Title: Quantum Foundations Lecture - 230130

Speakers: Lucien Hardy

Collection: Quantum Foundations (2022/2023)

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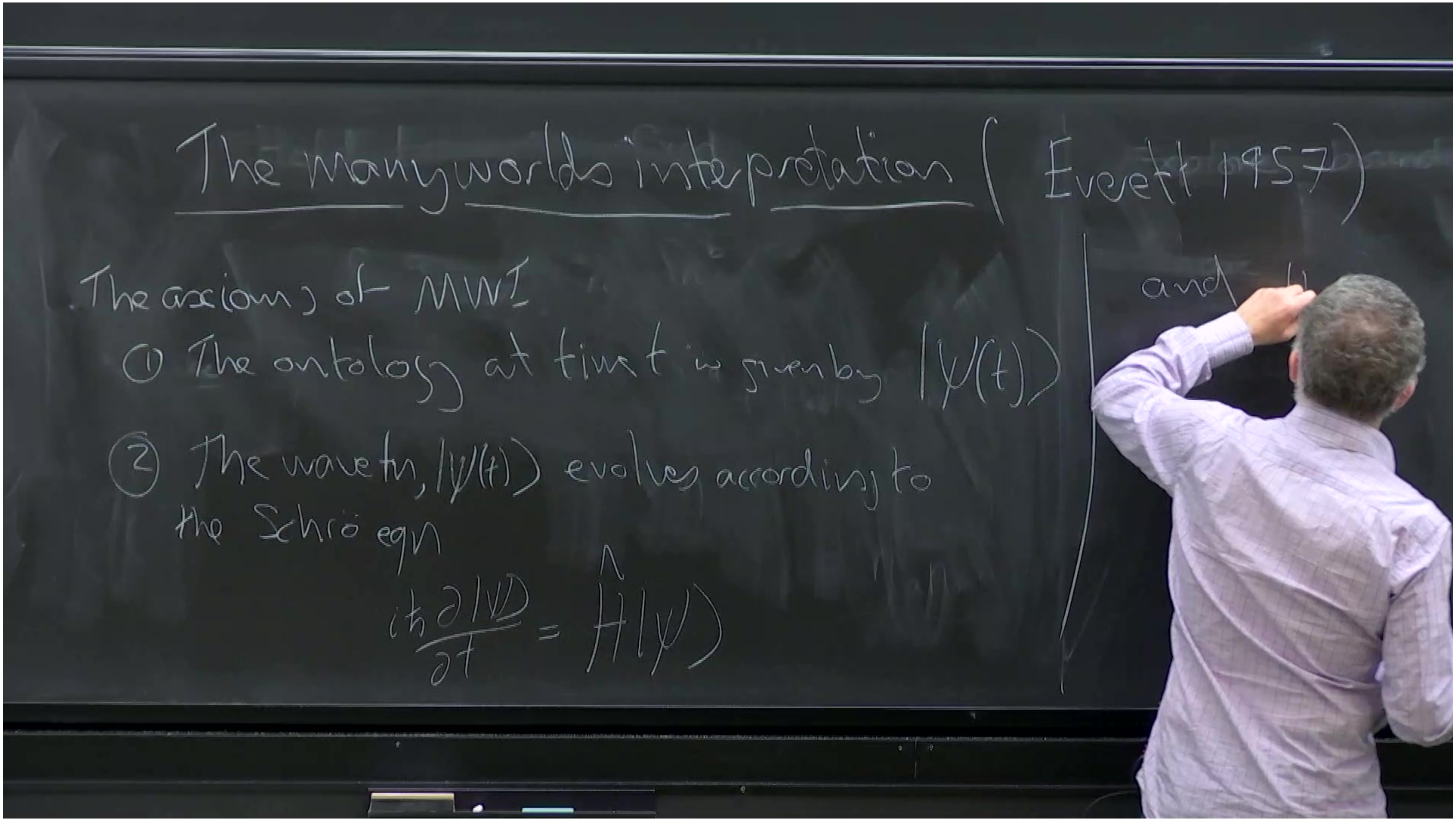
