Title: Higher-order transformations and the causal structure of quantum processes

Speakers: HlÃ©r KristjÃ¡nsson

Series: Quantum Foundations

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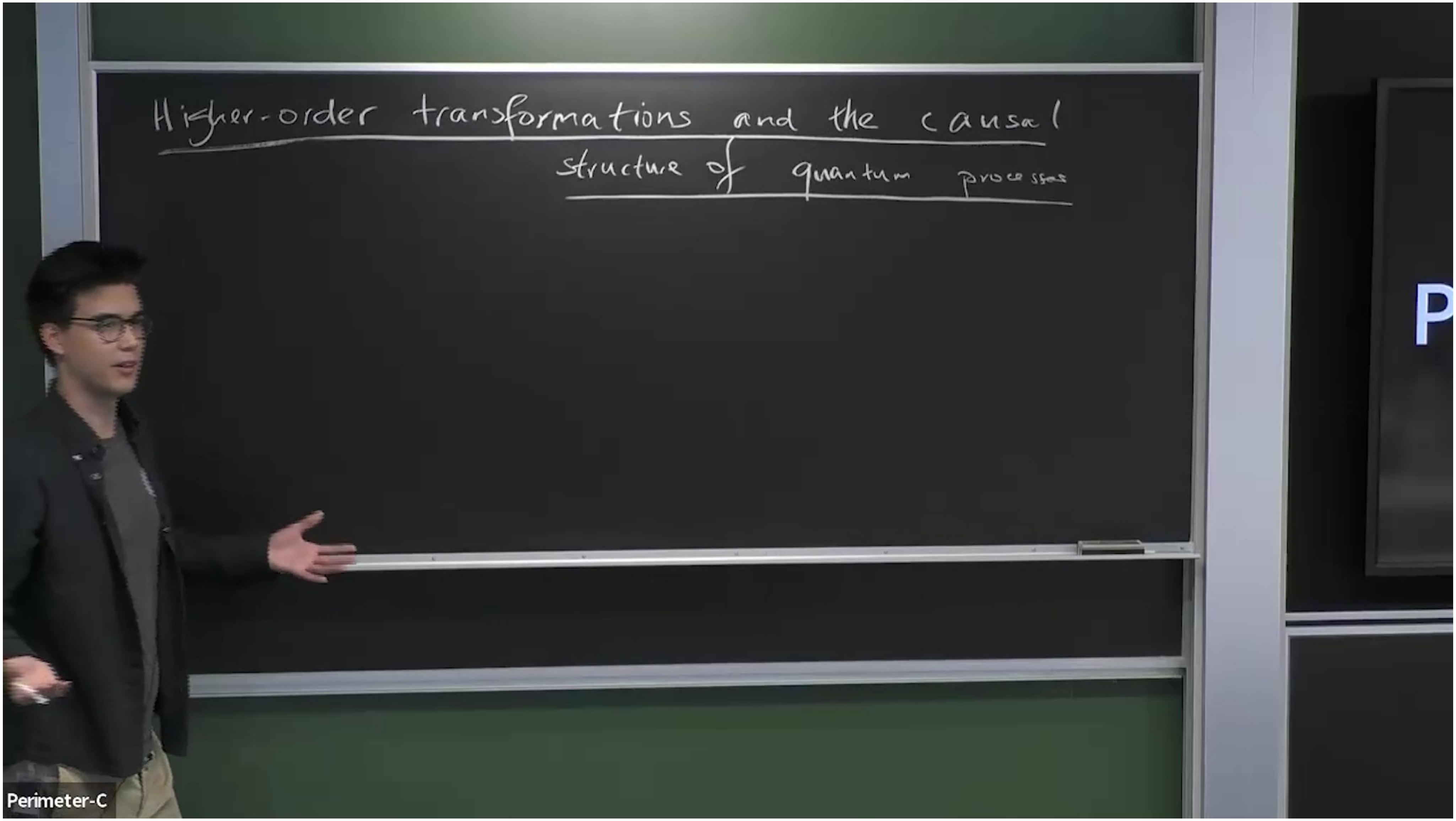
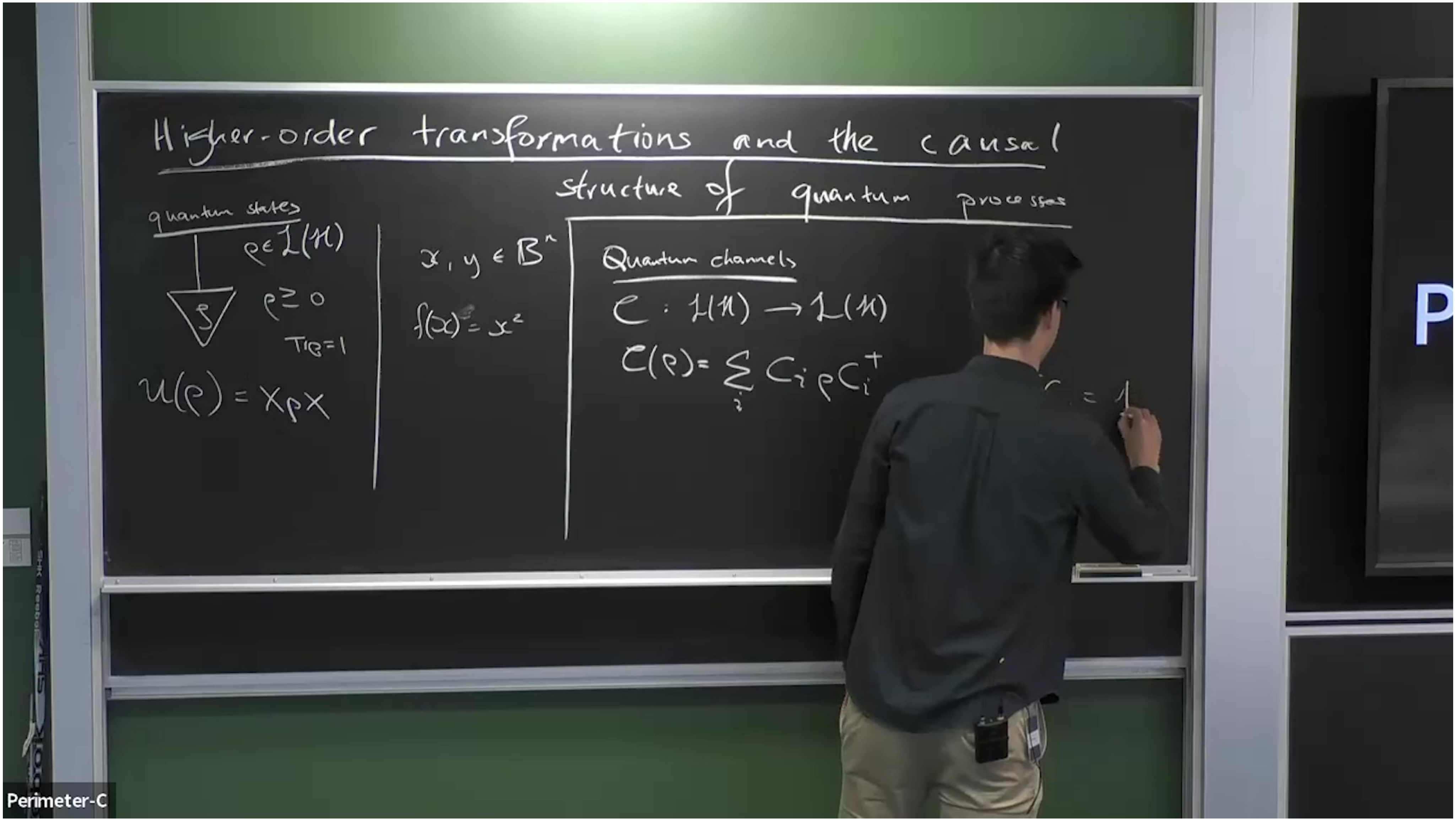
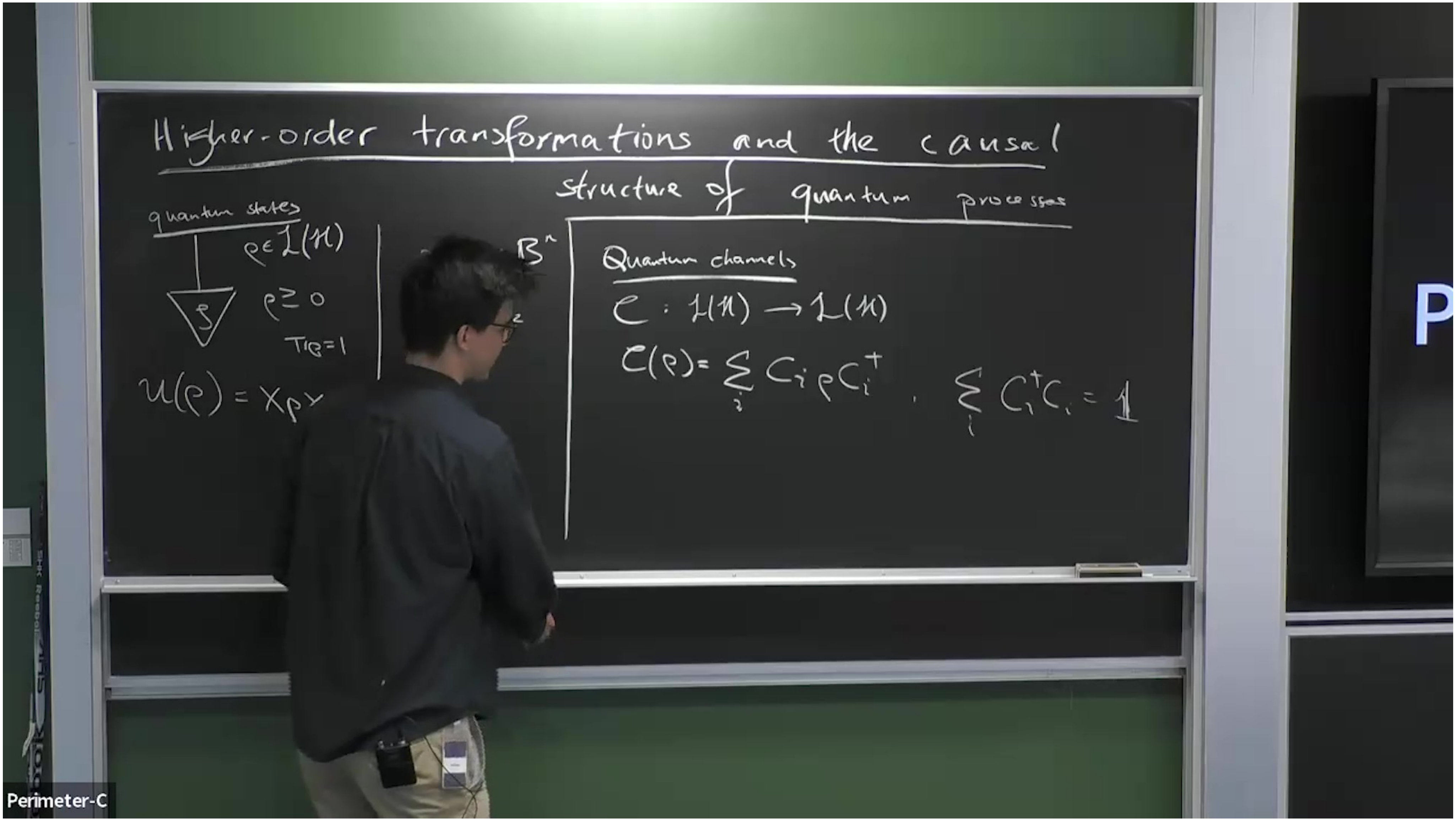
Abstract: In this informal talk, I shall give a short introduction to the field of higher-order quantum transformations, including its subfield of indefinite causal order. I shall discuss some of the motivations and important results in the field, current research directions and open problems, as well potential applications in quantum information processing.


