

Title: 12/13 PSI - Found Quantum Mechanics Lecture 2

Date: Jan 08, 2013 11:30 AM

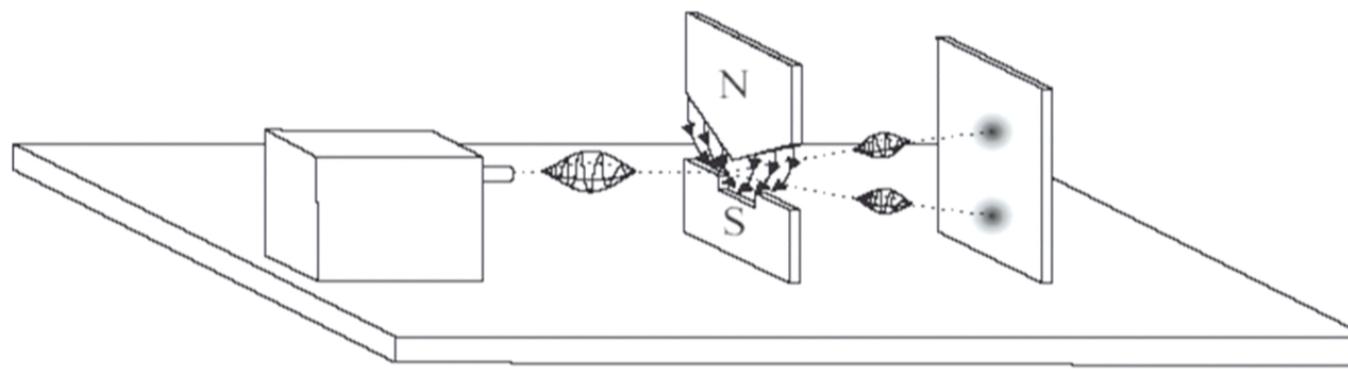
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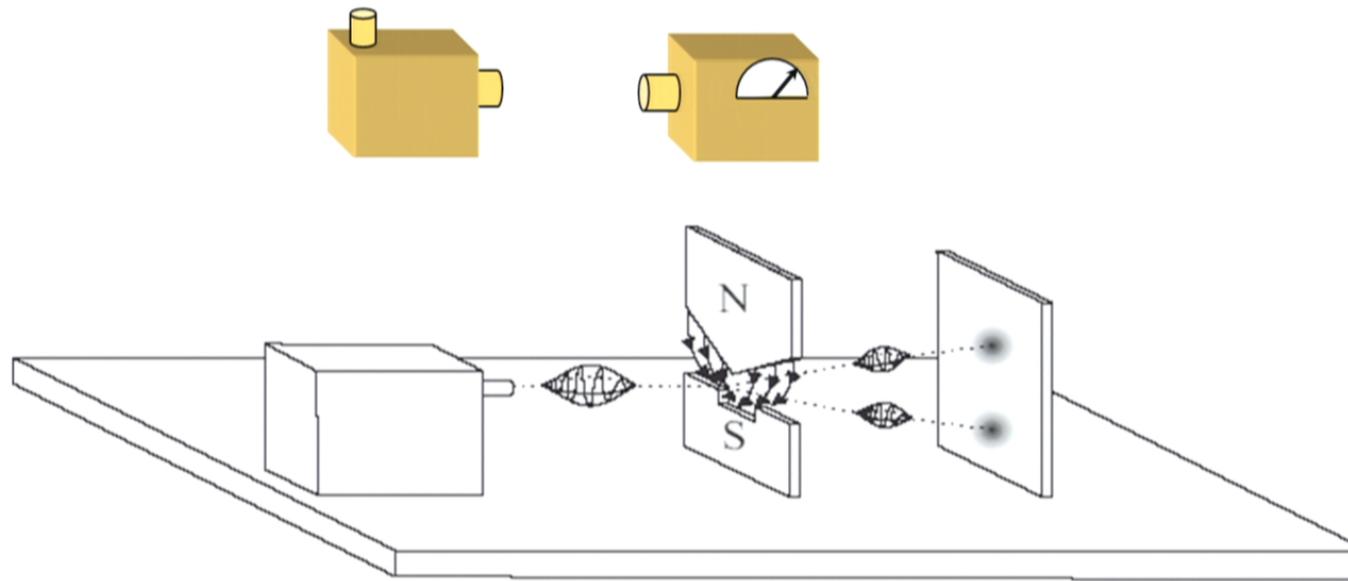
Abstract:

First problem: the term “measurement” is not defined in terms of the more primitive “physical states of systems”. Isn’t a measurement just another kind of physical interaction?