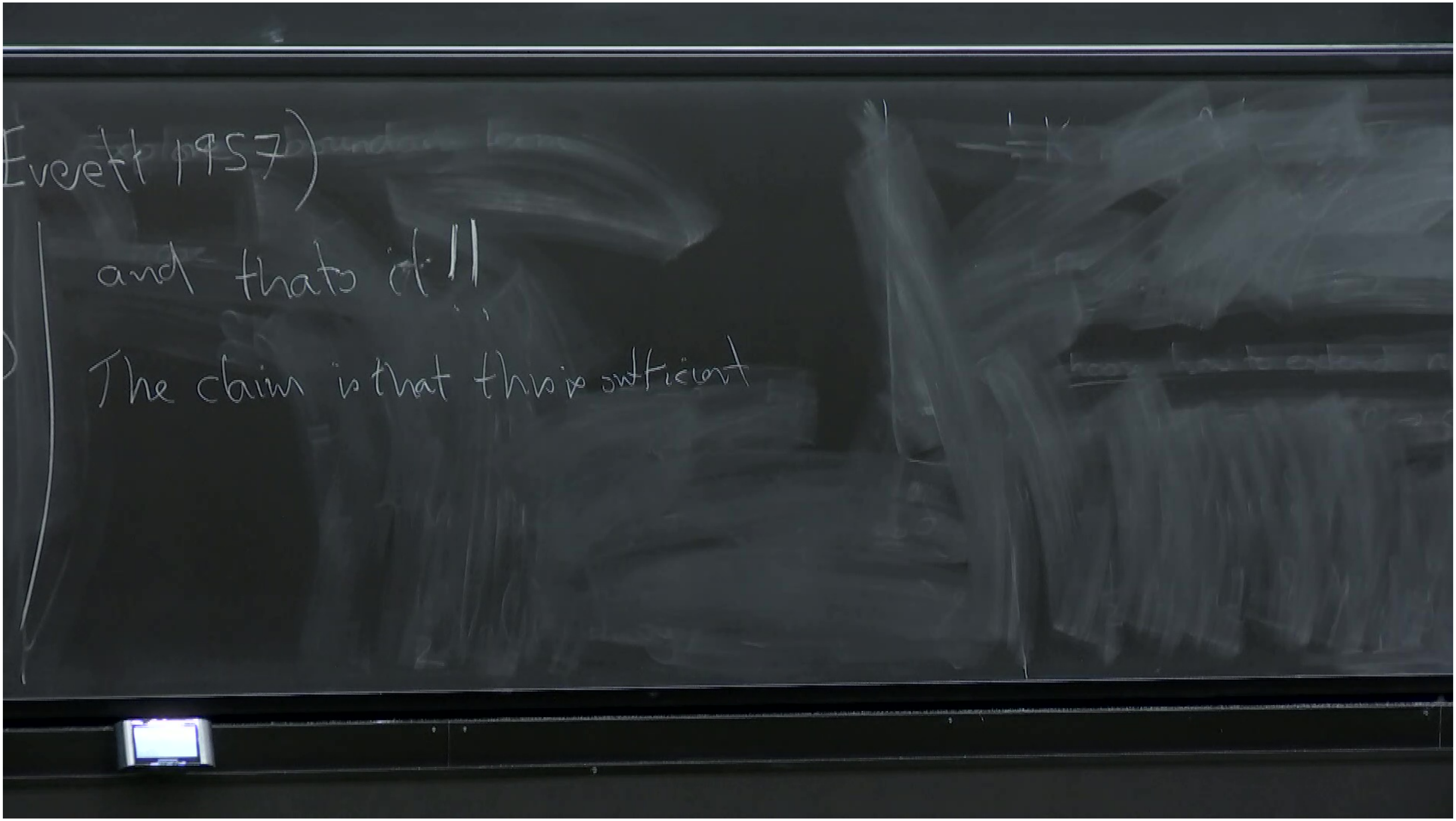
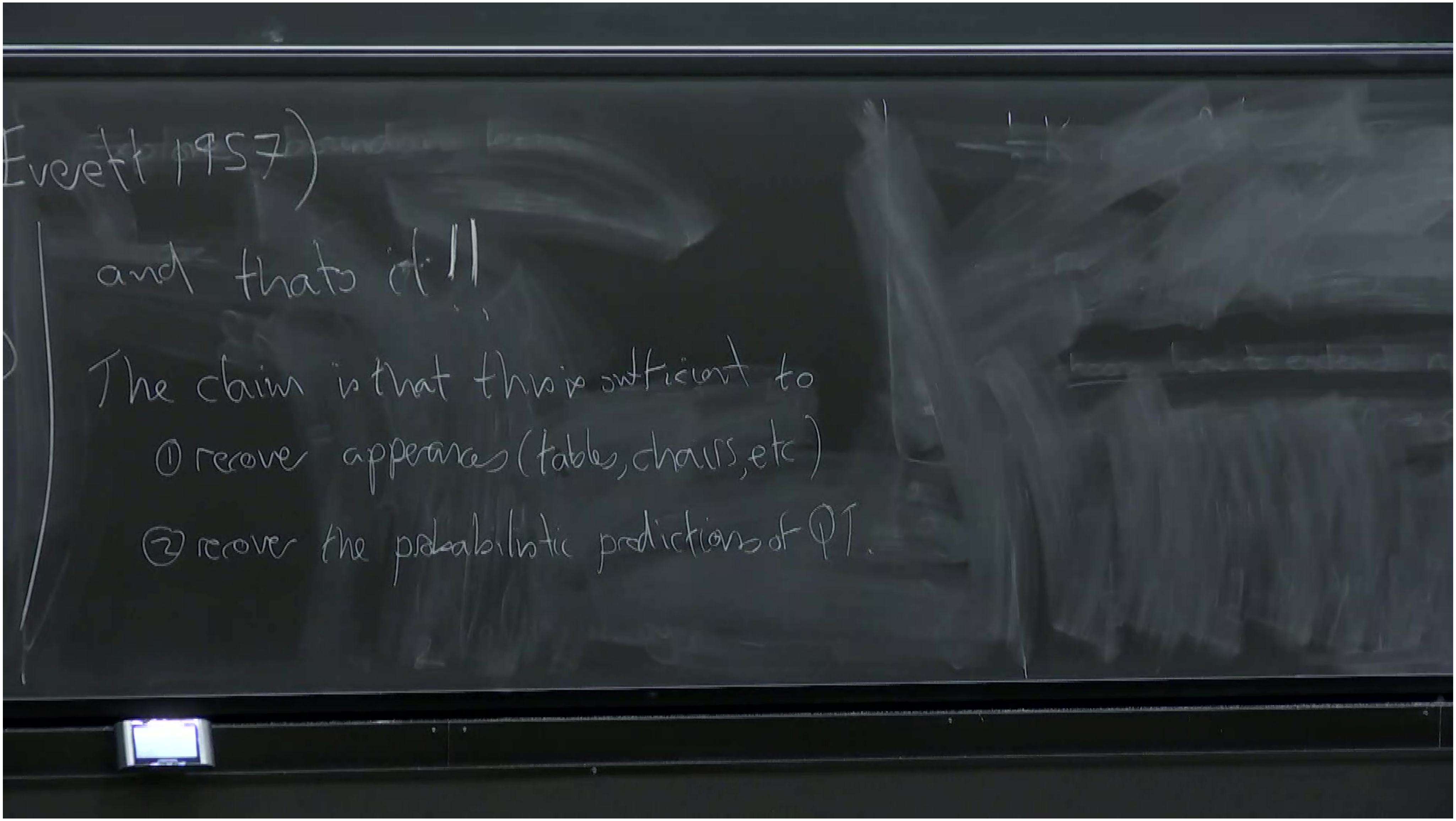
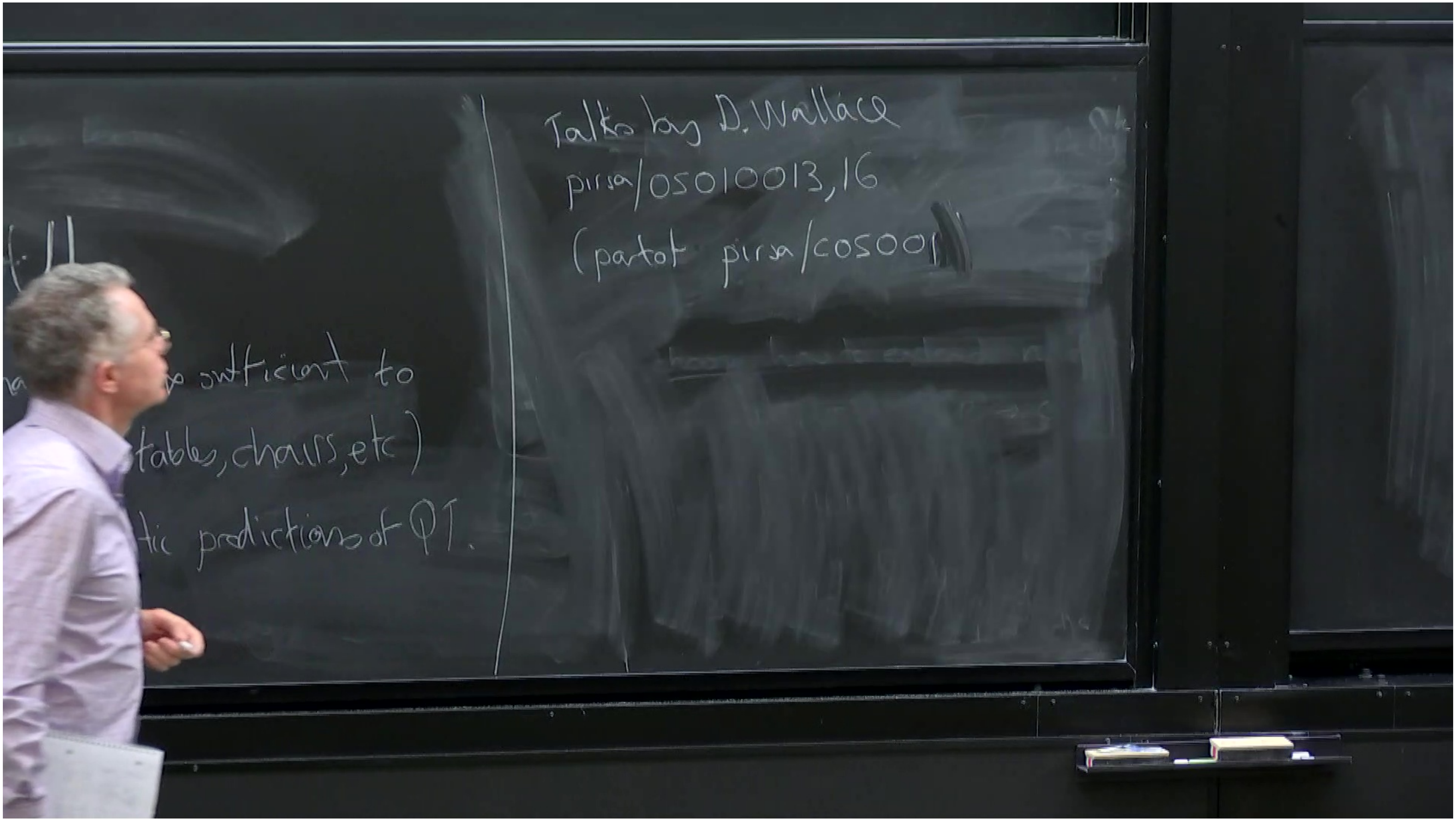
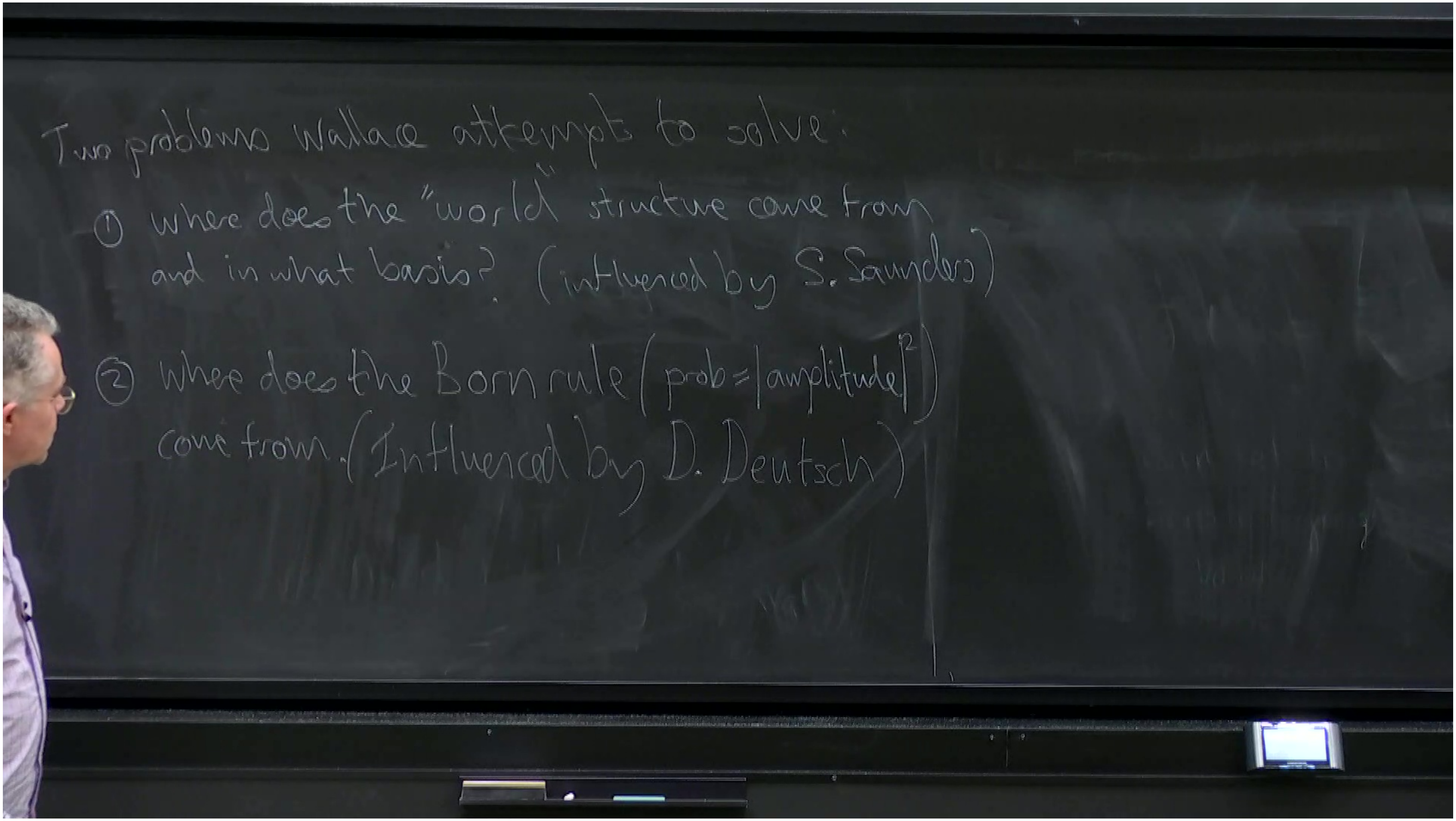
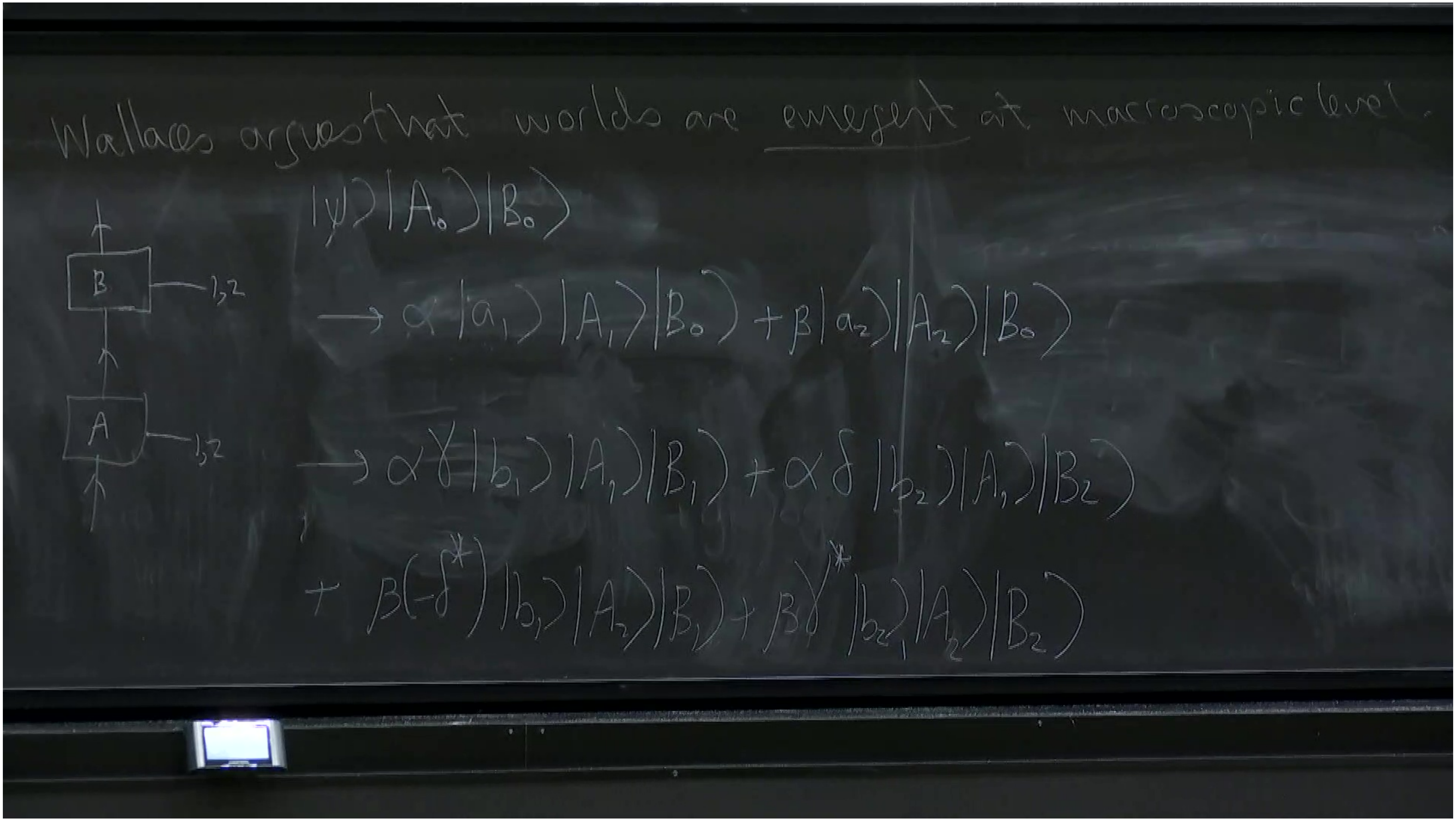