Higher-order transformations and the causal structure of quantum processes
Perimeter-C


Higher-order transformations and the causal structure of quantum processes
quantum states
ρ ∈ L(H)
ρ ≥ 0
Tr ρ = 1
U(ρ) = XρX
x, y ∈ B^n
f(x) = x^2
Quantum channels
C : L(H) → L(H)
C(ρ) = Σ_i C_i ρ C_i^†
Perimeter-C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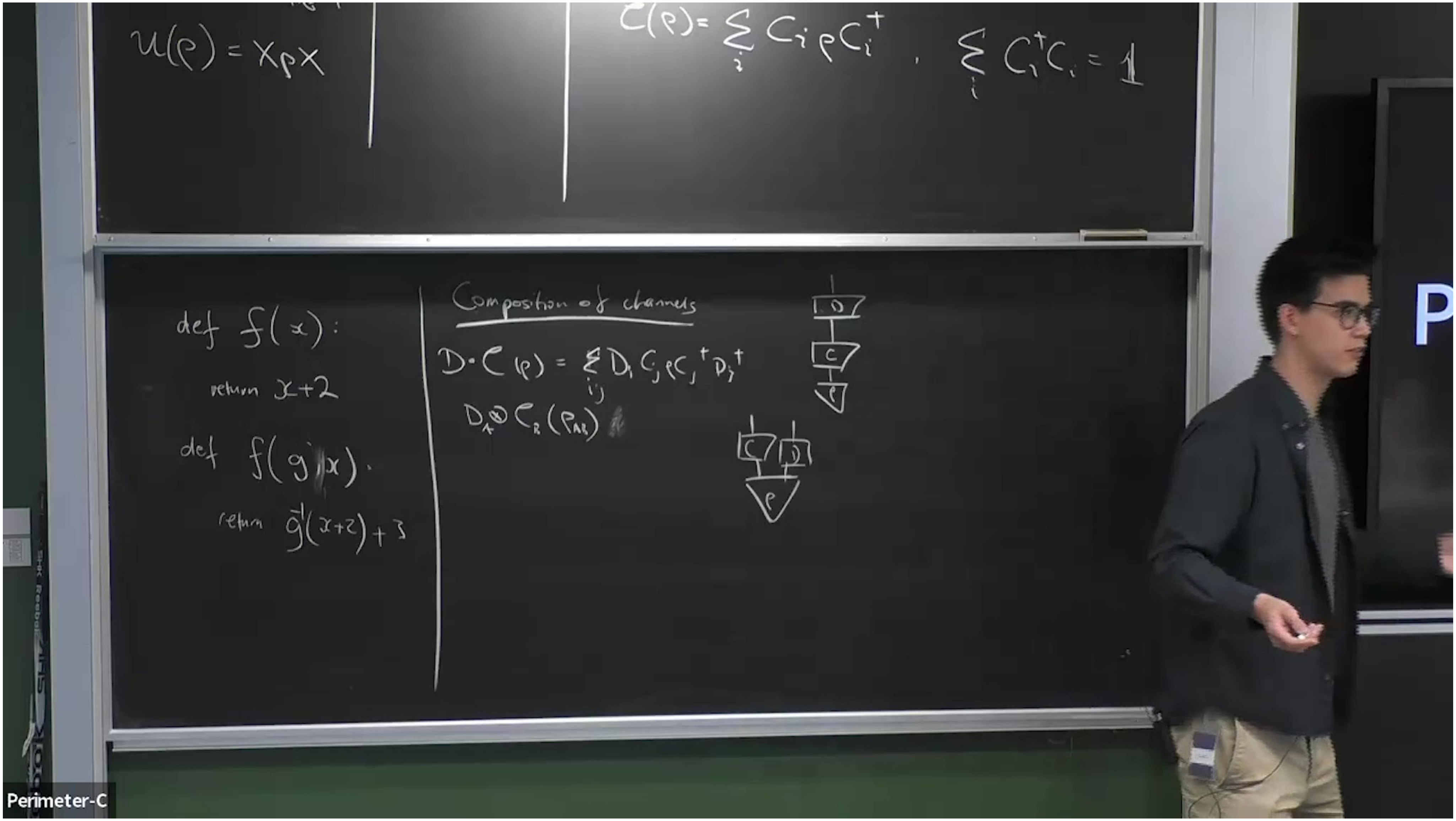
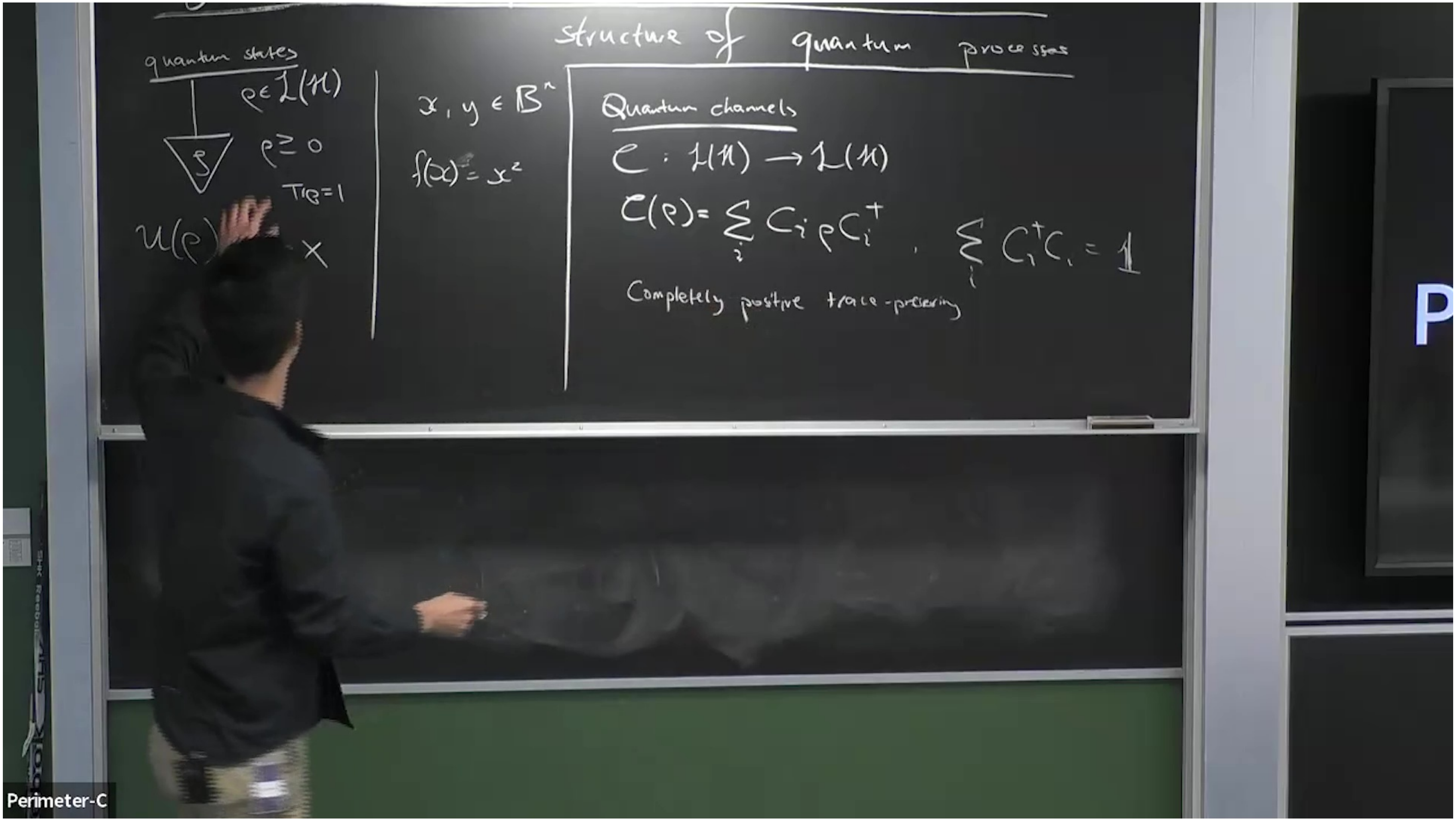
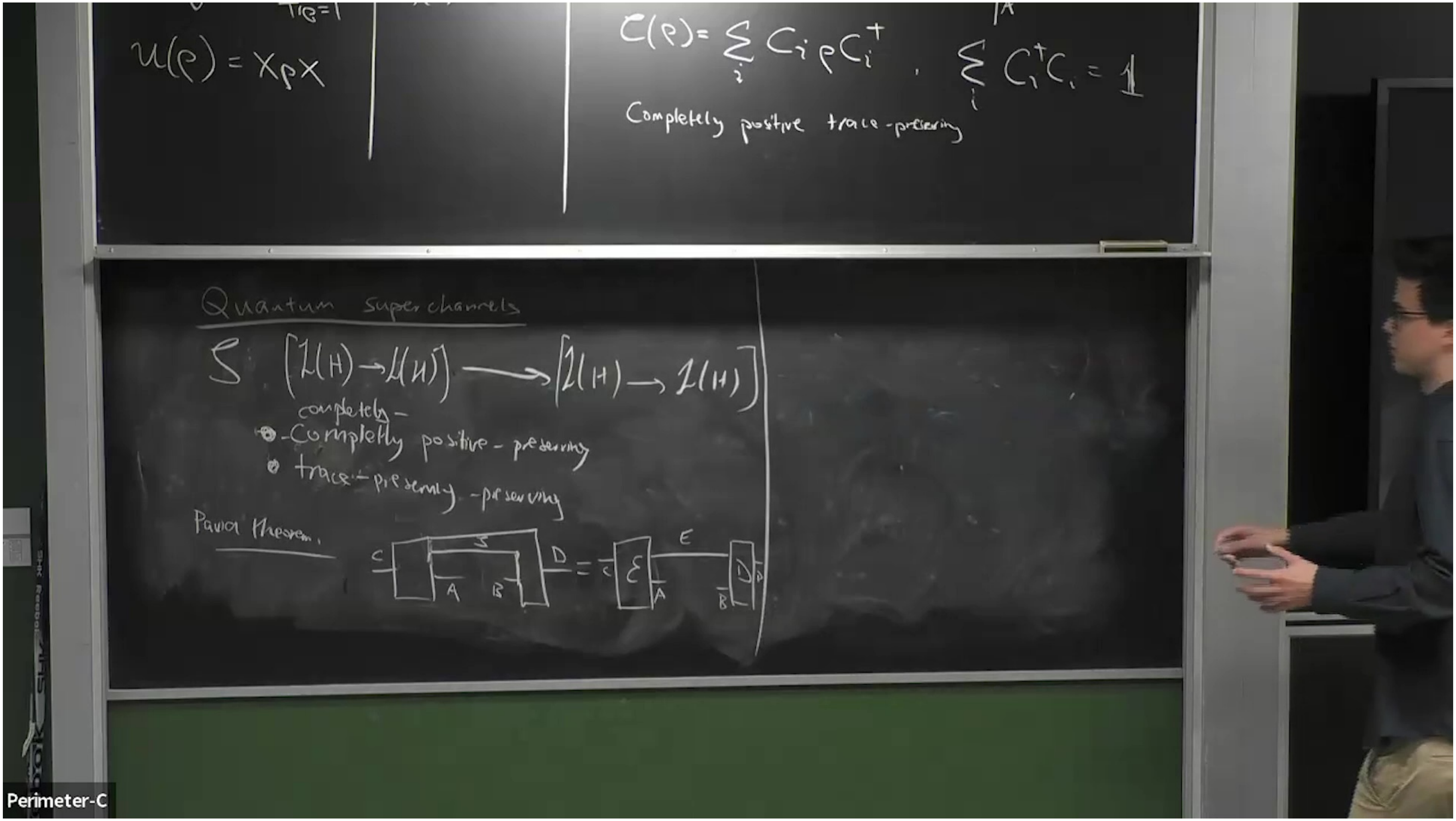
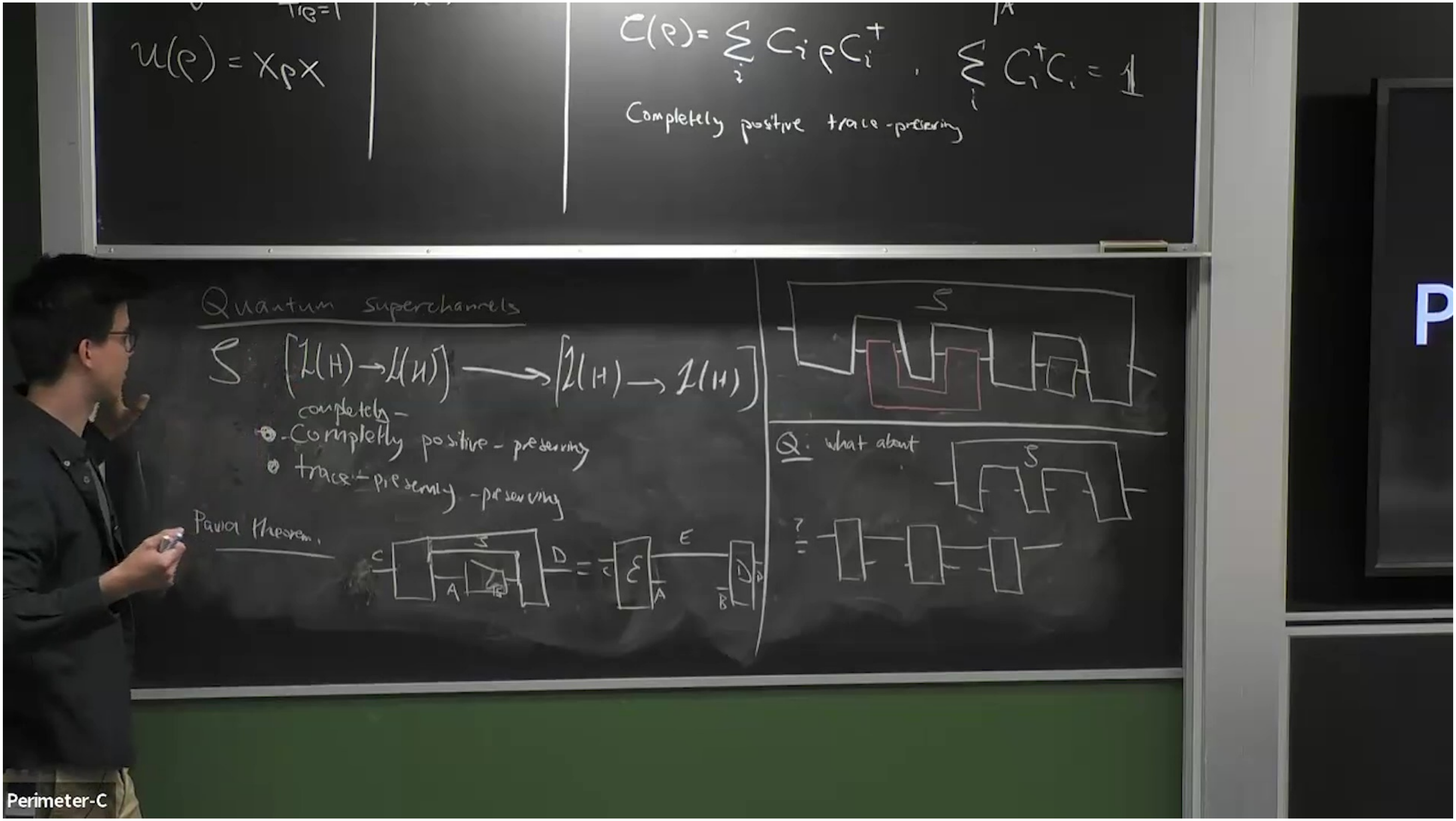


