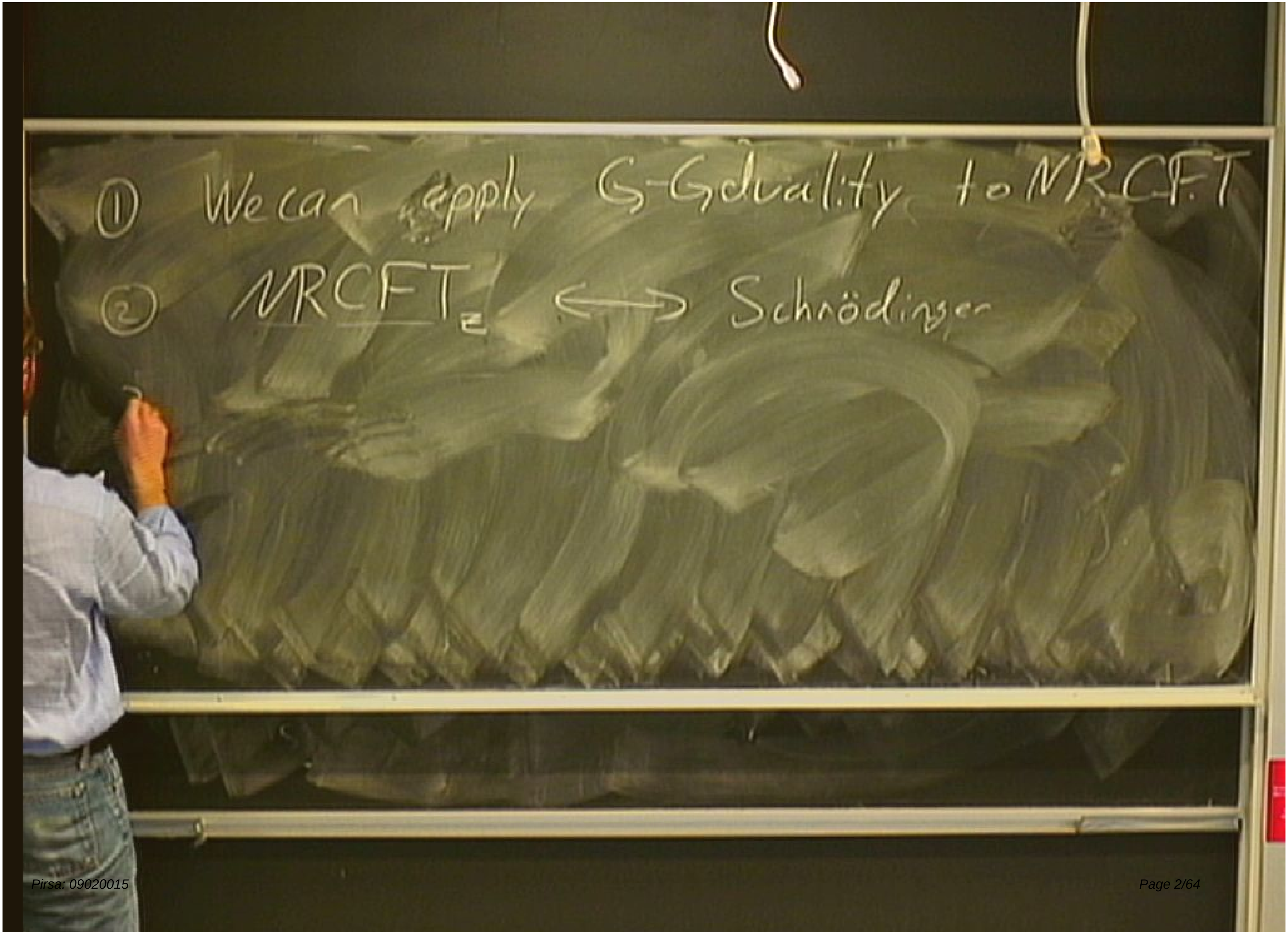
Title: Hot spacetime for cold atoms

Date: Feb 20, 2009 02:30 PM

URL: http://pirsa.org/09020015

Abstract: TBA


① We can apply G-G duality to NRCFT
② NRCFT_z ⟷ Schrödinger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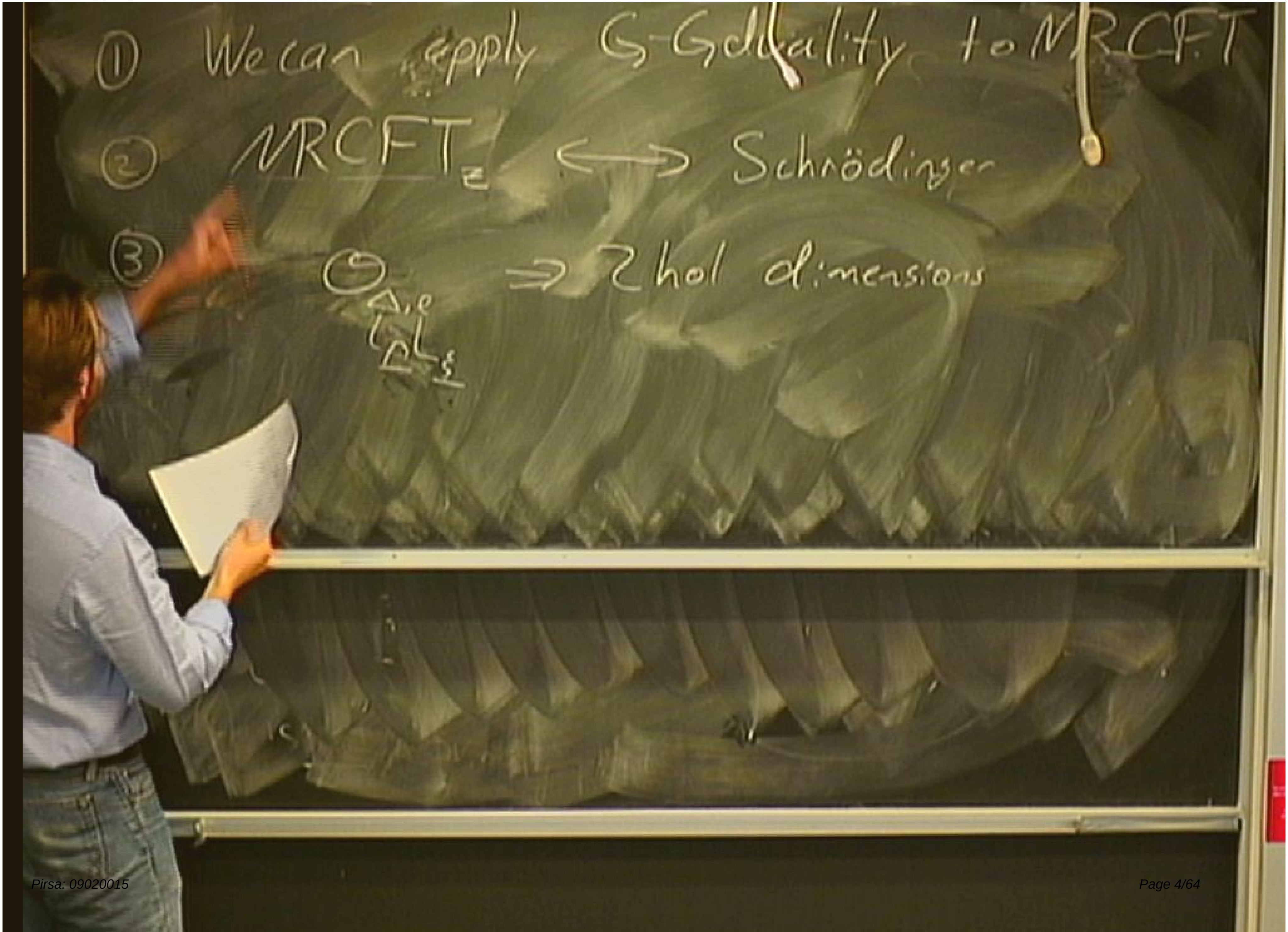
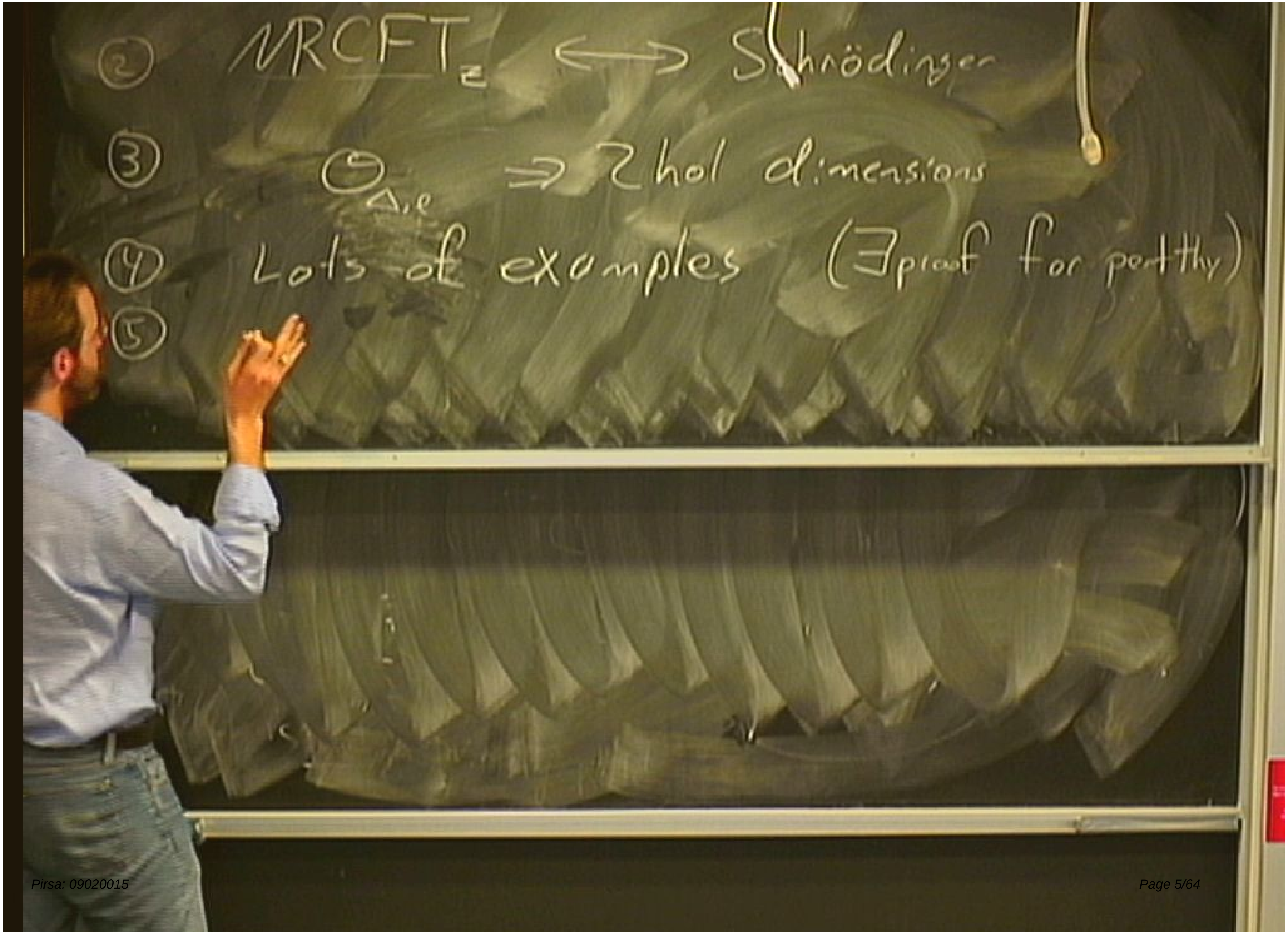
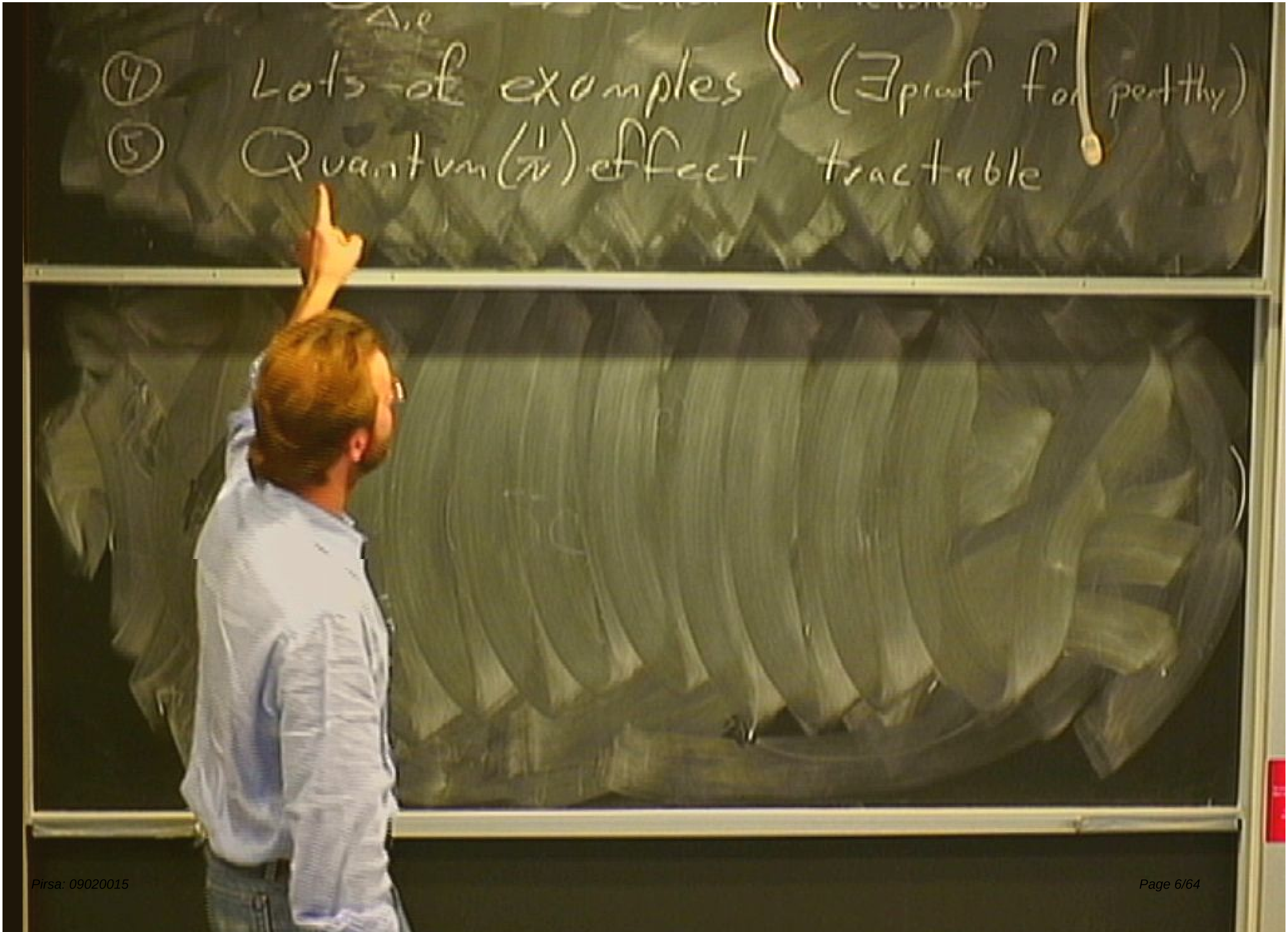
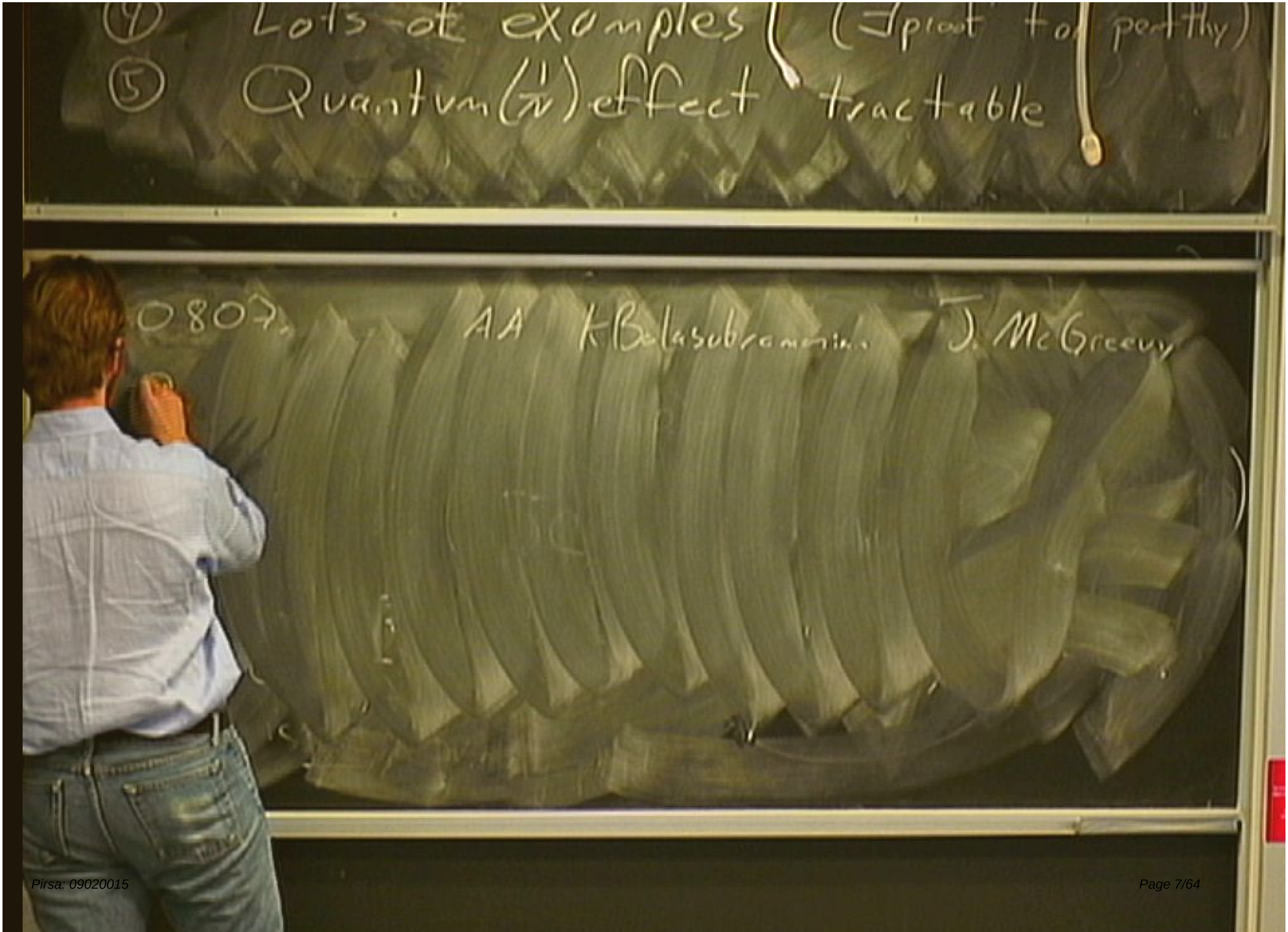
② NRCFT_z ⟷ Schrödinger
③ O_Δ,e

