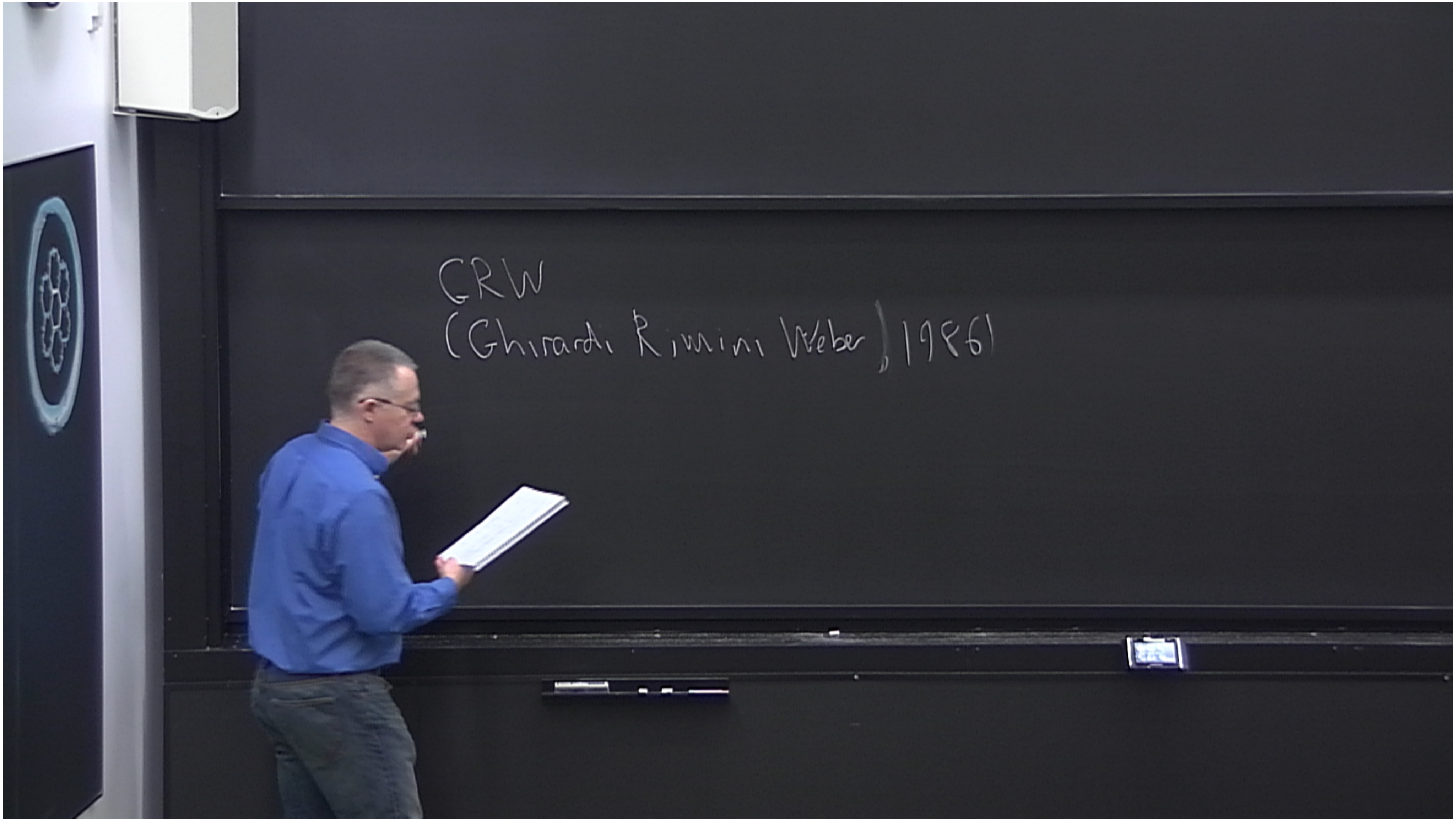
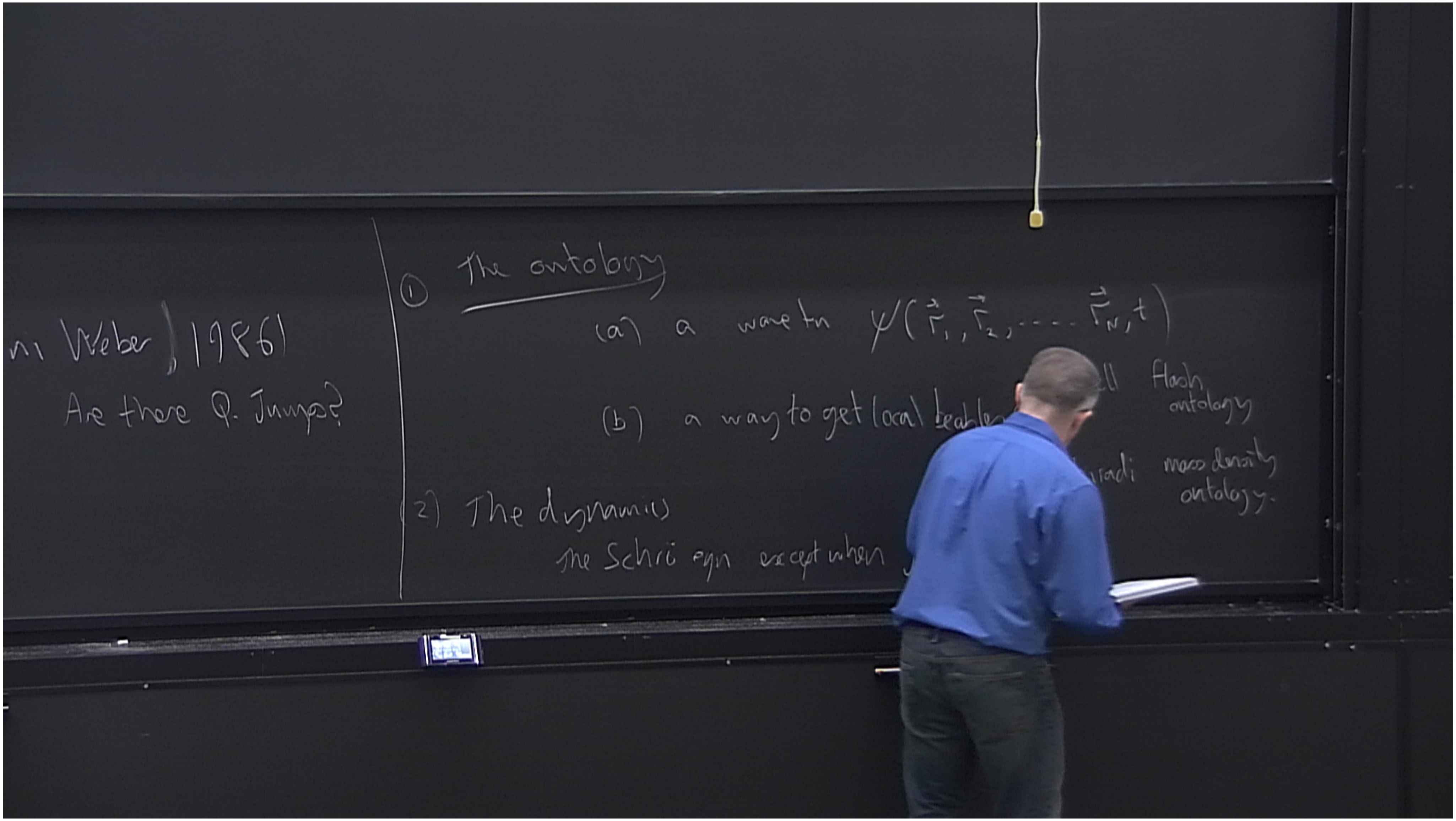
Title: PSI 2015/2016 Foundations of Quantum Mechanics - Lecture 10

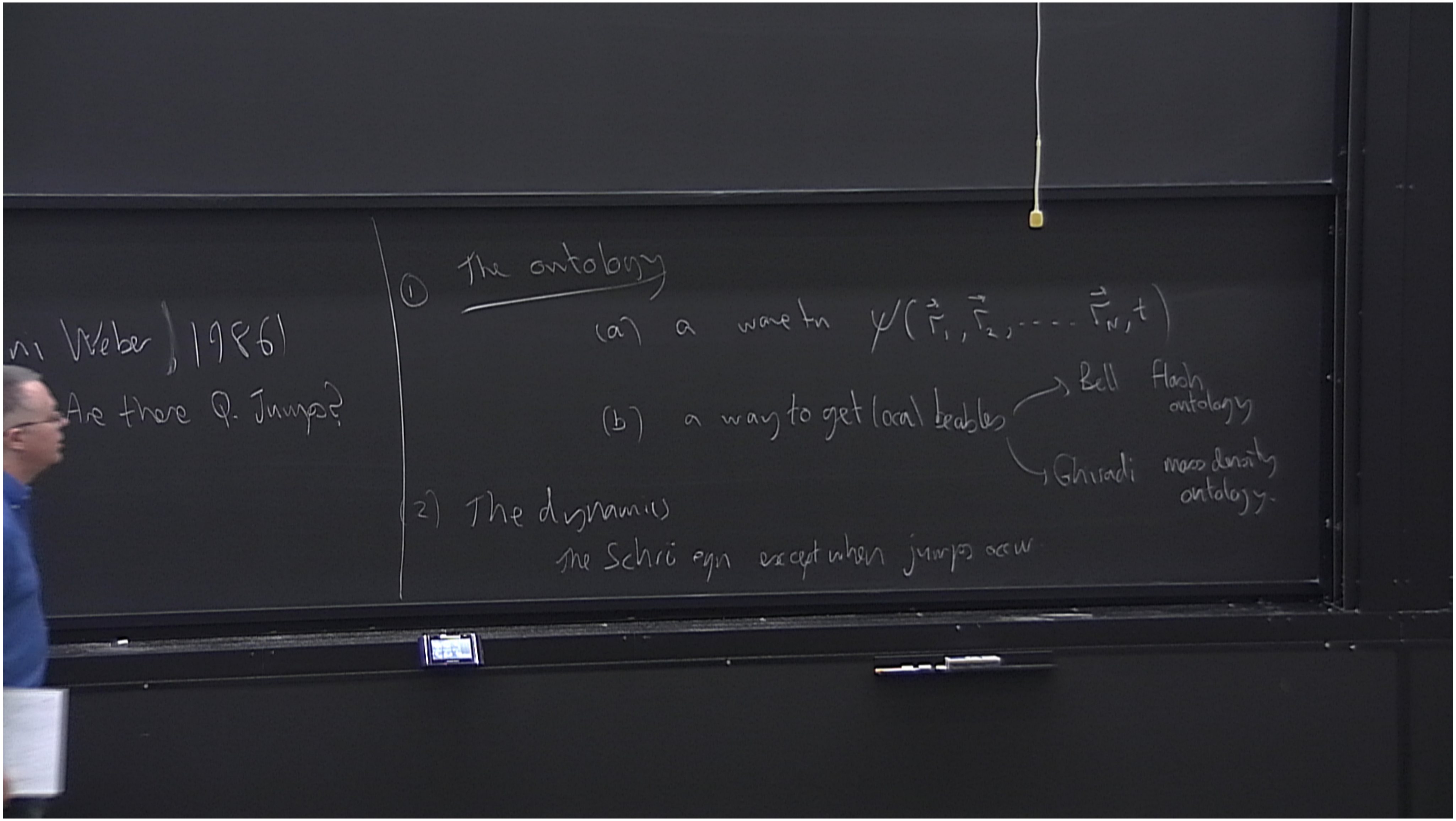
Date: Jan 15, 2016 11:30 AM

URL: http://pirsa.org/16010064

Abstract:


GRW
(Ghirardi Rimini Weber), 1986)


ni Weber, 1986)
Are there Q. Jumps?
① The ontology
(a) a wave fn ψ(r₁, r₂, ... r_N, t)
(b) a way to get local beables
flash ontology
mass density ontology.
(2) The dynamics
The Schrö eqn except when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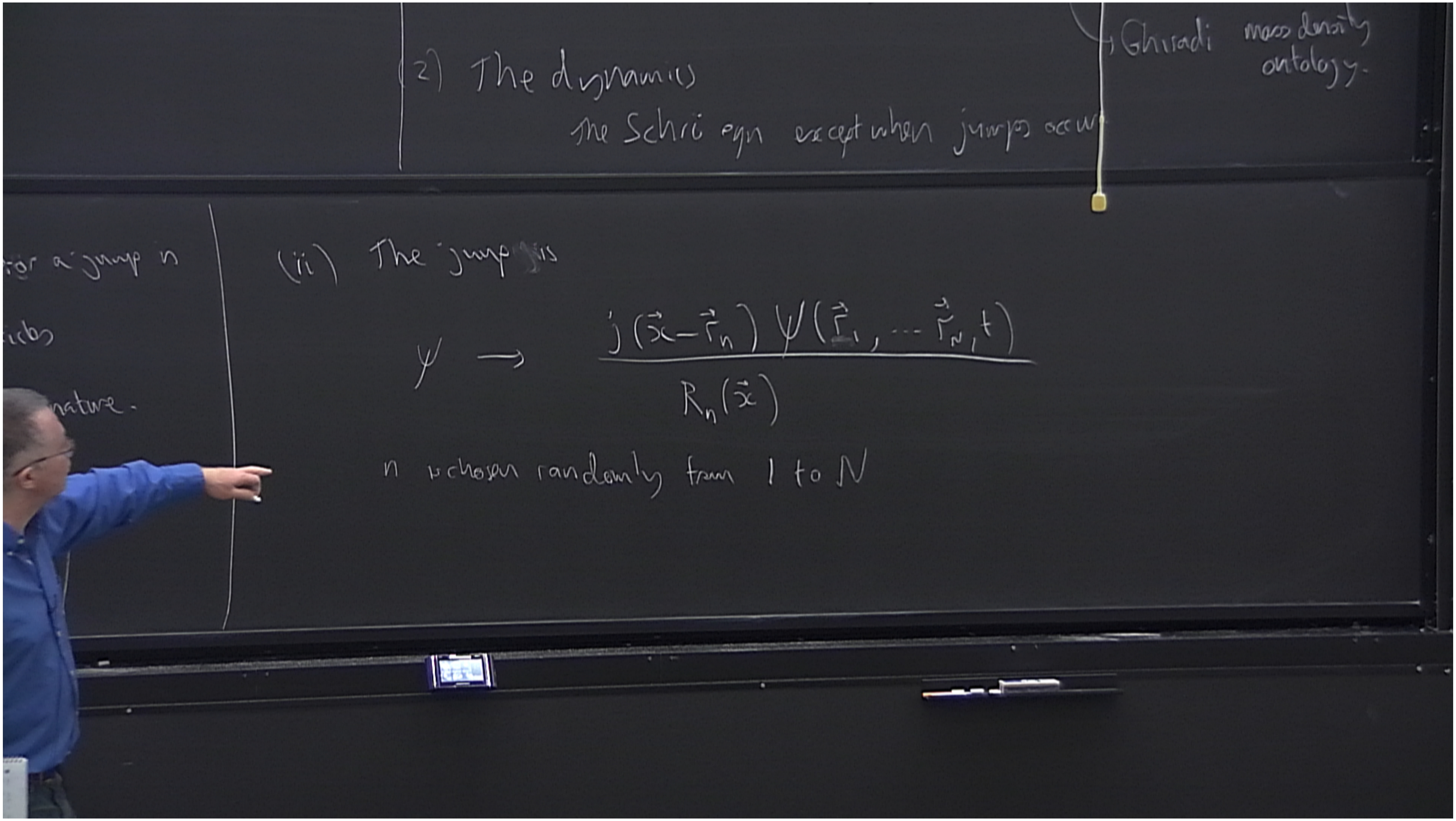
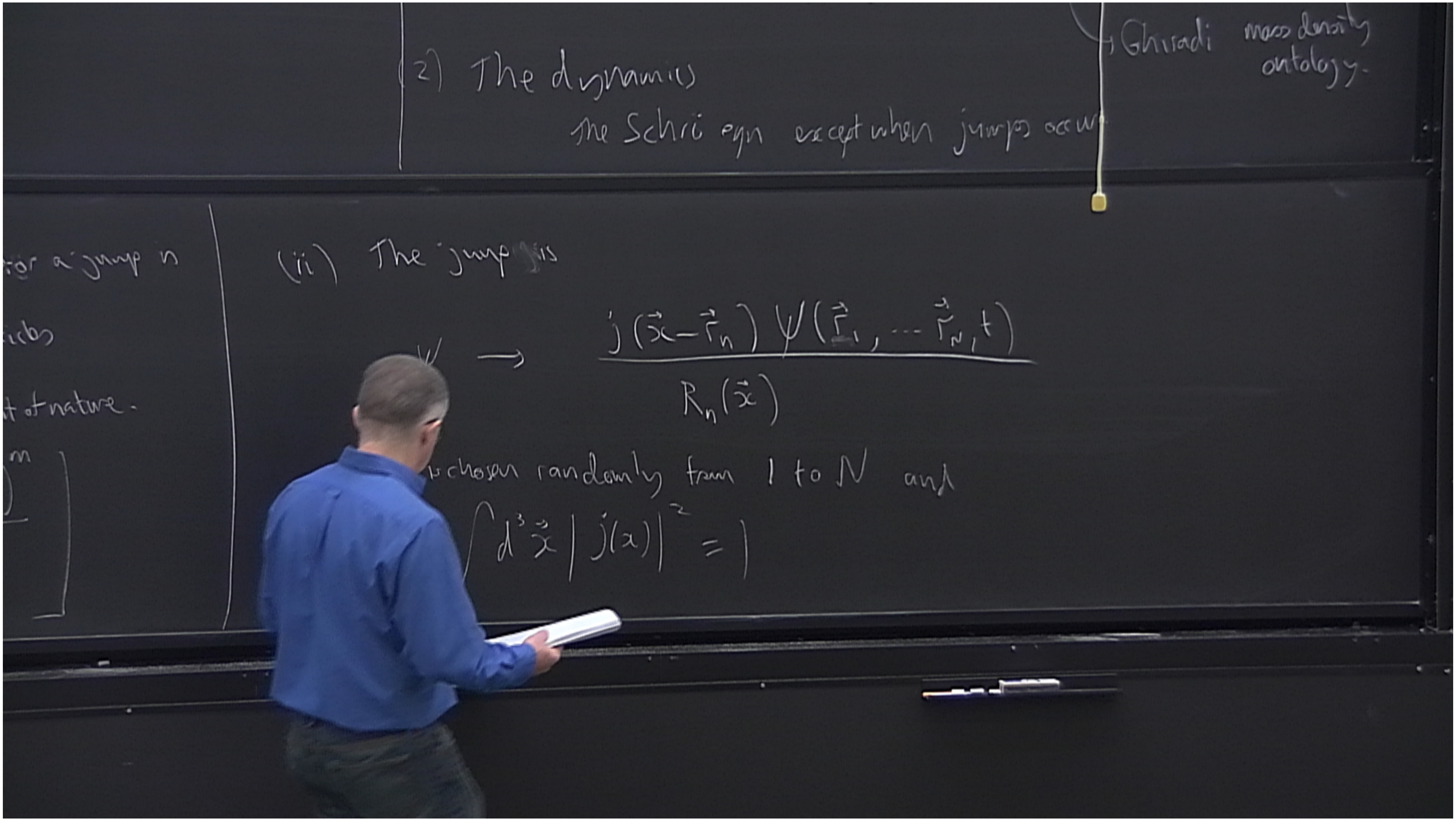
Are there Q. Jumps?
① The ontology
(a) a wave fn $\psi(\vec{r}_1, \vec{r}_2, \ldots \vec{r}_N, t)$
(b) a way to get local beables
Bell flash ontology
Ghirardi mass density ontology.
2) The dynamics
The Schrö eqn except when jumps occur


(2) The dynamics
The Schr. eqn except when jumps occur
Ghiradi mass density ontology.
for a jump in
nature.
(ii) The jump is
$\psi \longrightarrow \frac{j(\vec{x}-\vec{r}_n)\,\psi(\vec{r}_1,\dots\vec{r}_N,t)}{R_n(\vec{x})}$
n is chosen randomly from 1 to N