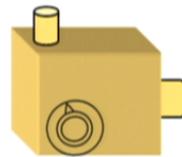
Two strategies:

- (1) **Realist strategy:** Eliminate measurement as a primitive concept and describe everything in terms of physical states
- (2) **Operational strategy:** Eliminate “the physical state of a system” as a primitive concept and describe everything in terms of operational concepts
Elements of the formalism correspond to lists of instructions of what to do in the laboratory

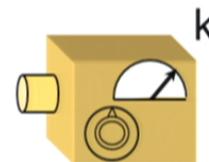




Operational Quantum Mechanics



Preparation
P



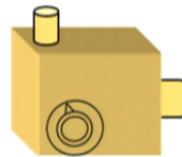
Measurement
M

Vector
 $|\psi\rangle$

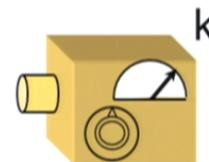
Hermitian operator
 A
 $A = \sum_k a_k \Pi_k$

$$Pr(k|P, M) = \langle \psi | \Pi_k | \psi \rangle$$

Operational Quantum Mechanics



Preparation
P



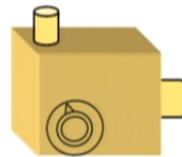
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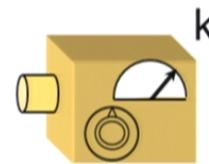
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Operational Quantum Mechanics



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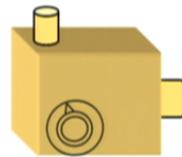
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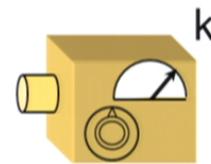
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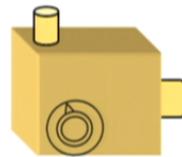
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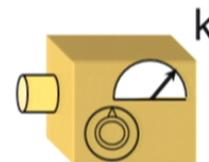
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Operational Quantum Mechanics



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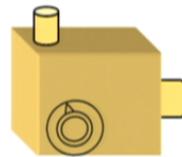
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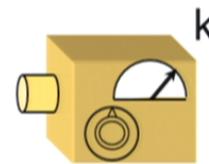
Hermitian operator
 A
 $A = \sum_k a_k |\phi_k\rangle\langle\phi_k|$

$$Pr(k|P, M) = \langle\psi|(|\phi_k\rangle\langle\phi_k|)|\psi\rangle$$

Operational Quantum Mechanics



Preparation
P



Measurement
M

Vector
 $|\psi\rangle$

Hermitian operator
 A
$$A = \sum_k a_k (\sum_j |\phi_{k,j}\rangle \langle \phi_{k,j}|)$$

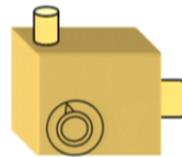
$$Pr(k|P, M) = \langle \psi | (\sum_j |\phi_{k,j}\rangle \langle \phi_{k,j}|) | \psi \rangle$$

What is the expectation value of A ?

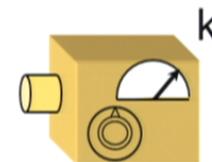
$$A = \sum_k a_k \Pi_k$$

$$\begin{aligned}\langle \psi | A | \psi \rangle &= \sum_k a_k \langle \psi | \Pi_k | \psi \rangle \\ &= \sum_k a_k |\langle \psi | \phi_k \rangle|^2\end{aligned}$$

Operational Quantum Mechanics



Preparation
P



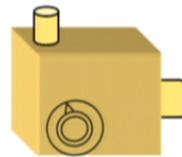
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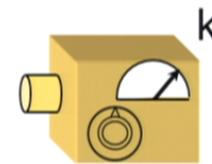
Projection valued
measure (PVM)
 $\{\Pi_k\}$

$$Pr(k|P, M) = \langle \psi | \Pi_k | \psi \rangle$$

Operational Quantum Mechanics



Preparation
 P



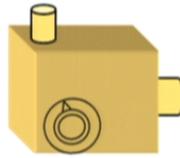
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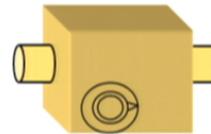
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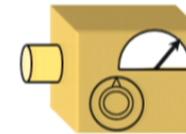
Operational Quantum Mechanics