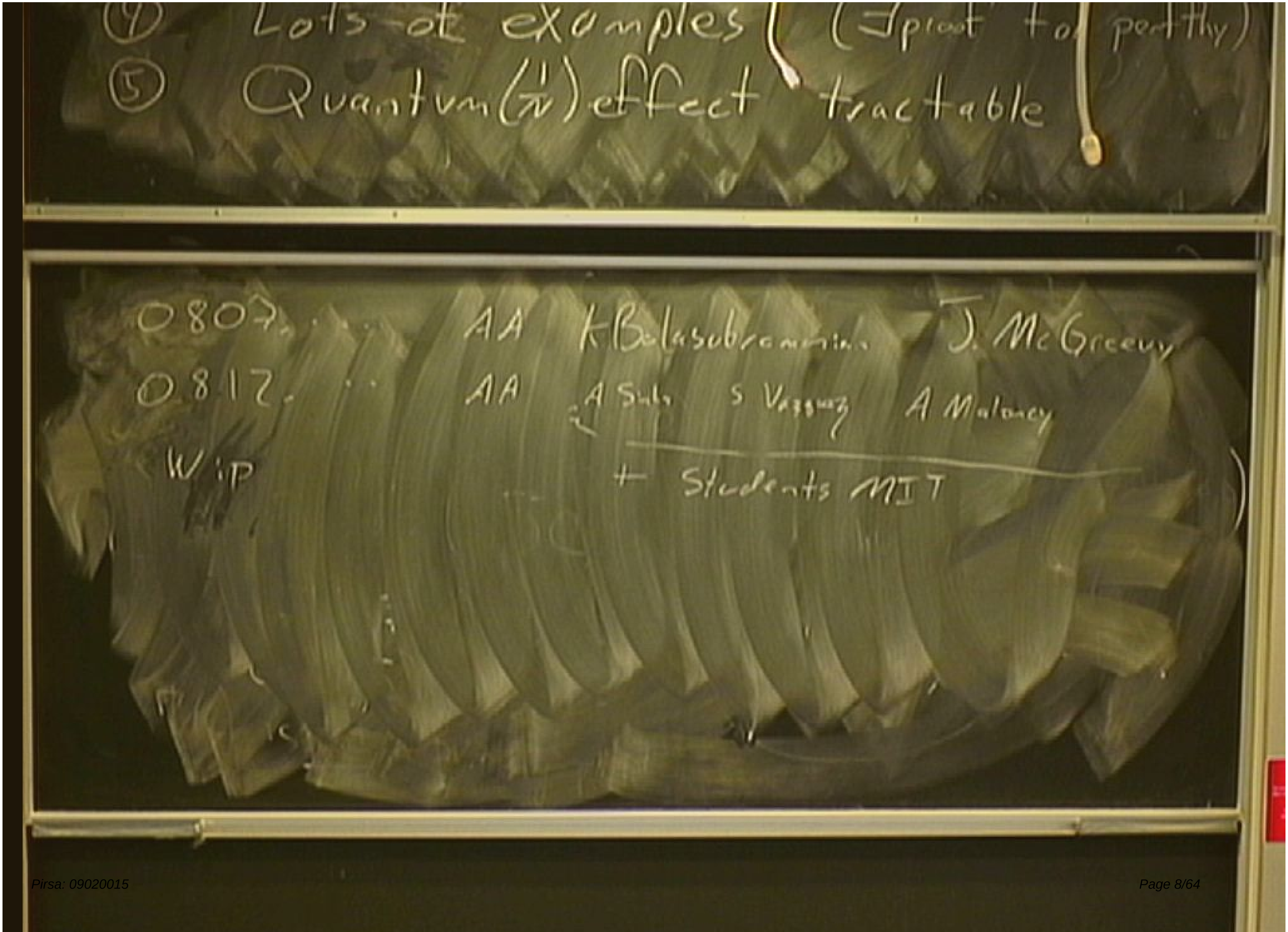

① We can apply G-Gduality to NRCFT
② NRCFT ⟷ Schrödinger
③ ⇒ 2 hol dimensions

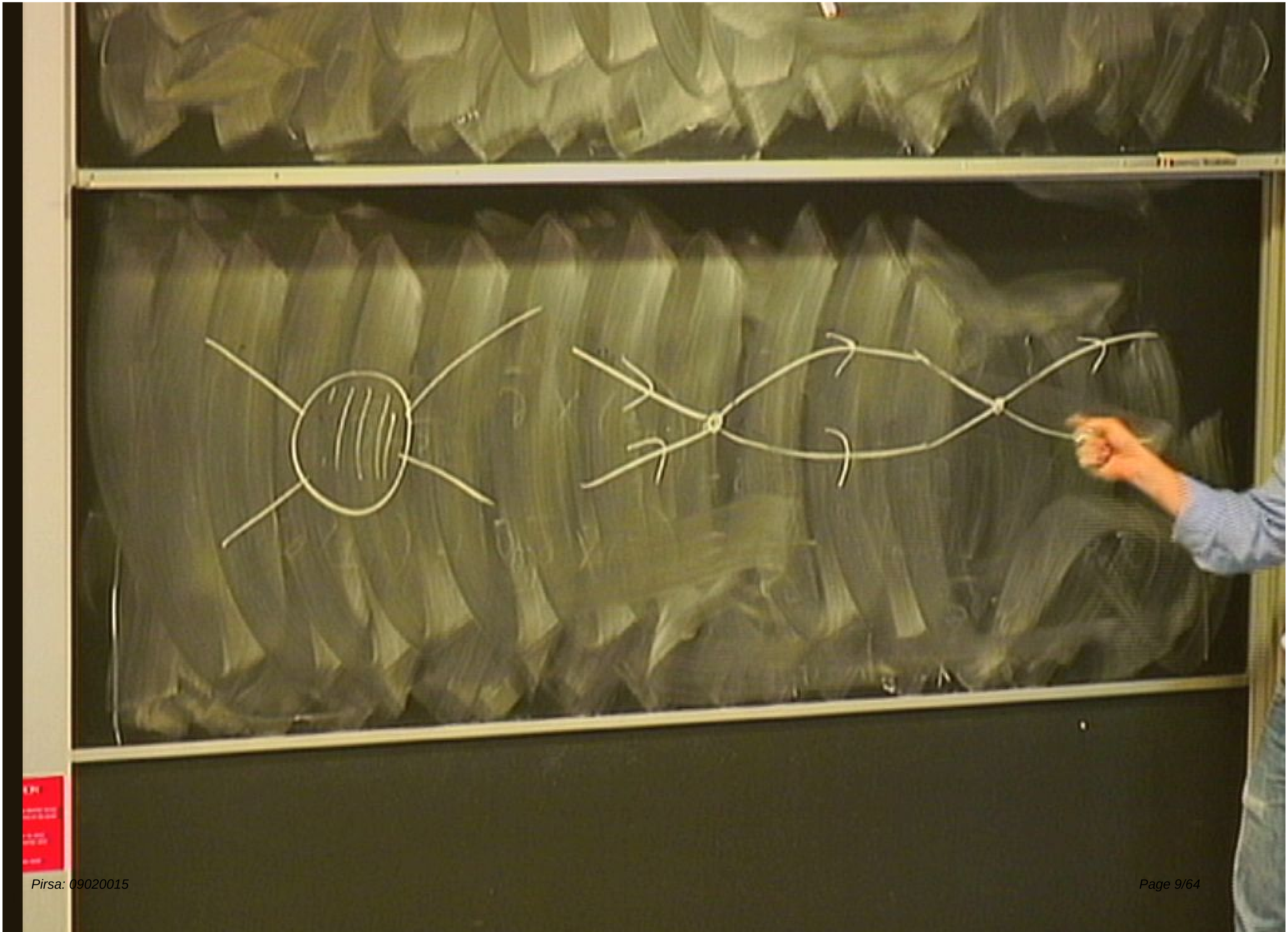

② NRCFT_z ⟺ Schrödinger
③ O_{Δ,ℓ} ⇒ 2 hol dimensions
④ Lots of examples (∃ proof for pert thy)
⑤