def f(x):
return x+2
def f(g, x):
return g(x+2)+3
Composition of channels
Perimeter-C


structure of quantum processes
quantum states
Quantum channels
Completely positive trace-preserving
Perimeter-C


U(ρ) = XρX
C(ρ) = Σ_i C_i ρ C_i^† , Σ_i C_i^† C_i = 1
Completely positive trace-preserving
Quantum superchannels
S: [L(H) → L(H)] → [L(H) → L(H)]
completely-
-Completely positive - preserving
trace-preserving -preserving
Pavia theorem.
C
S
D
E
A
B
Perimeter-C



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Completely positive trace-preserving
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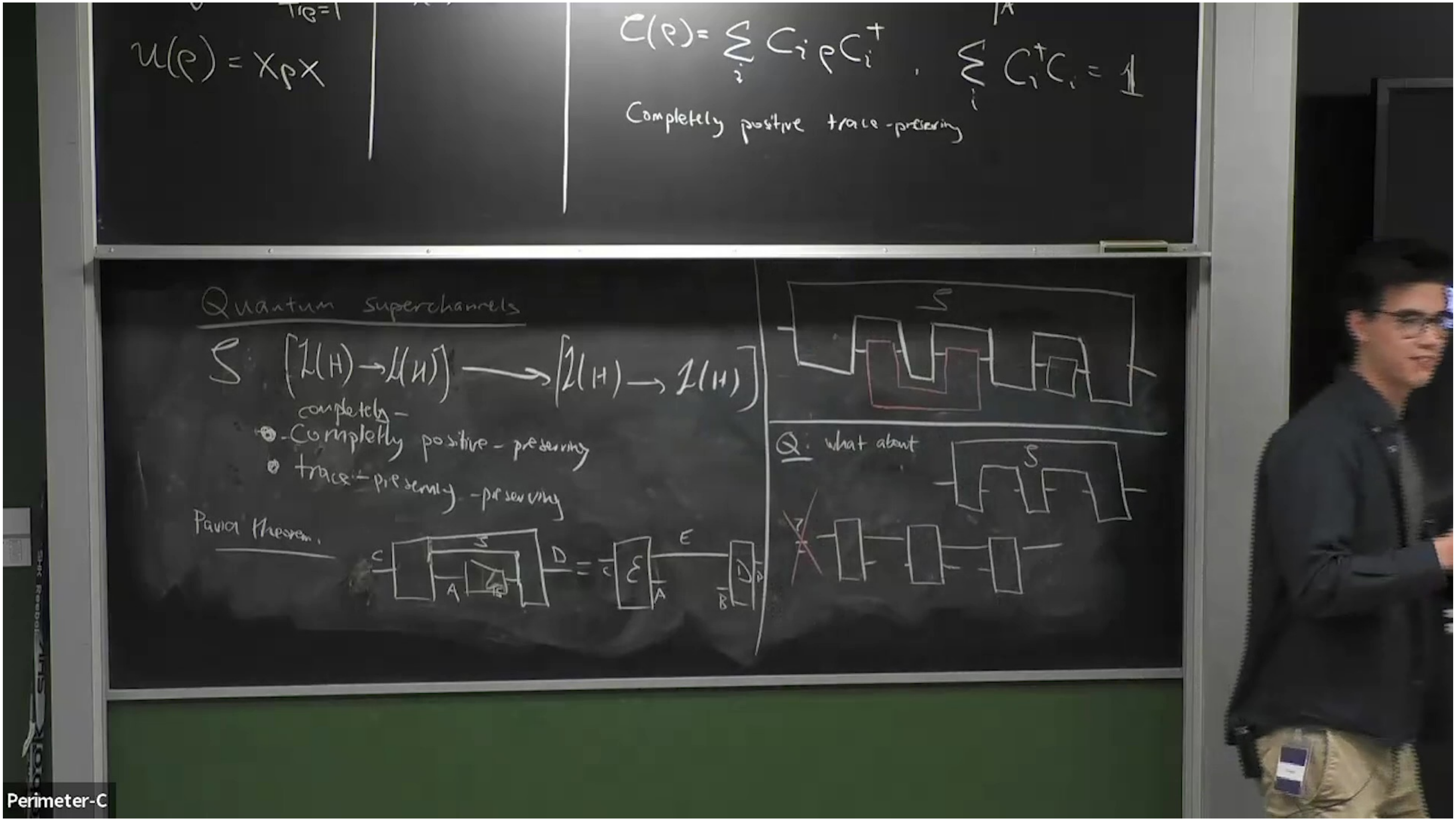
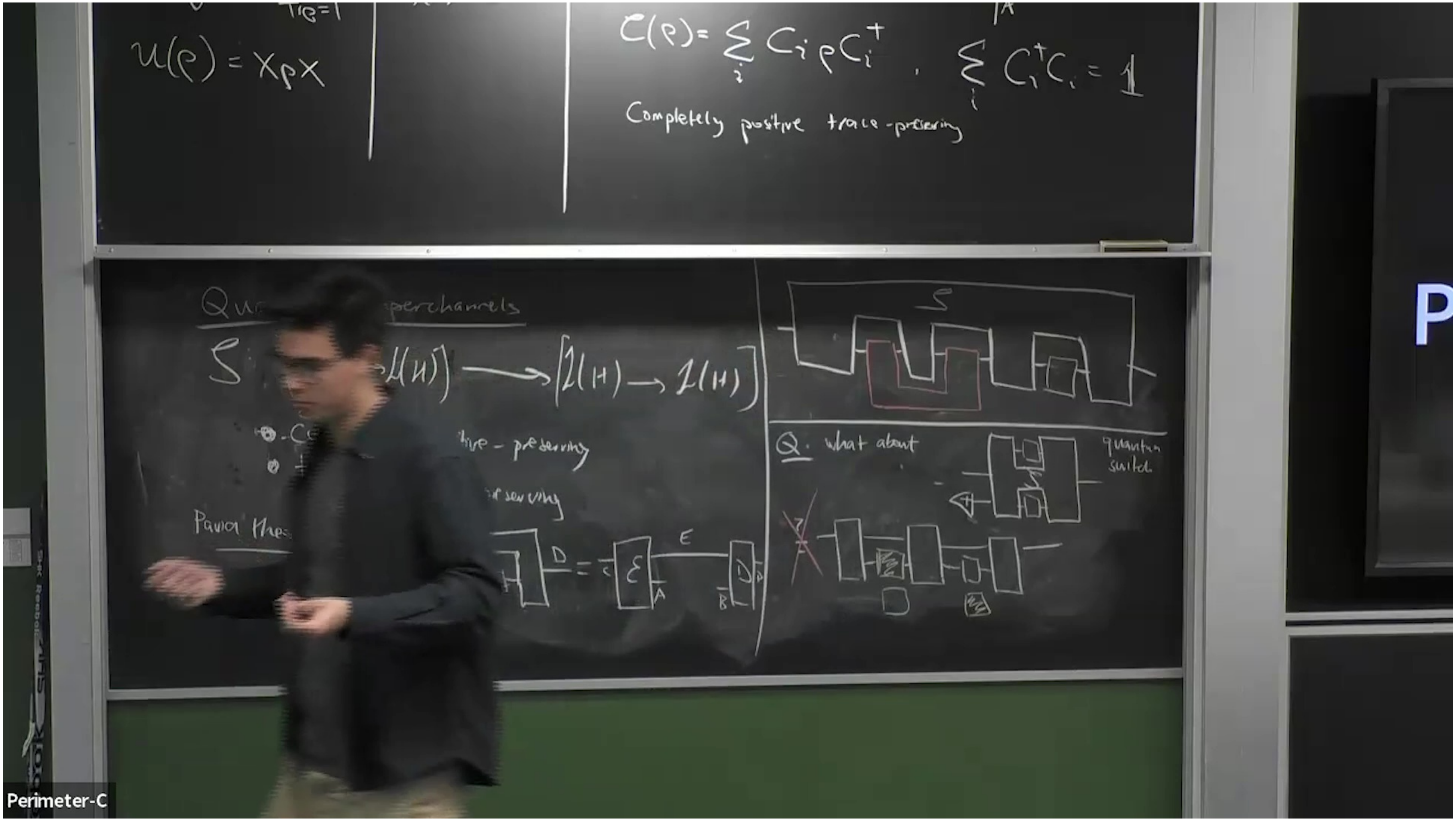
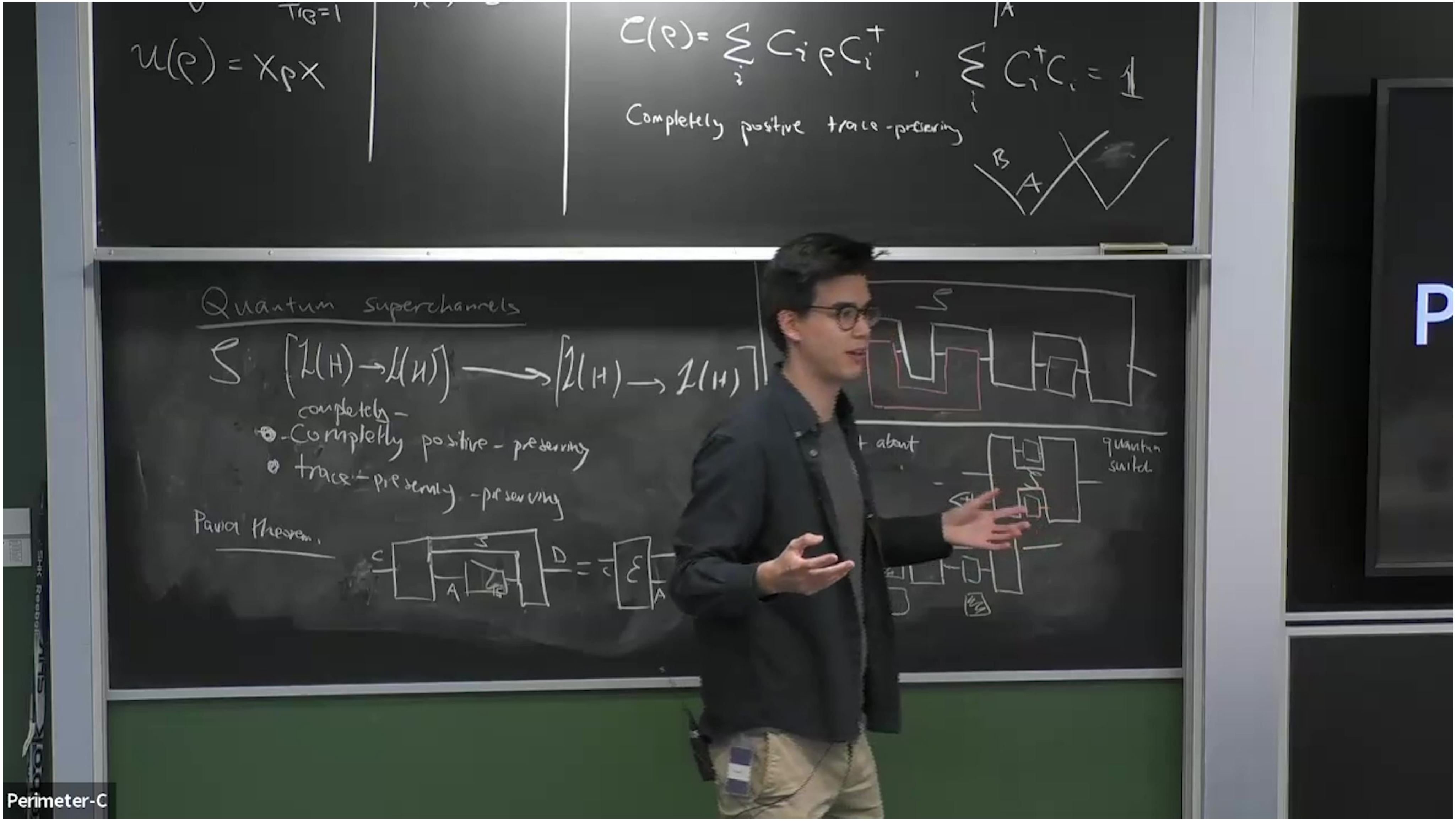
• trace - preserving - preserving
Pavia theorem.
Q: what about
Perimeter-C