Preparation
P



Transformation
T



Measurement
M

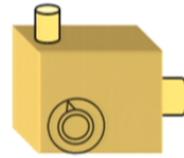
Vector
 $|\psi\rangle$

Unitary map
 U

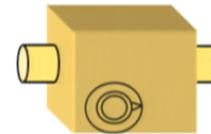
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$$Pr(k|P, T, M) = \langle \psi | U^\dagger \Pi_k U | \psi \rangle$$

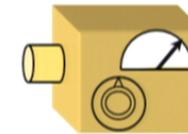
Operational Quantum Mechanics



Preparation
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Measurement
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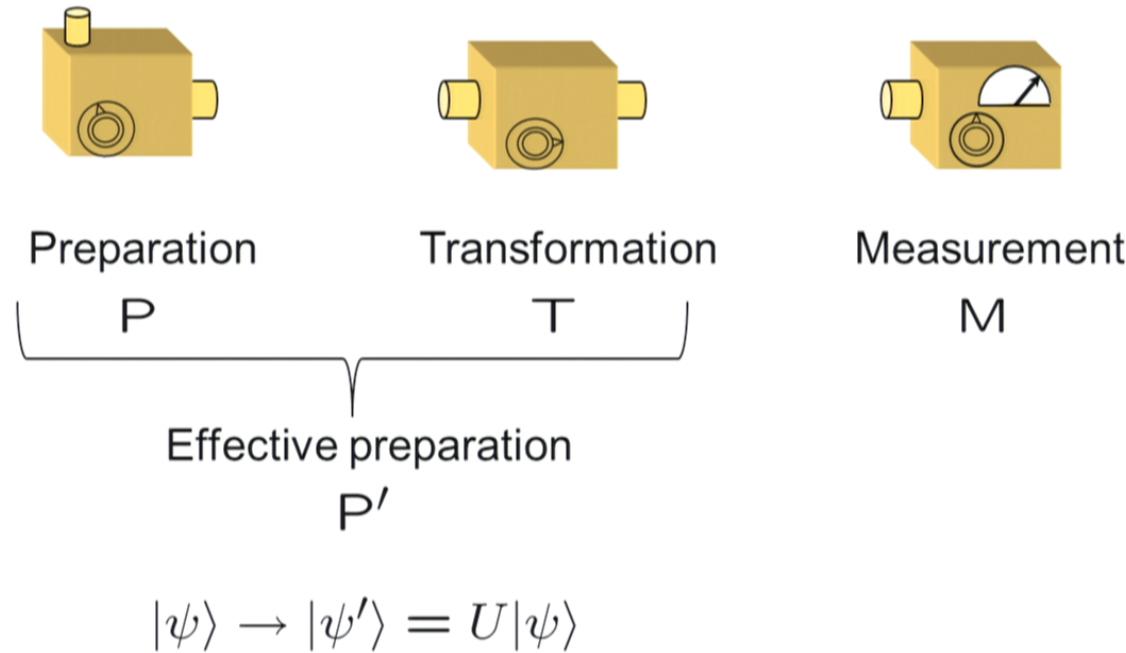
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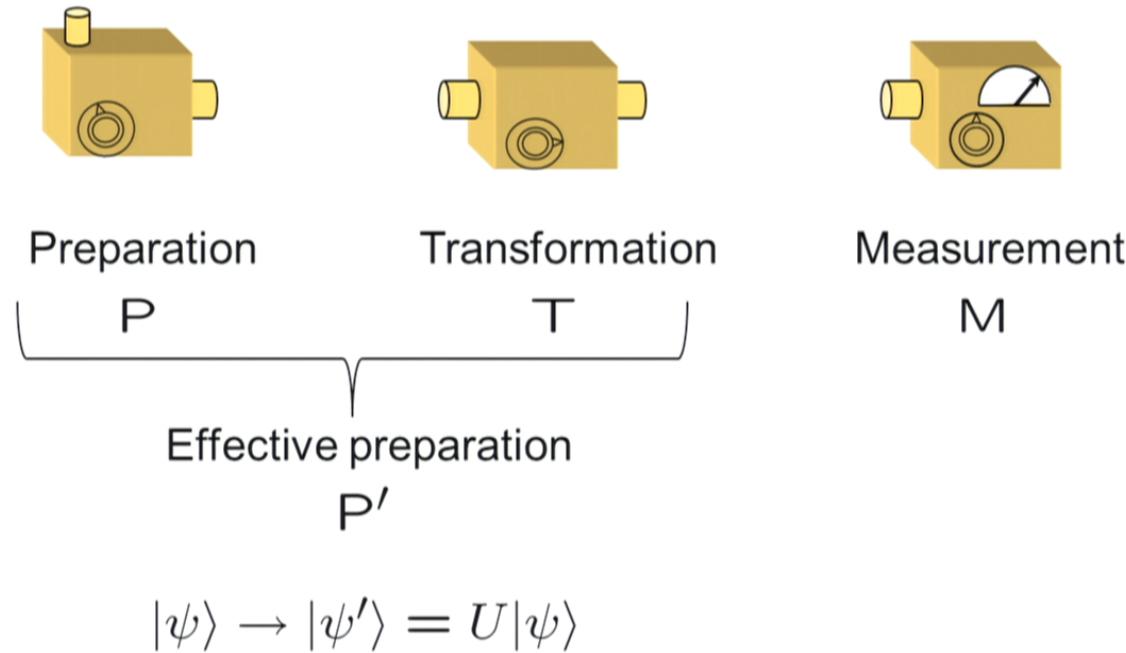
$$Pr(k|P, T, M) = \langle \psi | U^\dagger \Pi_k U | \psi \rangle$$