(2) The dynamics
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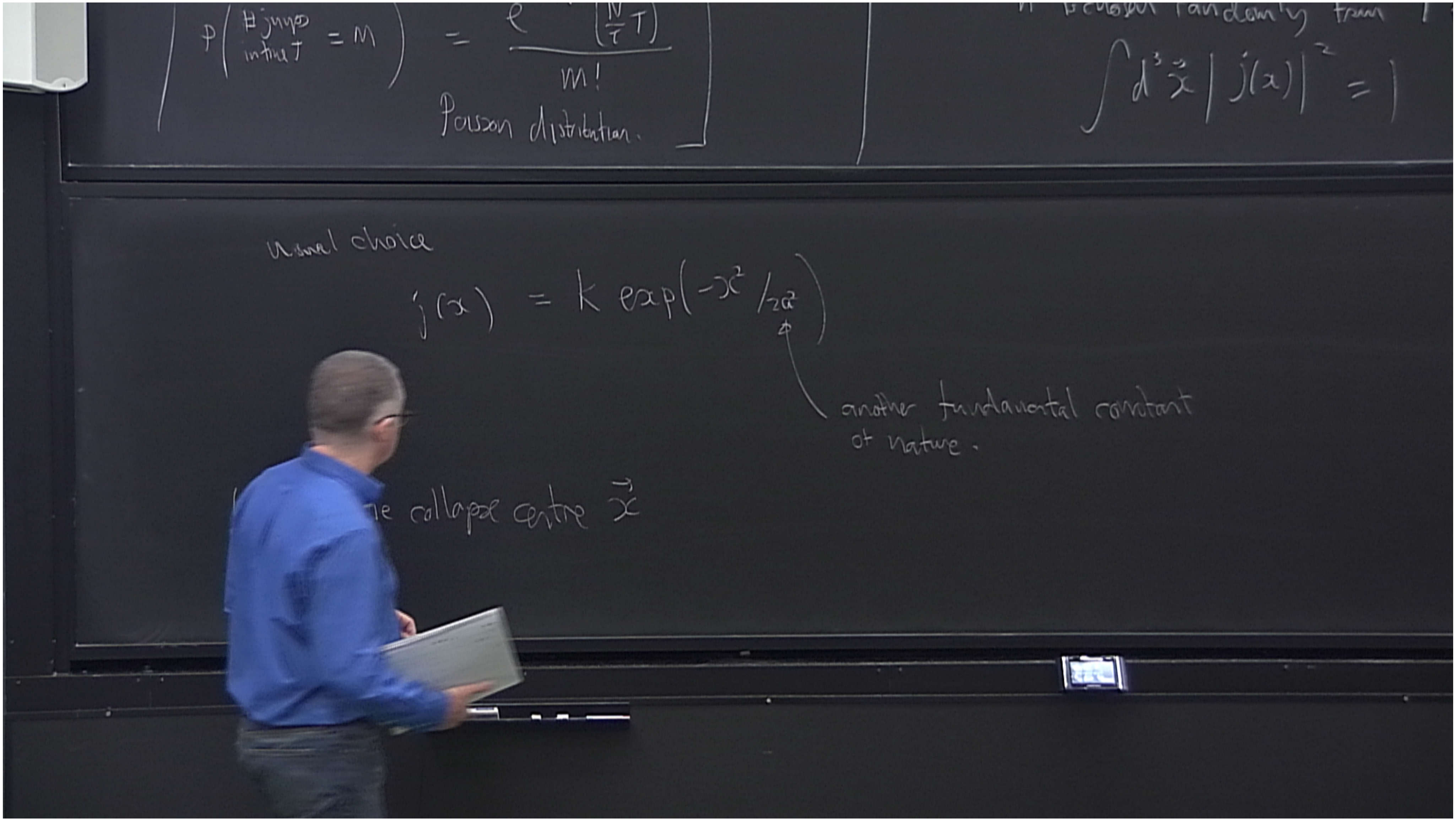
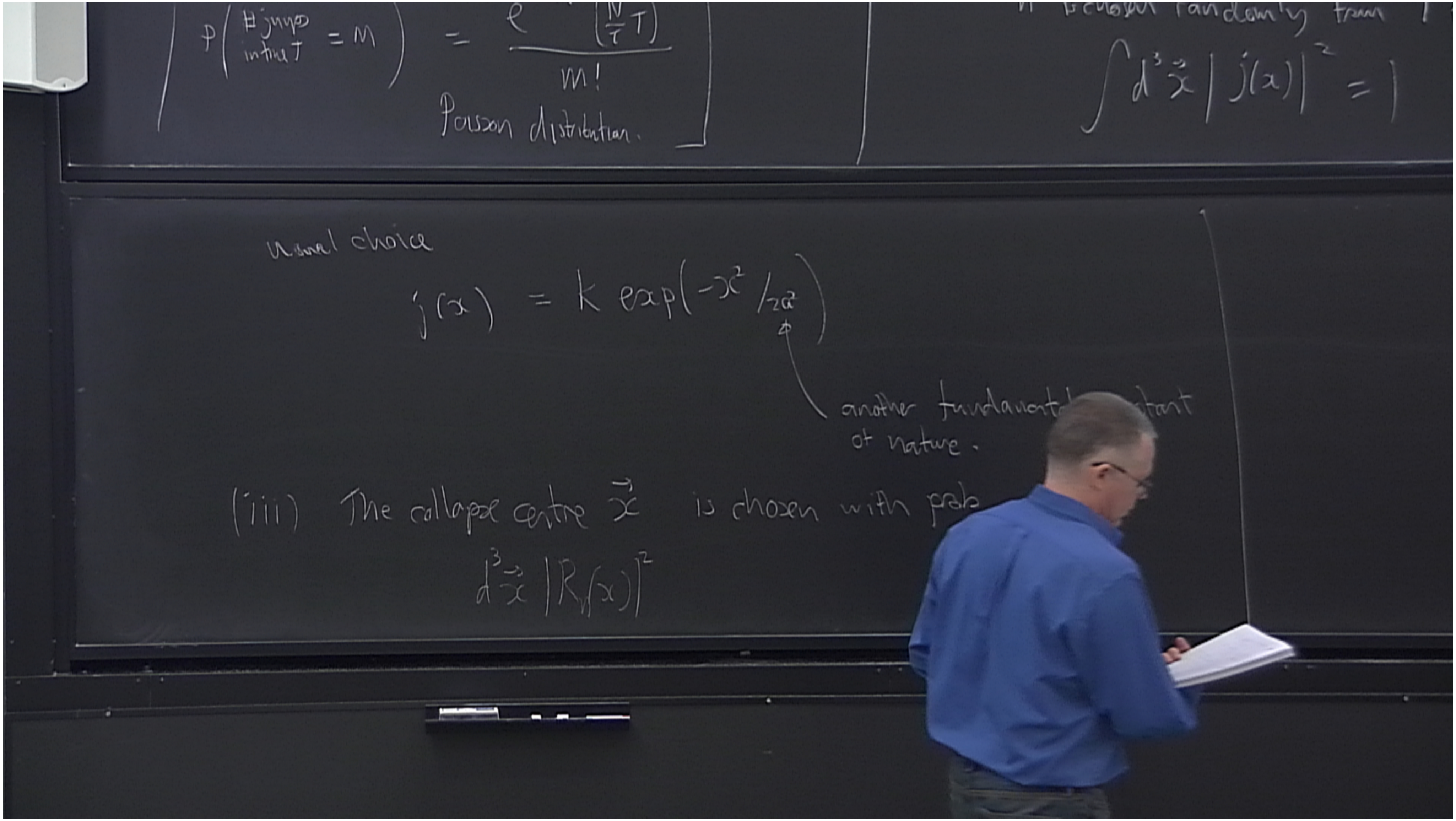
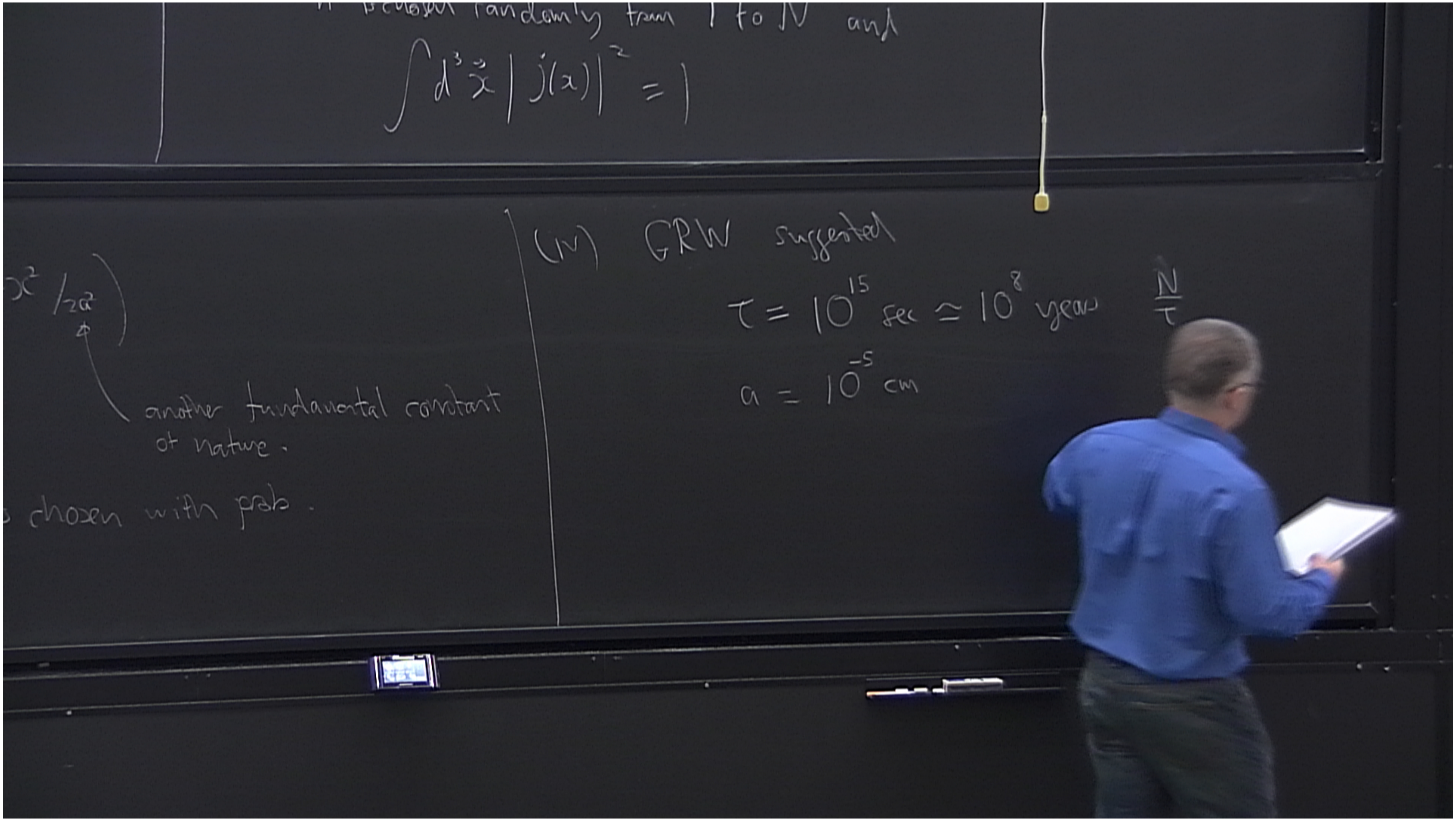
(ii) The jump is
$\psi \longrightarrow \frac{j(\vec{x}-\vec{r}_n)\,\psi(\vec{r}_1, \dots \vec{r}_N, t)}{R_n(\vec{x})}$
chosen randomly from 1 to N and
$\int d^3\vec{x}\, |j(x)|^2 = 1$


Poisson distribution.
usual choice
j(x) = k exp(-x²/2a²)
another fundamental constant
of nature.
collapse centre


Poisson distribution.
usual choice
j(x) = k exp(-x²/2a²)
another fundament constant
of nature.
(iii) The collapse centre x is chosen with prob
d³x |Rₙ(x)|²


chosen randomly from 1 to N and
∫ d³x |j(x)|² = 1
x² / 2a²
another fundamental constant
of nature.
chosen with prob.
(iv) GRW suggested
τ = 10^15 sec ≃ 10^8 years
N / τ
a = 10^-5 cm

$$\int d^3\vec{x}\,|j(x)|^2 = 1$$

another fundamental constant of nature.

chosen with prob.