Completely positive trace-preserving
Quantum superchannels
completely-
Completely positive-preserving
trace-preserving -preserving
Q: what about
Perimeter-C


$\mathcal{U}(\rho) = X\rho X$
$\mathcal{C}(\rho) = \sum_i C_i \rho C_i^\dagger$, $\sum_i C_i^\dagger C_i = \mathbb{1}$
Completely positive trace-preserving
Q. what about
quantum switch
Perimeter-C


Completely positive trace-preserving
Quantum superchannels
completely-
Completely positive-preserving
trace-preserving -preserving
Pavia theorem.
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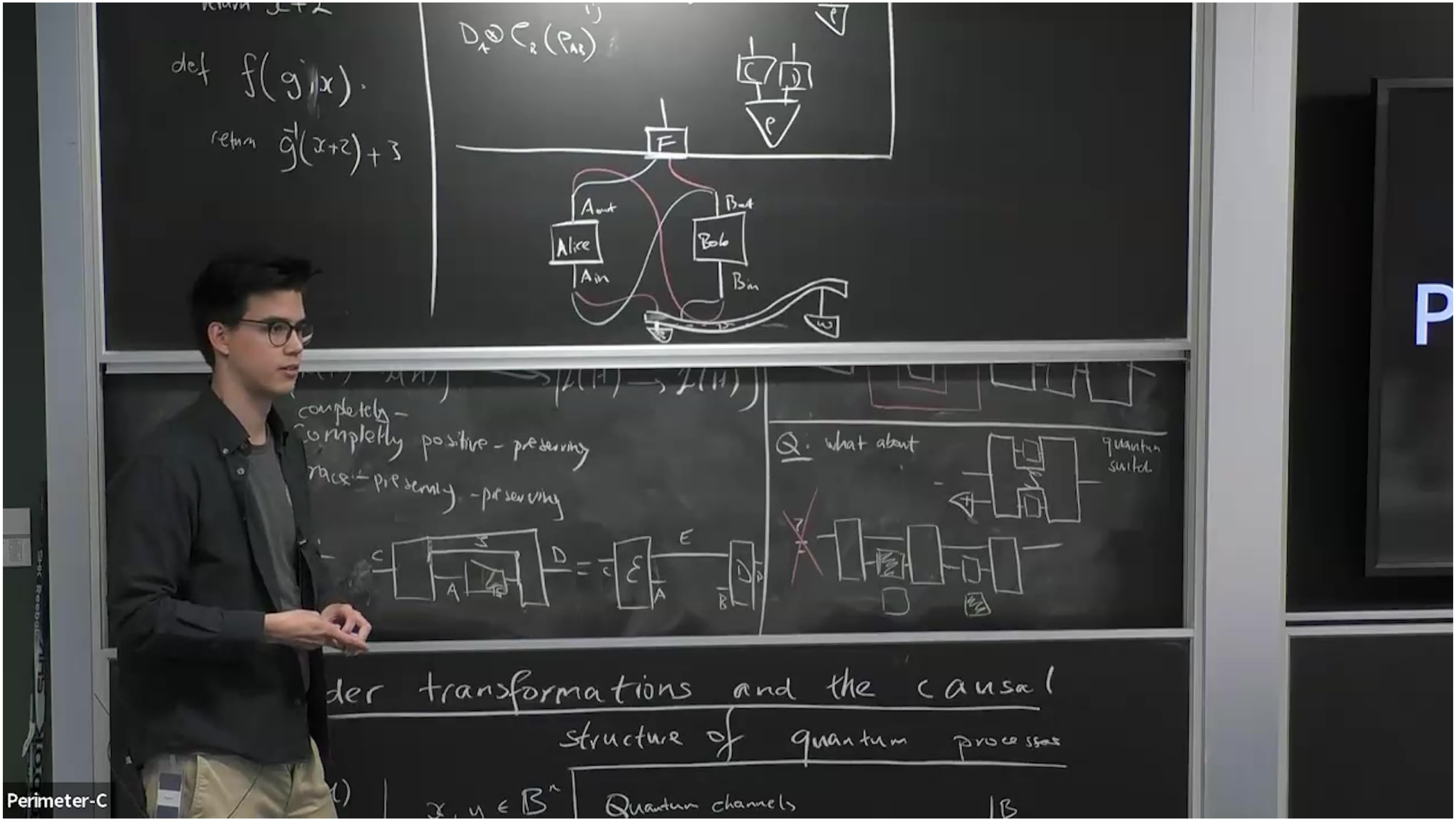
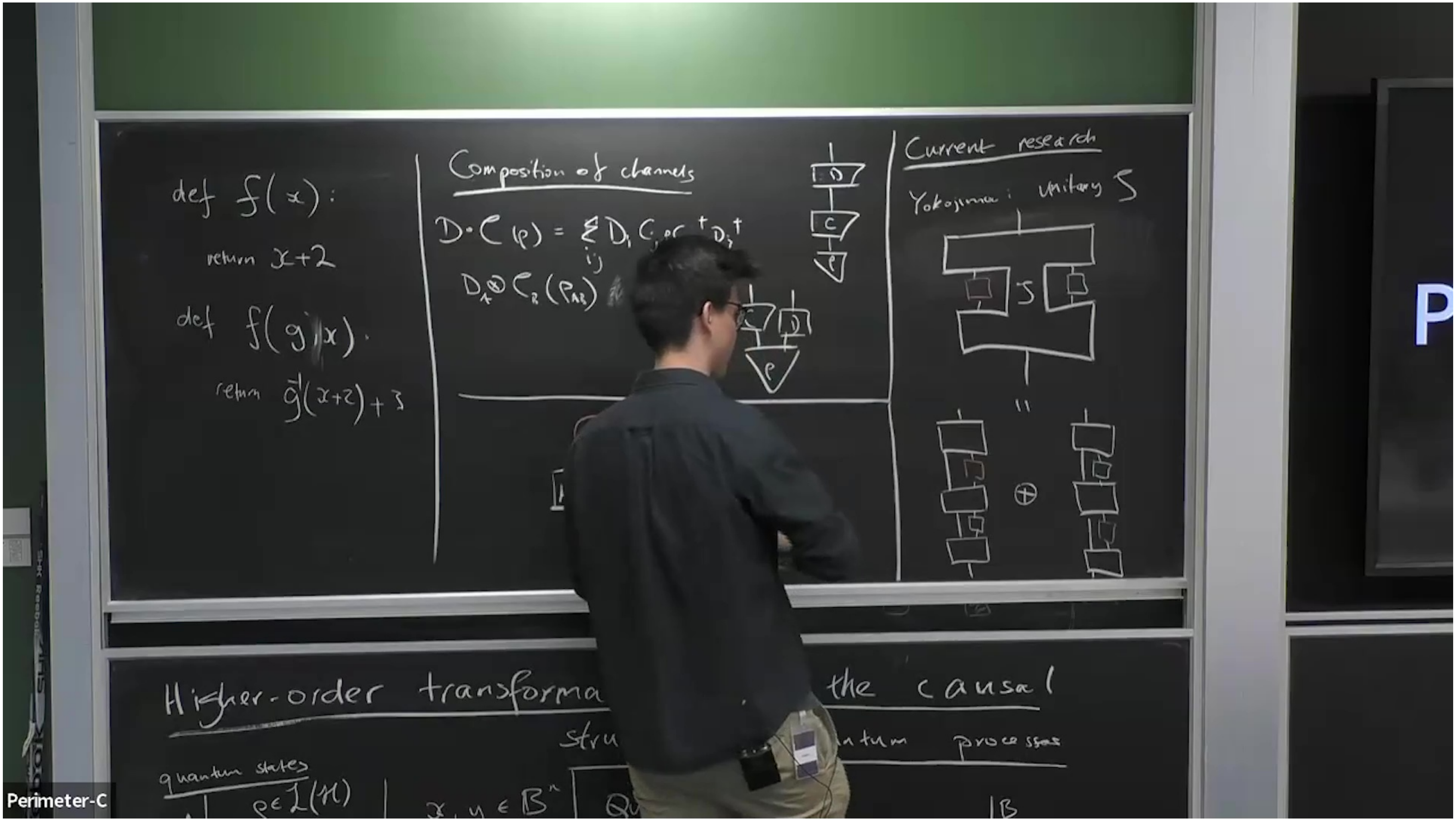
Perimeter-C