Operational Quantum Mechanics



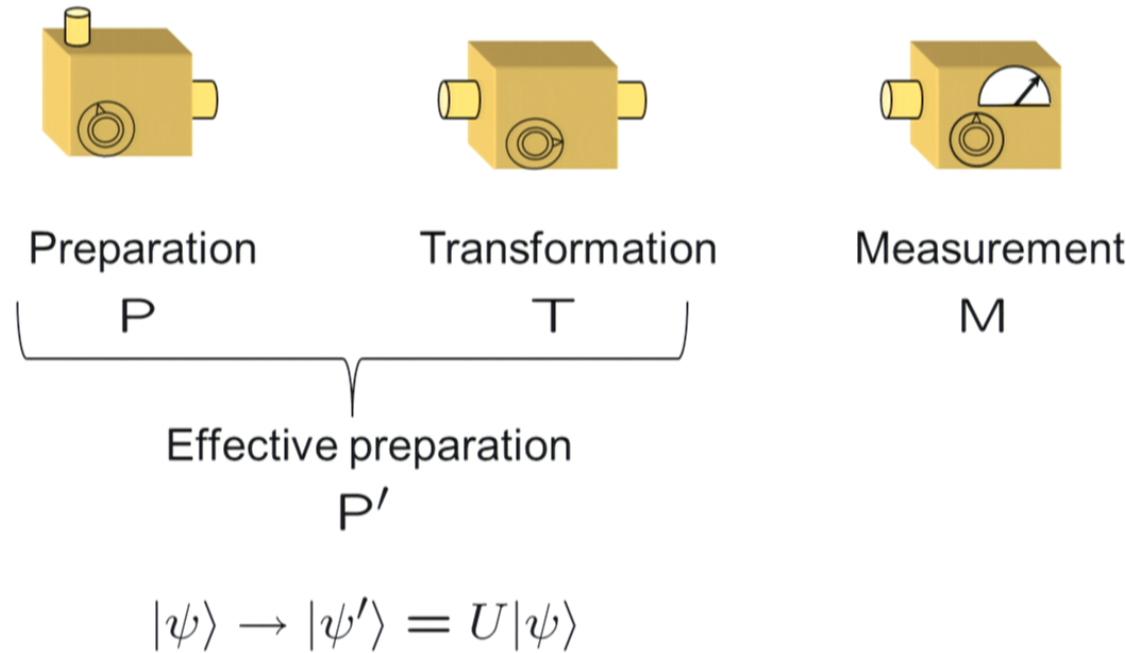
$$Pr(k|P', M) = \langle \psi' | \Pi_k | \psi' \rangle = \langle \psi | U^\dagger \Pi_k U | \psi \rangle$$