(iv) GRW suggested

$\tau = 10^{15}$ sec $\simeq 10^8$ years ($\frac{N}{\tau}$ can be big for big N)

$a = 10^{-5}$ cm bigger than an atom, smaller than eye can discern

... chosen randomly from 1 to N and

$$\int d^3\vec{x}\,|j(x)|^2 = 1$$

$x^2/2a^2)$

another fundamental constant of nature.

... chosen with prob.

(iv) GRW suggested

$\tau = 10^{15}$ sec $\simeq 10^8$ years ($\frac{N}{\tau}$ can be big for big N)

$a = 10^{-5}$ cm — bigger than an atom, smaller than eye can discern

and $$|R_n(x)|^2 = \int d^3\vec{r}_1\, d\vec{r}_2 \cdots d^3\vec{r}_N\, |j(\vec{x}-\vec{r}_n)\psi|^2$$

n is chosen randomly from 1 to N and

$$\int d^3\vec{x}\,\left|j(x)\right|^2 = 1$$

$x^2/2a^2$)

another fundamental constant of nature.

(iv) GRW suggested

$\tau = 10^{15}$ sec $\simeq 10^{8}$ years ($\frac{N}{\tau}$ can be big for big N)

$a = 10^{-5}$ cm bigger than an atom smaller than eye can discern

is chosen with prob.

and $$\left|R_n(x)\right|^2 = \int d^3\vec{r}_1\, d\vec{r}_2 \cdots d^3\vec{r}_N \left| j(\vec{x}-\vec{r}_n)\psi\right|^2$$

... be chosen randomly from 1 to N and

$$\int d^3\vec{x}\, |j(x)|^2 = 1$$

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$\tau = 10^{15}$ sec $\simeq 10^8$ years $\left(\frac{N}{\tau} \right.$ can be big for big N $\left. \right)$

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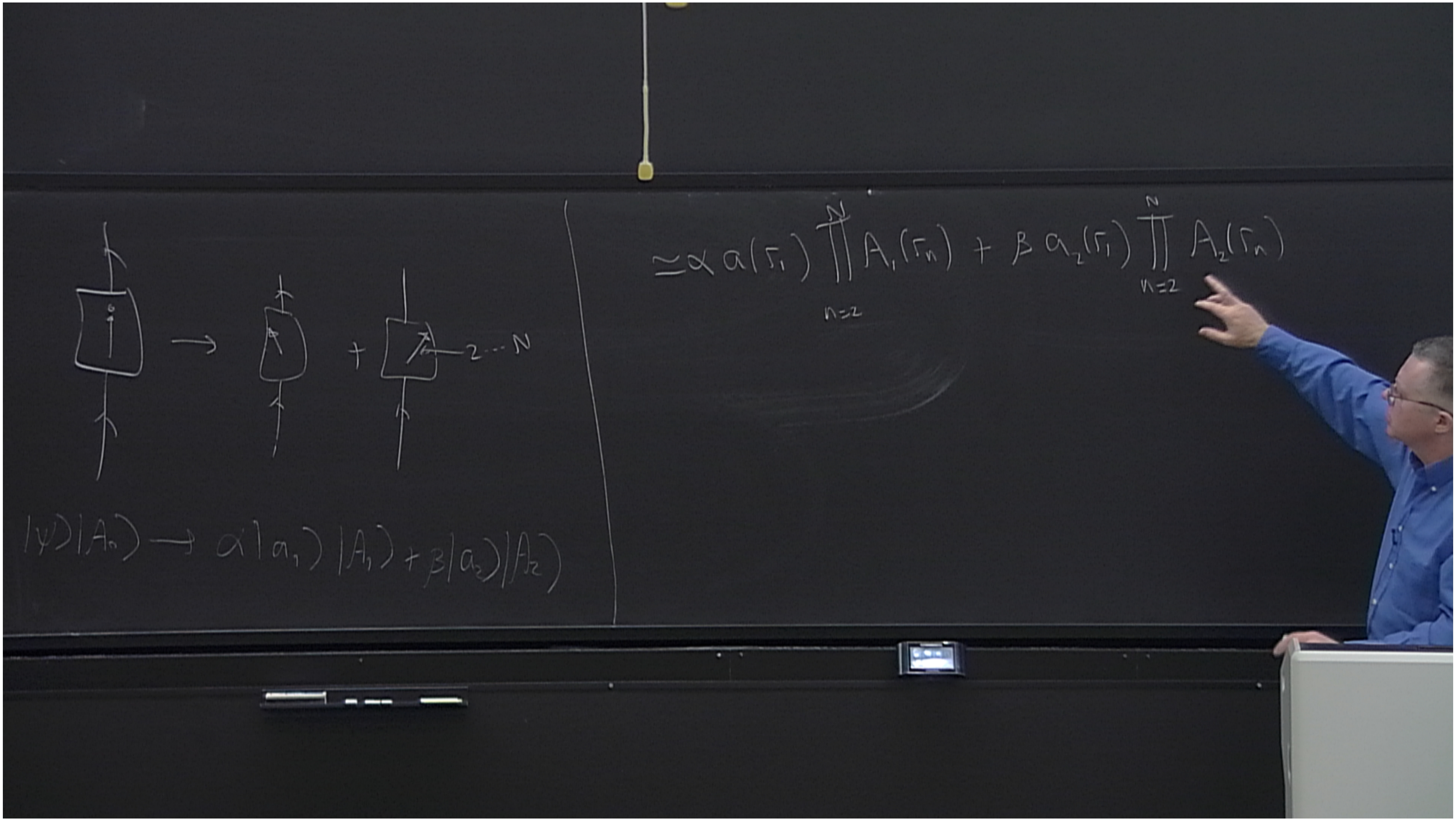
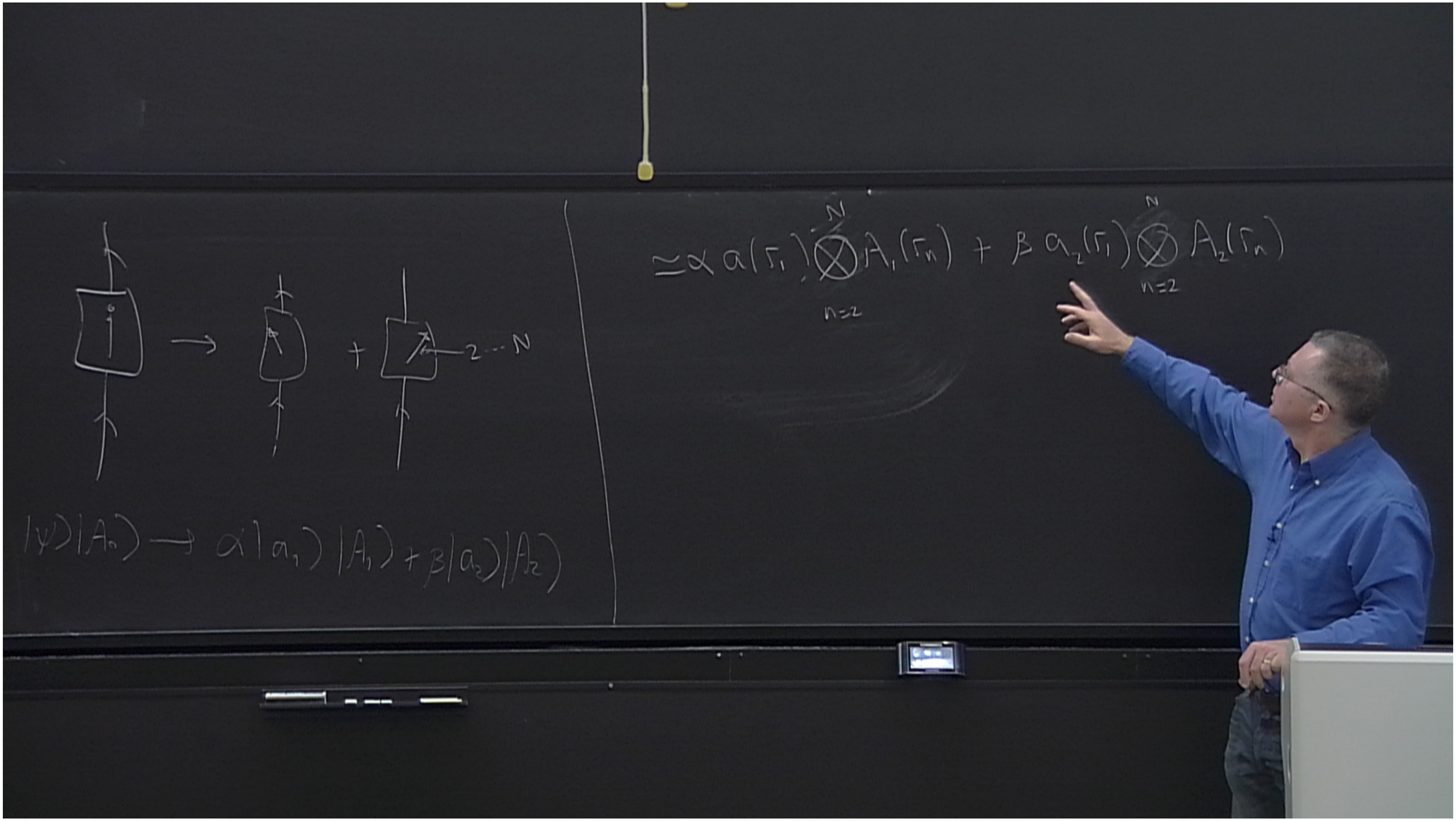
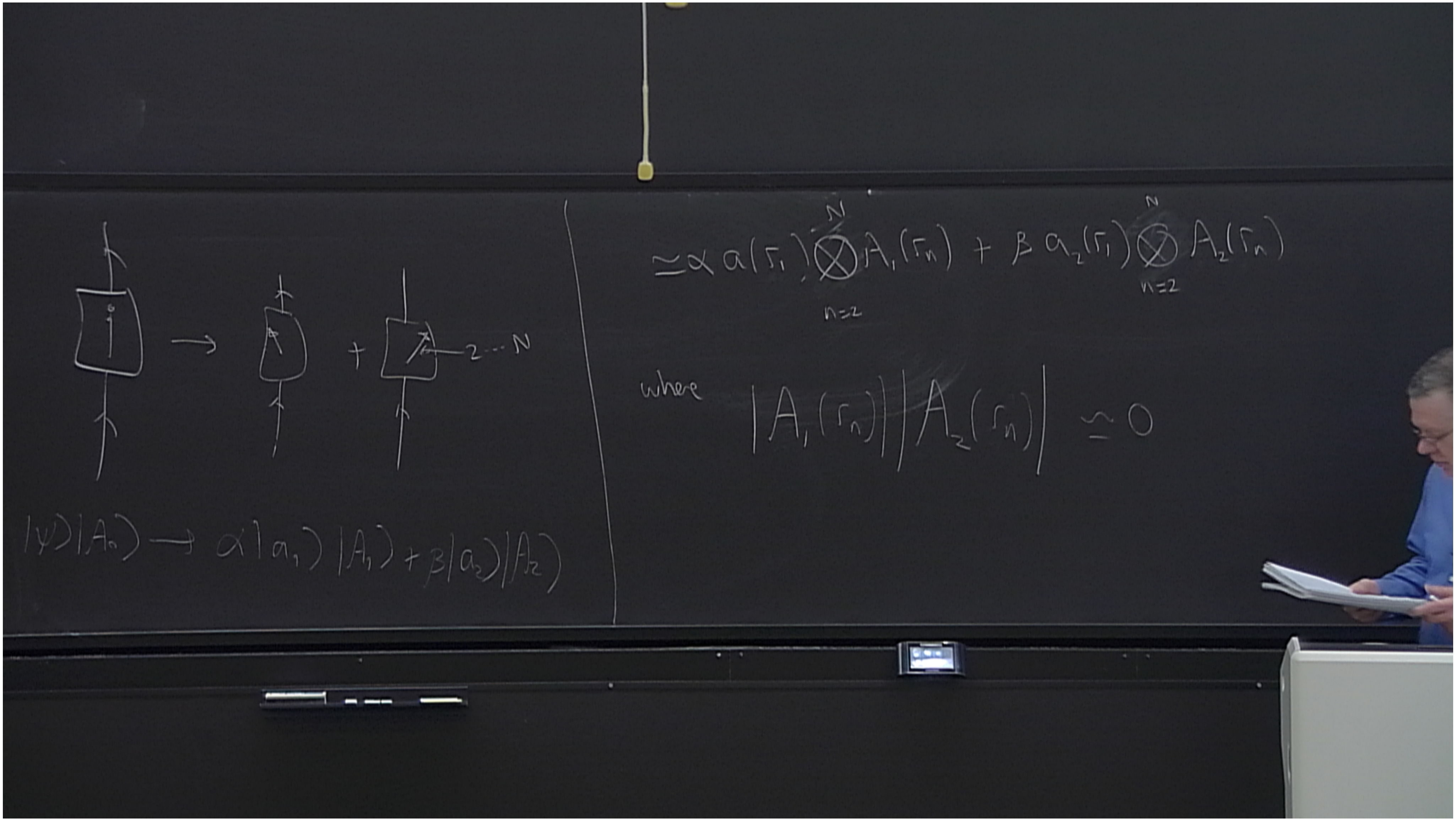
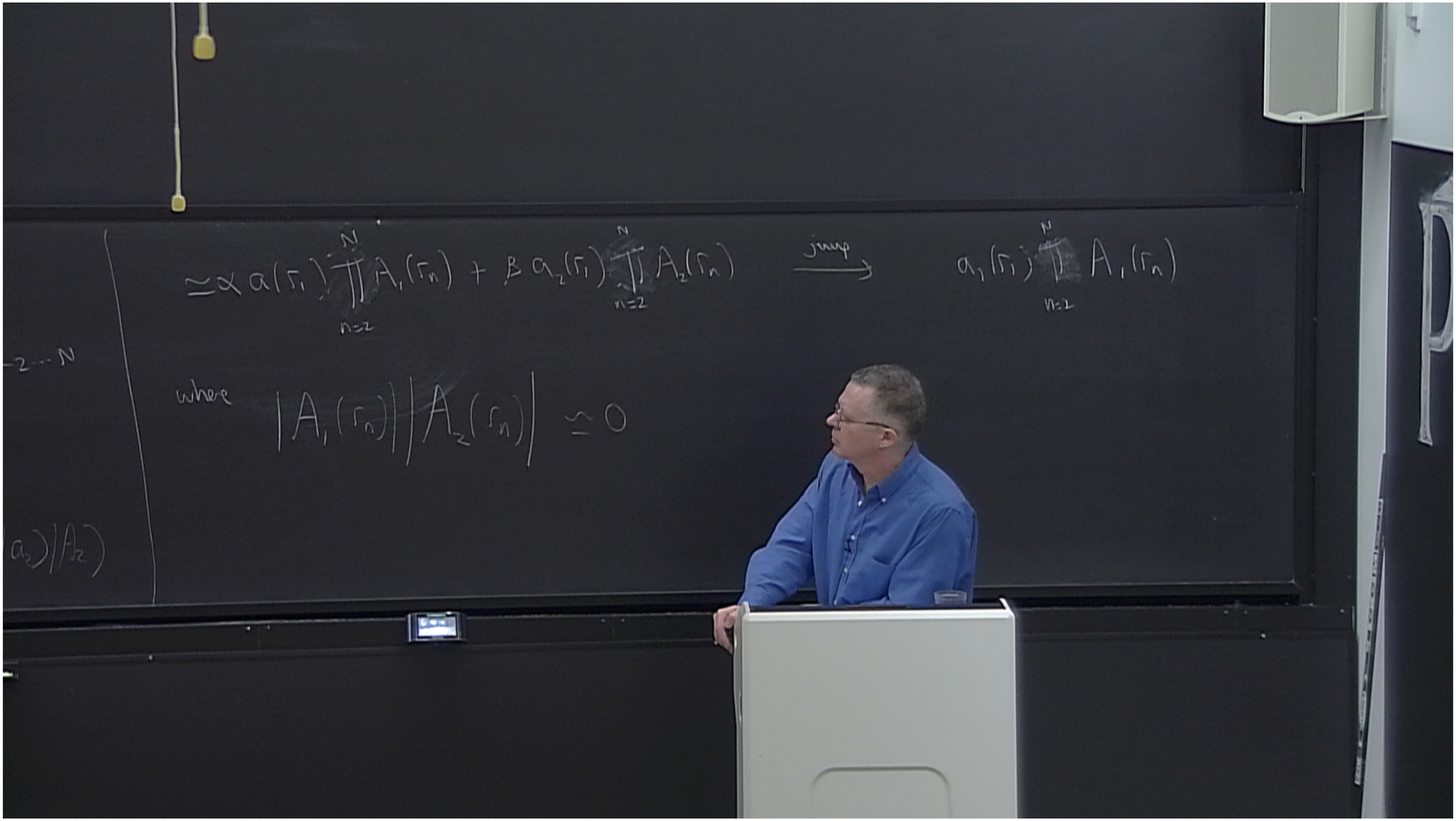