The many worlds interpretation (Everett 1957)
The axioms of MWI
① The ontology at time t is given by |ψ(t)⟩
② The wave fn, |ψ(t)⟩ evolves according to
the Schrö eqn
iħ ∂|ψ⟩/∂t = Ĥ|ψ⟩
and

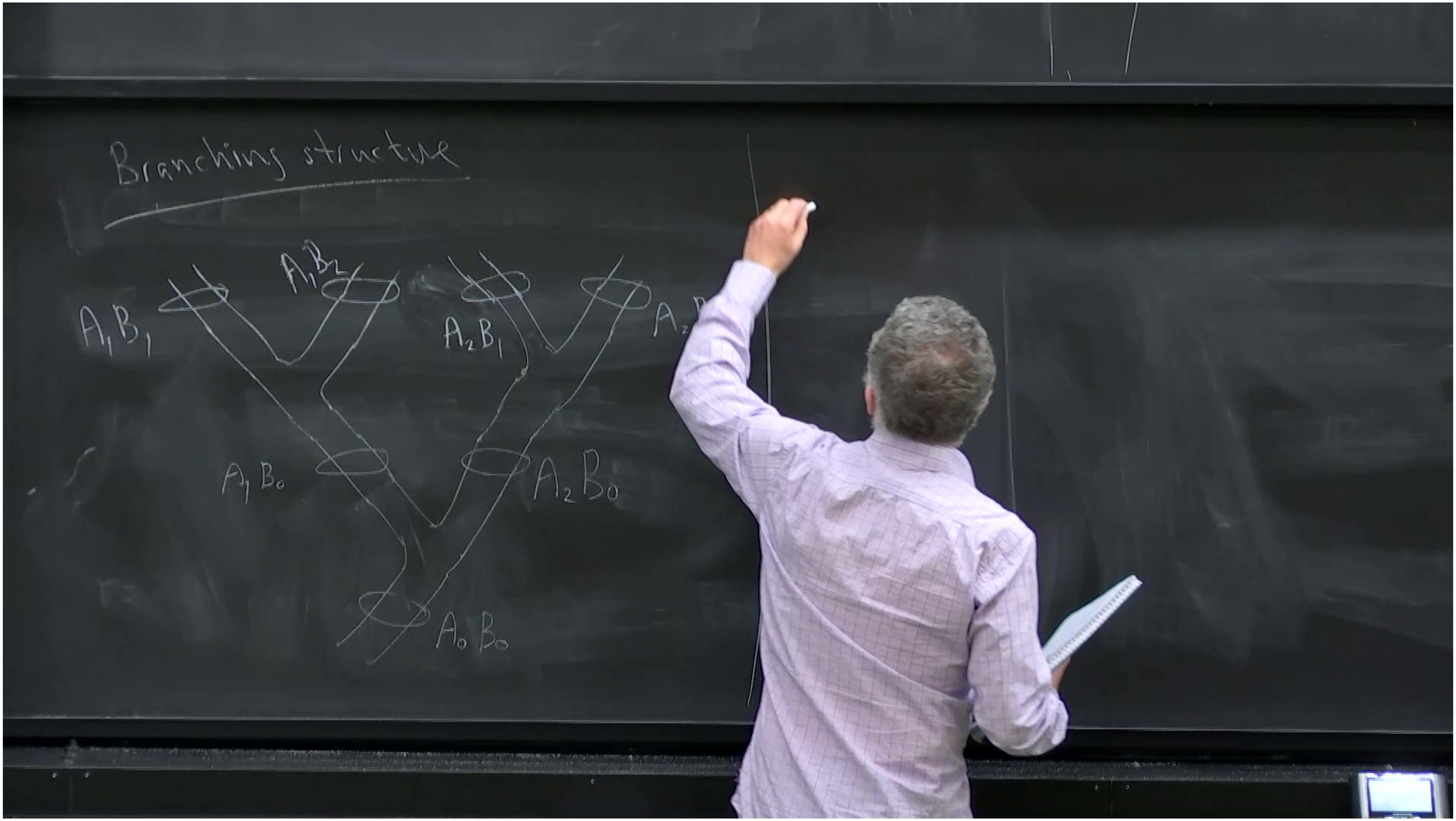

Everett 1957)
and thats it!!
The claim is that this is sufficient

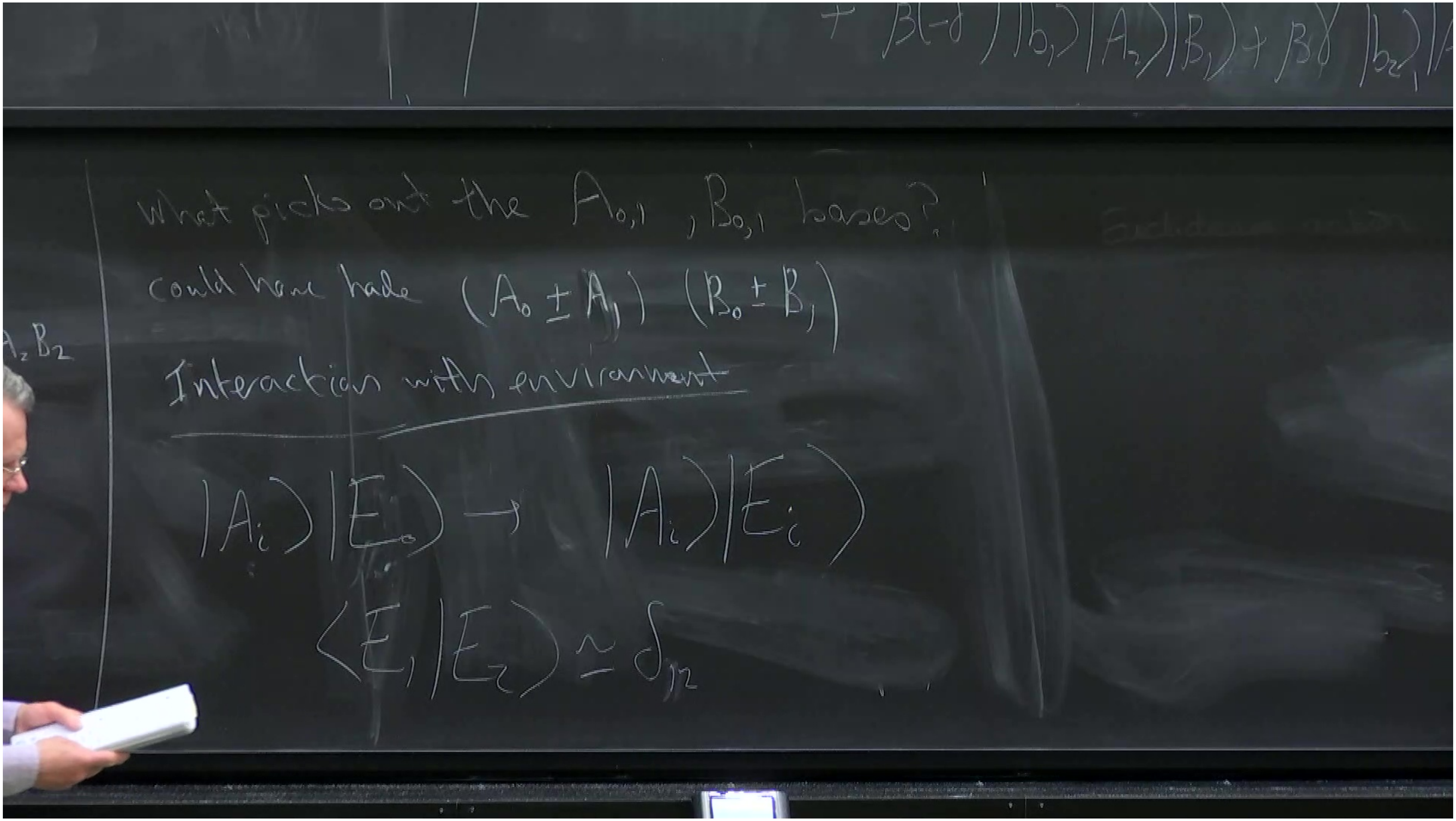

Everett 1957)
and thats it!!
The claim is that this is sufficient to
① recover apperances (tables, chairs, etc)