Operational Quantum Mechanics



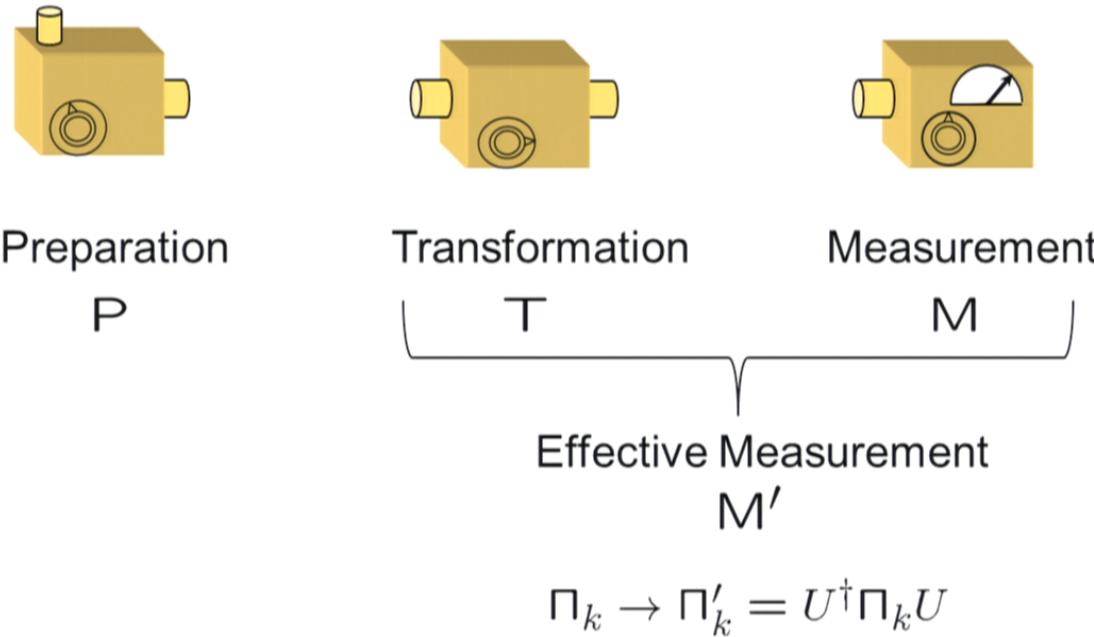
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Operational Quantum Mechanics



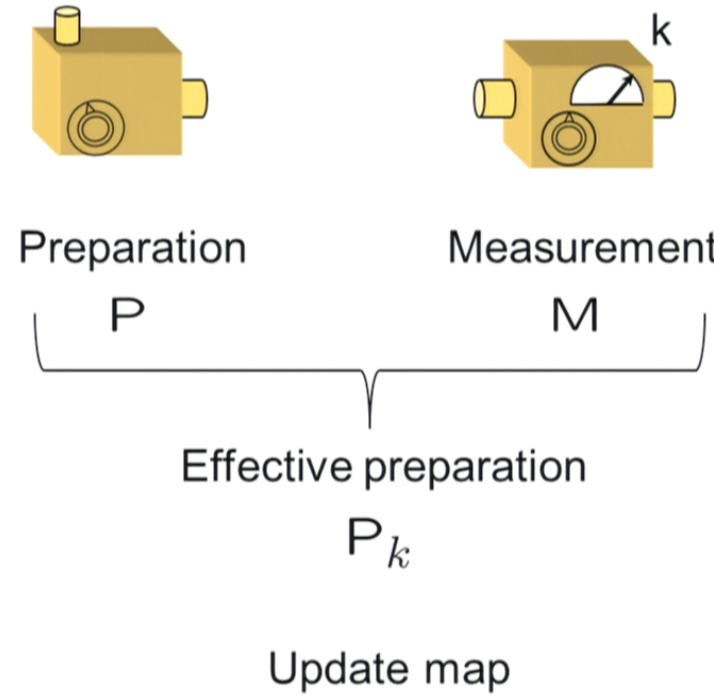
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Operational Quantum Mechanics