2 ··· N
|ψ⟩|A₀⟩ → α|a₁⟩|A₁⟩ + β|a₂⟩|A₂⟩
≃ α a(r₁) ∏ A₁(rₙ) + β a₂(r₁) ∏ A₂(rₙ)
N
n=2

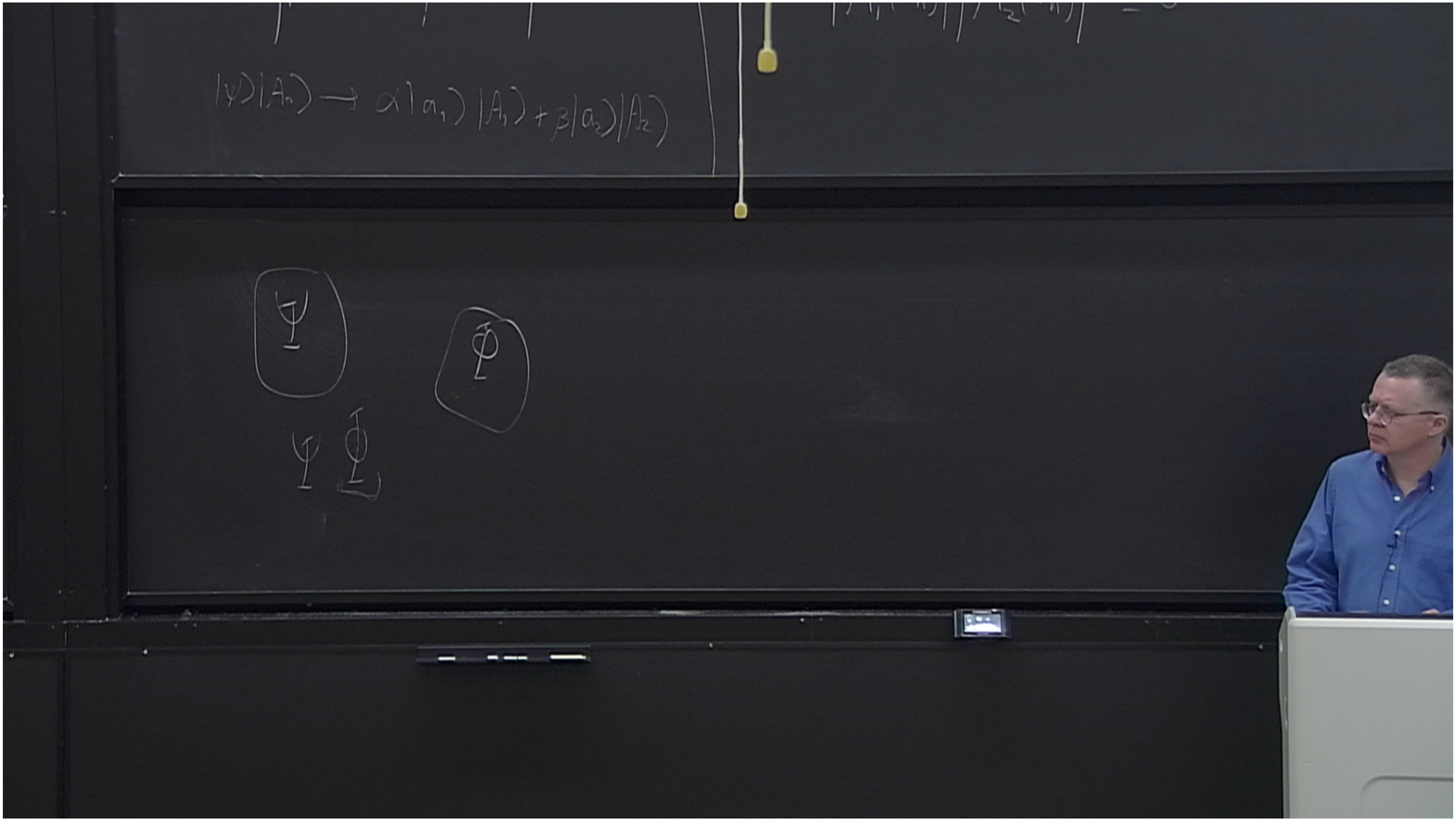


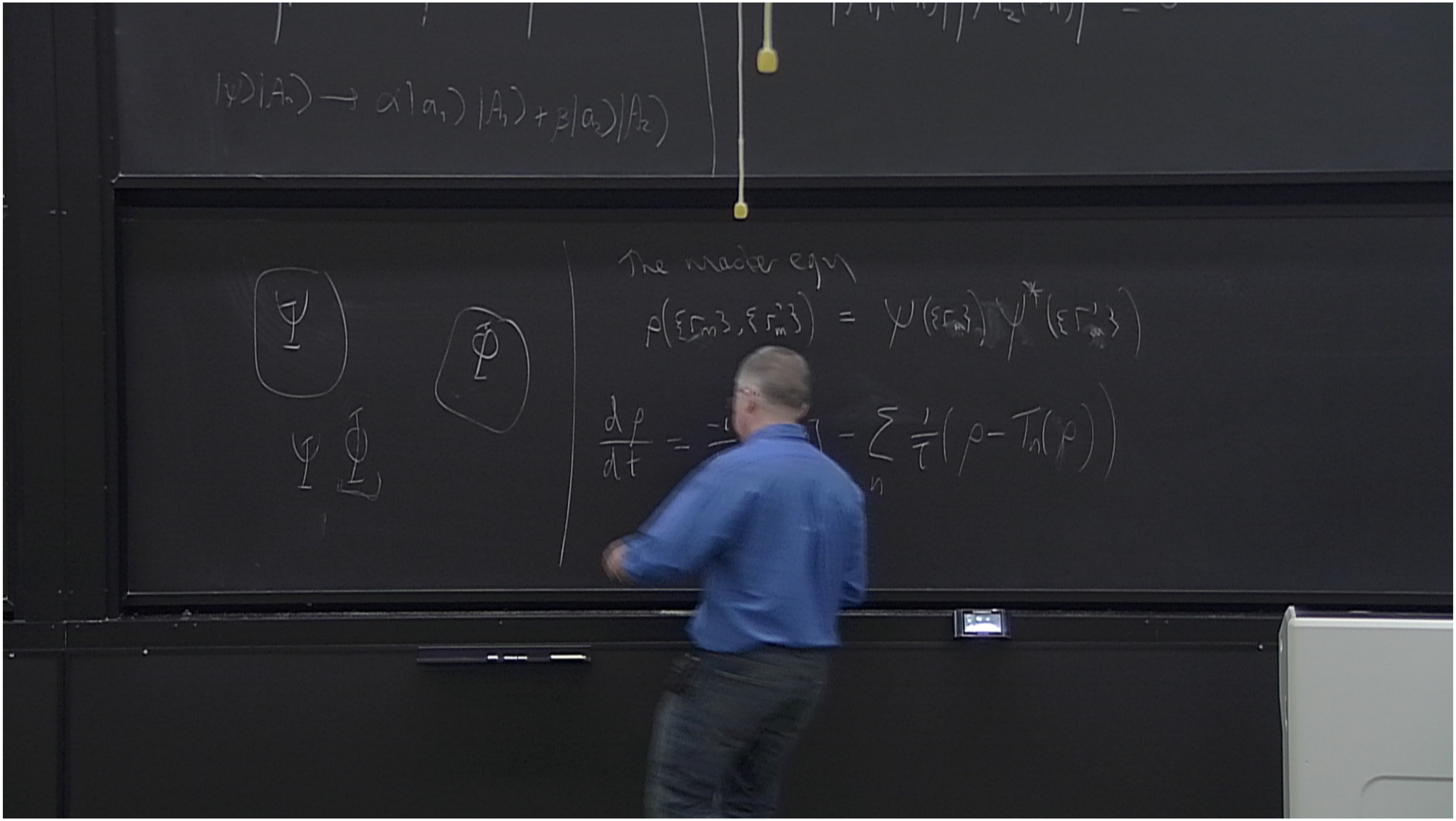
2 ⋯ N
$|\psi\rangle|A_n\rangle \rightarrow \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$
$\simeq \alpha\, a(r_1) \bigotimes_{n=2}^{N} A_1(r_n) + \beta\, a_2(r_1) \bigotimes_{n=2}^{N} A_2(r_n)$

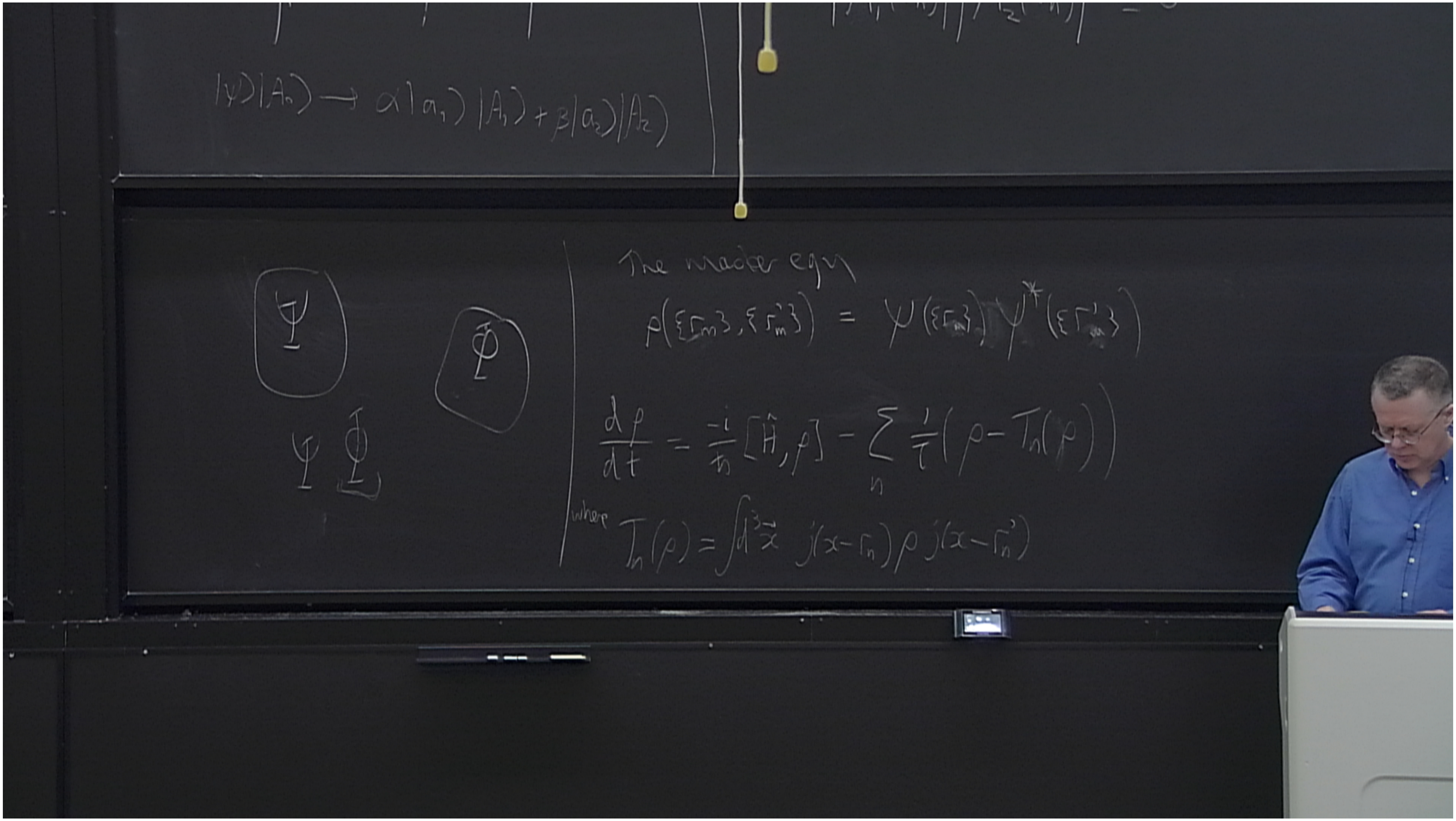

2 ··· N
$|\psi\rangle|A_0\rangle \rightarrow \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$
$\simeq \alpha\, a(r_1) \bigotimes_{n=2}^{N} A_1(r_n) + \beta\, a_2(r_1) \bigotimes_{n=2}^{N} A_2(r_n)$
where $|A_1(r_n)||A_2(r_n)| \simeq 0$

