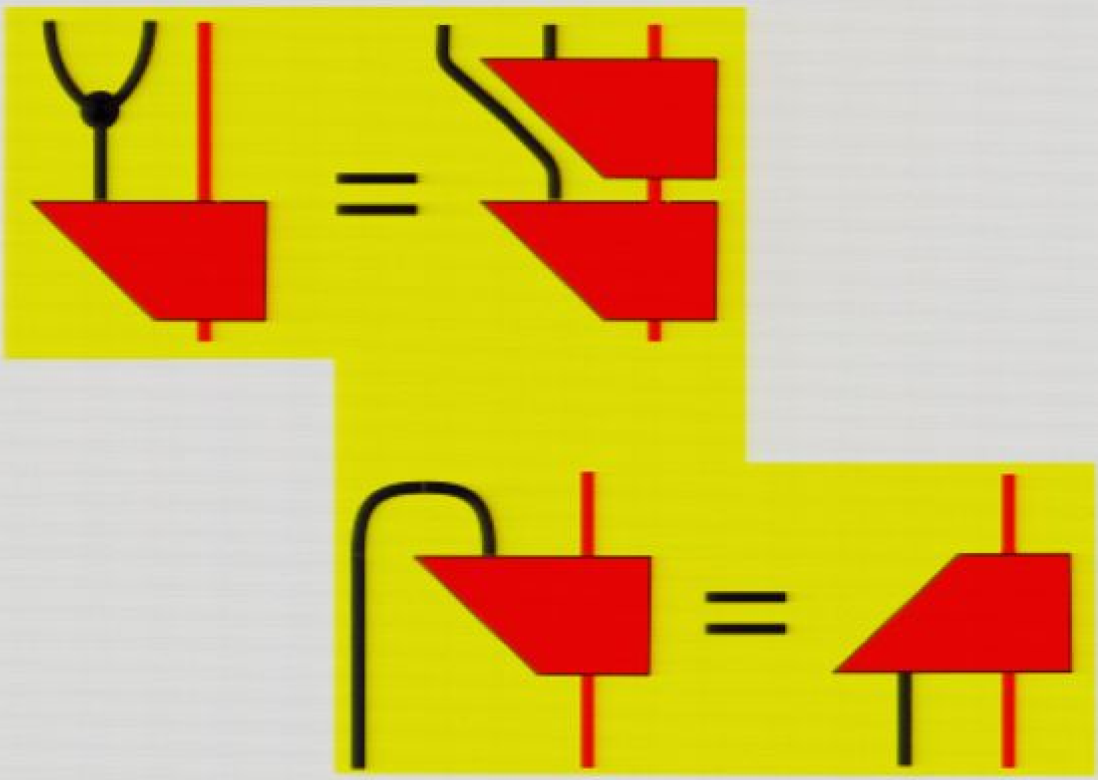
PROJECTOR SPECTRUM

(100%) Tue 4:56:15 pm

Canonical observable :=

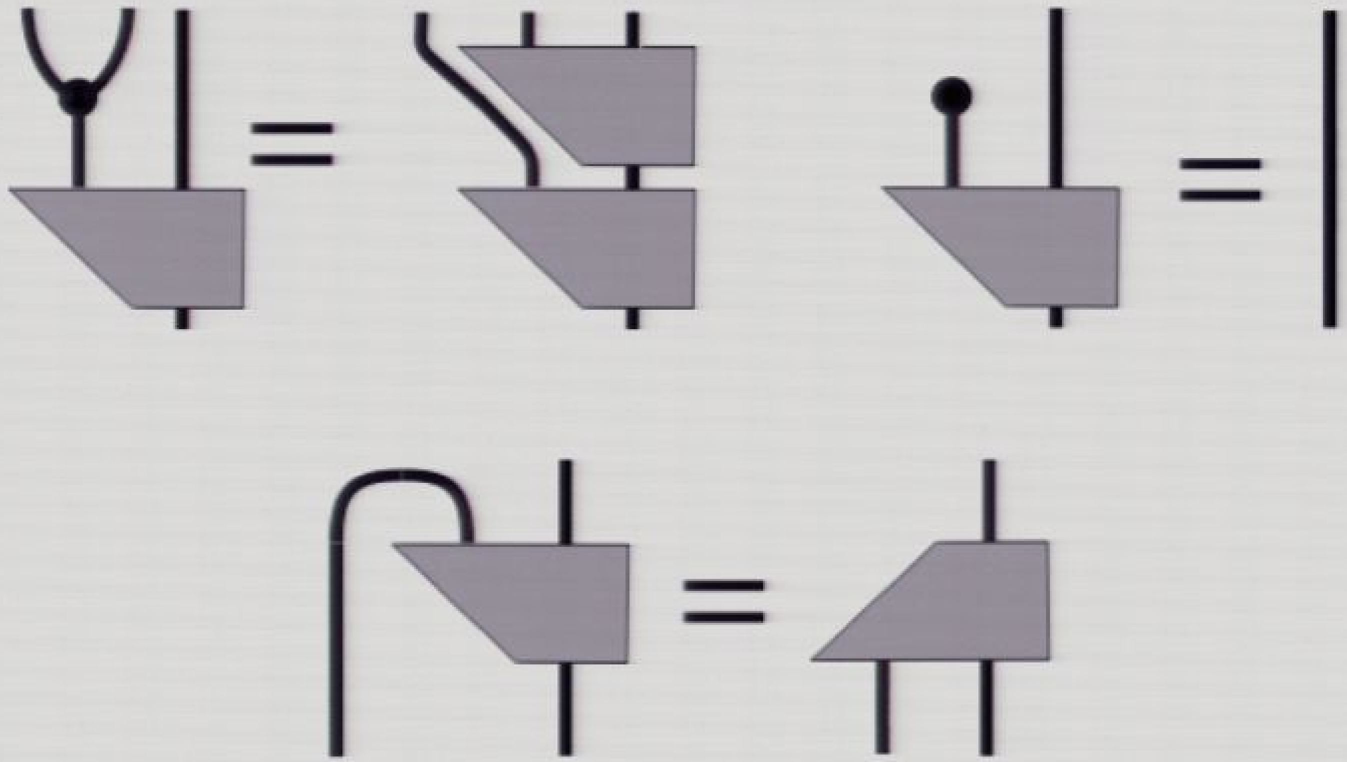


Quantum measurement:

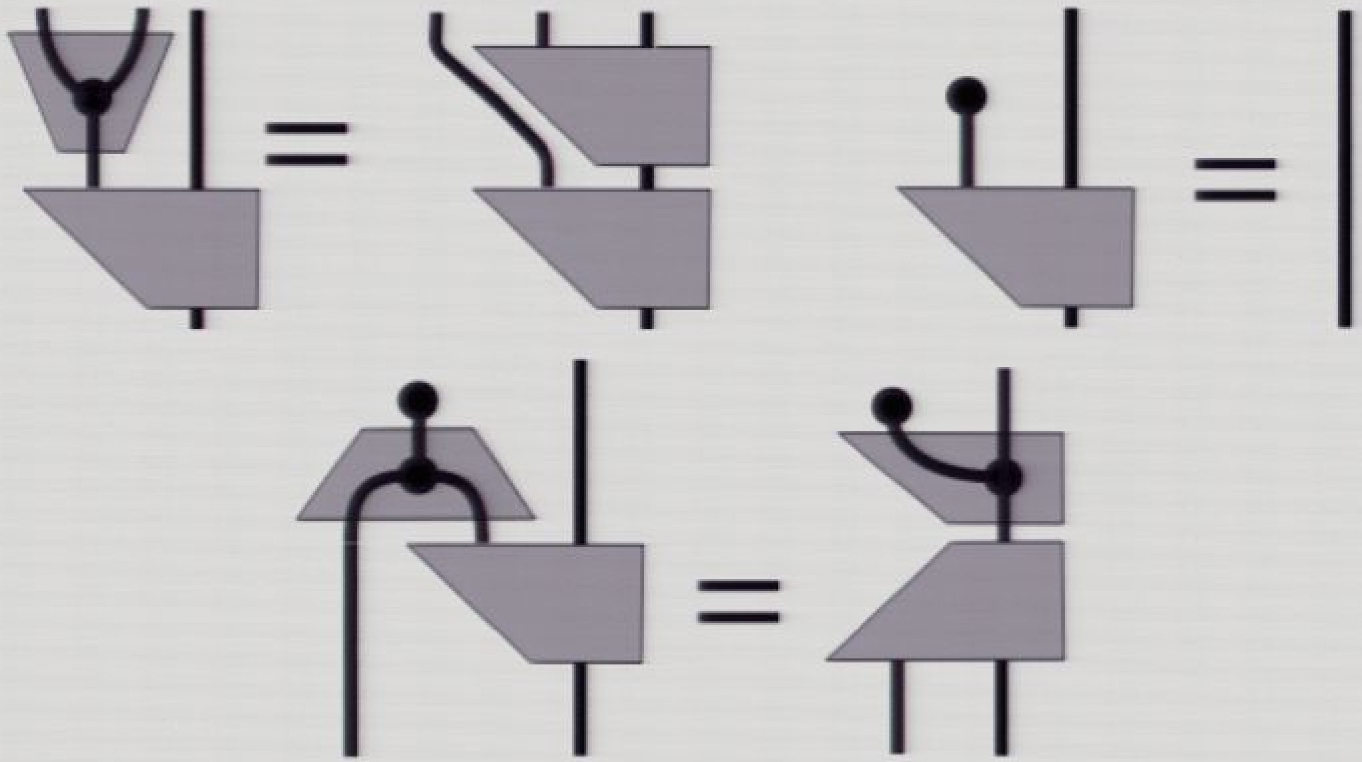


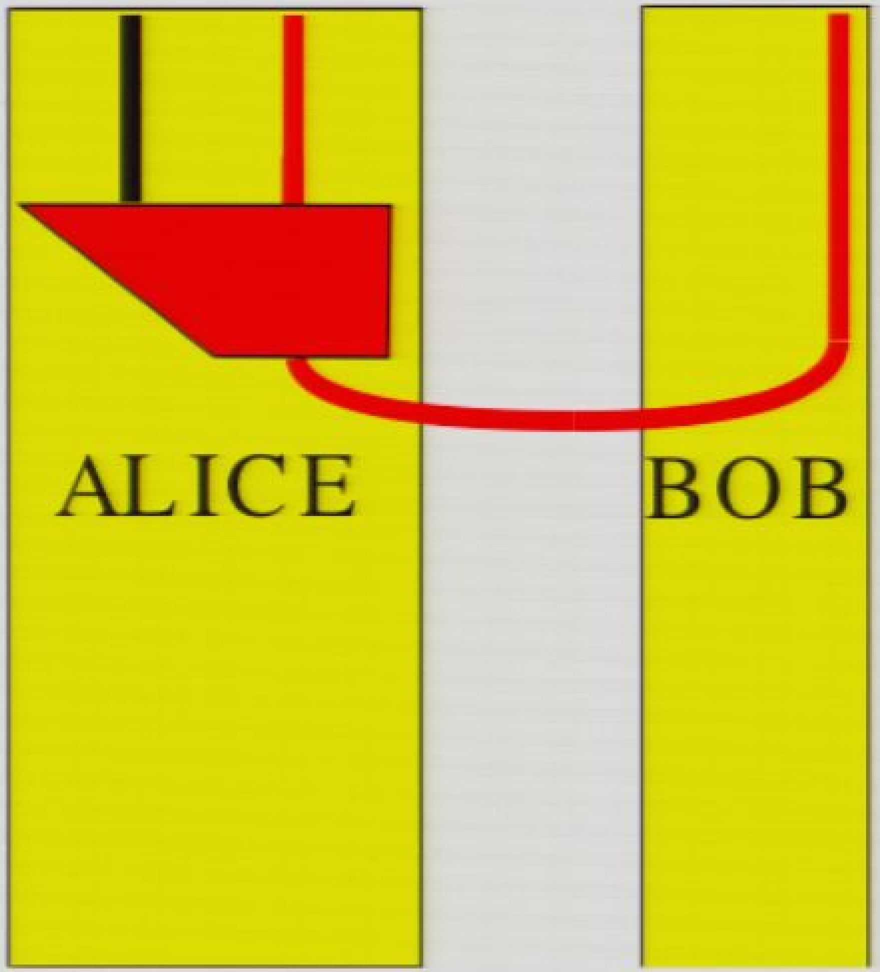
Minimal requirements for reasonable notion of measurement