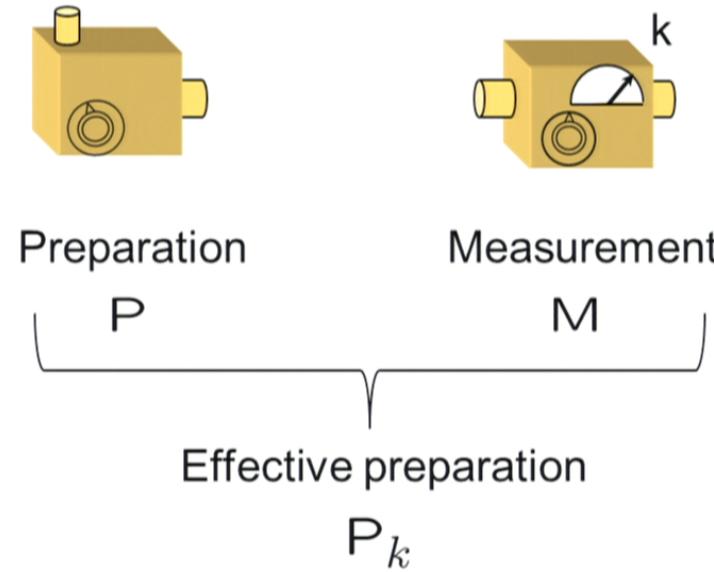


$$Pr(k|P, M) = \langle \psi | \Pi'_k | \psi \rangle = \langle \psi | U^\dagger \Pi_k U | \psi \rangle$$

Operational Quantum Mechanics



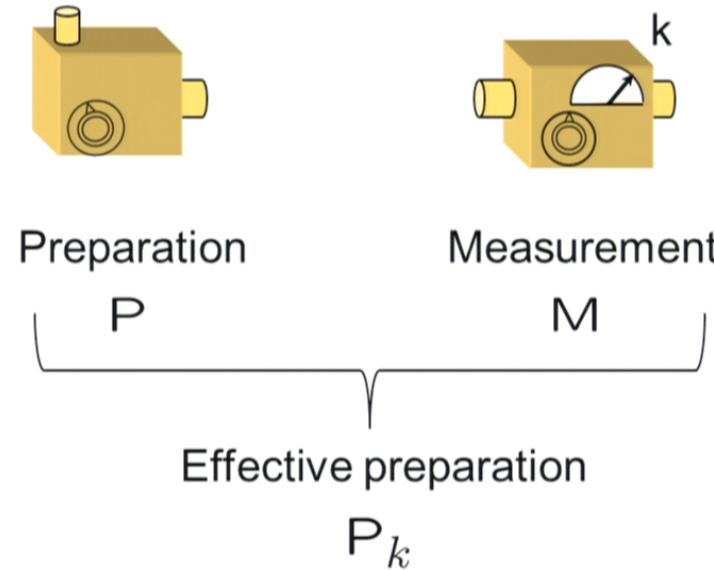
Operational Quantum Mechanics



Update map

$$|\psi\rangle \rightarrow |\psi_k\rangle = \frac{\Pi_k|\psi\rangle}{\sqrt{\langle\psi|\Pi_k|\psi\rangle}}$$