② recover the probabilistic predictions of QT.

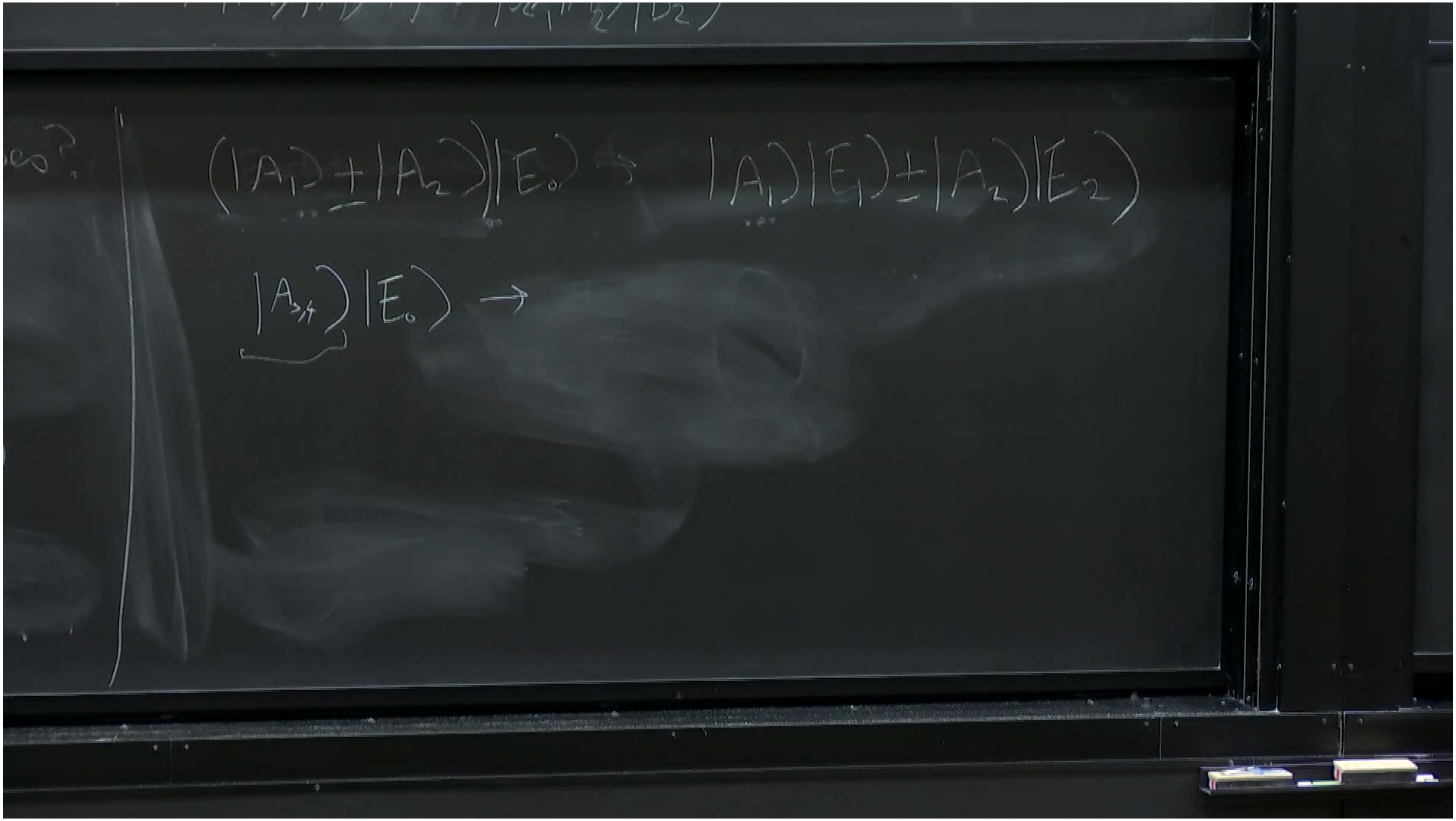

sufficient to
tables, chairs, etc)
predictions of QT.
Talks by D. Wallace
pirsa/05010013, 16
(part of pirsa/C05001

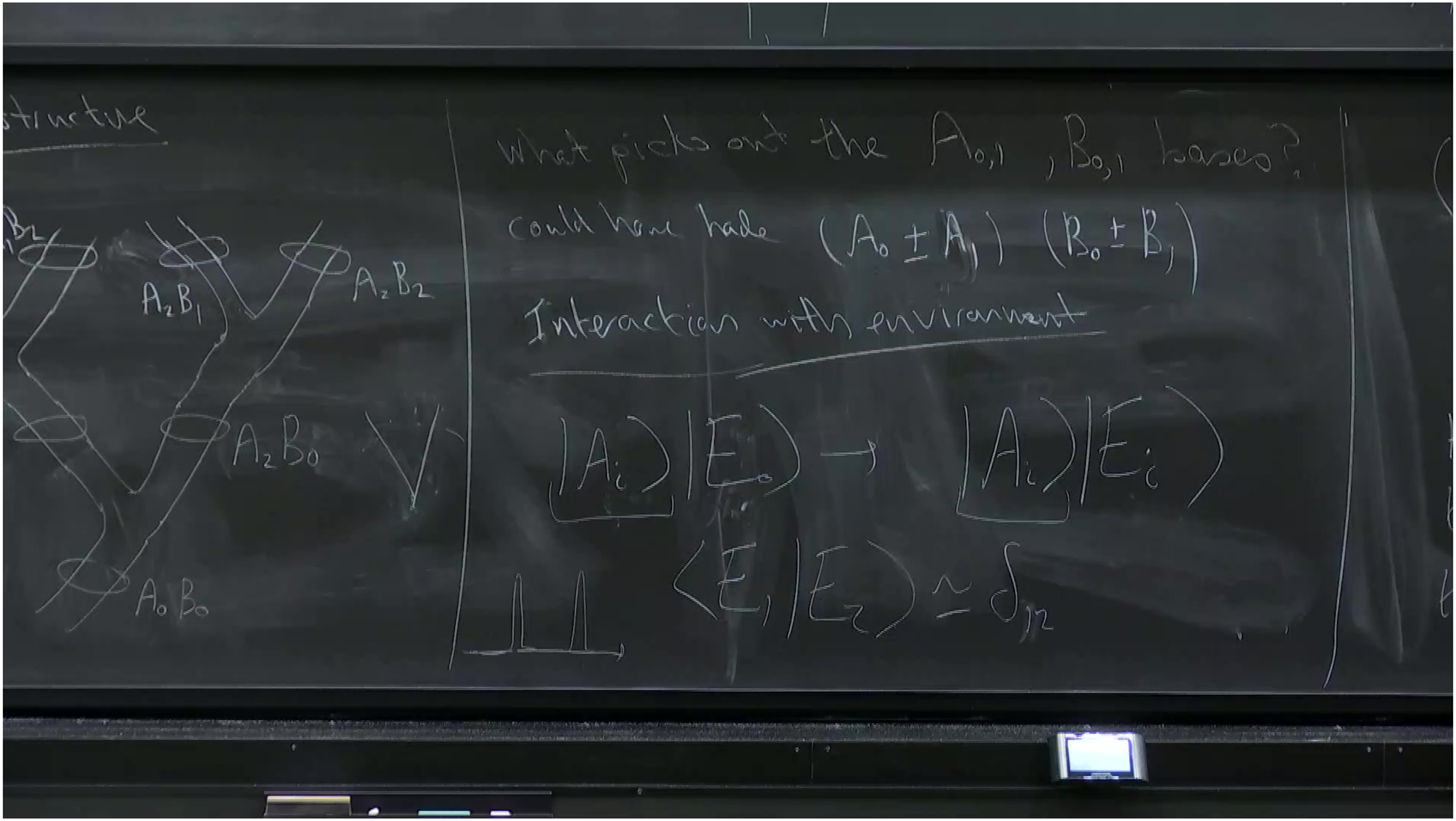

Two problems Wallace attempts to solve:
① Where does the "world" structure come from and in what basis? (influenced by S. Saunders)
② Where does the Born rule (prob = |amplitude|²) come from. (Influenced by D. Deutsch)