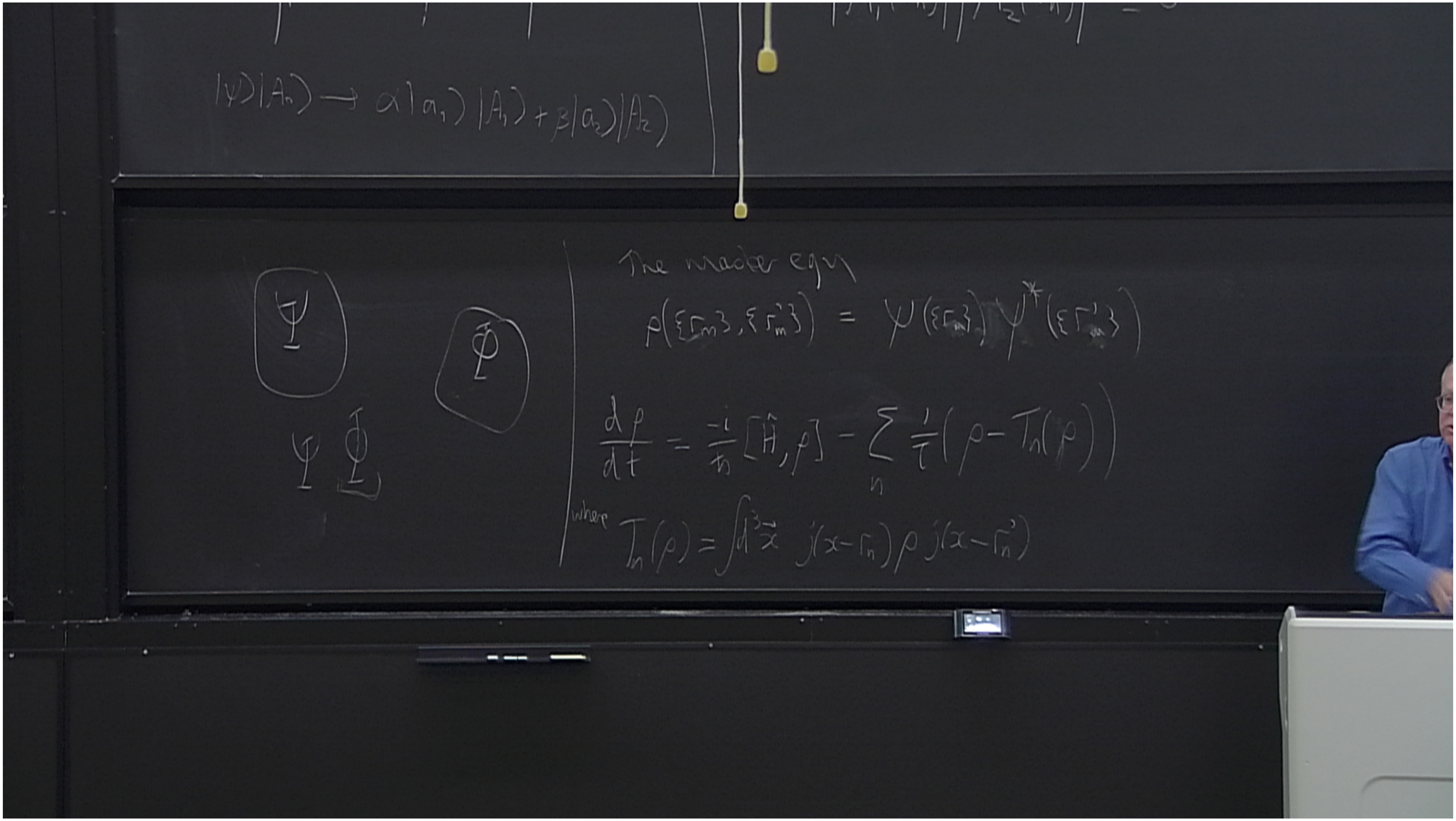


$\simeq \alpha\, a(r_1) \prod_{n=2}^{N} A_1(r_n) + \beta\, a_2(r_1) \prod_{n=2}^{N} A_2(r_n) \xrightarrow{\text{jump}} a_1(r_1) \prod_{n=2}^{N} A_1(r_n)$
where $|A_1(r_n)|\,|A_2(r_n)| \simeq 0$
$2 \cdots N$
$a_2)|A_2)$


$|\psi\rangle|A_0\rangle \to \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$
Ψ
Φ
$\Psi \; \Phi$


The master eqn


|ψ⟩|A₀⟩ → α|a₁⟩|A₁⟩ + β|a₂⟩|A₂⟩
The master eqn
ρ({r_m}, {r'_m}) = ψ({r_m}) ψ*({r'_m})
dρ/dt = −i/ℏ [Ĥ, ρ] − Σ_n 1/τ (ρ − T_n(ρ))
where T_n(ρ) = ∫d³x j(x − r_n) ρ j(x − r'_n)



$|\psi\rangle|A_0\rangle \to \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$
Ψ
Φ
Ψ Φ
The master eqn
$\rho(\{r_m\},\{r'_m\}) = \psi(\{r_m\})\,\psi^*(\{r'_m\})$
$\frac{d\rho}{dt} = \frac{-i}{\hbar}[\hat{H},\rho] - \sum_n \frac{1}{\tau}(\rho - T_n(\rho))$
where $T_n(\rho) = \int d^3\vec{x}\; j(x-r_n)\,\rho\, j(x-r'_n)$

$$|\psi\rangle|A_0\rangle \longrightarrow \alpha|a_1\rangle|A_1\rangle + \beta|a_2\rangle|A_2\rangle$$