Canonical observable := Copying



Canonical observable := Copying

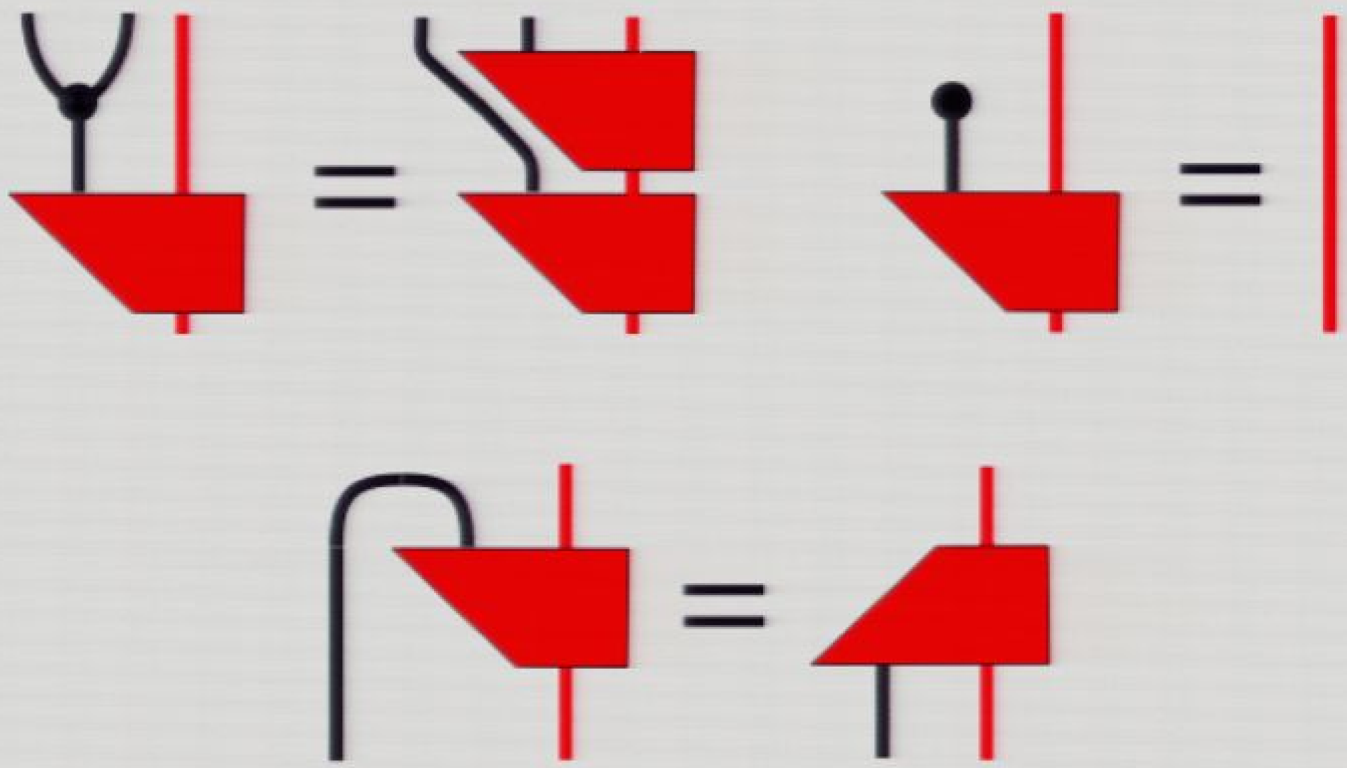


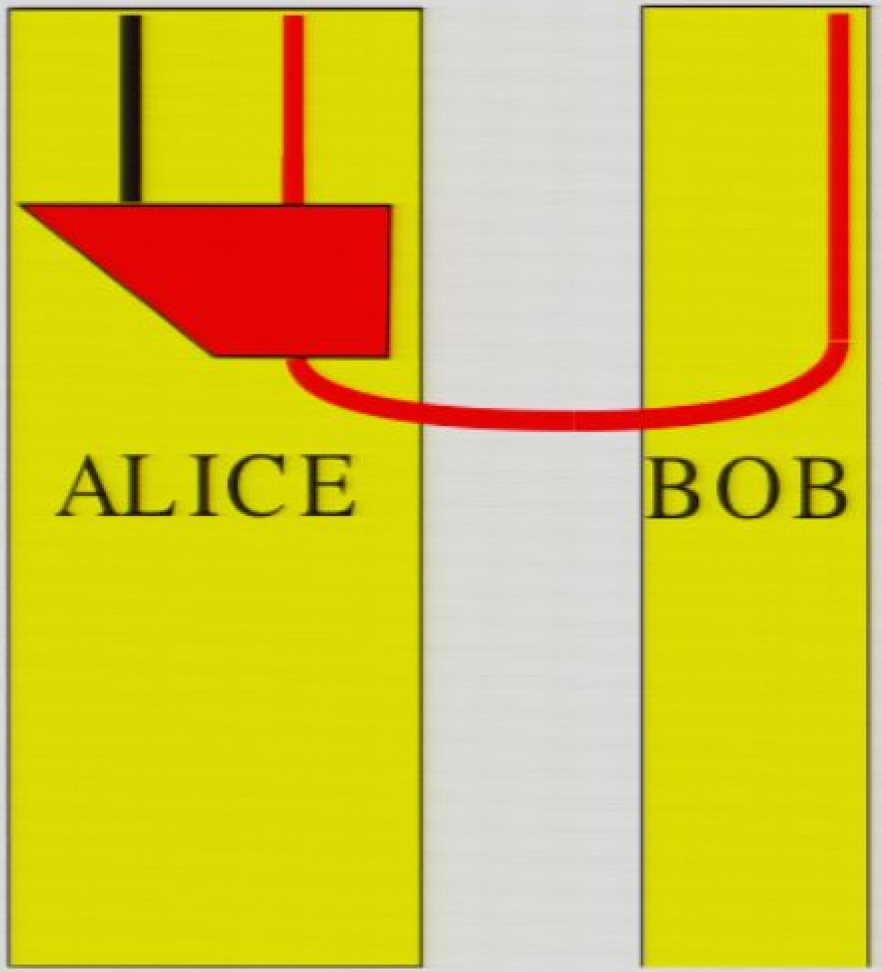


ALICE
BOB

Tue 4:57:53 pm

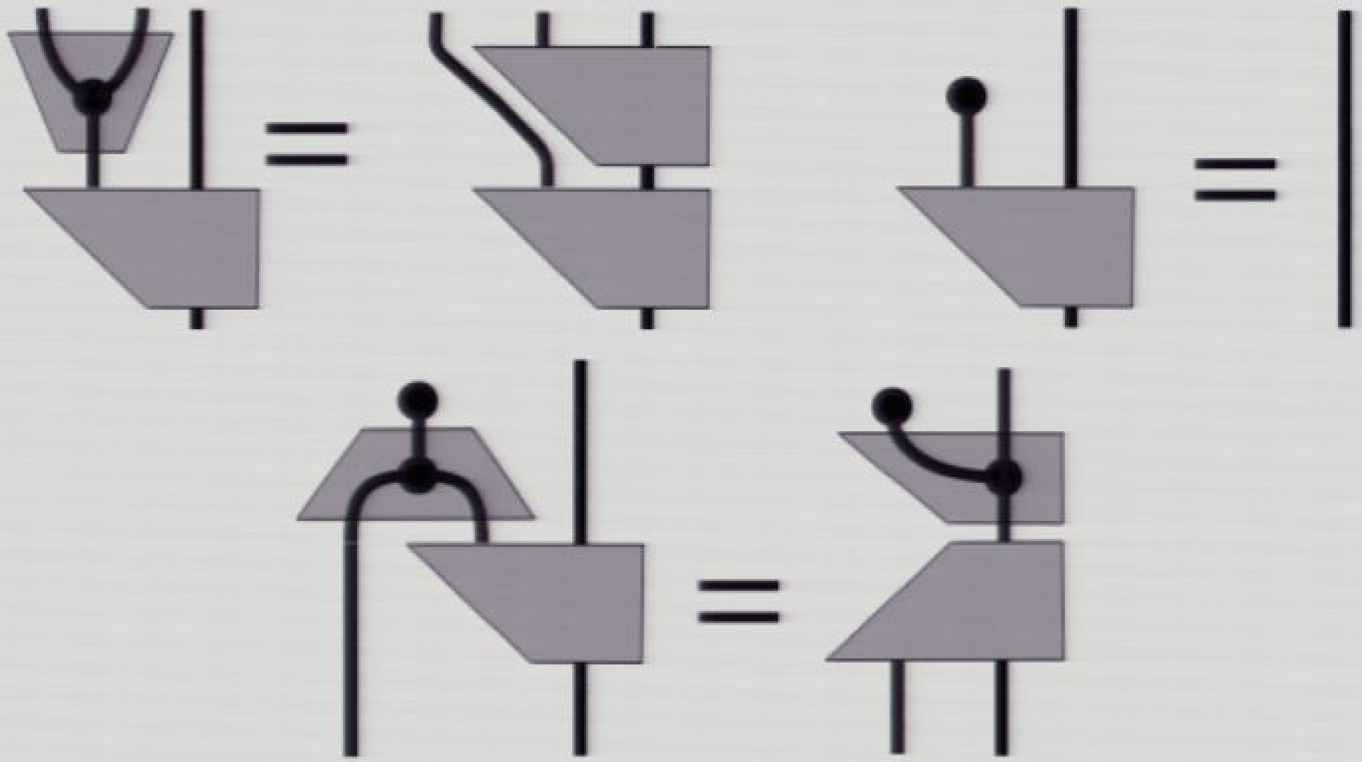
Canonical observable :=



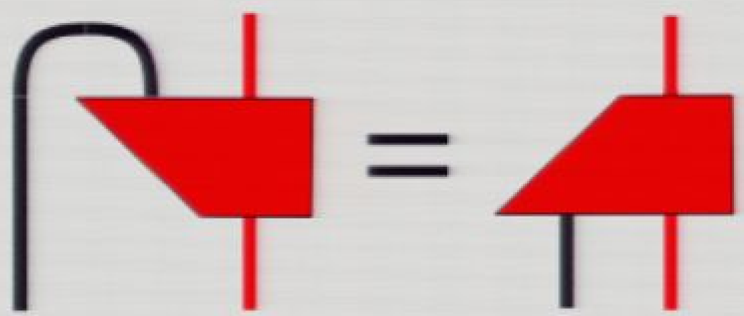