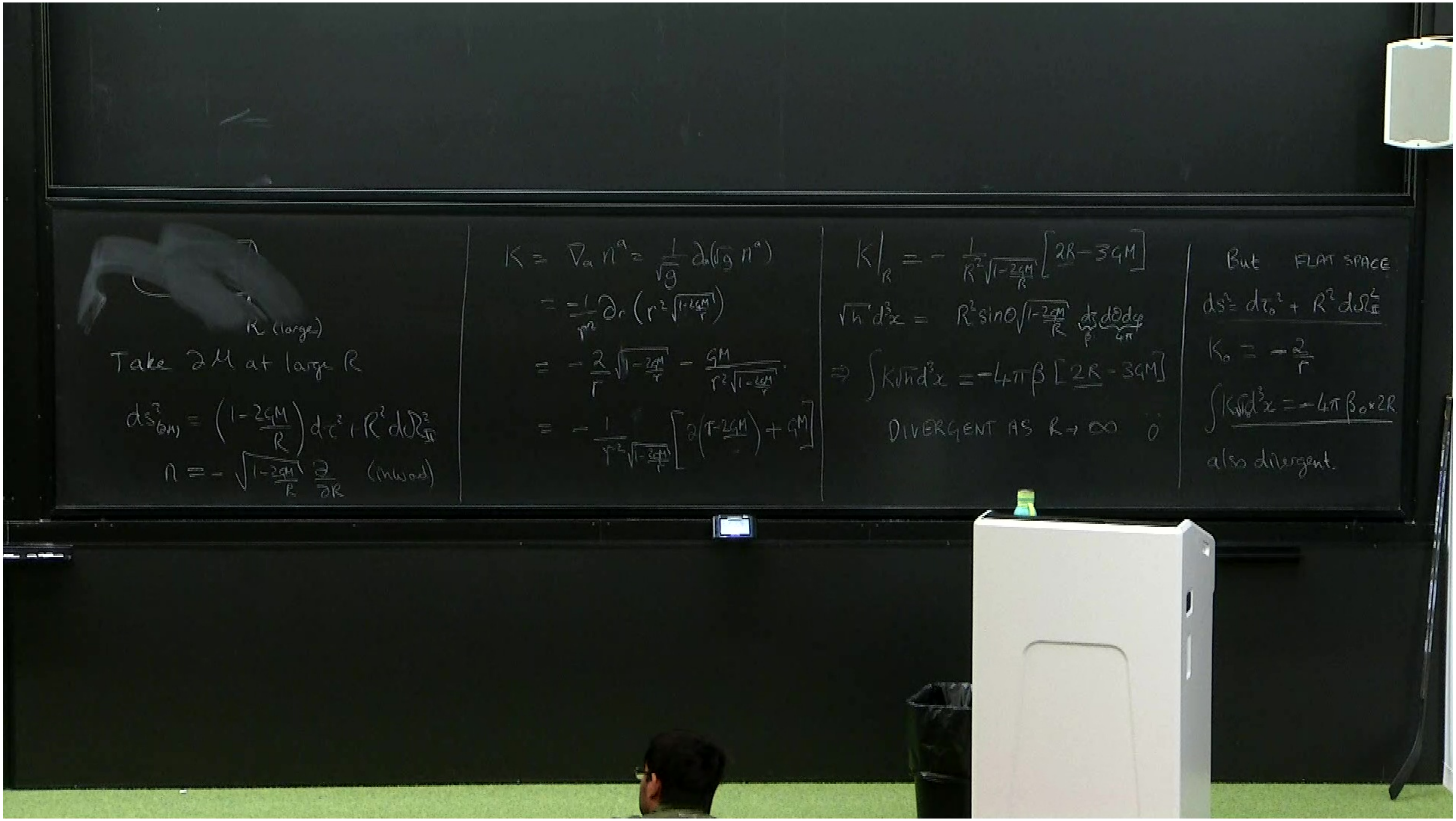

Wallace argues that worlds are emergent at macroscopic level.
B
1,2
A
1,2
$|\psi\rangle|A_0\rangle|B_0\rangle$
$\rightarrow \alpha|a_1\rangle|A_1\rangle|B_0\rangle + \beta|a_2\rangle|A_2\rangle|B_0\rangle$
$\rightarrow \alpha\gamma|b_1\rangle|A_1\rangle|B_1\rangle + \alpha\delta|b_2\rangle|A_1\rangle|B_2\rangle$
$+ \beta(-\delta^*)|b_1\rangle|A_2\rangle|B_1\rangle + \beta\gamma^*|b_2\rangle|A_2\rangle|B_2\rangle$


Branching structure
A1 B1
A1 B2
A2 B1
A1 B0
A2 B0
A0 B0

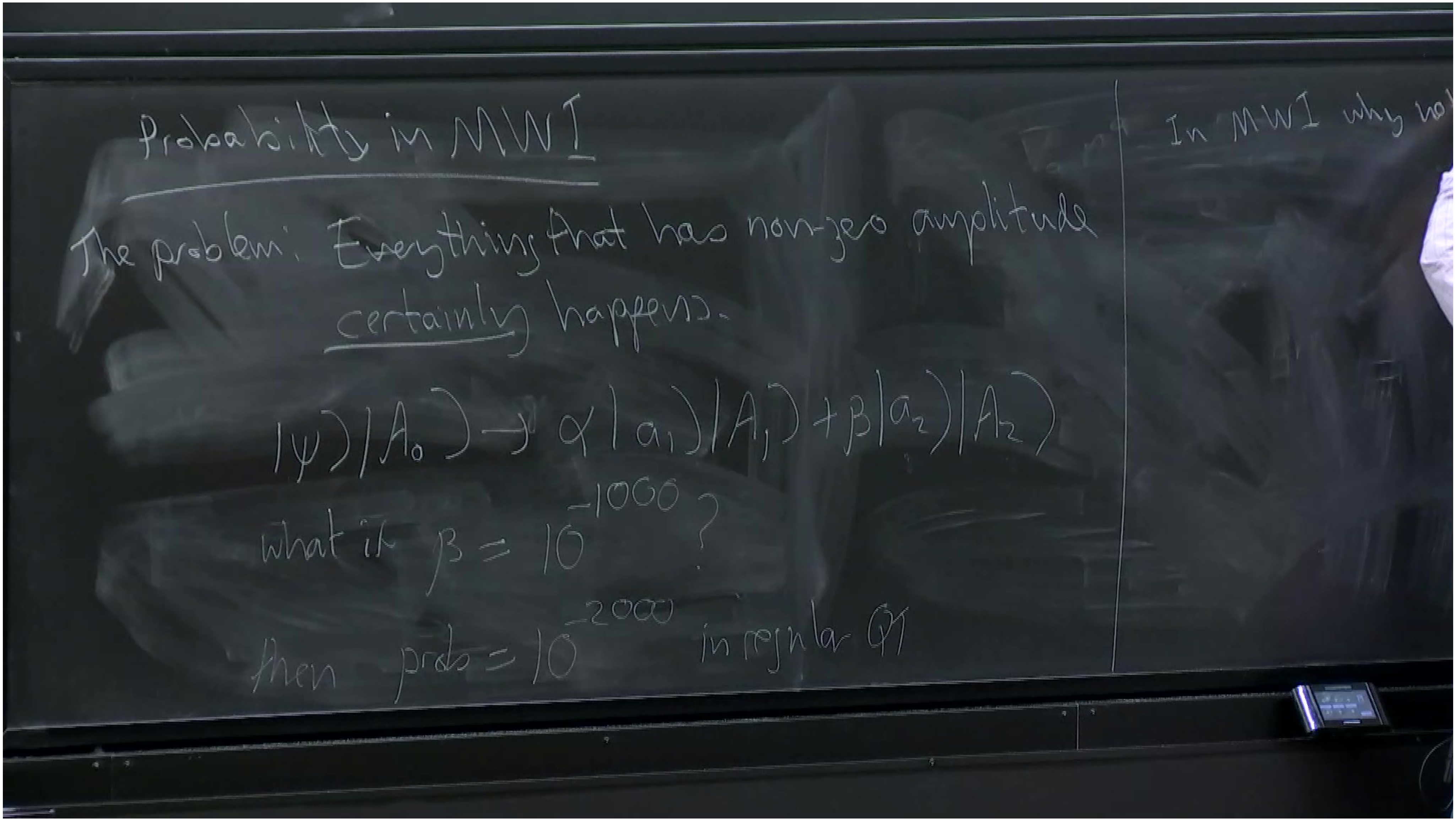

What picks out the $A_{0,1}$, $B_{0,1}$ bases?
could have had $(A_0 \pm A_1)$ $(B_0 \pm B_1)$
Interaction with environment
$|A_i)|E_0) \to |A_i)|E_i)$
$\langle E_1|E_2) \simeq \delta_{12}$