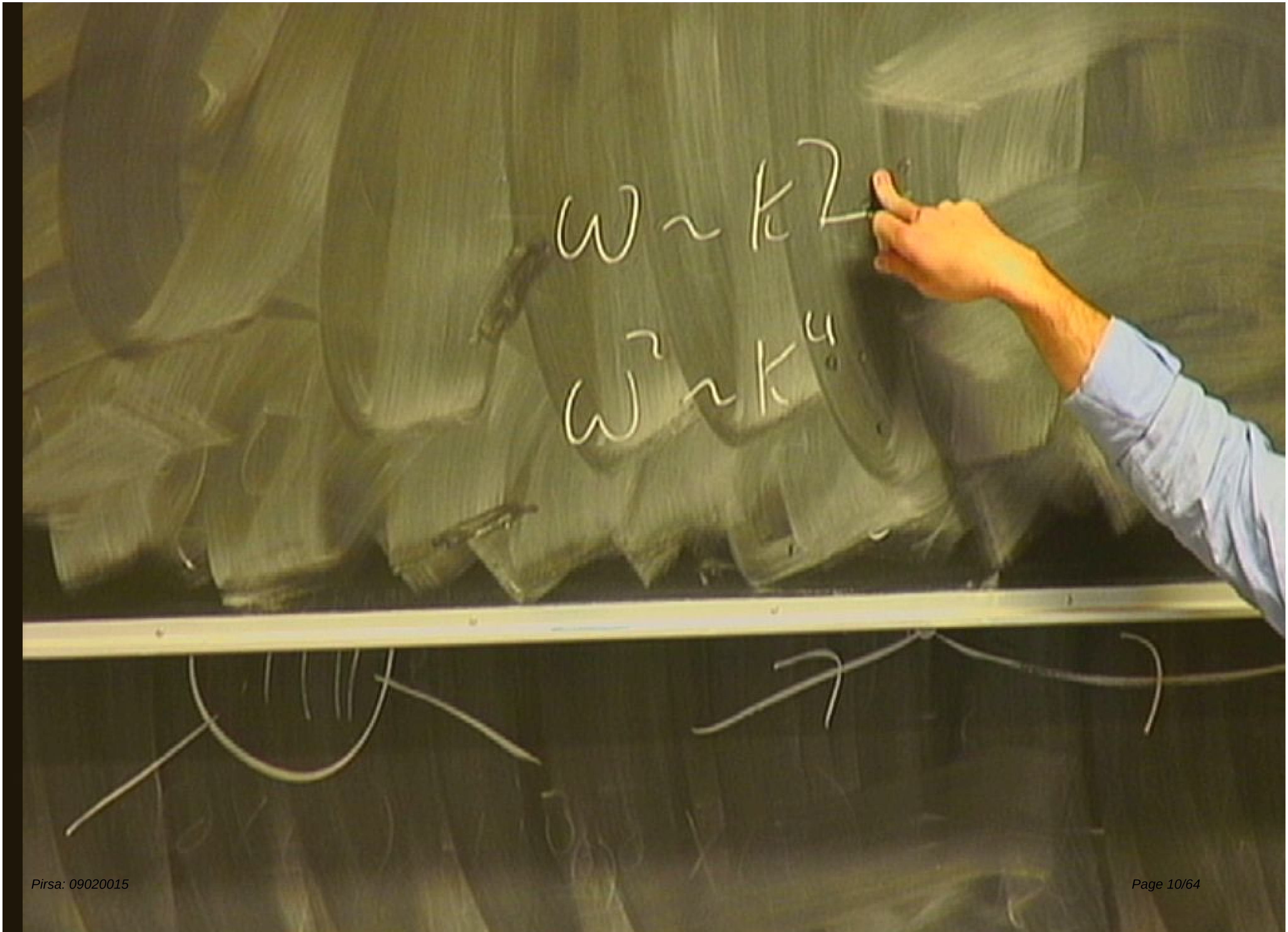

④ Lots of examples (∃ proof for pert thy)
⑤ Quantum (ħ) effect tractable

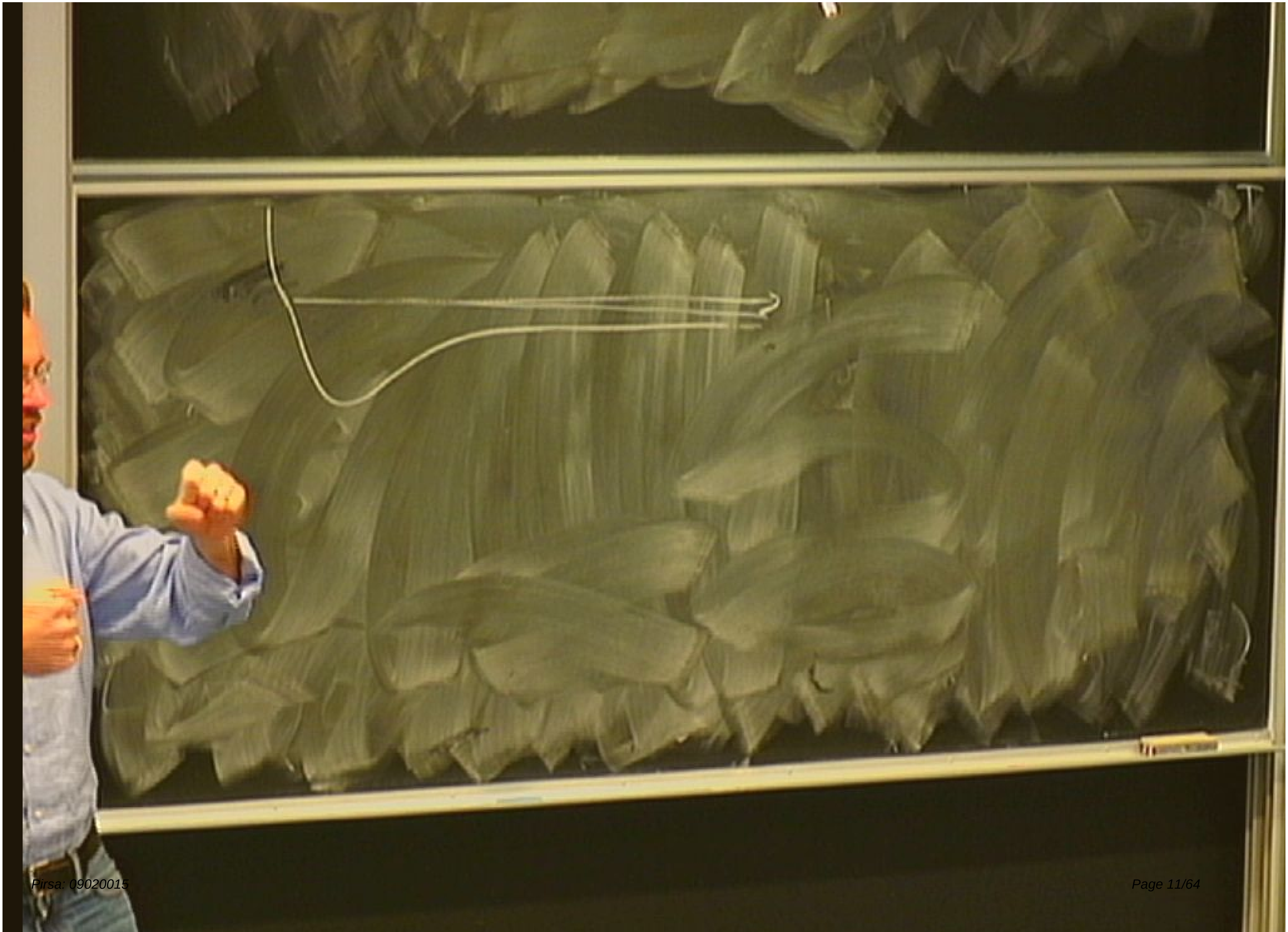


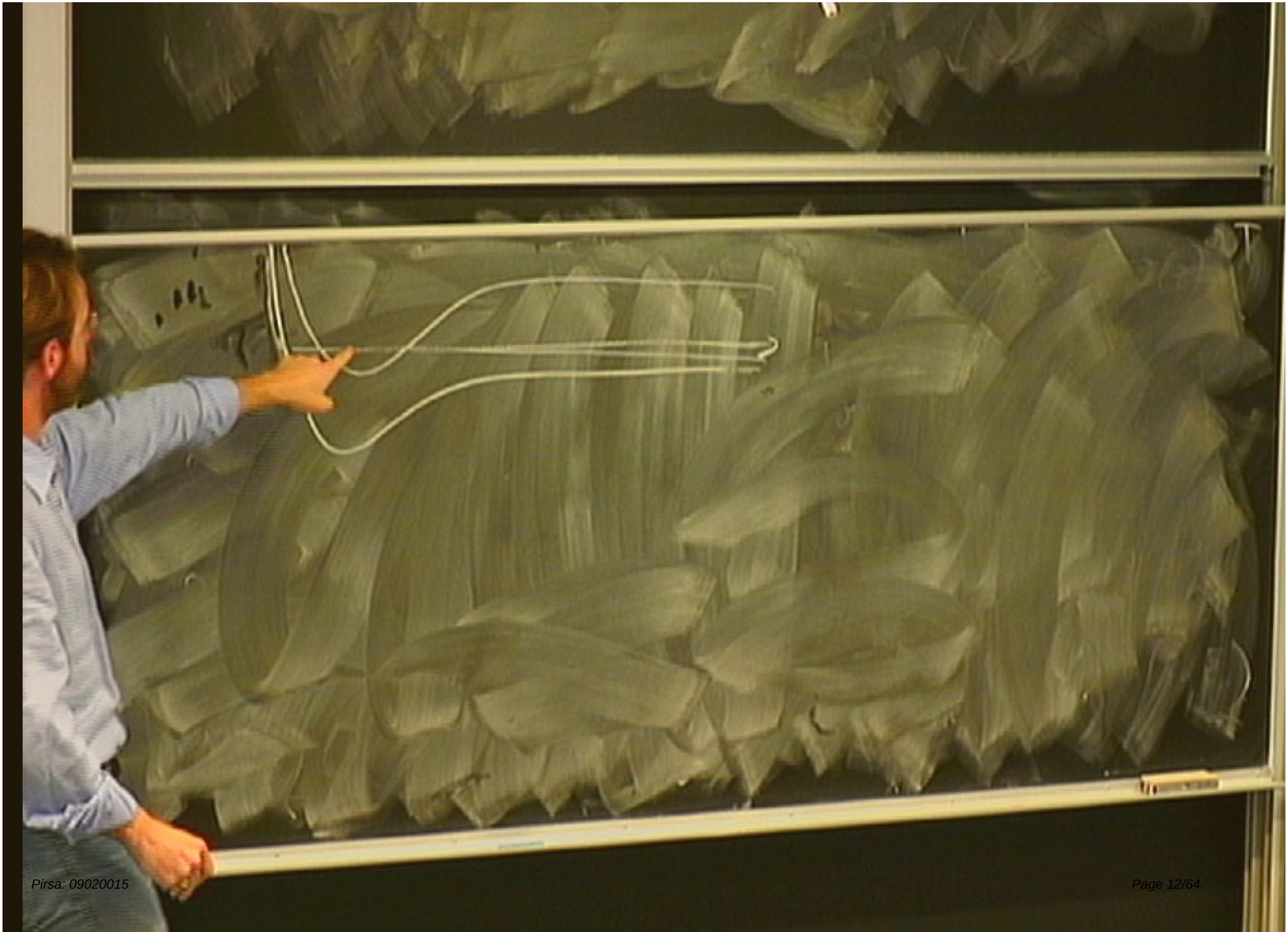
Lots of examples
5 Quantum (1/N) effect tractable
0807
AA
J. McGreevy


Lots of examples
⑤ Quantum (ħ) effect tractable
0807.... AA K Balasubramanian J. McGreevy
0812.... AA S Vazquez A Maloney
WIP
+ Students MIT