Ψ Φ

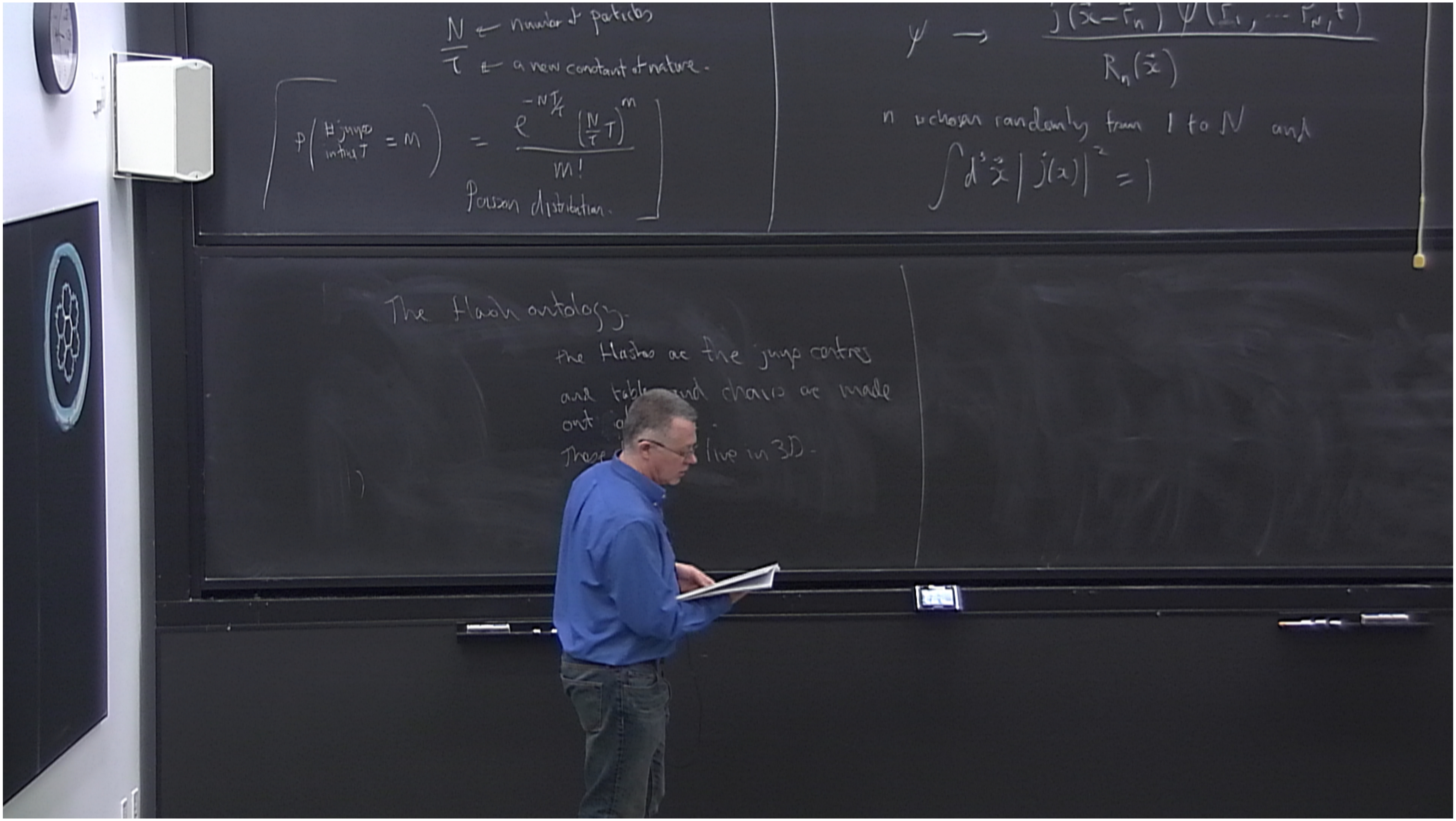
$\Psi\ \Phi$

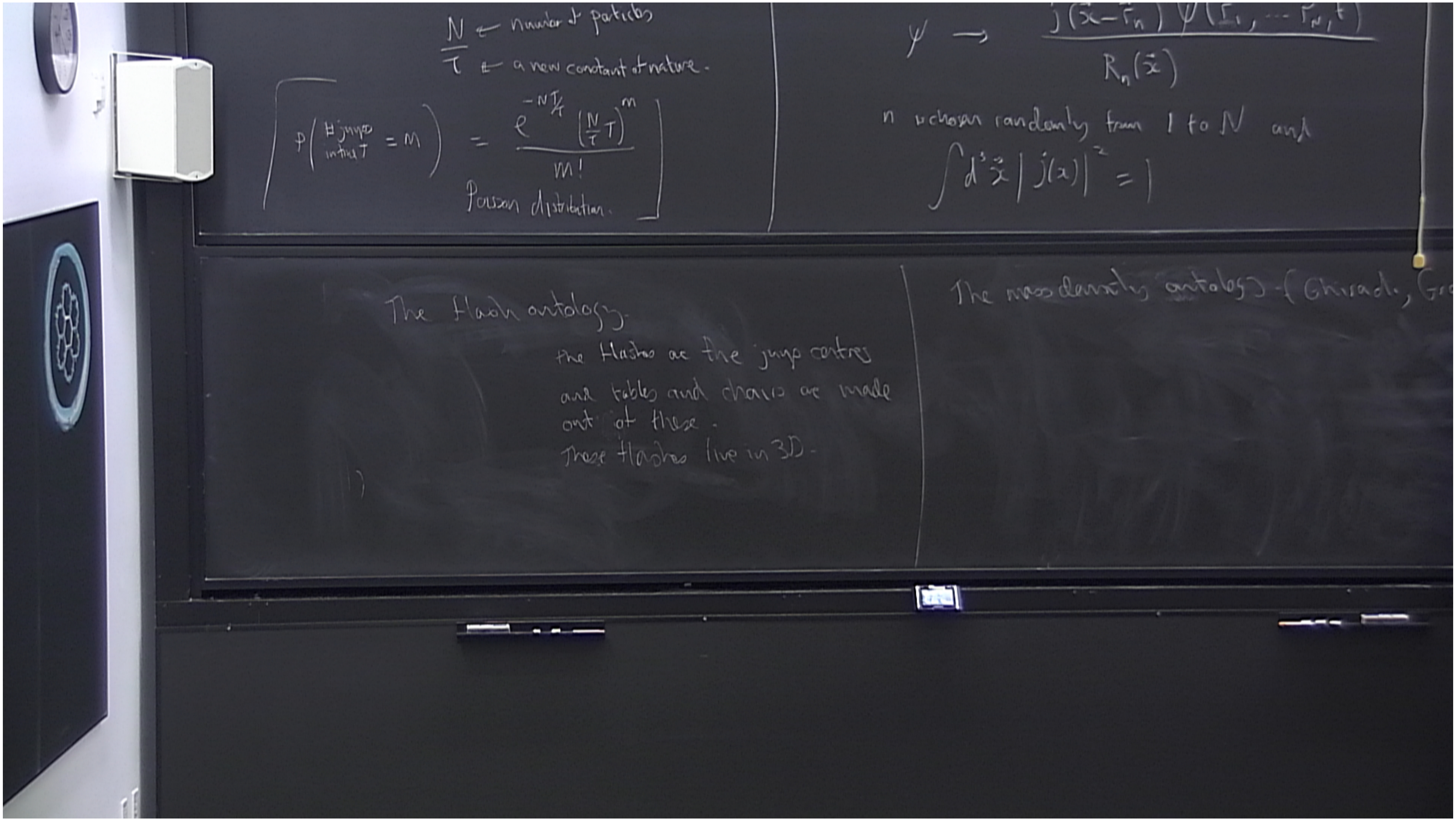
The master eqn

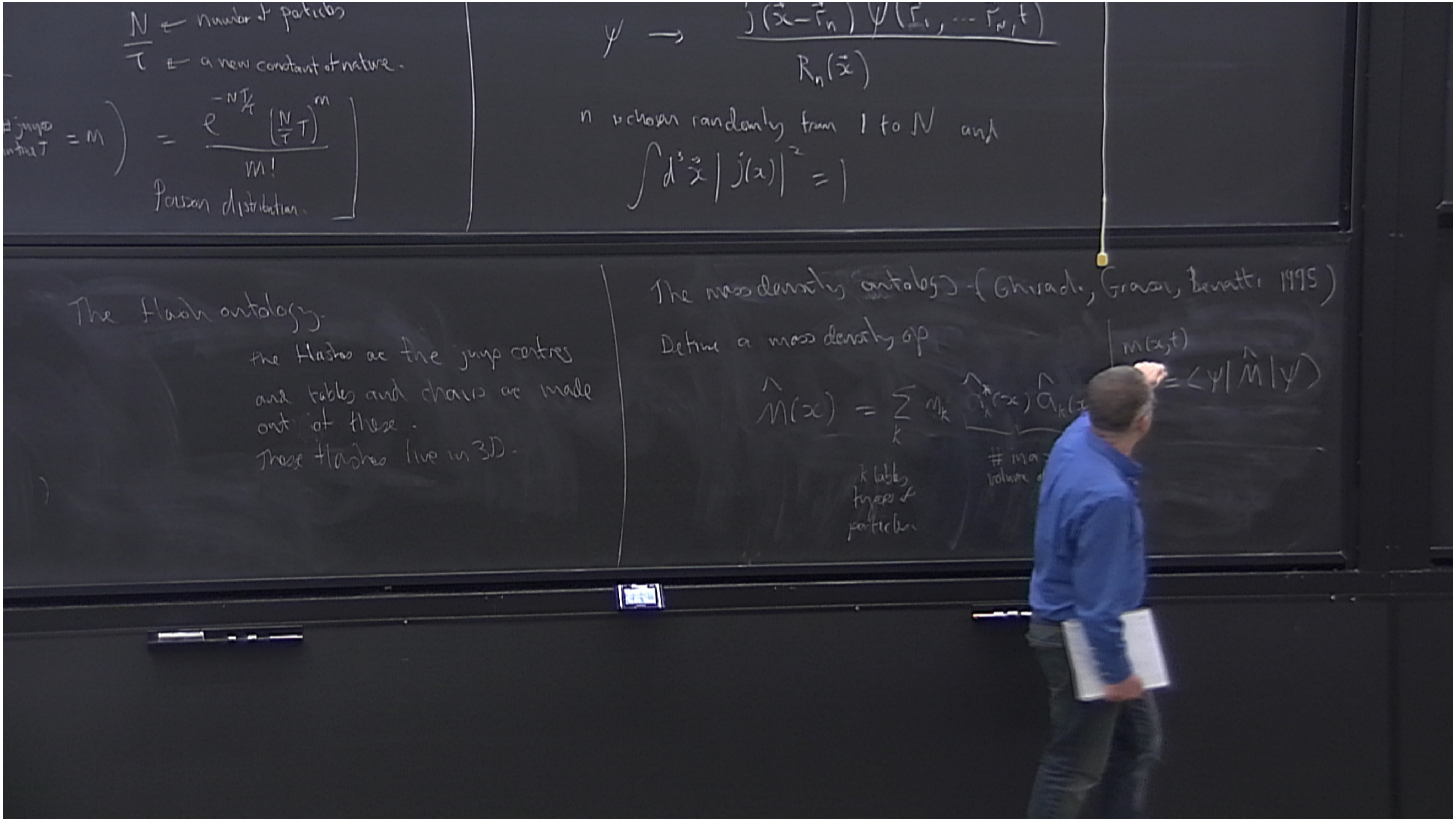
$$\rho(\{r_m\},\{r'_m\}) = \psi(\{r_m\})\,\psi^*(\{r'_m\})$$

$$\frac{d\rho}{dt} = \frac{-i}{\hbar}[\hat{H},\rho] - \sum_n \frac{1}{\tau}\left(\rho - T_n(\rho)\right)$$

where $T_n(\rho) = \int d^3\vec{x}\; j(x-r_n)\,\rho\, j^*(x-r'_n)$


N ← number of particles
τ ← a new constant of nature.
Poisson distribution.
n is chosen randomly from 1 to N and
The Flash ontology.
the Flashes are the jump centres
live in 3D.


N ← number of particles
τ ← a new constant of nature.
$P\left(\begin{smallmatrix}\#\text{ jumps}\\ \text{in time } T\end{smallmatrix} = m\right) = \frac{e^{-NT/\tau}\left(\frac{N}{\tau}T\right)^m}{m!}$
Poisson distribution.
$\psi \to \frac{j(\vec{x}-\vec{r}_n)\,\psi(\vec{r}_1, \ldots \vec{r}_N, t)}{R_n(\vec{x})}$
n chosen randomly from 1 to N and
$\int d^3\vec{x}\,|j(x)|^2 = 1$
The flash ontology.