ALICE
BOB

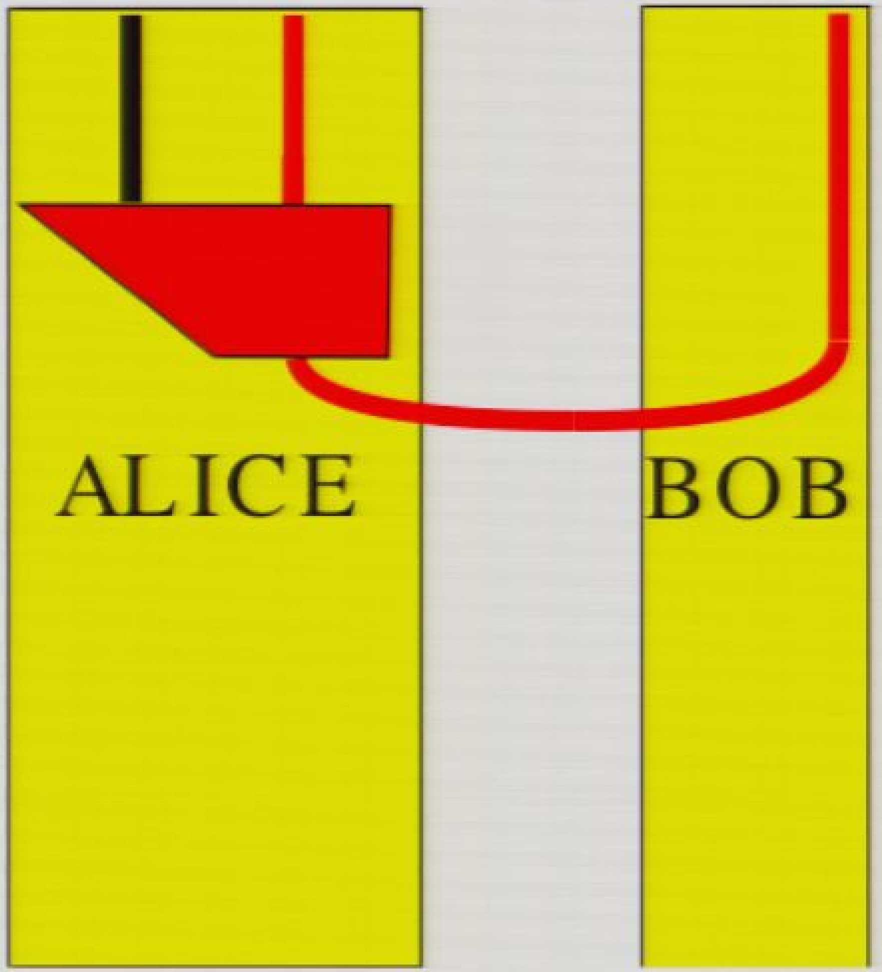
(100%) Tue 4:59:04 pm

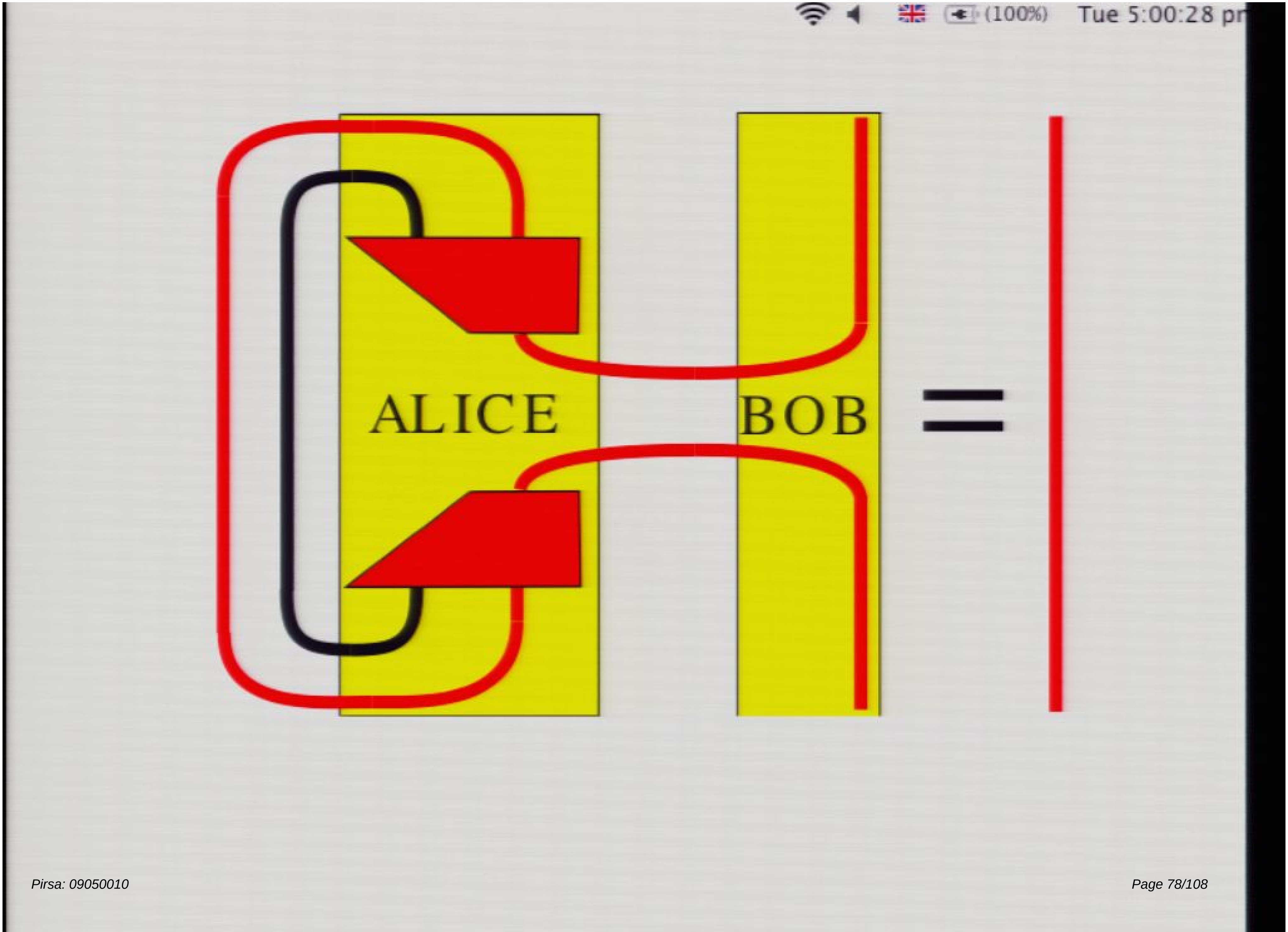
Canonical observable := Copying



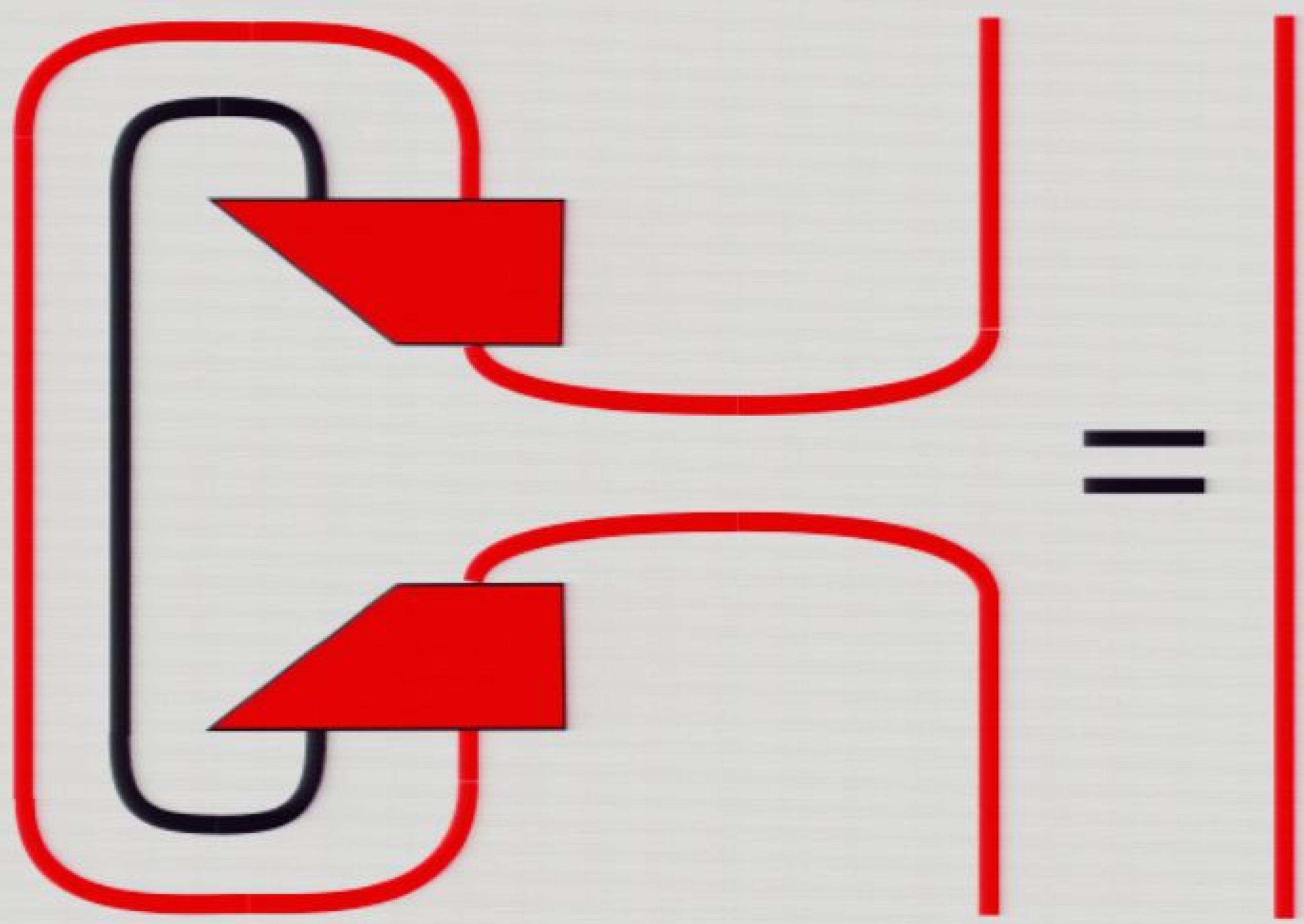
Canonical observable :=

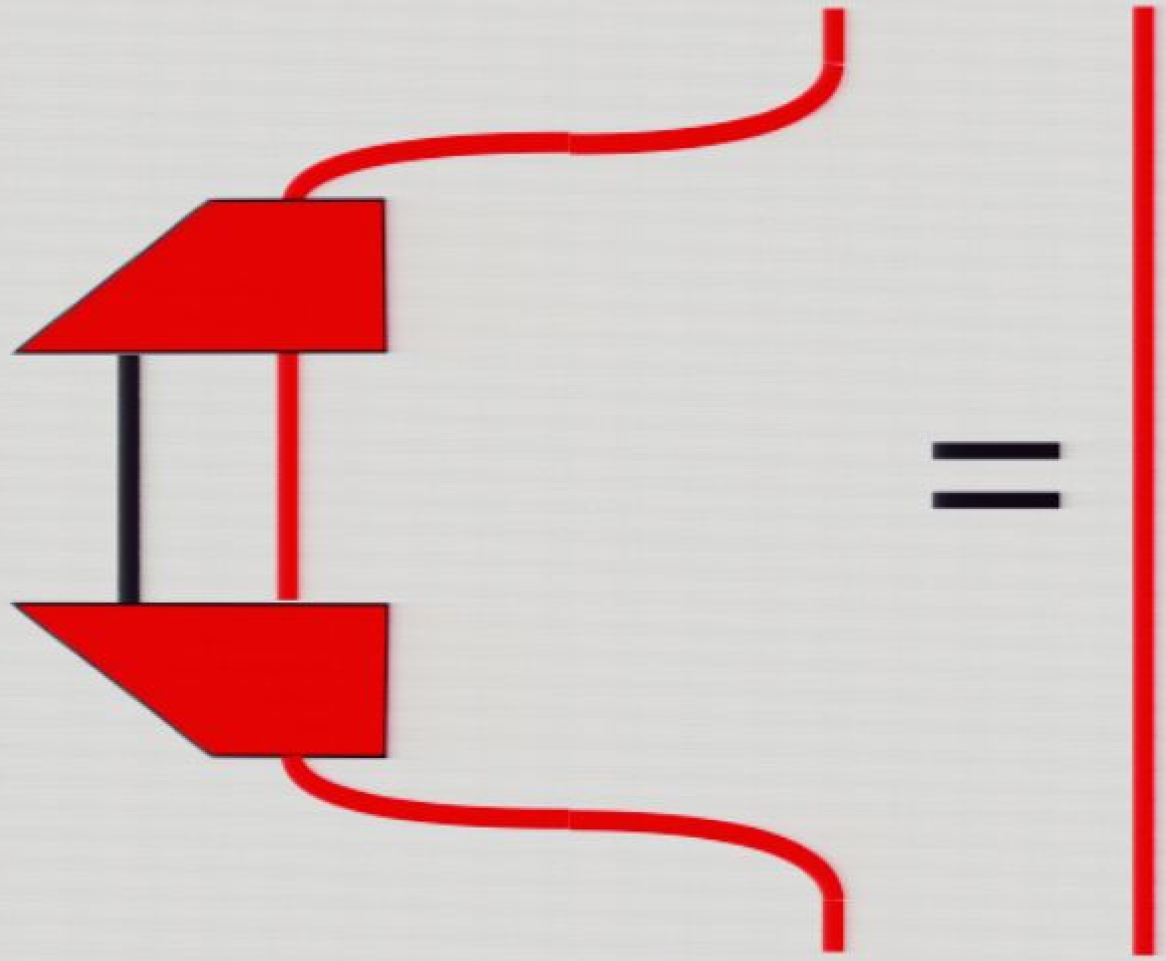