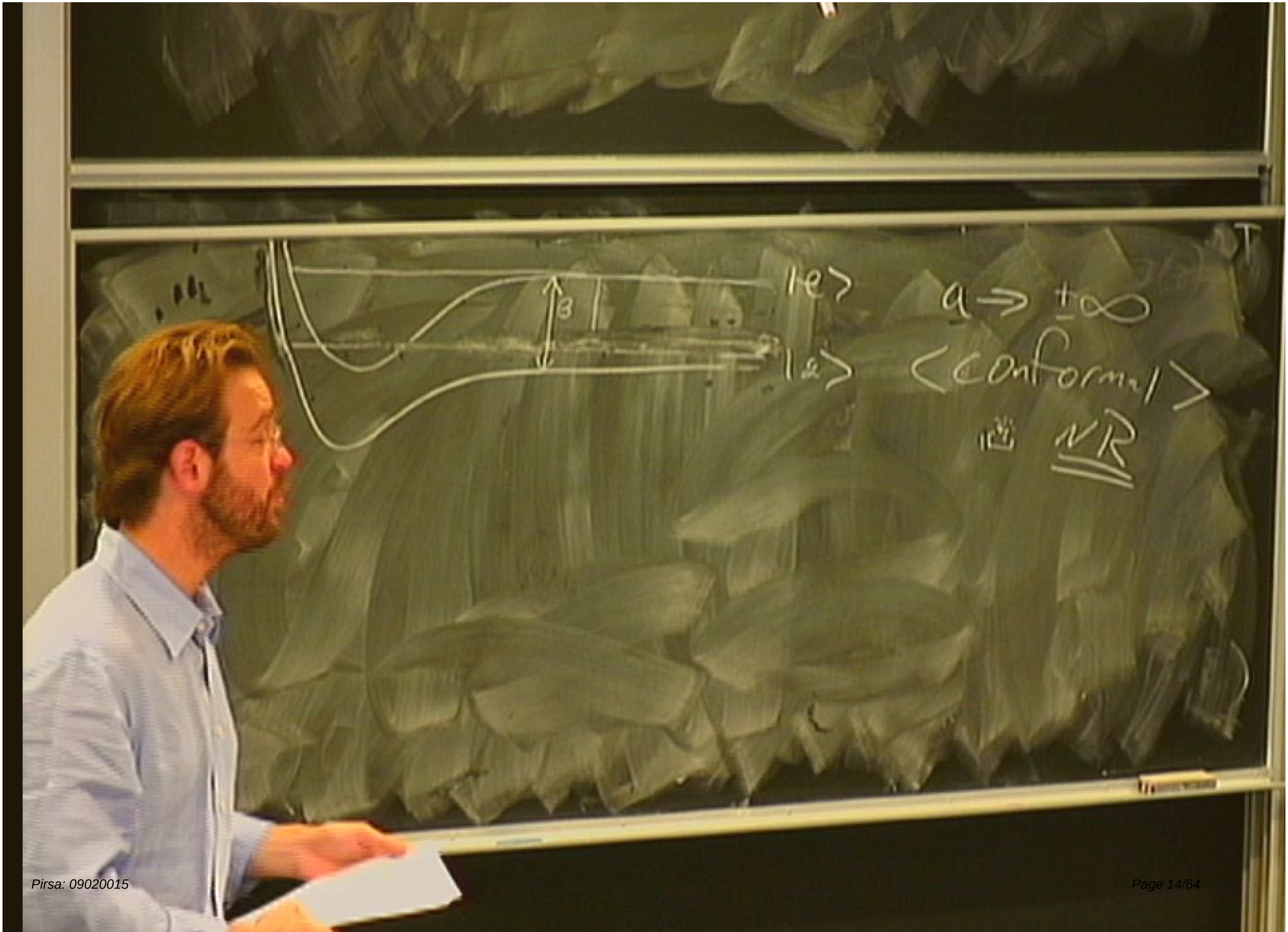



ω ~ k²
ω² ~ k⁴

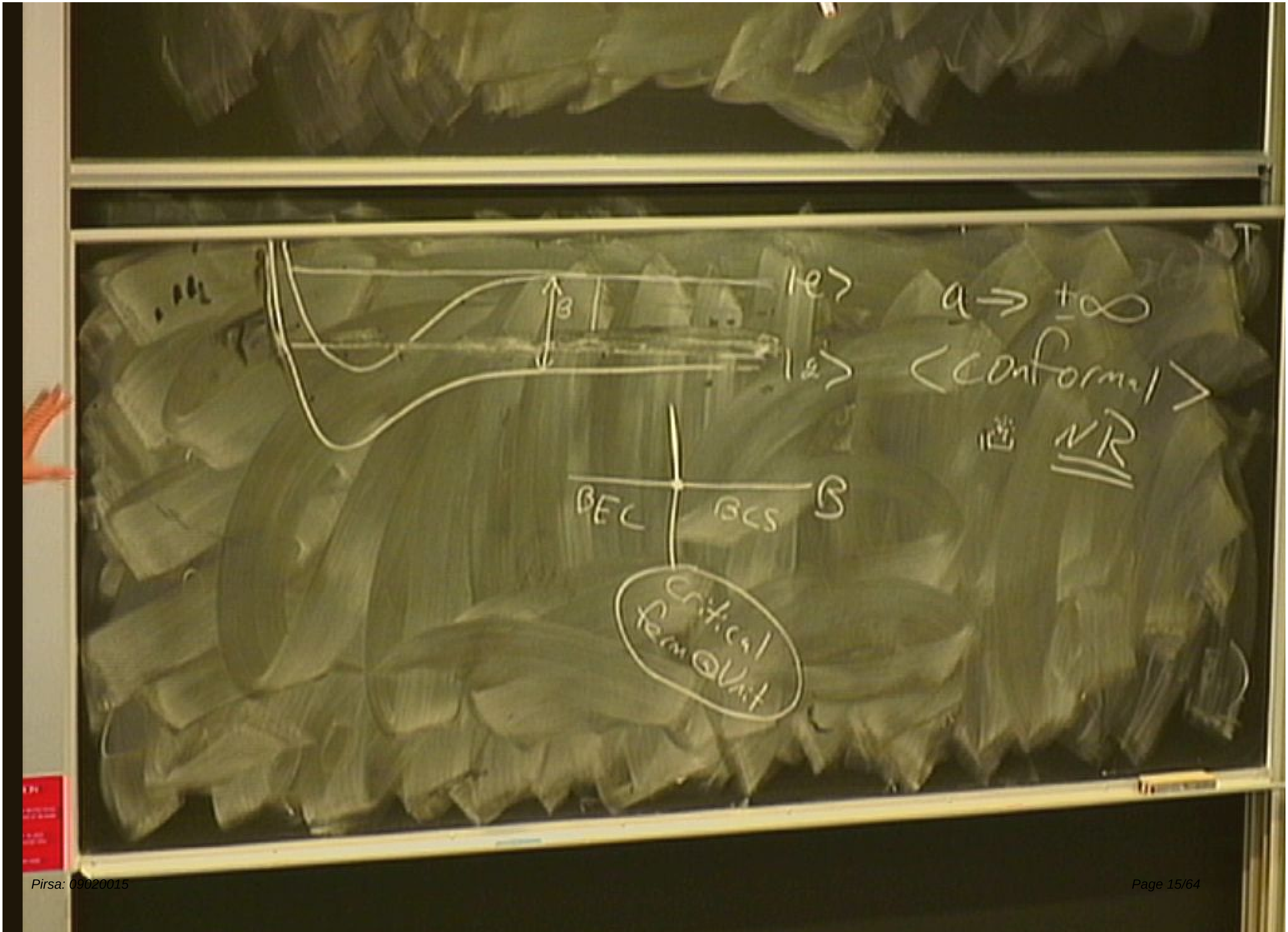


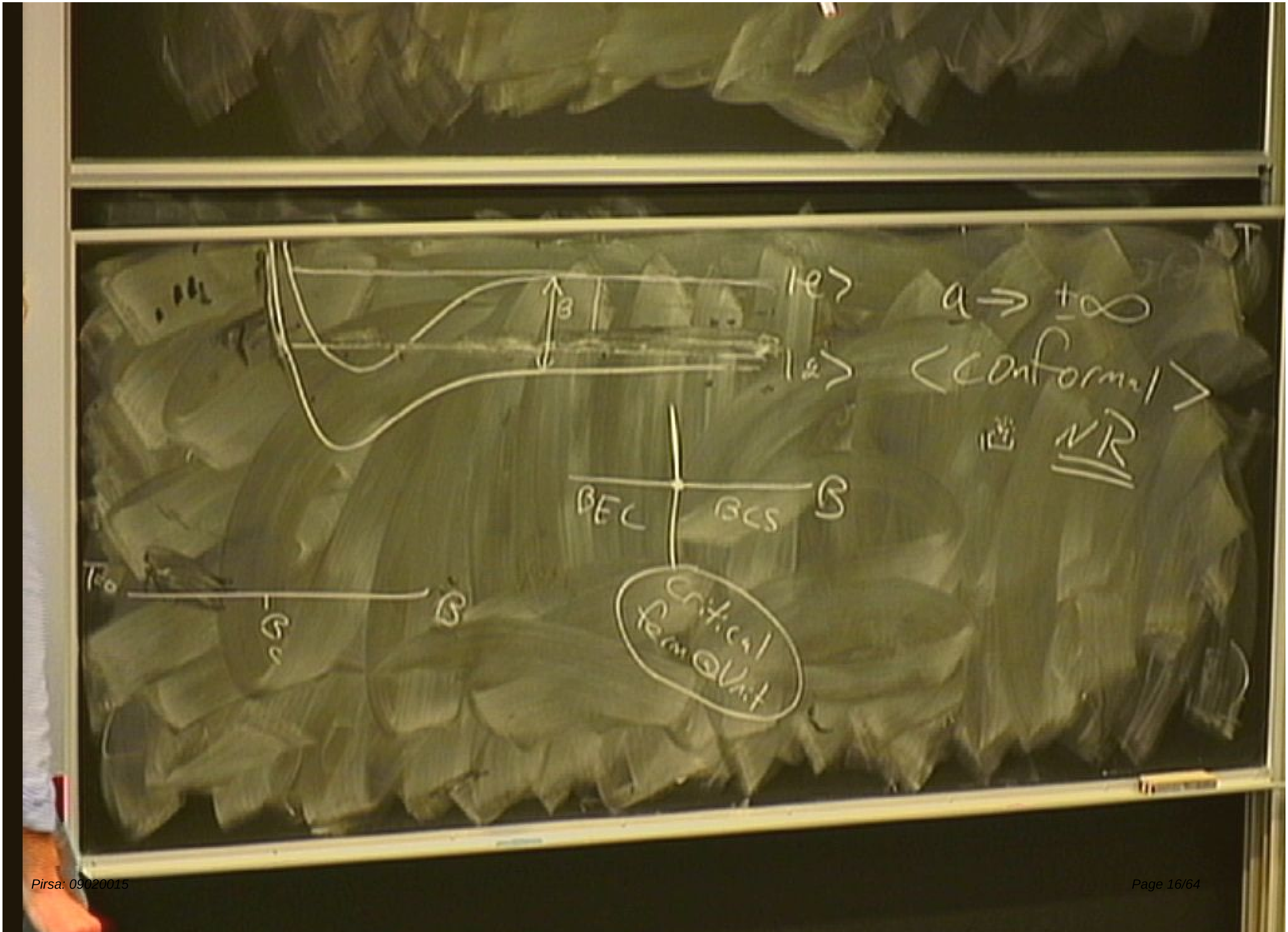