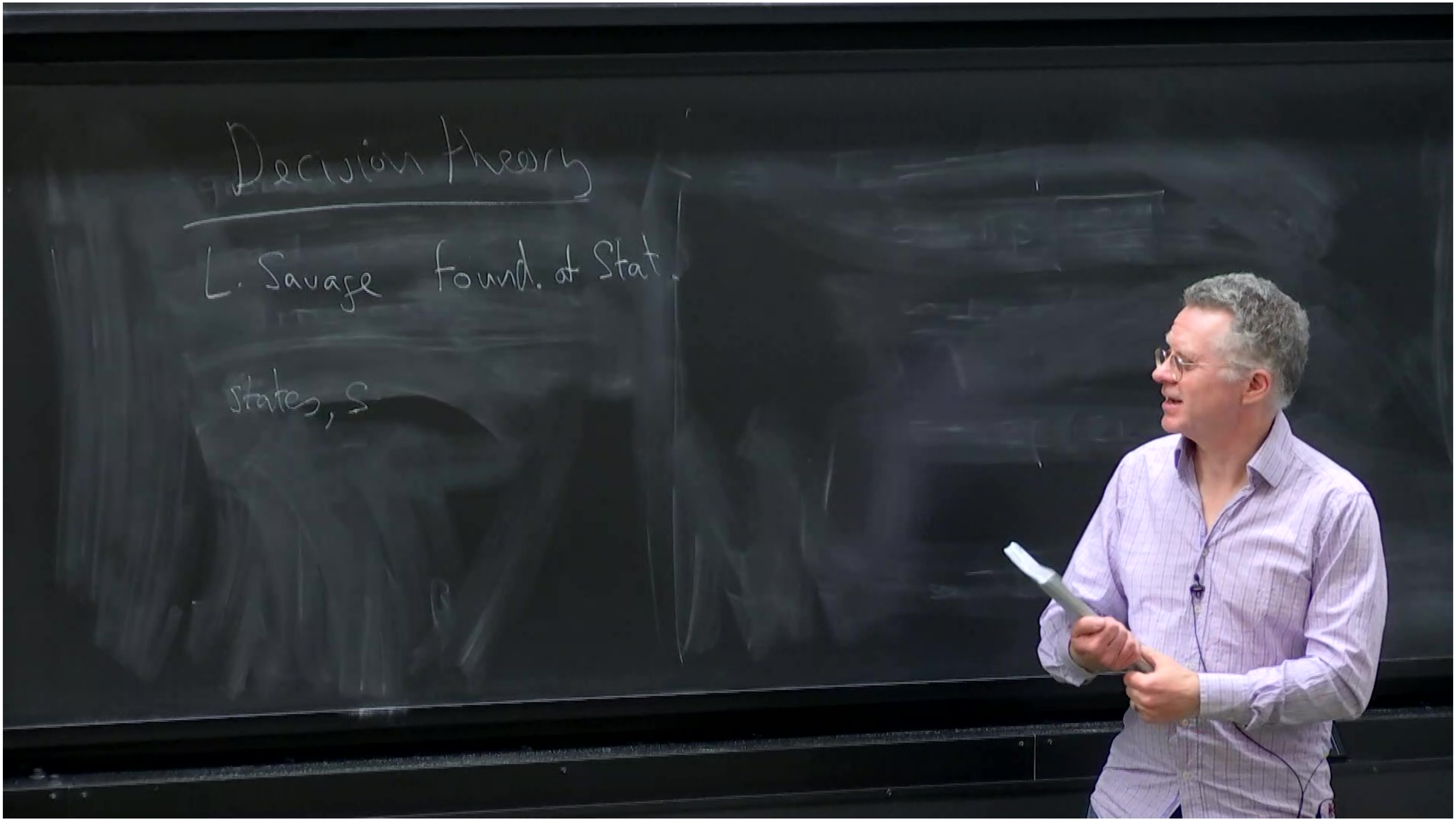

$(|A_1\rangle \pm |A_2\rangle)|E_0\rangle \to |A_1\rangle|E_1\rangle \pm |A_2\rangle|E_2\rangle$
$|A_{3,4}\rangle|E_0\rangle \to$

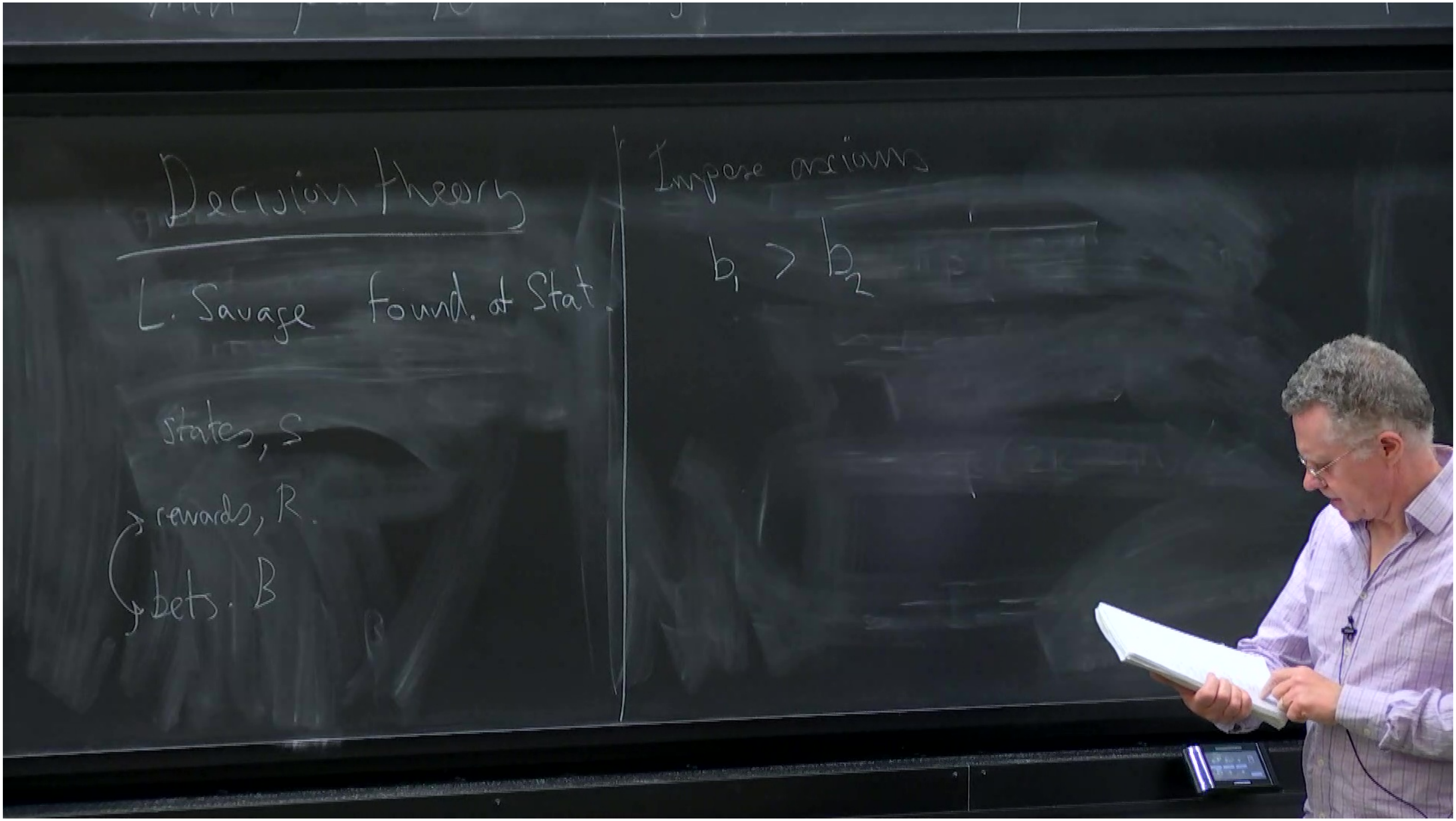

structure
What picks out the A0,1 , B0,1 bases?
could have had (A0 ± A1) (B0 ± B1)
Interaction with environment
|Ai⟩|E0⟩ → |Ai⟩|Ei⟩
⟨E1|E2⟩ ≃ δ12
A2B1
A2B2
A2B0
A0B0