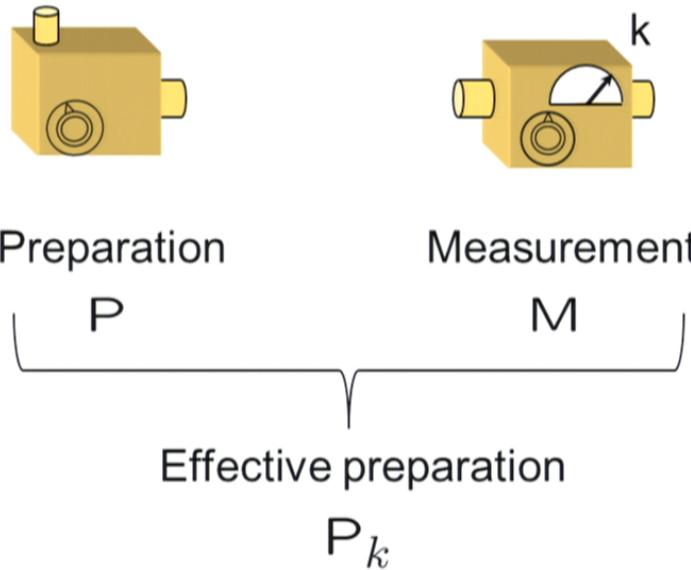
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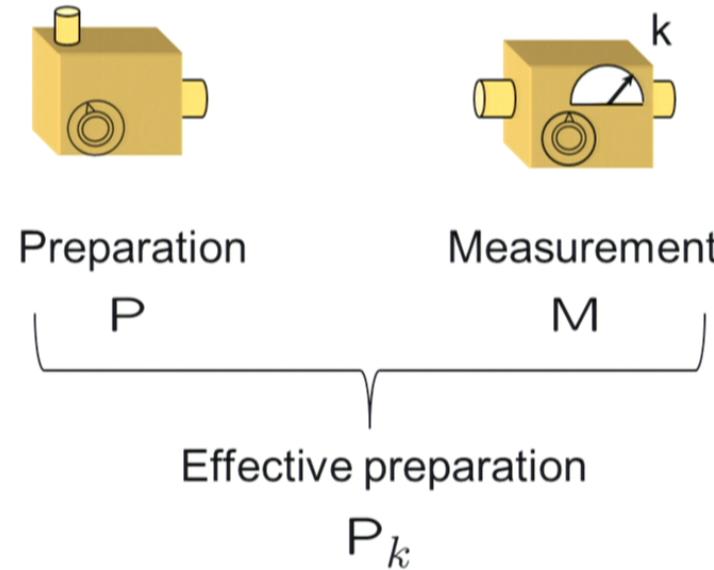
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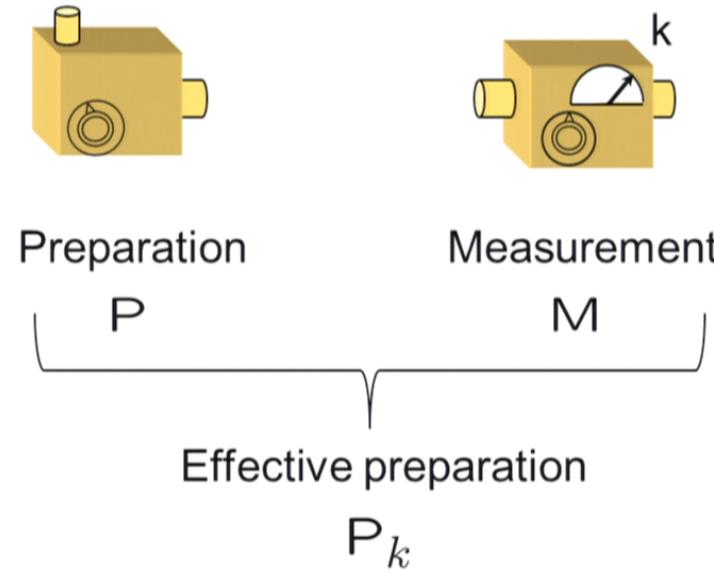
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Is the operational interpretation satisfactory?



Operational Quantum Mechanics

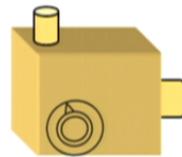


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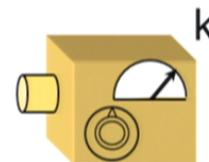
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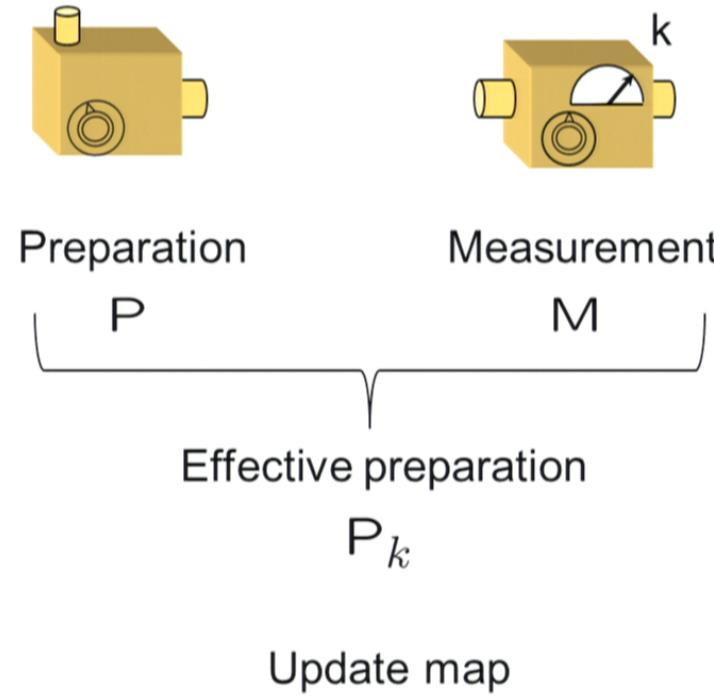
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