def f(g, x).
return g⁻¹(x+2) + 3
Alice
Bob
Q. what about
quantum switch
completely positive-preserving
trace-preserving-preserving
der transformations and the causal structure of quantum processes
Quantum channels
Perimeter-C


def f(x):
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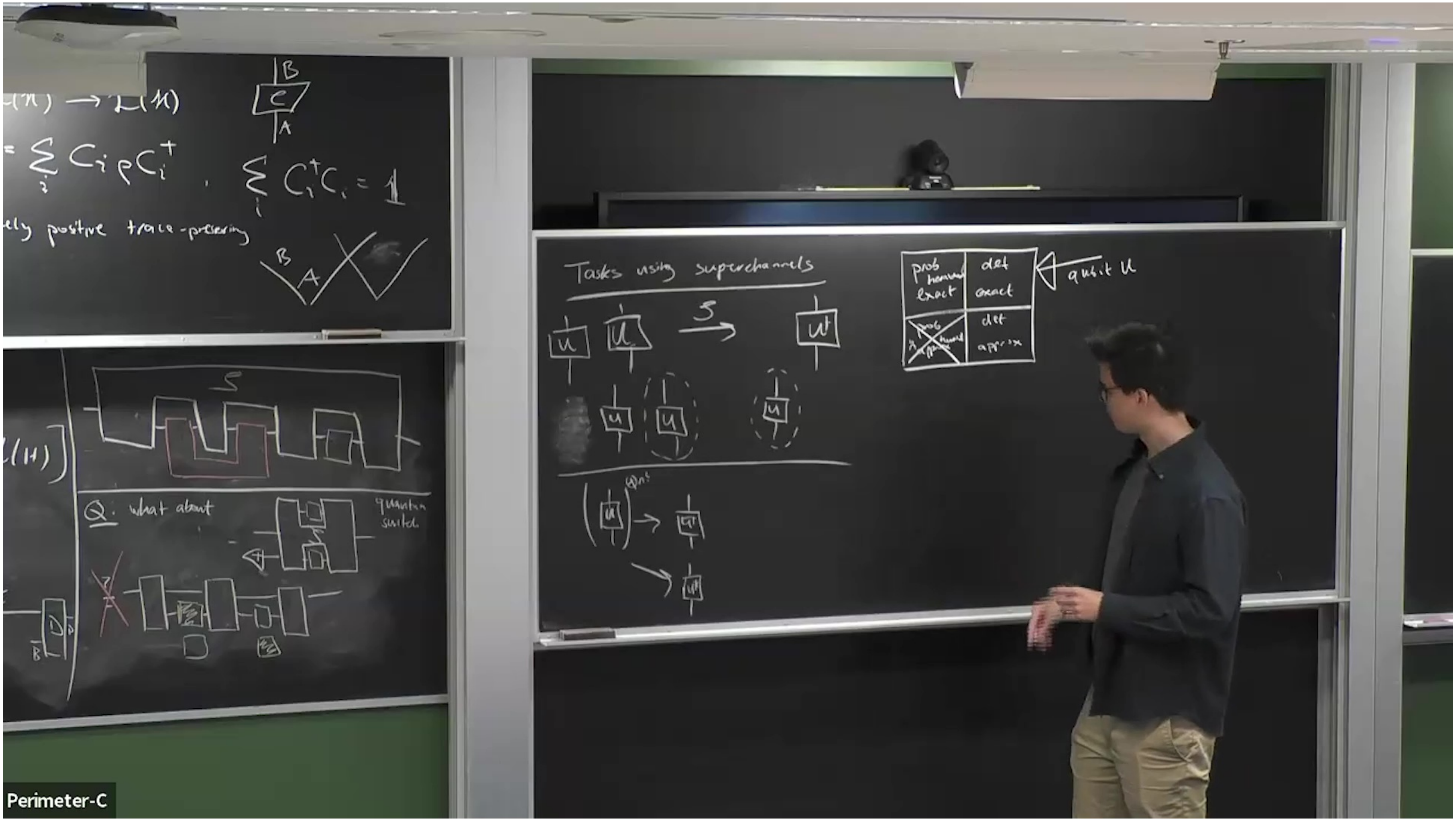
Composition of channels
Current research
Yokojima: unitary S
Higher-order transforma
the causal
quantum states
Perimeter-C