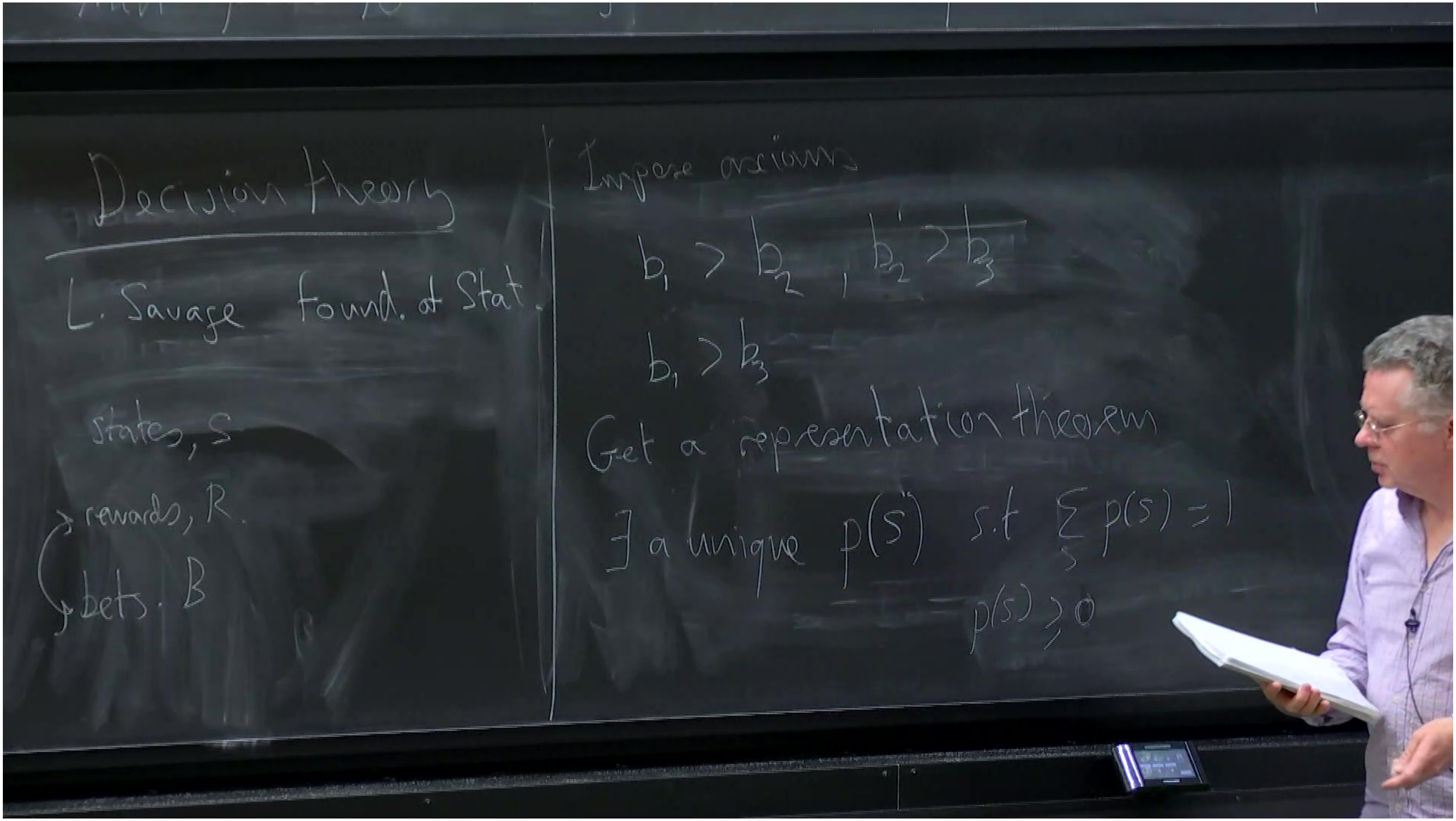


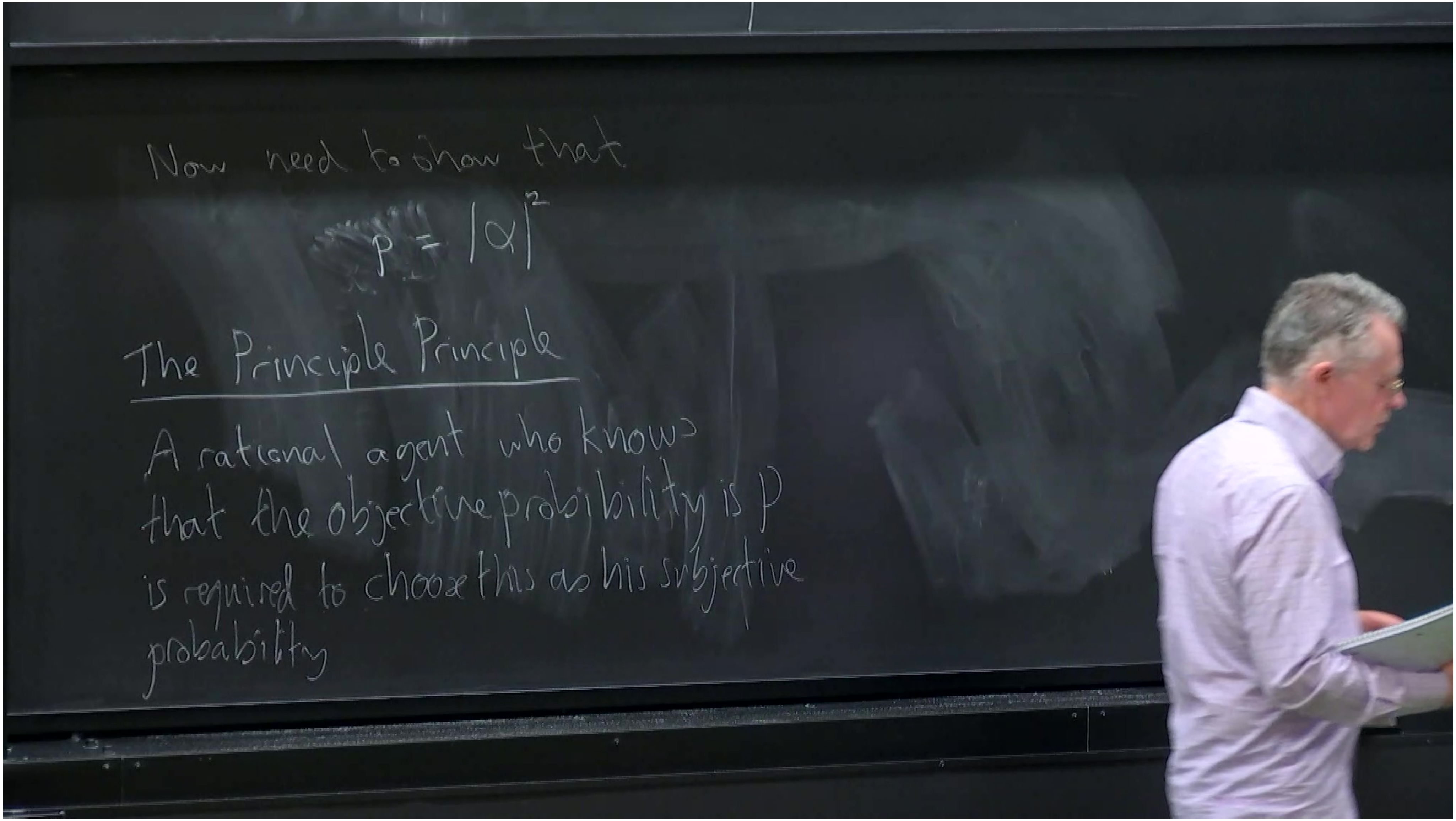
R (large)
Take ∂M at large R
ds²(∂M) = (1 − 2GM/R) dτ² + R² dΩ²II
n = − √(1 − 2GM/R) ∂/∂R (inward)
K = ∇a n^a = (1/√g) ∂a(√g n^a)
= − (1/r²) ∂r (r² √(1 − 2GM/r))
= − (2/r) √(1 − 2GM/r) − GM / (r² √(1 − 2GM/r))
= − 1 / (r² √(1 − 2GM/r)) [2(r − 2GM) + GM]
K|R = − 1 / (R² √(1 − 2GM/R)) [2R − 3GM]
√h d³x = R² sinθ √(1 − 2GM/R) dτ dθ dφ
β 4π
⇒ ∫ K √h d³x = − 4π β [2R − 3GM]
DIVERGENT AS R → ∞
But FLAT SPACE
ds² = dτ0² + R² dΩ²II
K0 = − 2/r
∫ K √h0 d³x = − 4π β0 × 2R
also divergent.

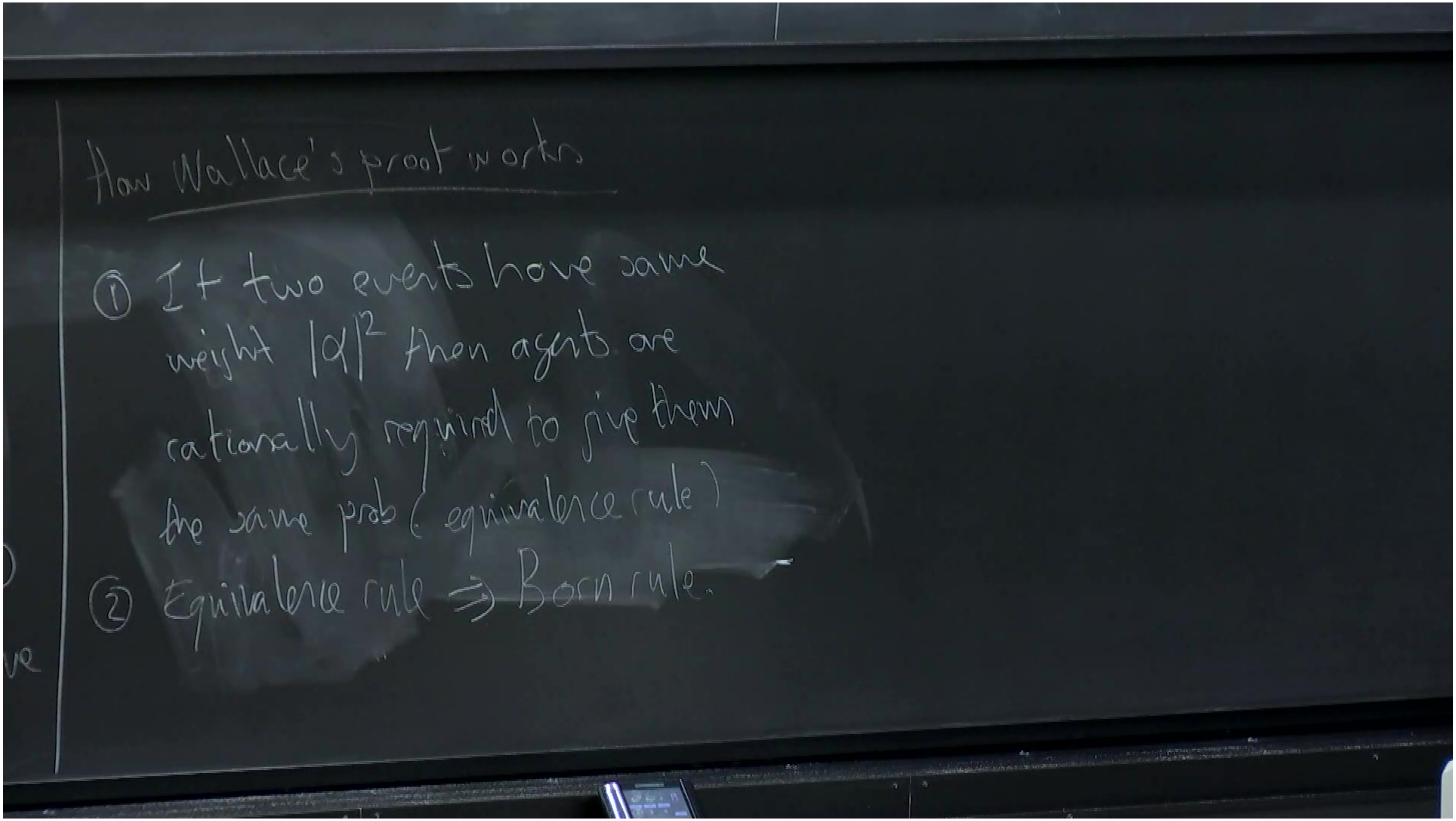

Probability in MWI
The problem: Everything that has non-zero amplitude certainly happens.
|ψ)|A₀) → α|a₁)|A₁) + β|a₂)|A₂)
what if β = 10^-1000 ?
then prob = 10^-2000 in regular QT
In MWI why no