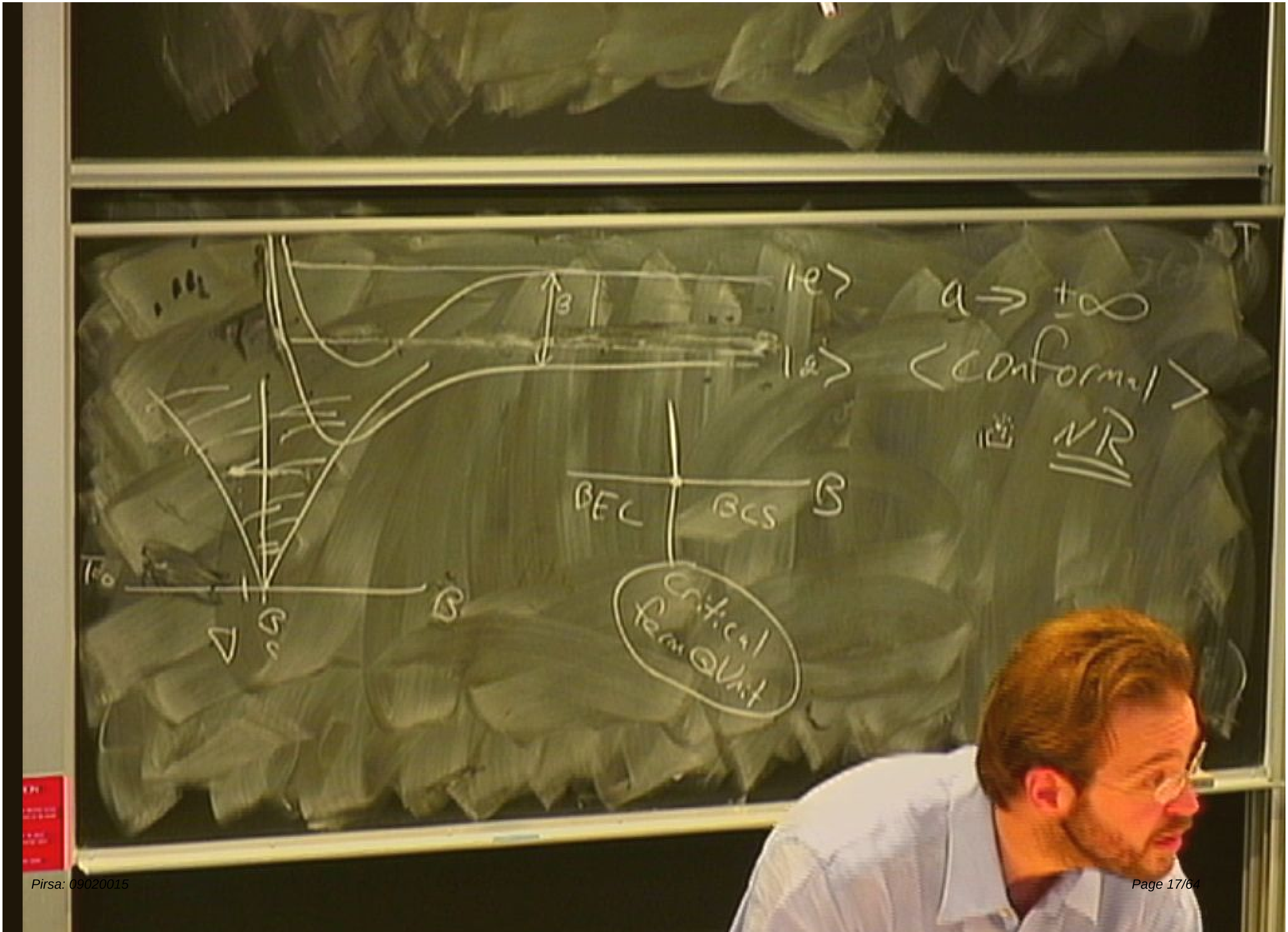

$|e\rangle$
$|a\rangle$

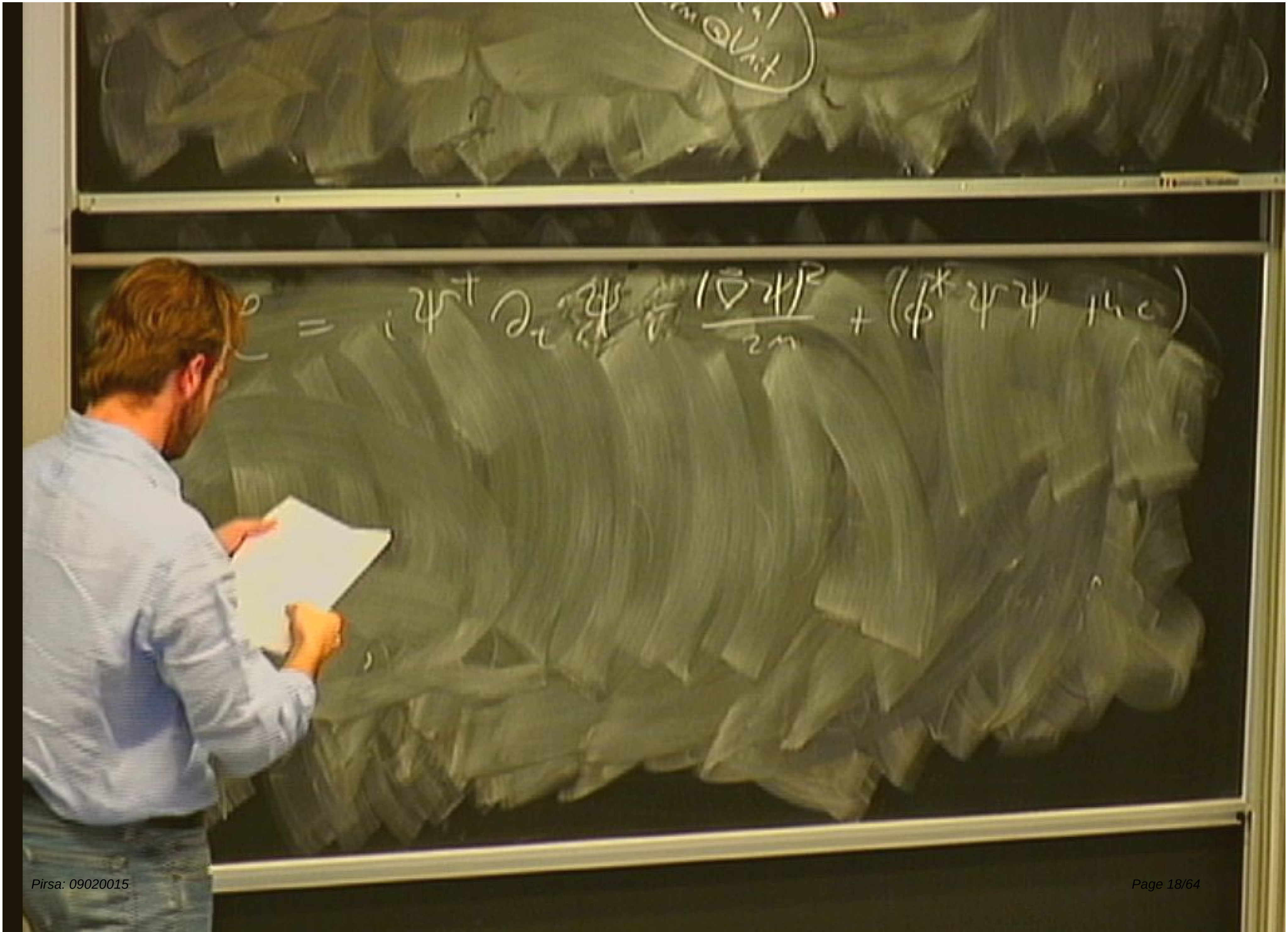


|e>
a → ±∞
|g>
<conformal>
NR


|e>
|g>