the flashes are the jump centres
and tables and chairs are made
out of these.
These flashes live in 3D.
The mass density ontology. (Ghirardi, Gr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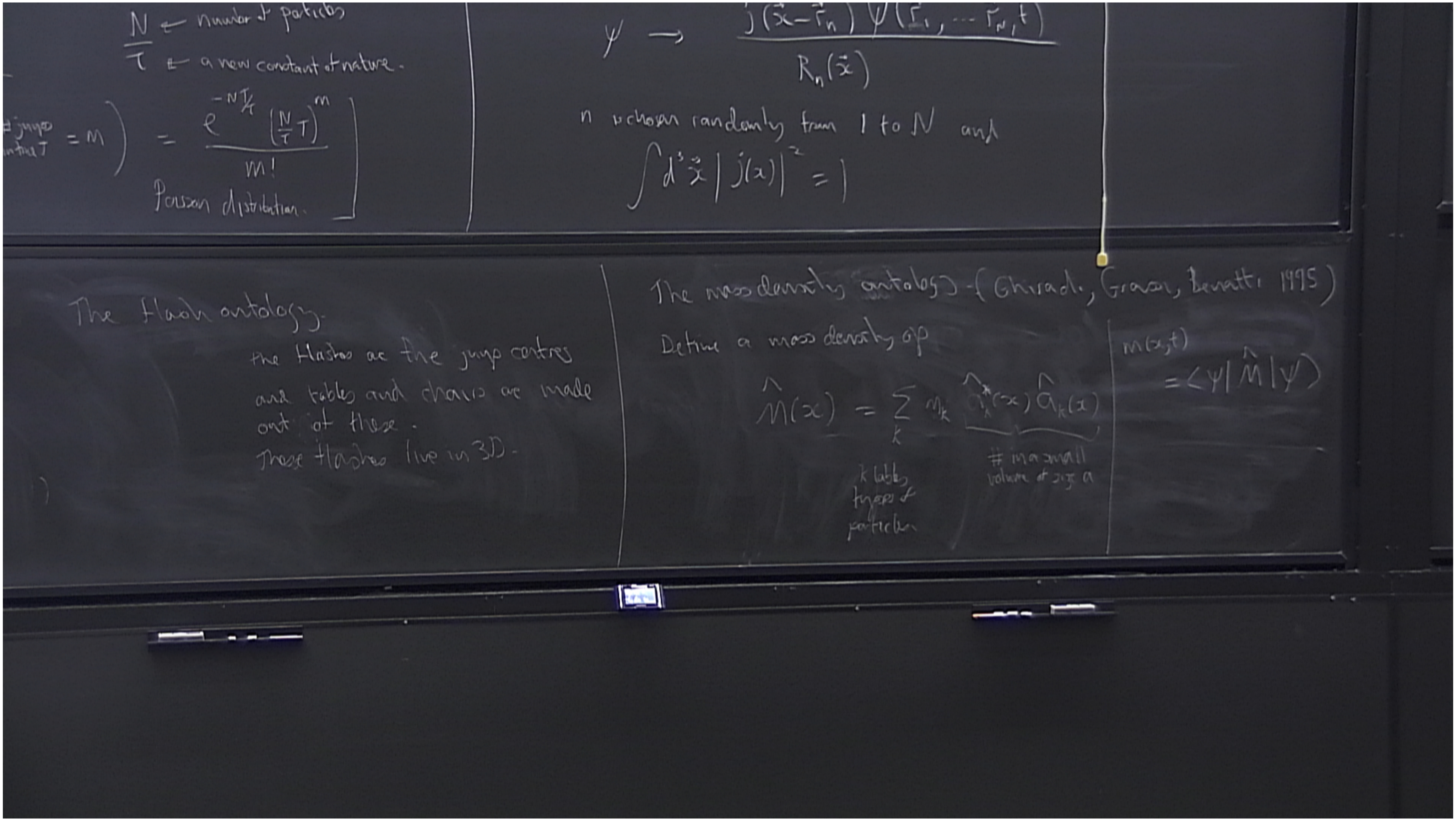
Poisson distribution.
ψ → j(x − r_n) ψ(r_1, … r_N, t) / R_n(x)
n is chosen randomly from 1 to N and
∫ d³x |j(x)|² = 1
The flash ontology.
the flashes are the jump centres
and tables and chairs are made
out of these.
These flashes live in 3D.
The mass density ontology - (Ghirardi, Grassi, Benatti 1995)
Define a mass density op
M̂(x) = Σ_k m_k â*_k(x) â_k(x)
k labels types of particles
m(x,t) = ⟨ψ| M̂ |ψ⟩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The Flash ontology.
the flashes are the jump centres
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These flashes live in 3D.
The mass density ontology - (Ghirardi, Grassi, Benatti 1995)
Define a mass density op
k labels types of particles
# in a small volume of size a
m(x,t)