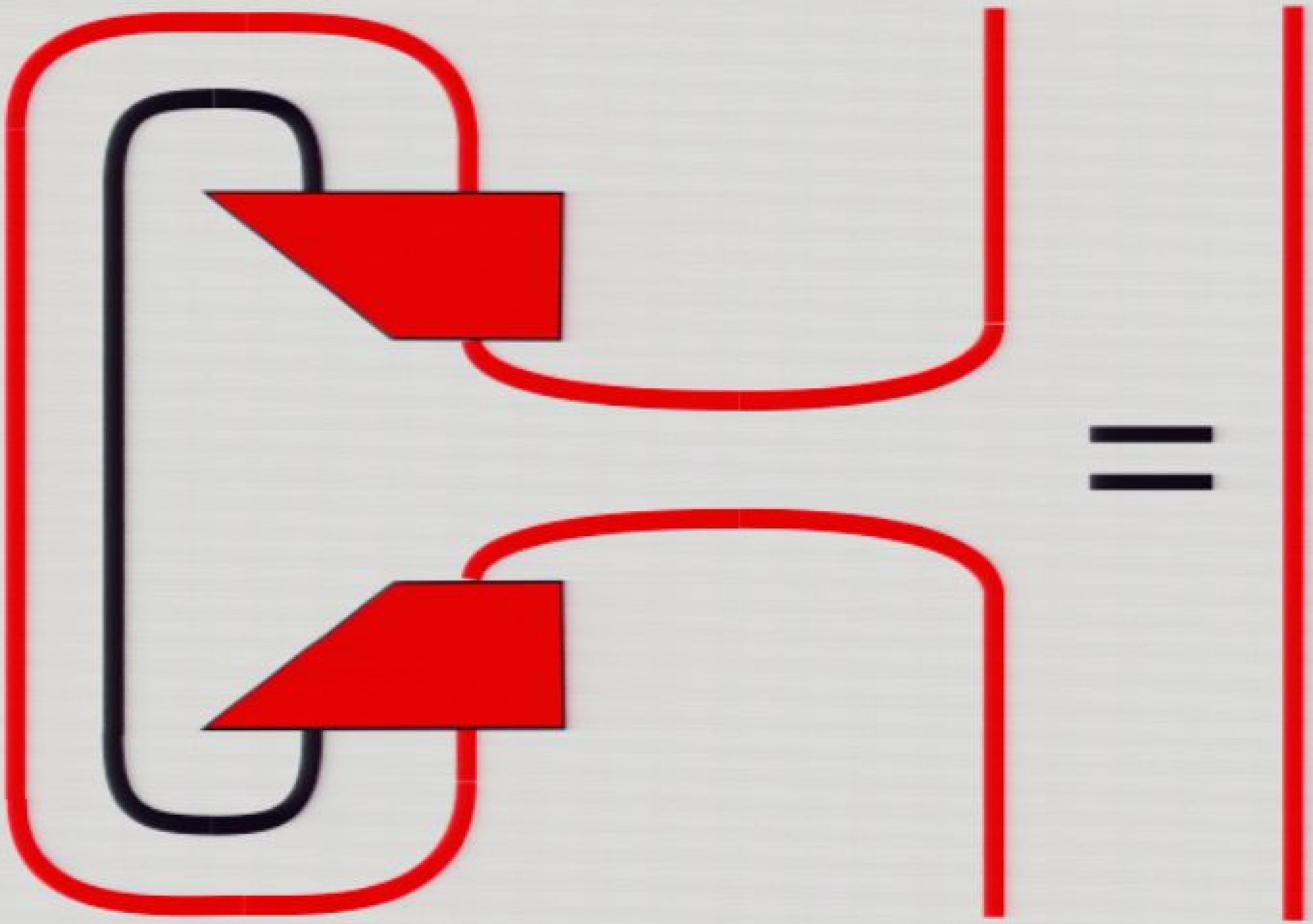

ALICE
BOB

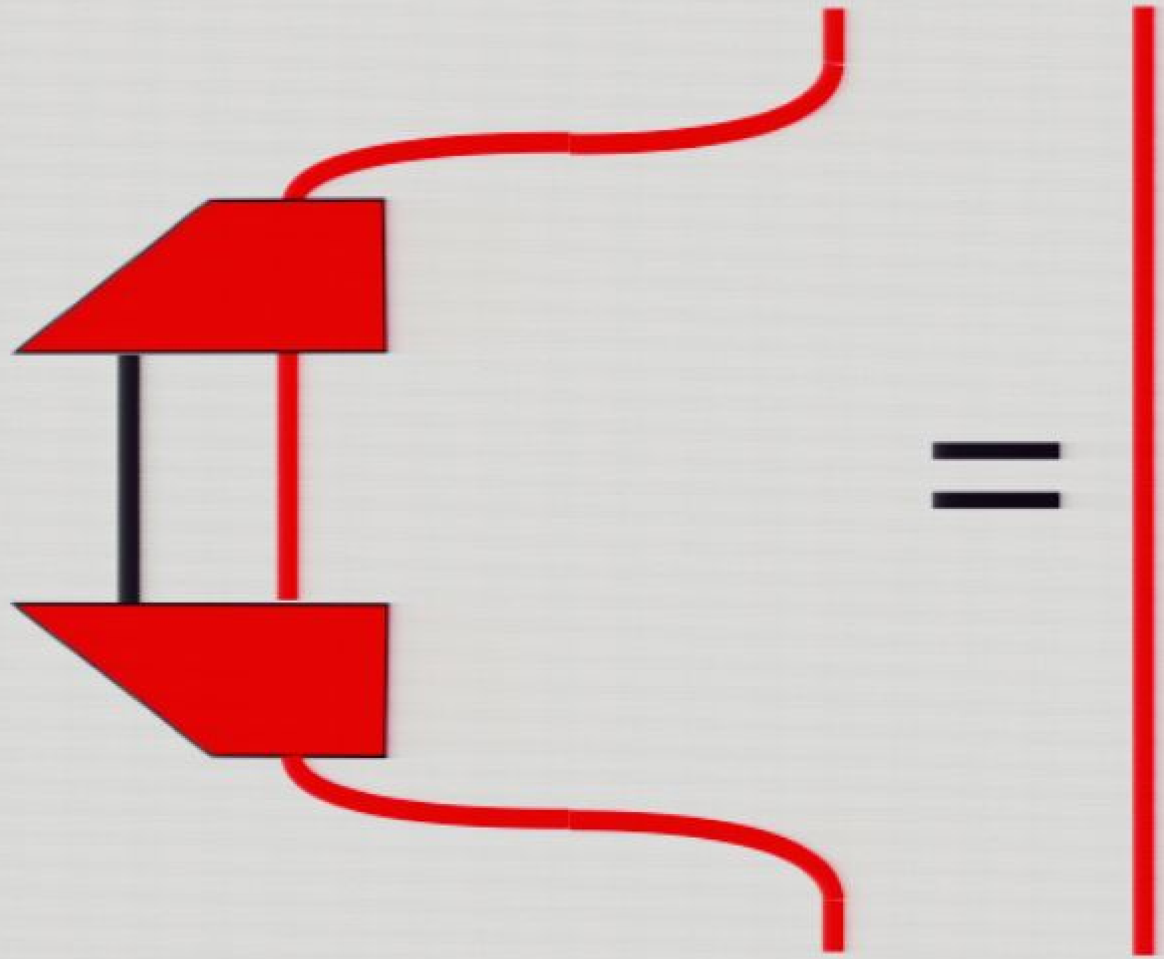


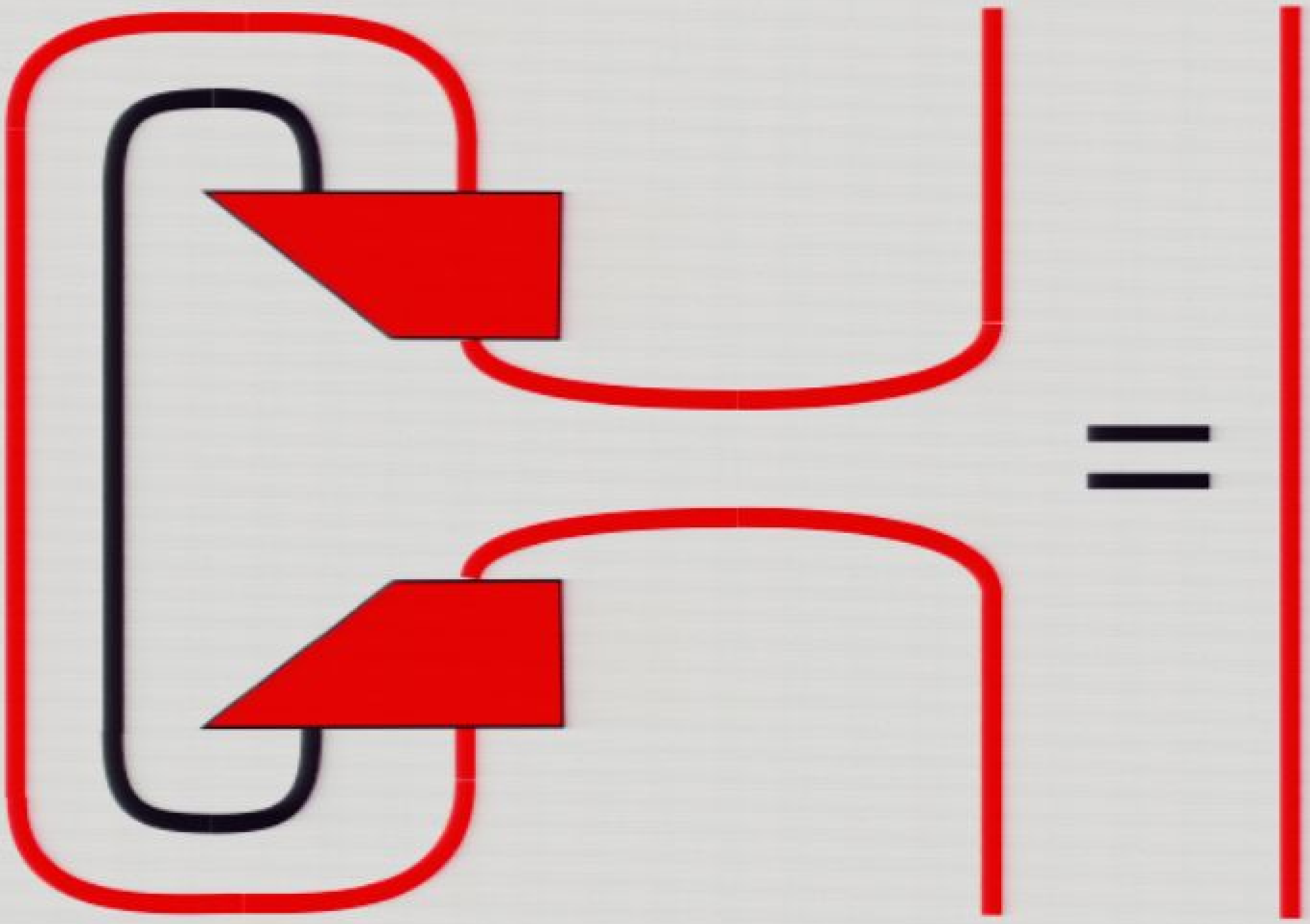
(100%)
Tue 5:00:28 pm
ALICE
BOB
=

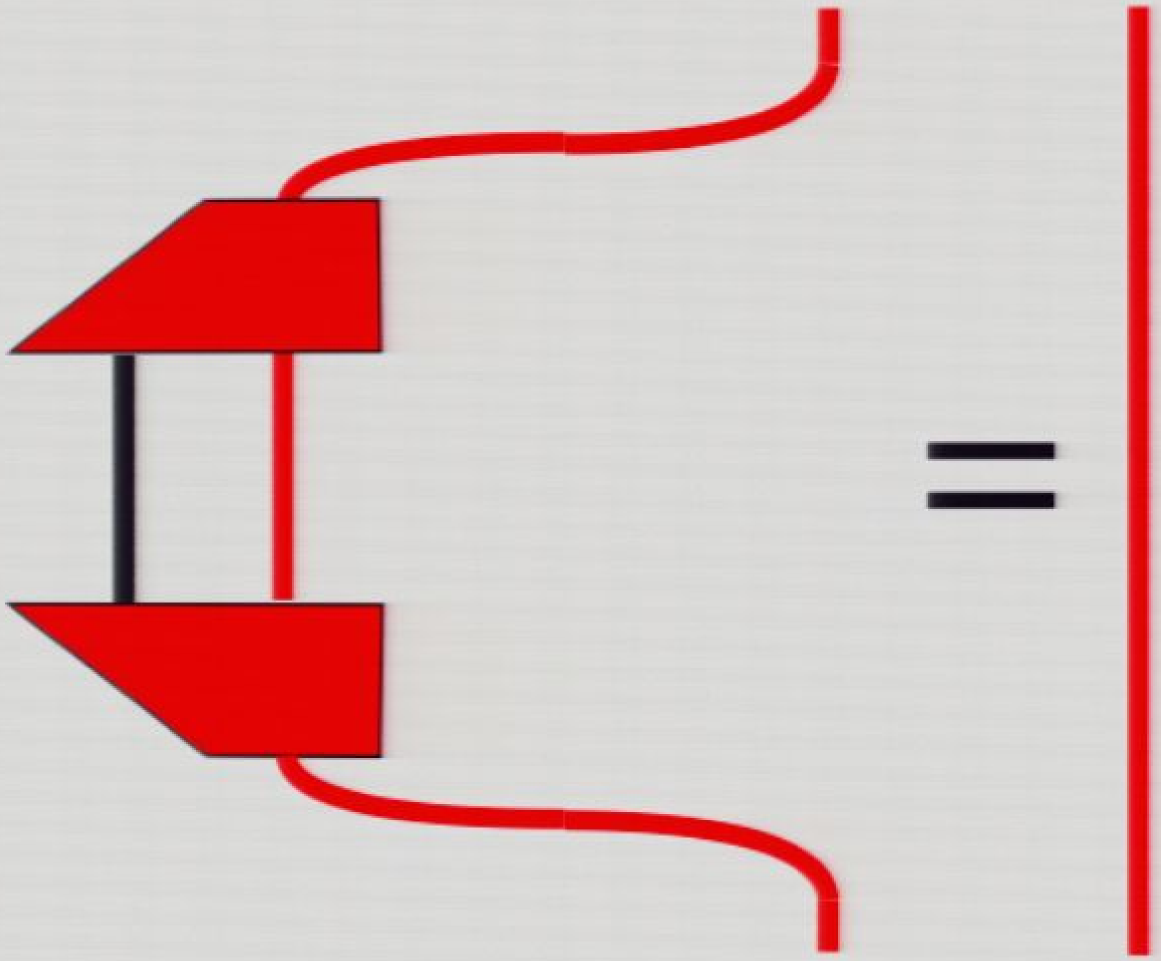


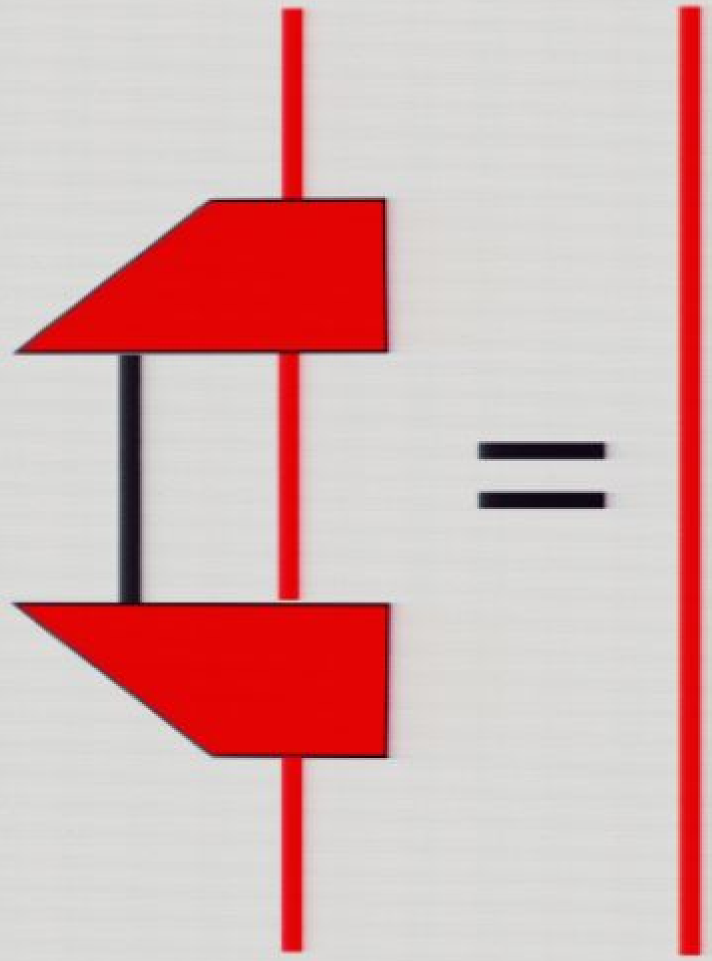