B
a → ±∞
<conformal>
NR
BEC
BCS
B
Critical

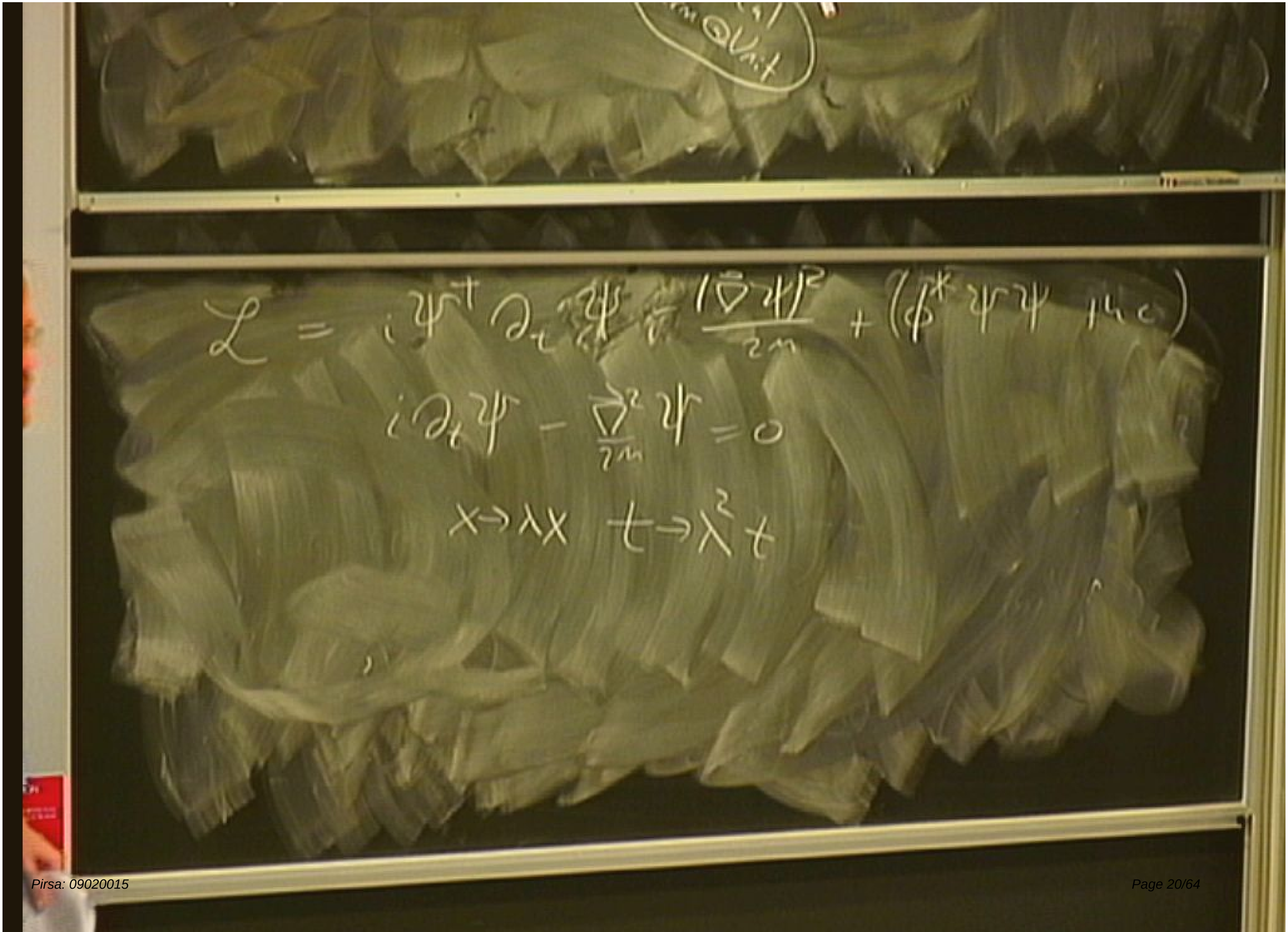

|e⟩
|g⟩
B
a → ±∞
⟨conformal⟩
NR
BEC
BCS
B
Critical
fermi@Unit