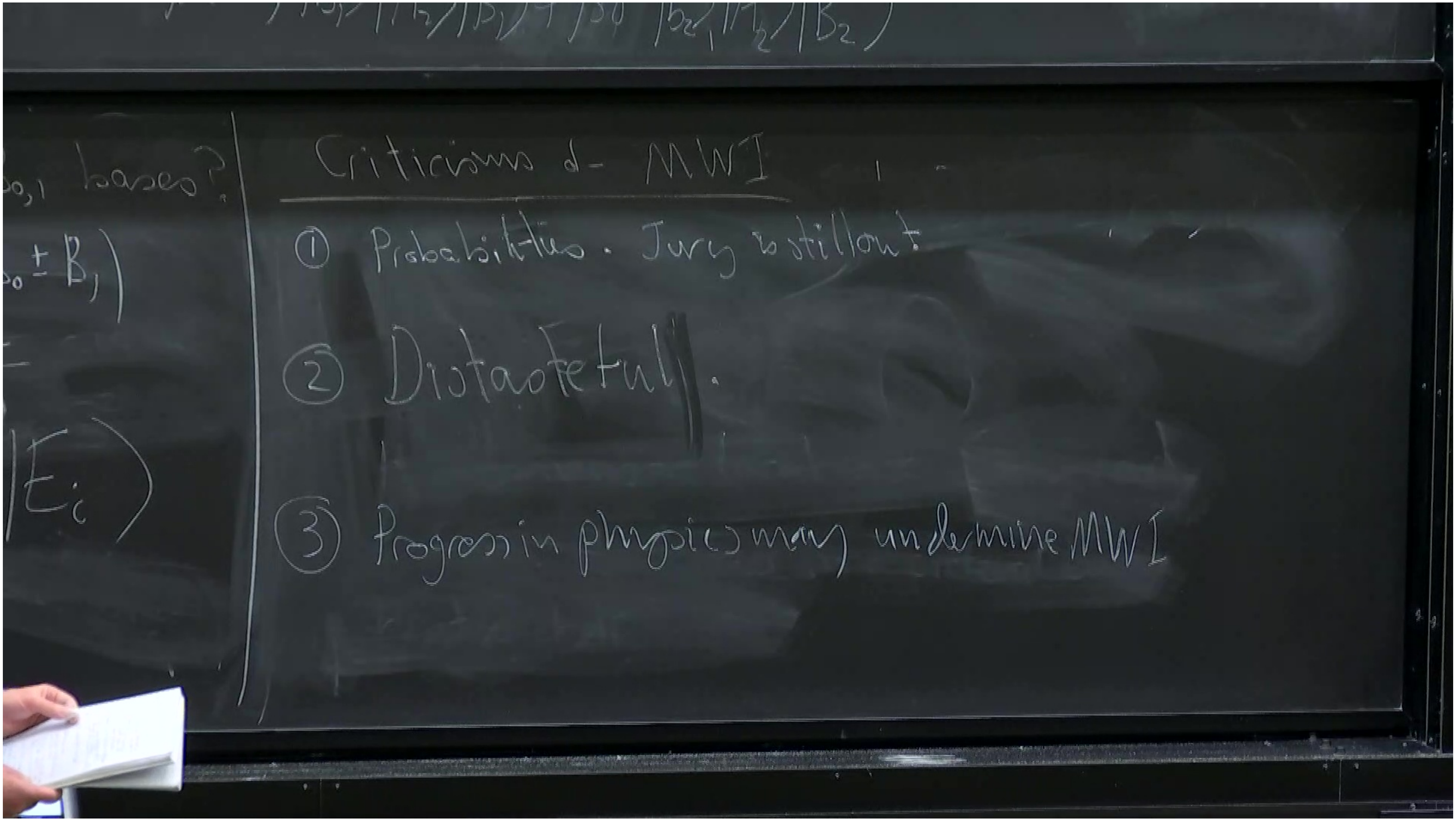

Decision theory
L. Savage found. of Stat.
states, S

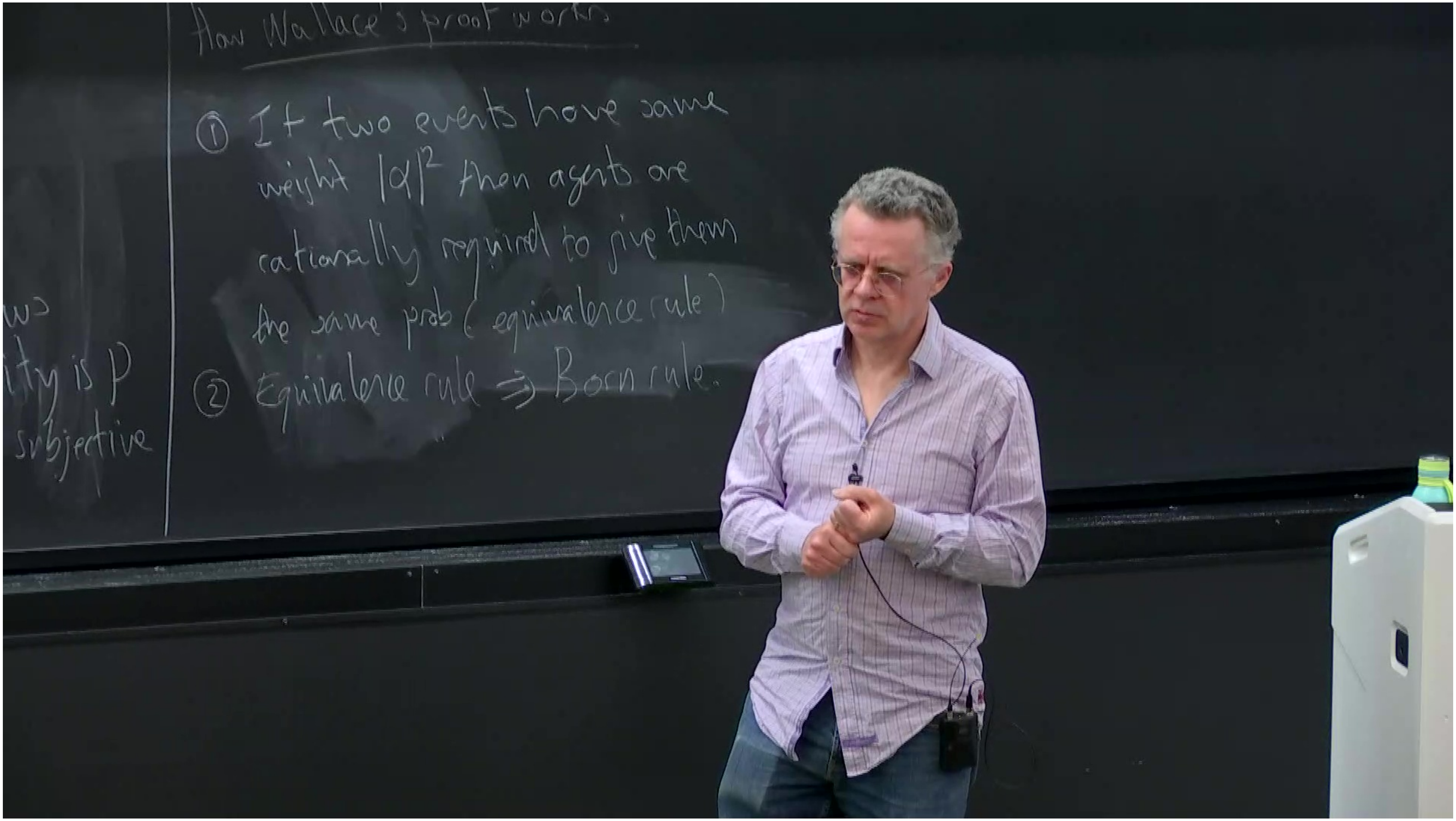

Decision theory
L. Savage found. of Stat.
states, S
rewards, R.
bets. B
Impose axioms
b1 > b2


Decision theory
L. Savage found. of Stat.
states, S
rewards, R.
bets. B
Impose axioms
$b_1 > b_2$, $b_2 > b_3$
$b_1 > b_3$
Get a representation theorem
$\exists$ a unique $p(s)$ s.t. $\sum_s p(s) = 1$
$p(s) \geq 0$


Now need to show that
p = |α|²
The Principle Principle
A rational agent who knows
that the objective probability is p
is required to choose this as his subjective
probability


How Wallace's proof works
① If two events have same weight $|\alpha|^2$ then agents are rationally required to give them the same prob (equivalence rule)
② Equivalence rule ⇒ Born rule.


Criticisms of MWI
① Probabilities. Jury is still out!
② Distasteful!
③ Progress in physics may undermine MWI


How Wallace's proof works
① If two events have same weight |α|² then agents are rationally required to give them the same prob (equivalence rule)
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ws
ity is p
subjective