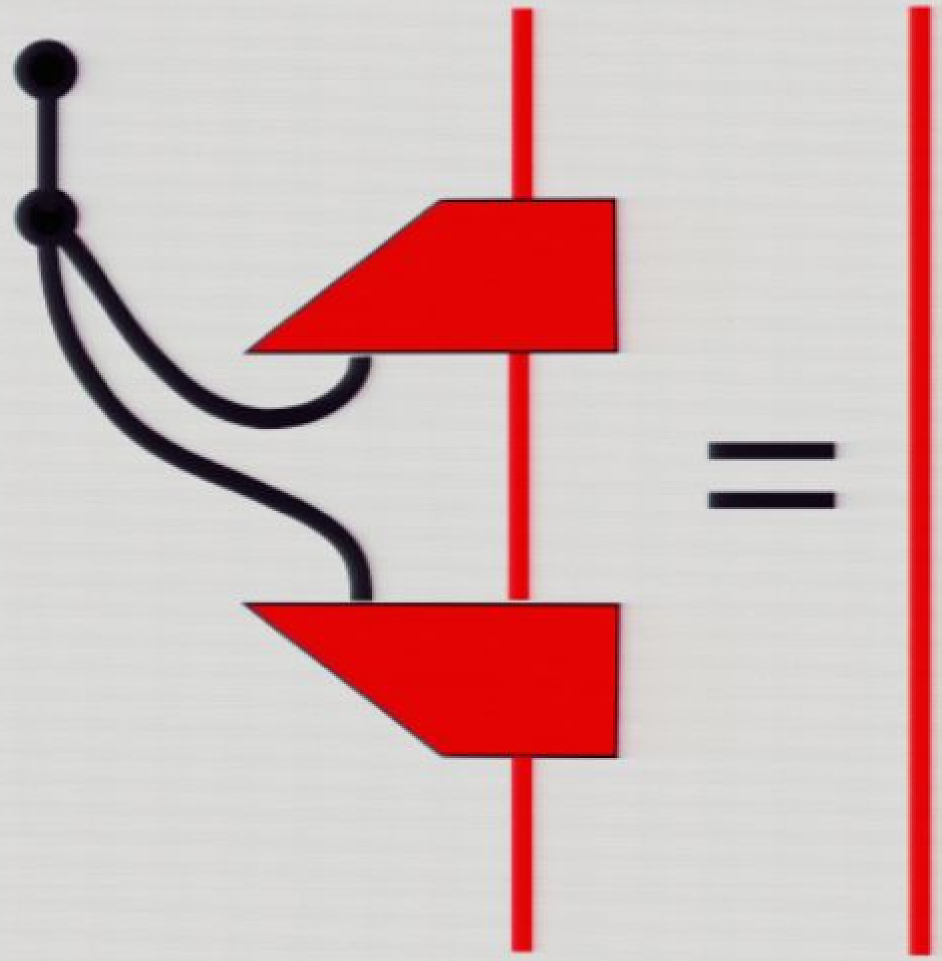


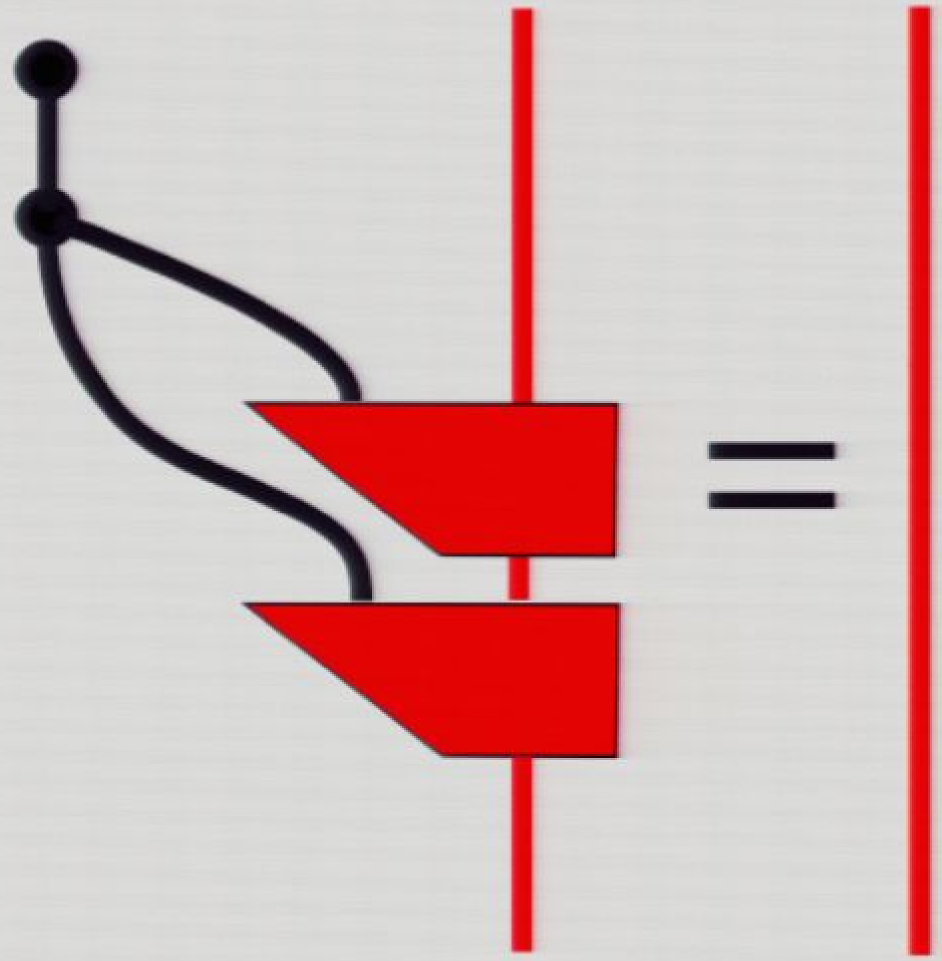


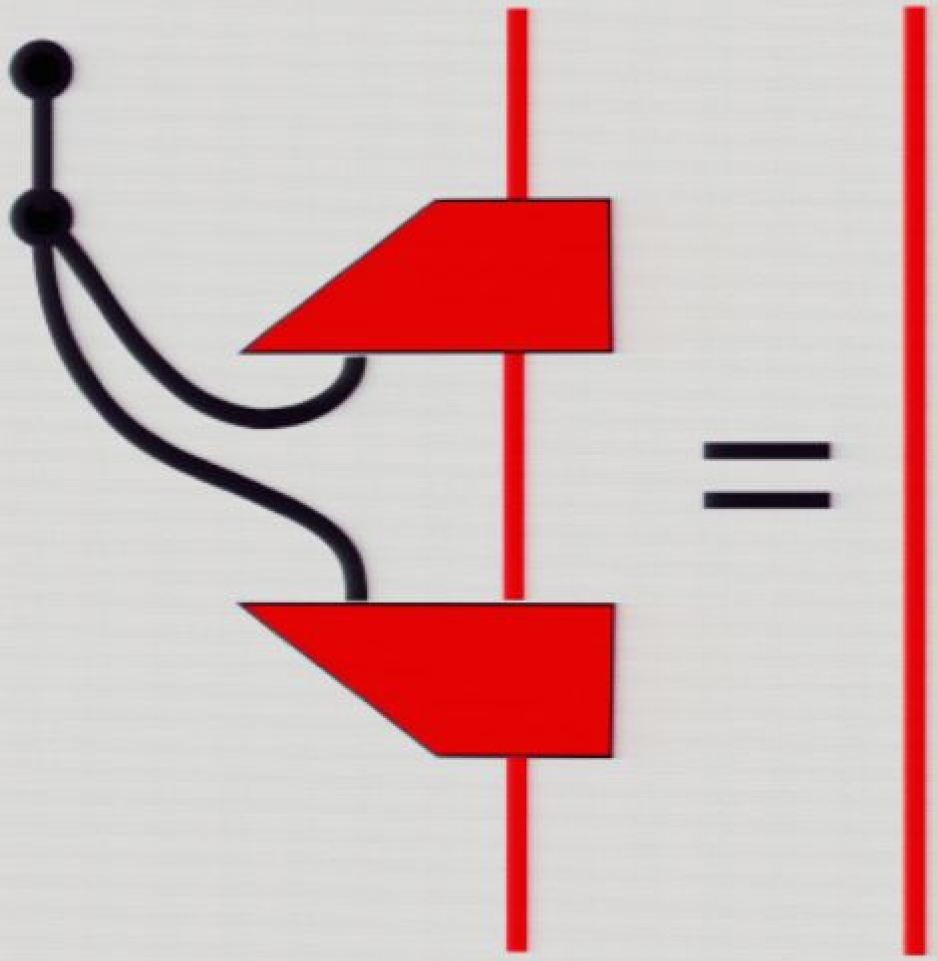


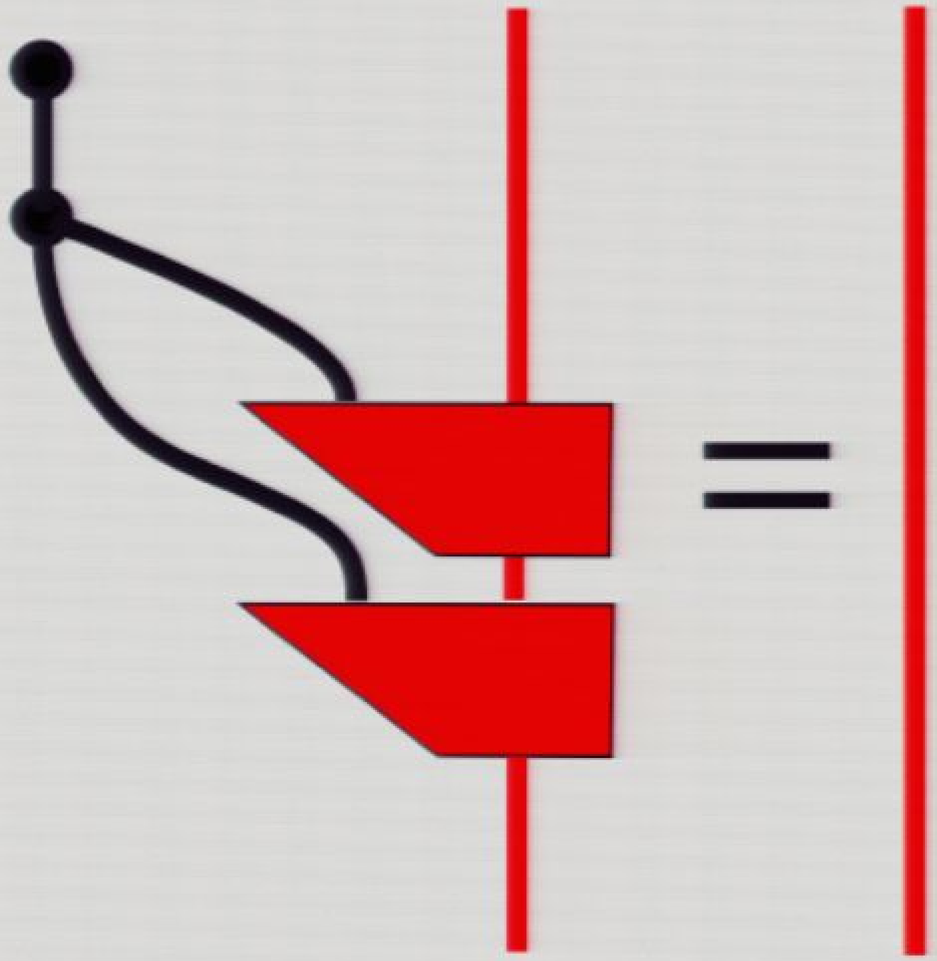


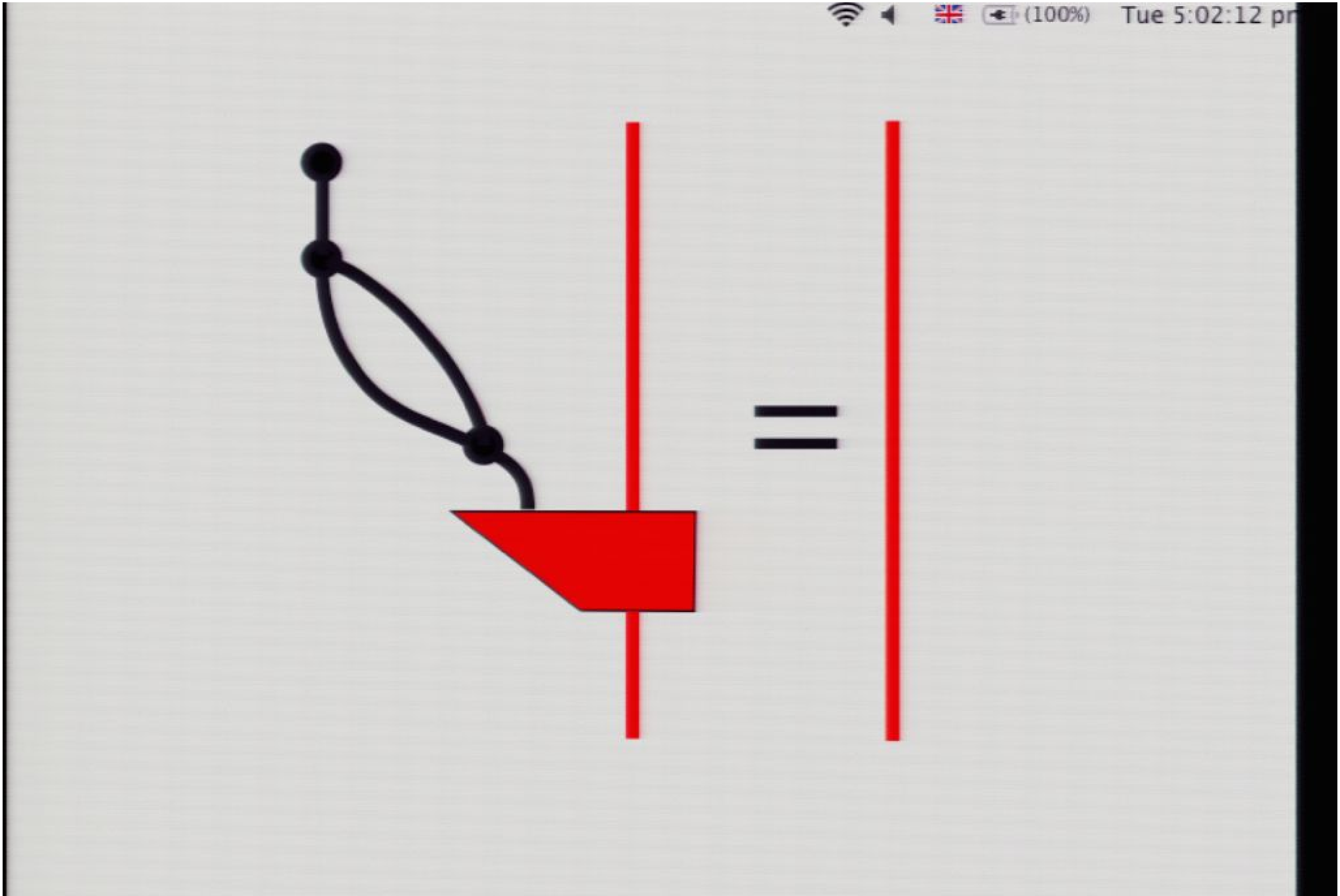


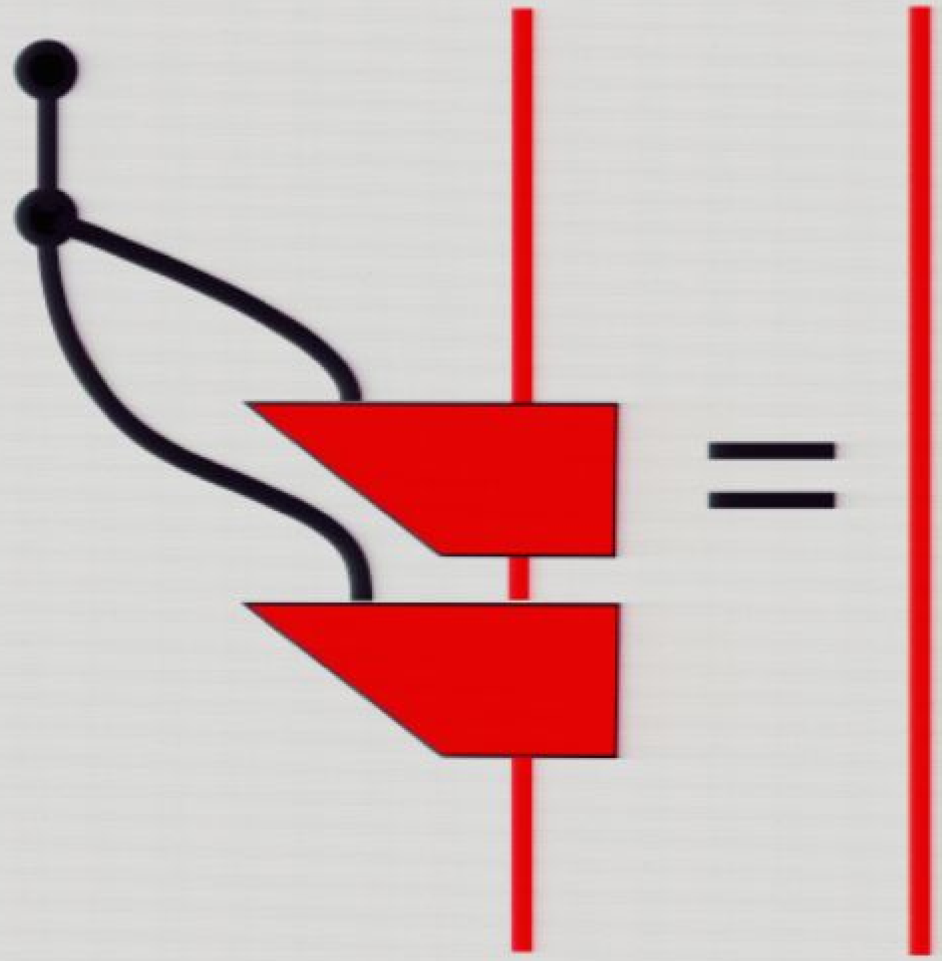


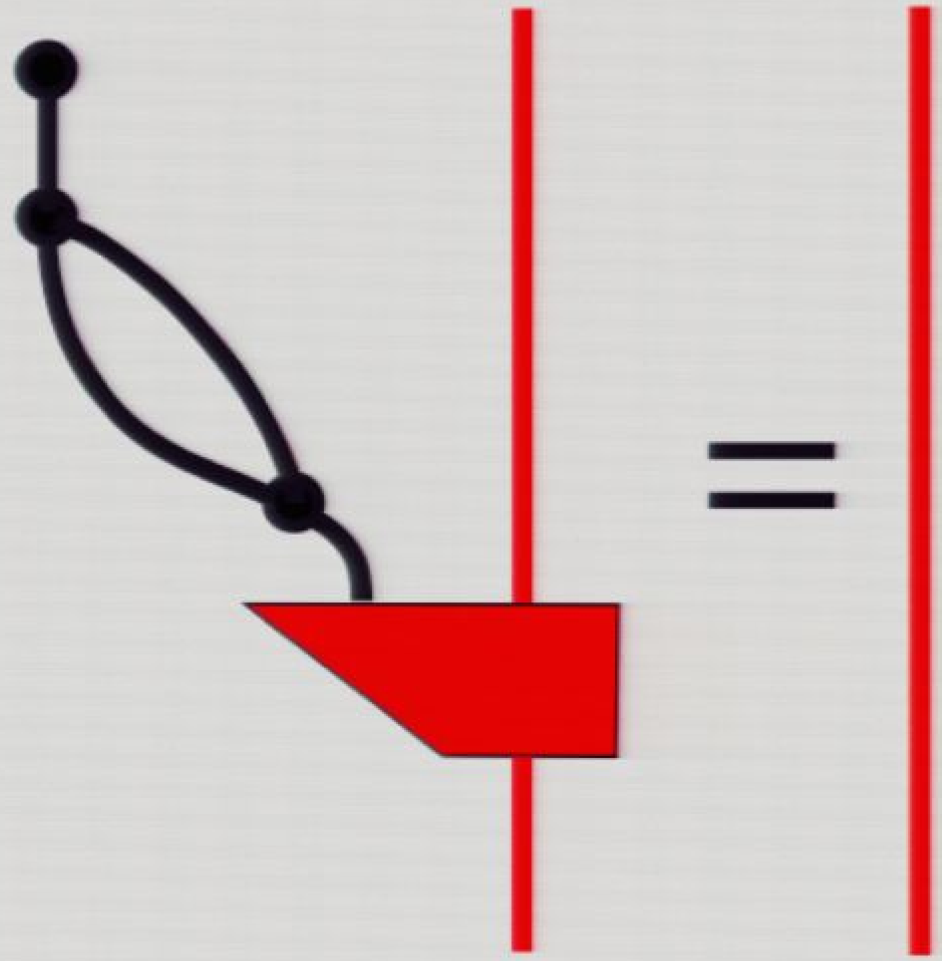