Tasks using superchannels
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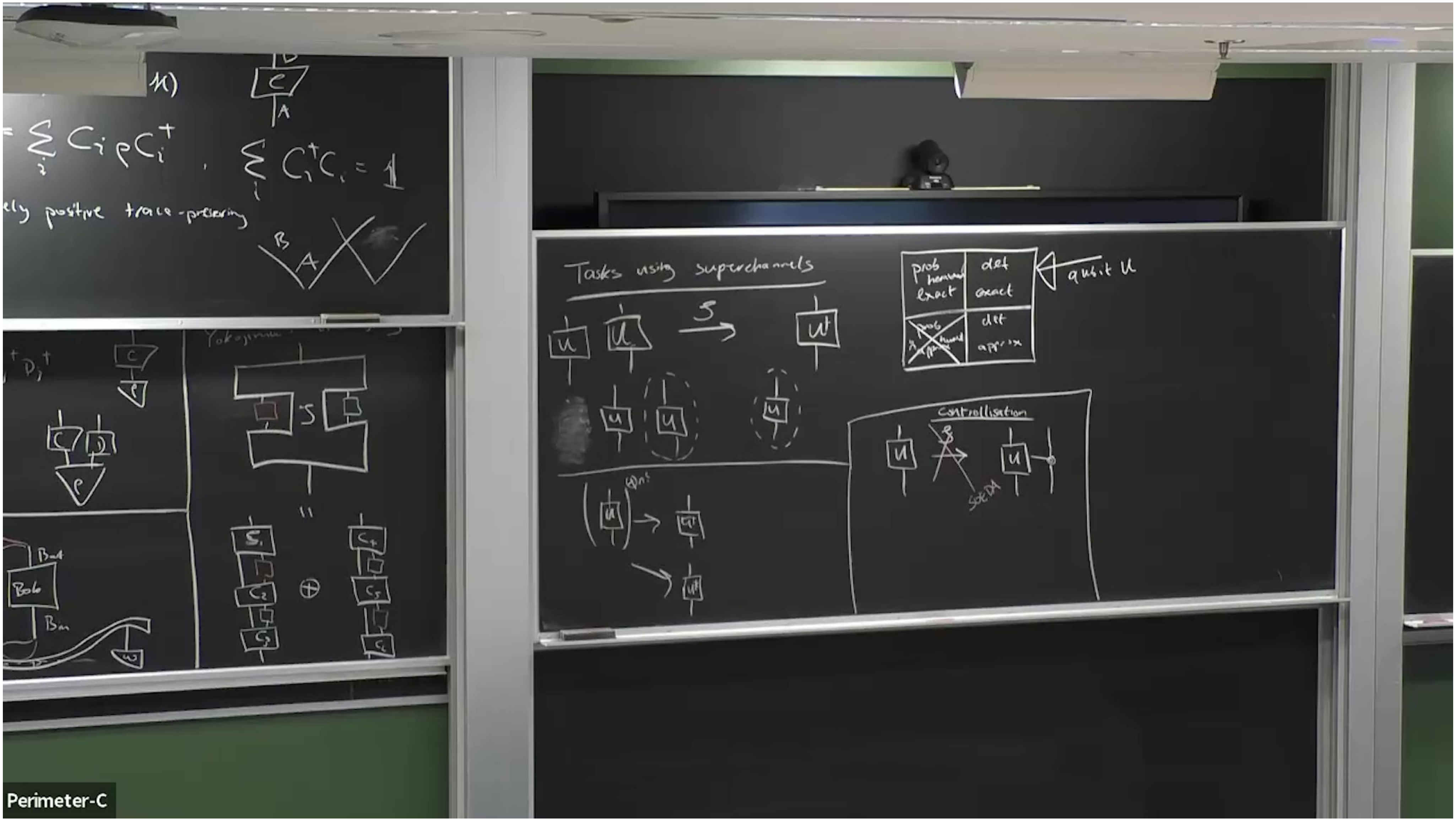
Q: what about
ely positive trace-preserving
Perimeter-C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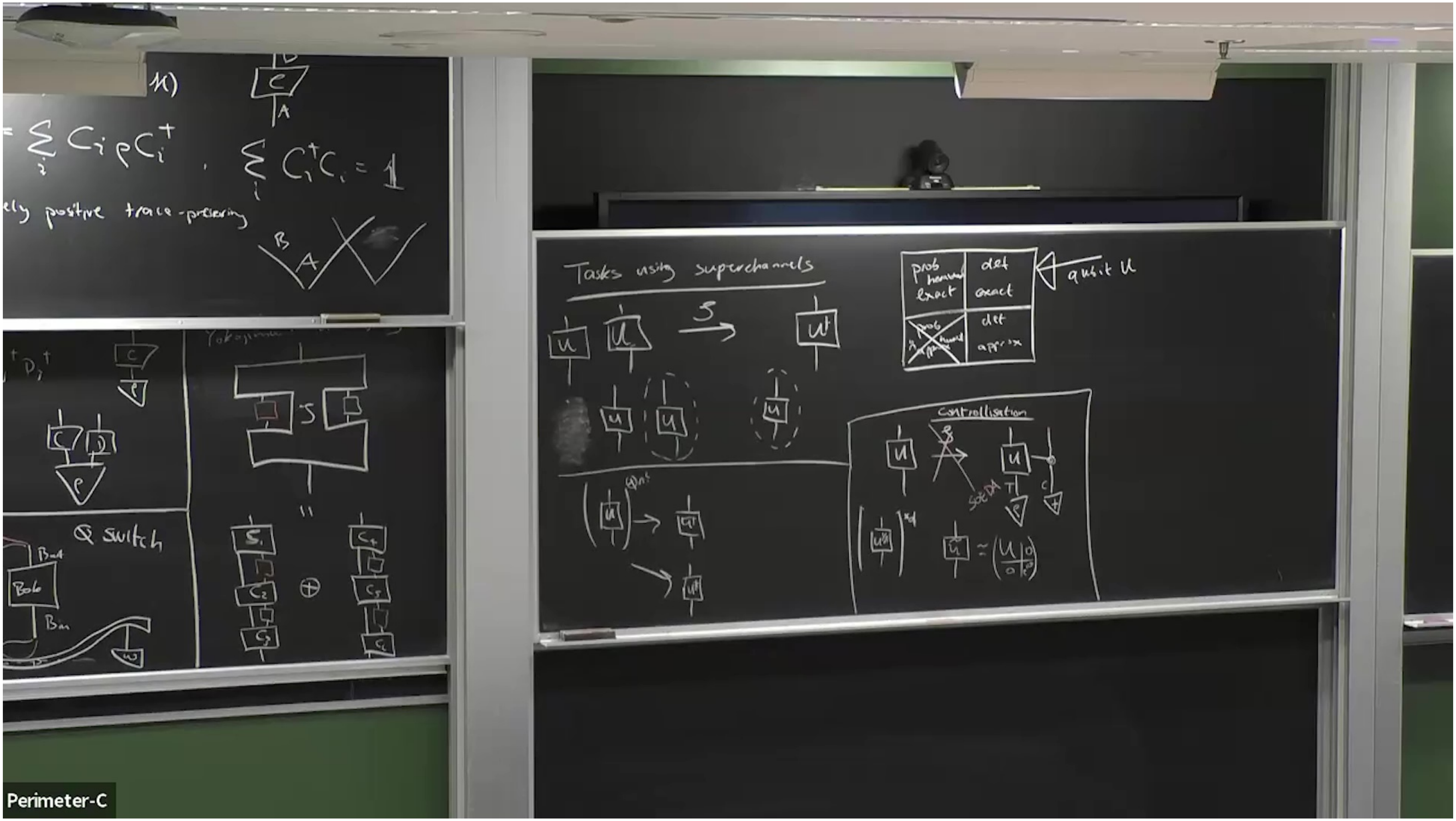
Tasks using superchannels
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Controllisation
Q switch
Perimeter-C