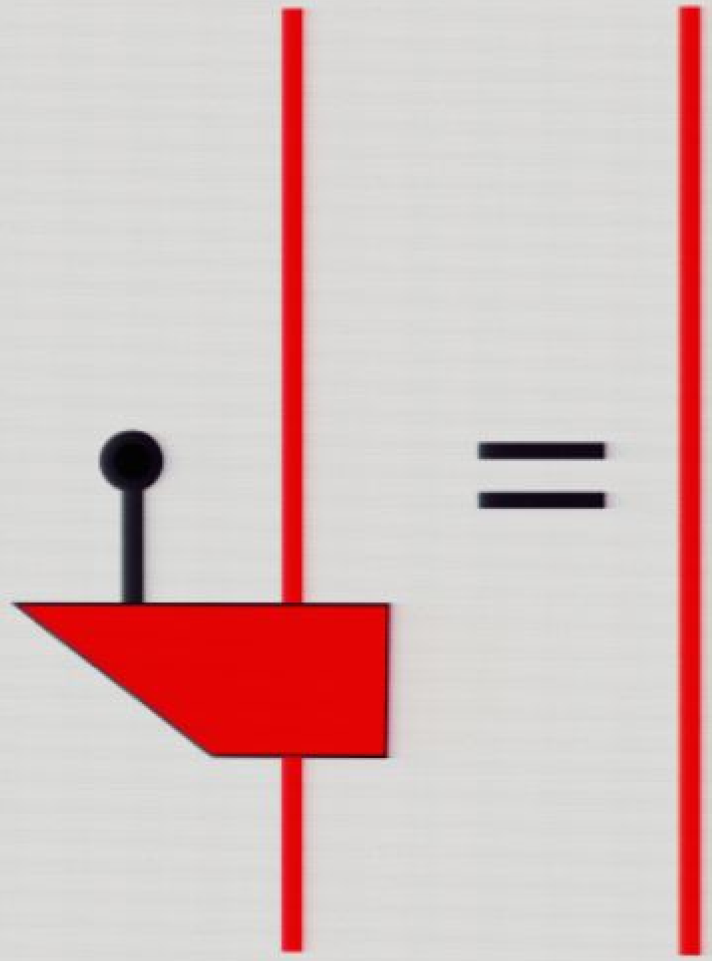




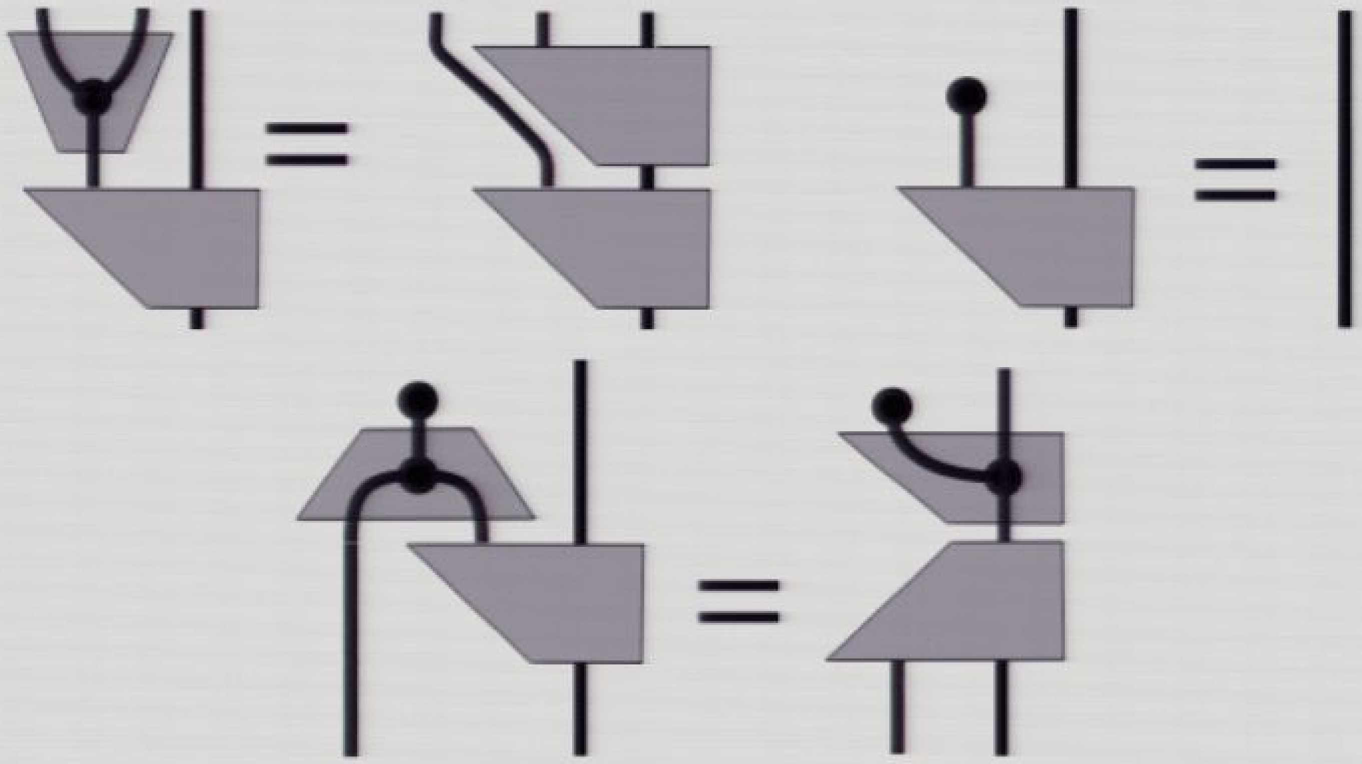

(100%)
Tue 5:02:12 p



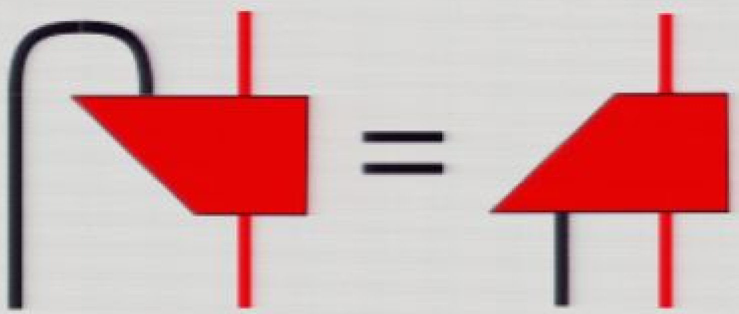




Canonical observable := Copying



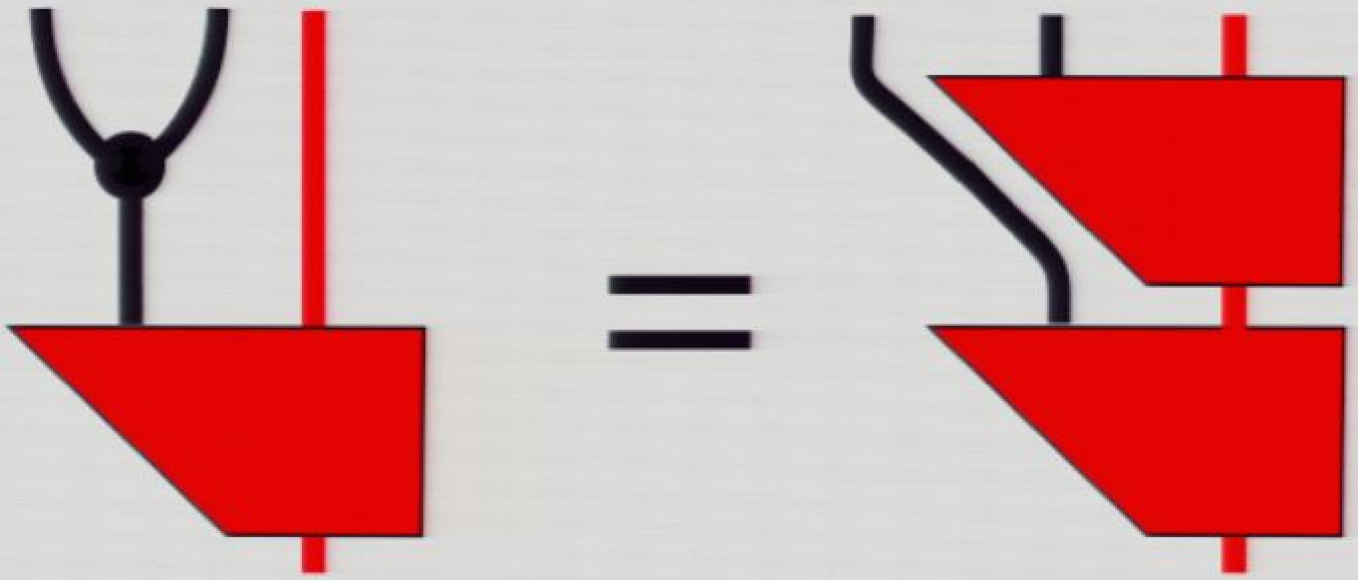
Quantum measurement:



Asserts *no-signaling*

Quantum measurement:

$$\mathcal{M} : A \to X \otimes A$$



$\Rightarrow$ **von Neumann projection postulate.**

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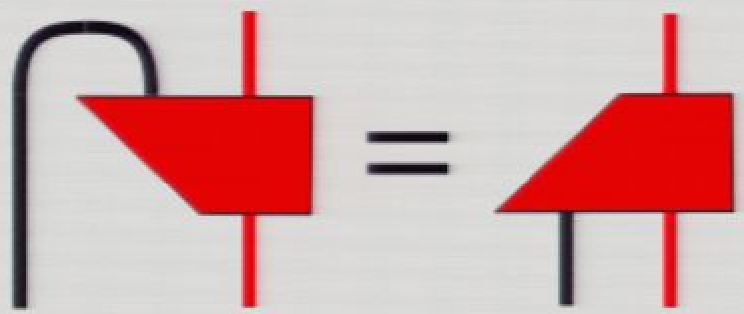
Quantum measurement:



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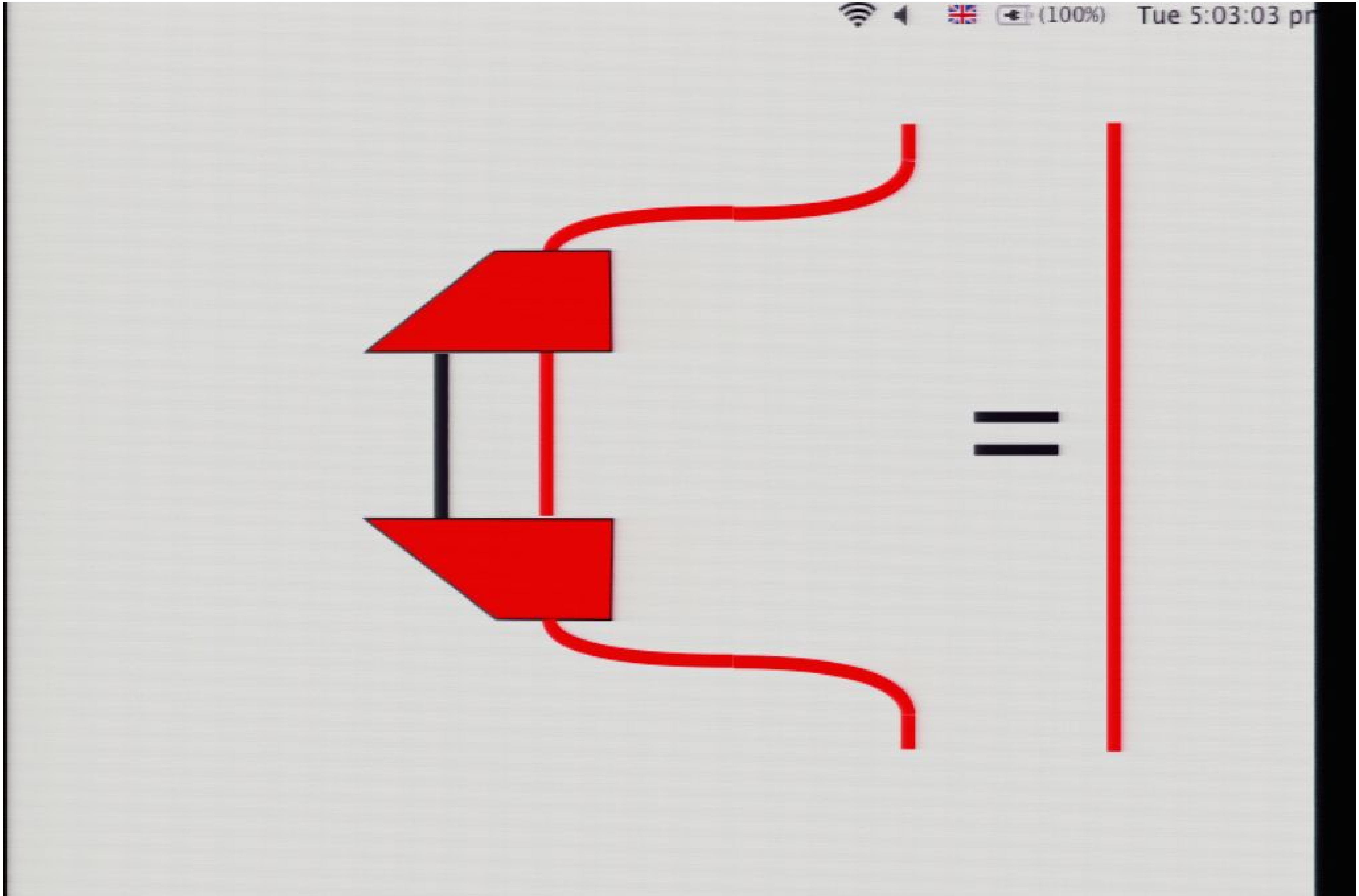
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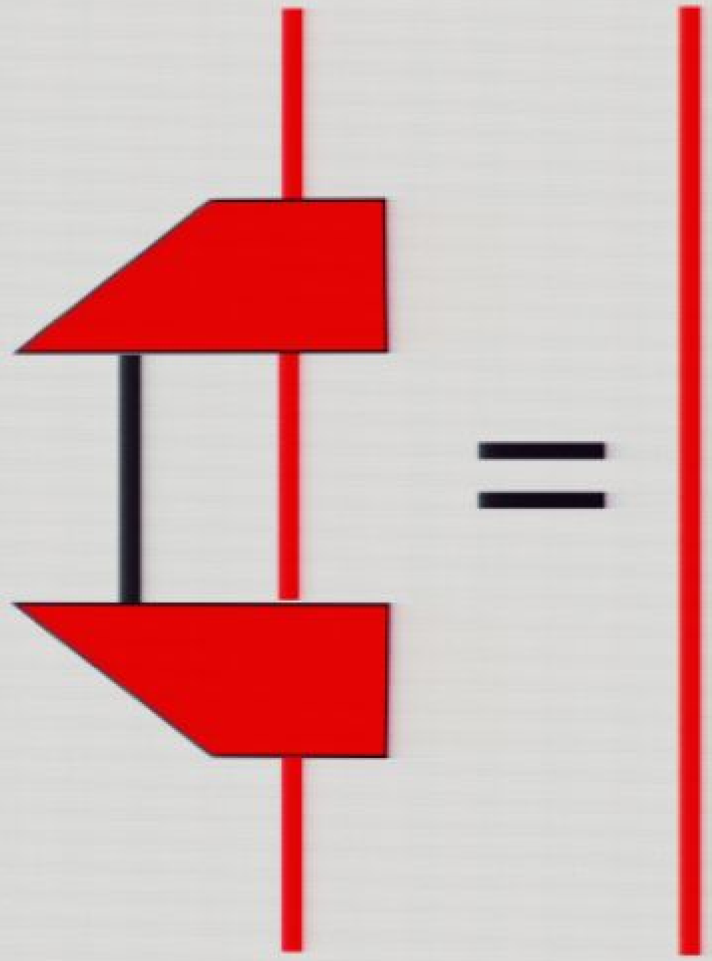
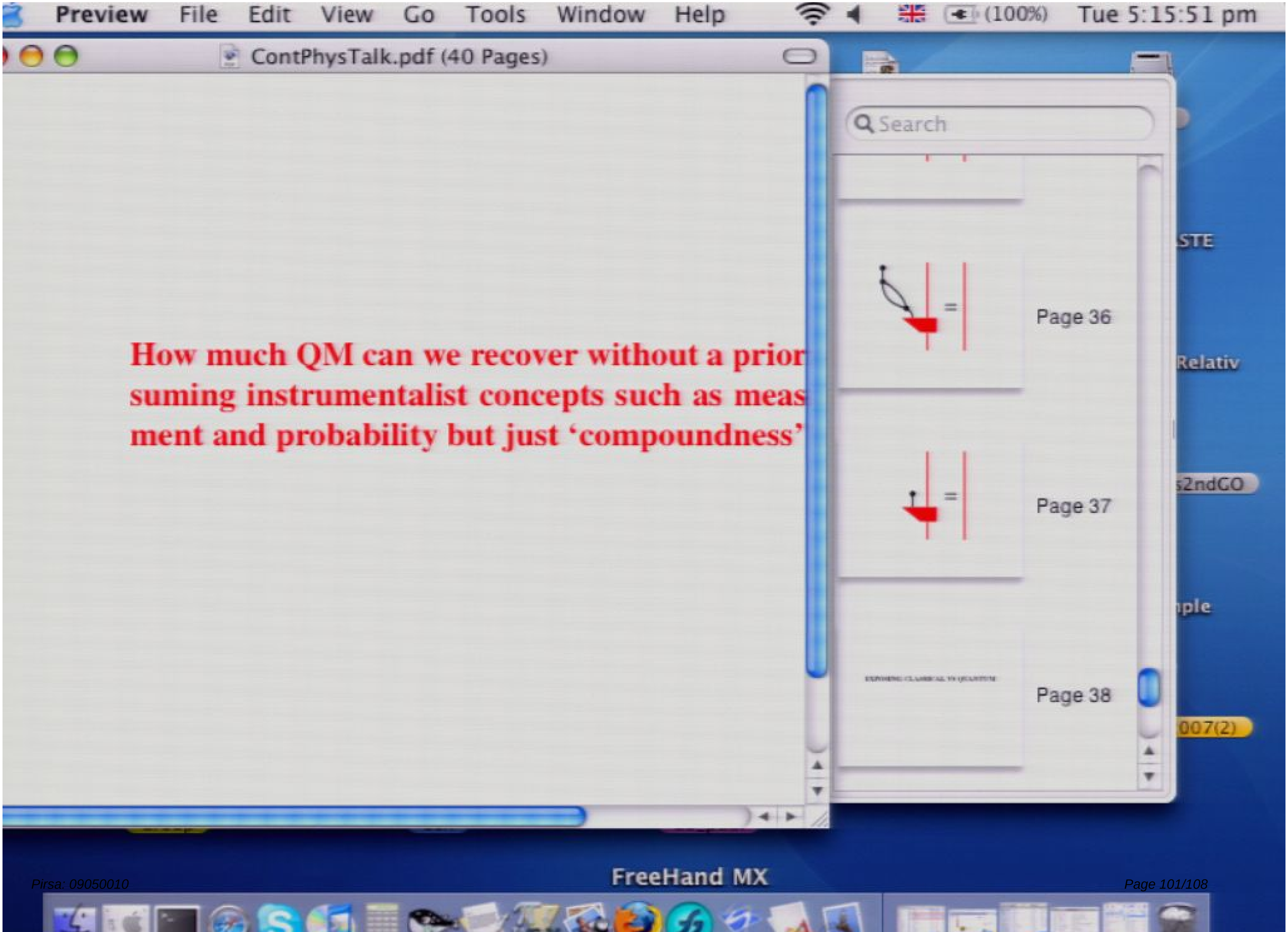


EXPOSING CLASSICAL VS QUANTUM


Preview File Edit View Go Tools Window Help
(100%) Tue 5:15:51 pm
ContPhysTalk.pdf (40 Pages)
Search
How much QM can we recover without a prior
suming instrumentalist concepts such as meas
ment and probability but just 'compoundness'
Page 36
Page 37
Page 38
FreeHand MX

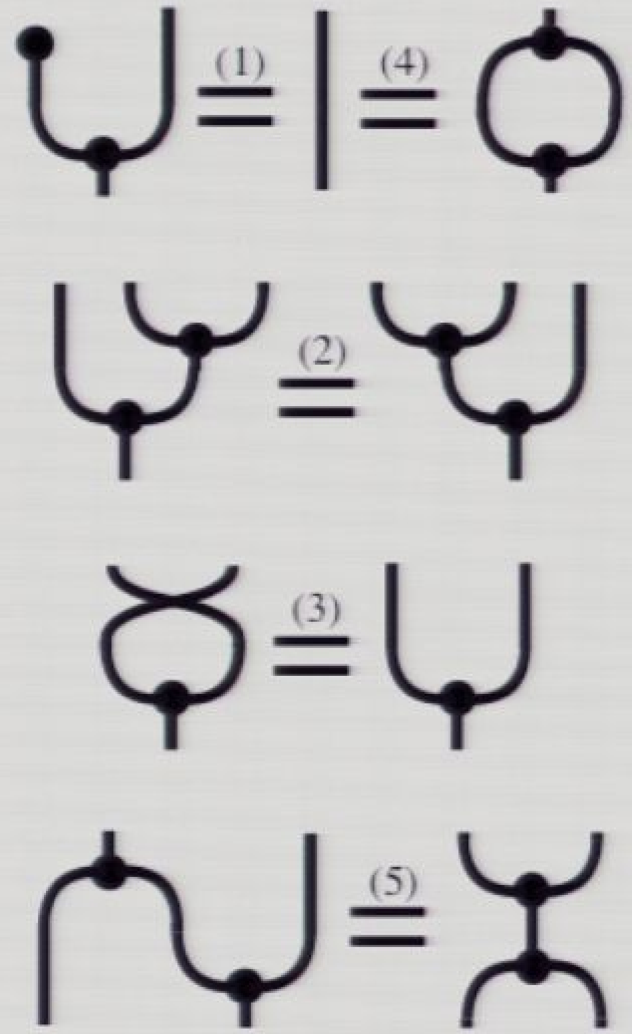
An *classical interface* is:

$$A \xrightarrow{\delta} A \otimes A =$$ 

$$A \xrightarrow{\varepsilon} \mathrm{I} =$$ 

such that:

1. ε is a *unit* for δ ;
2. δ is *coassociative* ;
3. δ is *cocommutative* ;
4. δ is *isometry* ;
5. δ is *Frobenius*.



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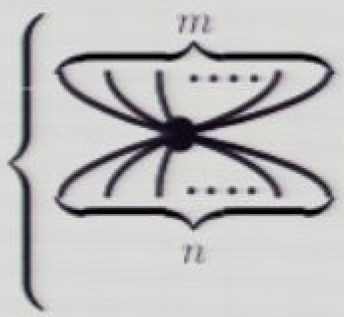
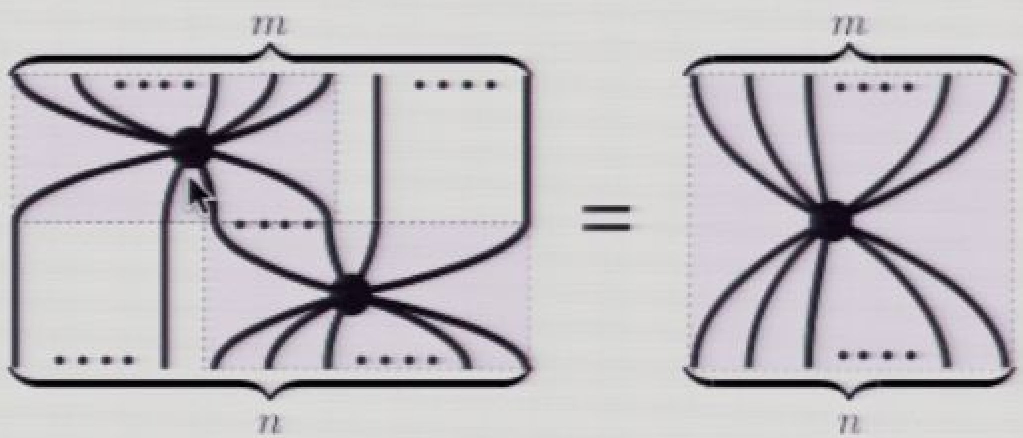


$$\left| \, n, m \in \mathbb{N} \right.$$

invariant under flipping and swapping, and such that:



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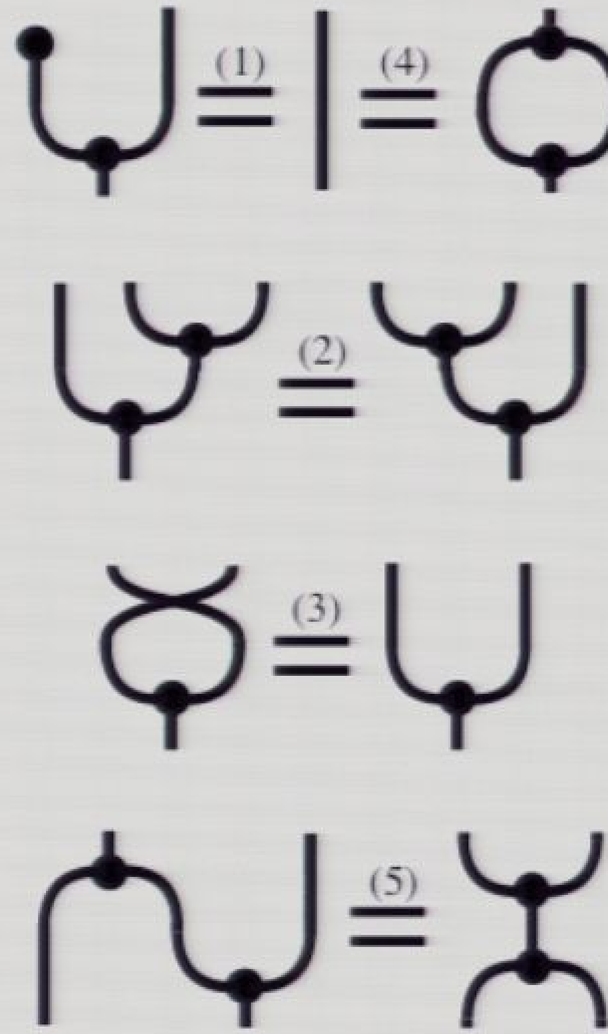

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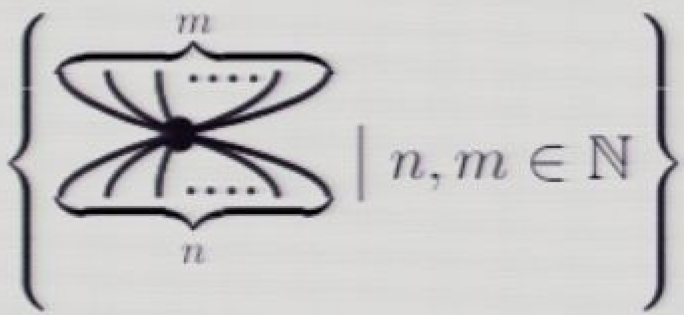

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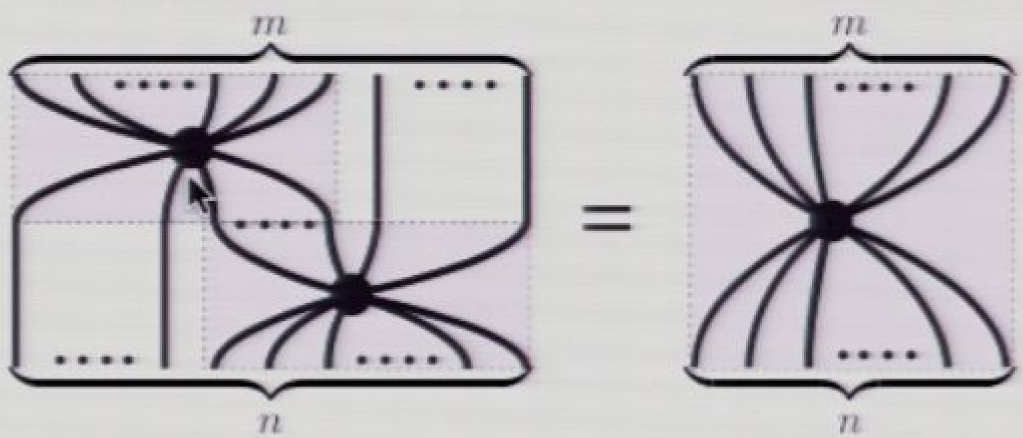

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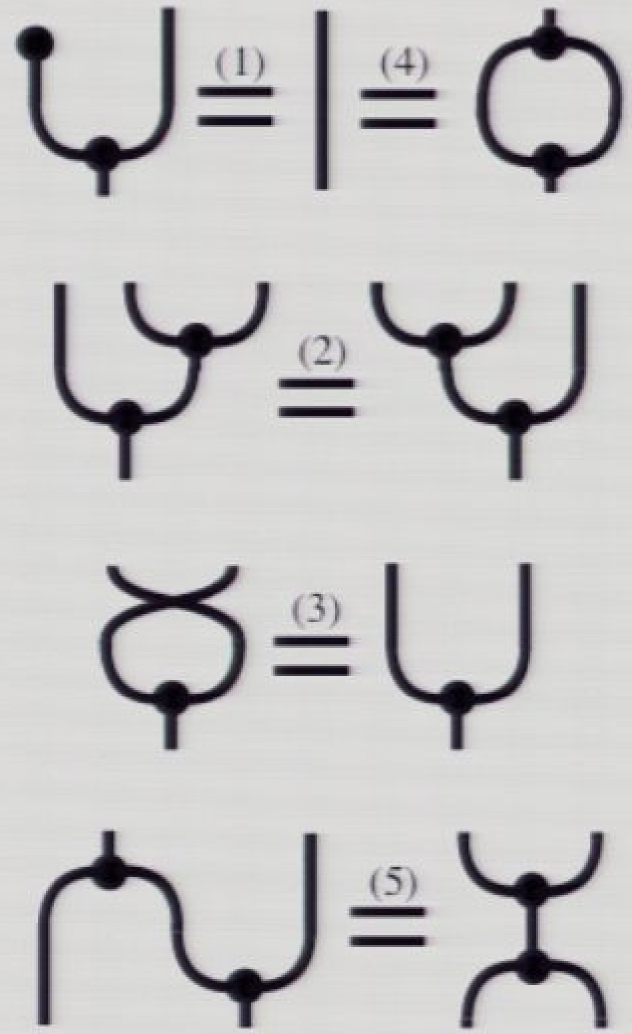
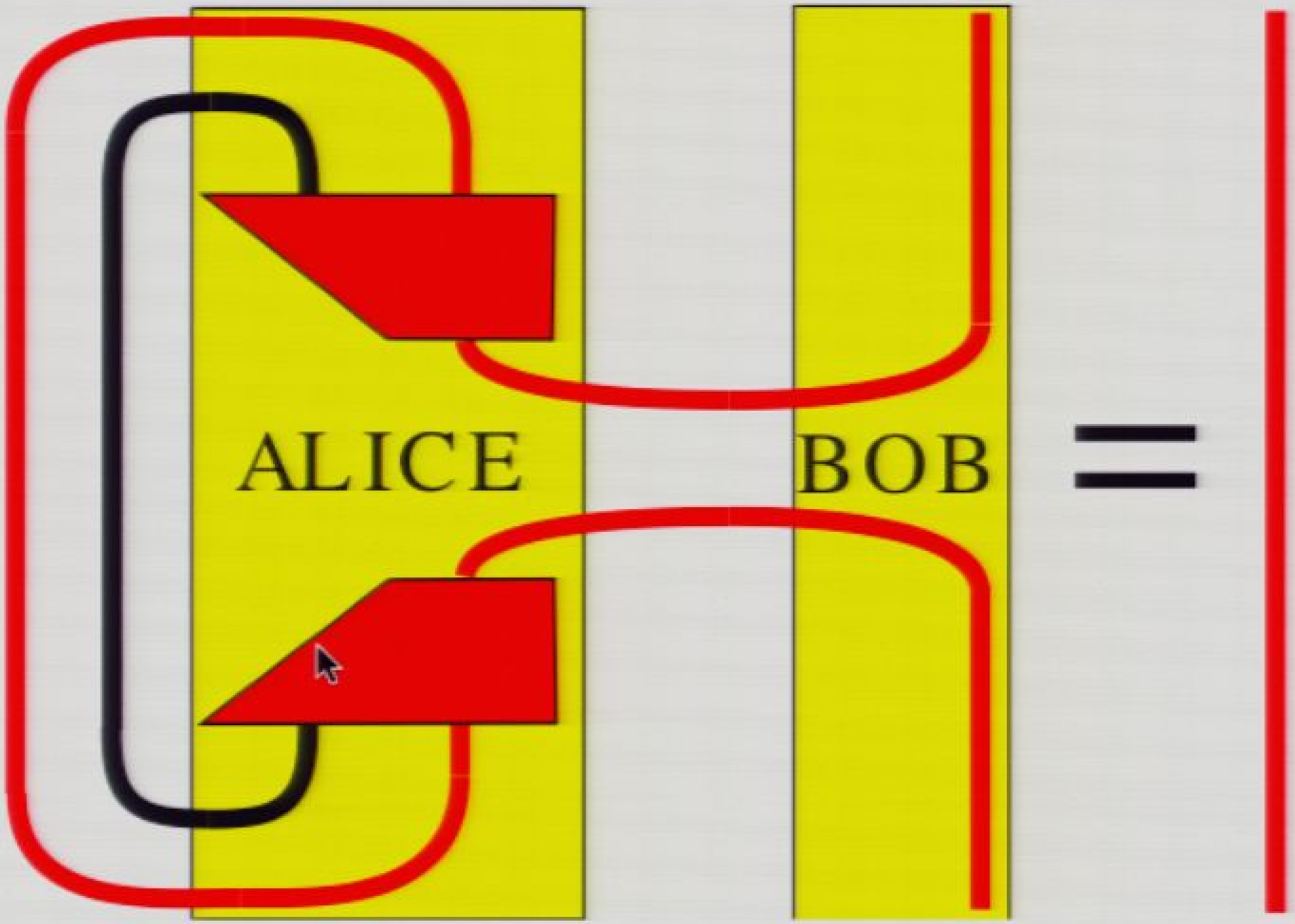


How much QM can we recover without a priori assuming instrumentalist concepts such as measurement and probability but just ‘compoundness’?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