T=0
B
Bc

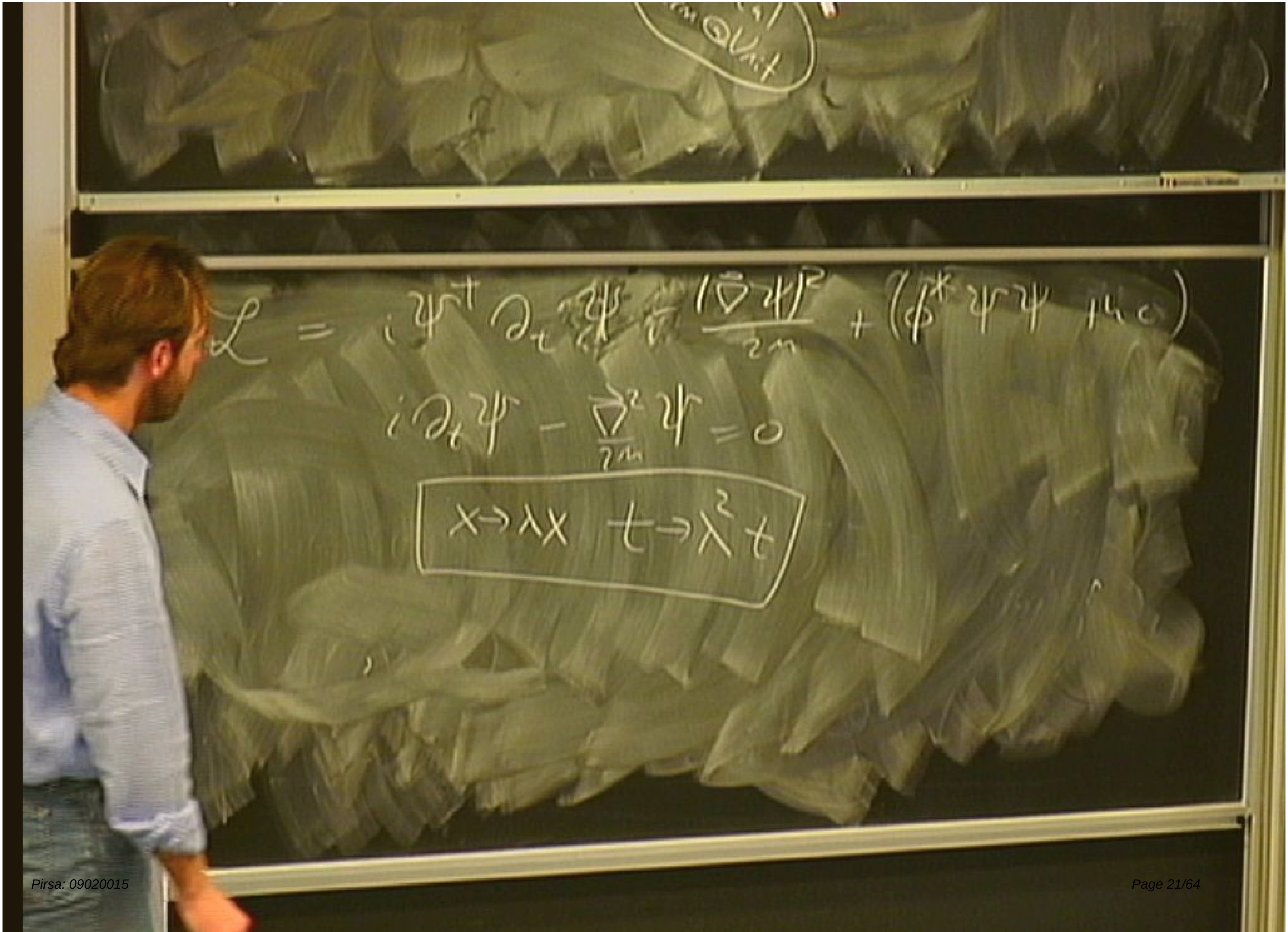

|e>
a → ±∞
<conformal>
NR
BEC
BCS
B
T=0
Critical

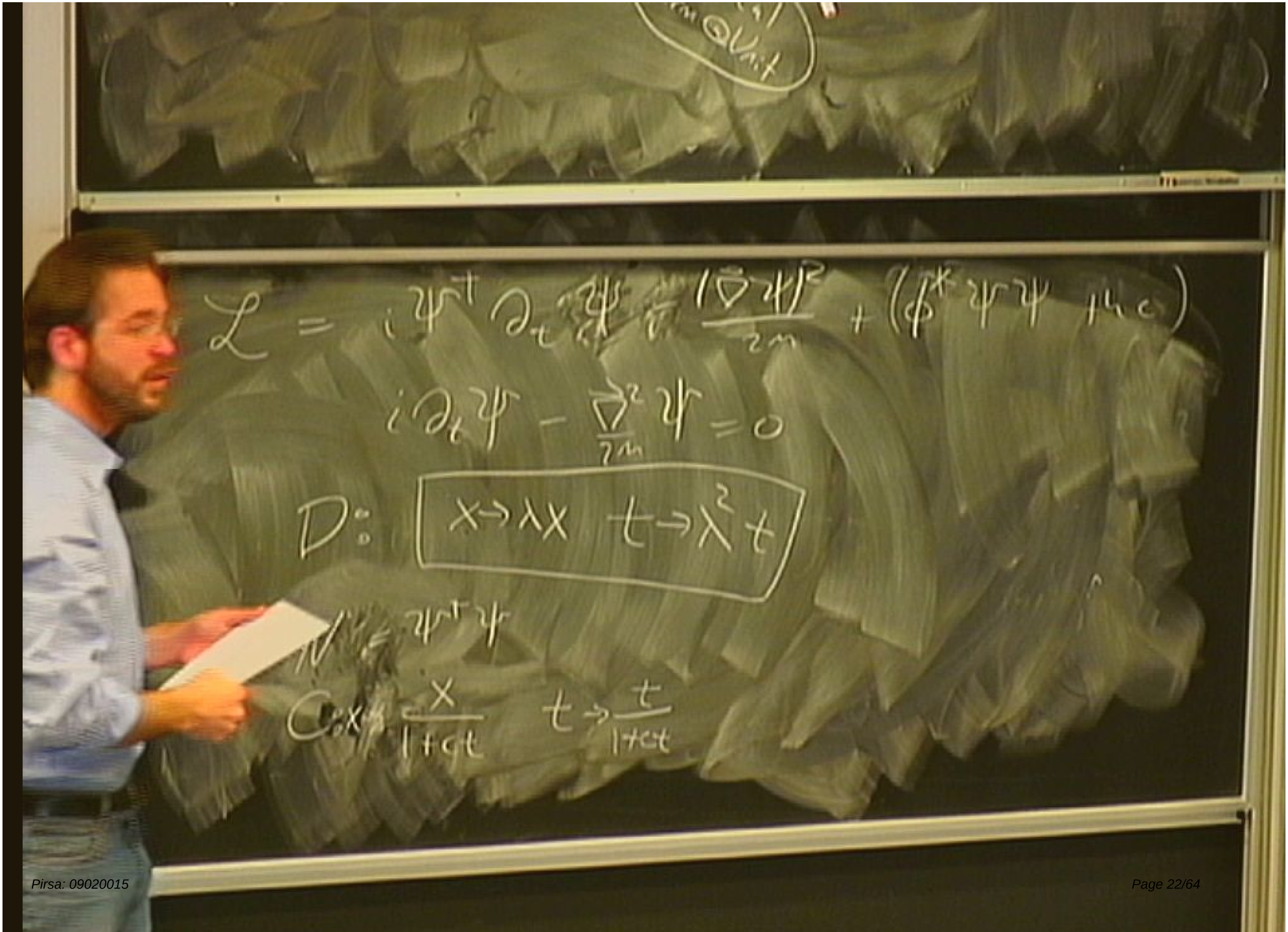


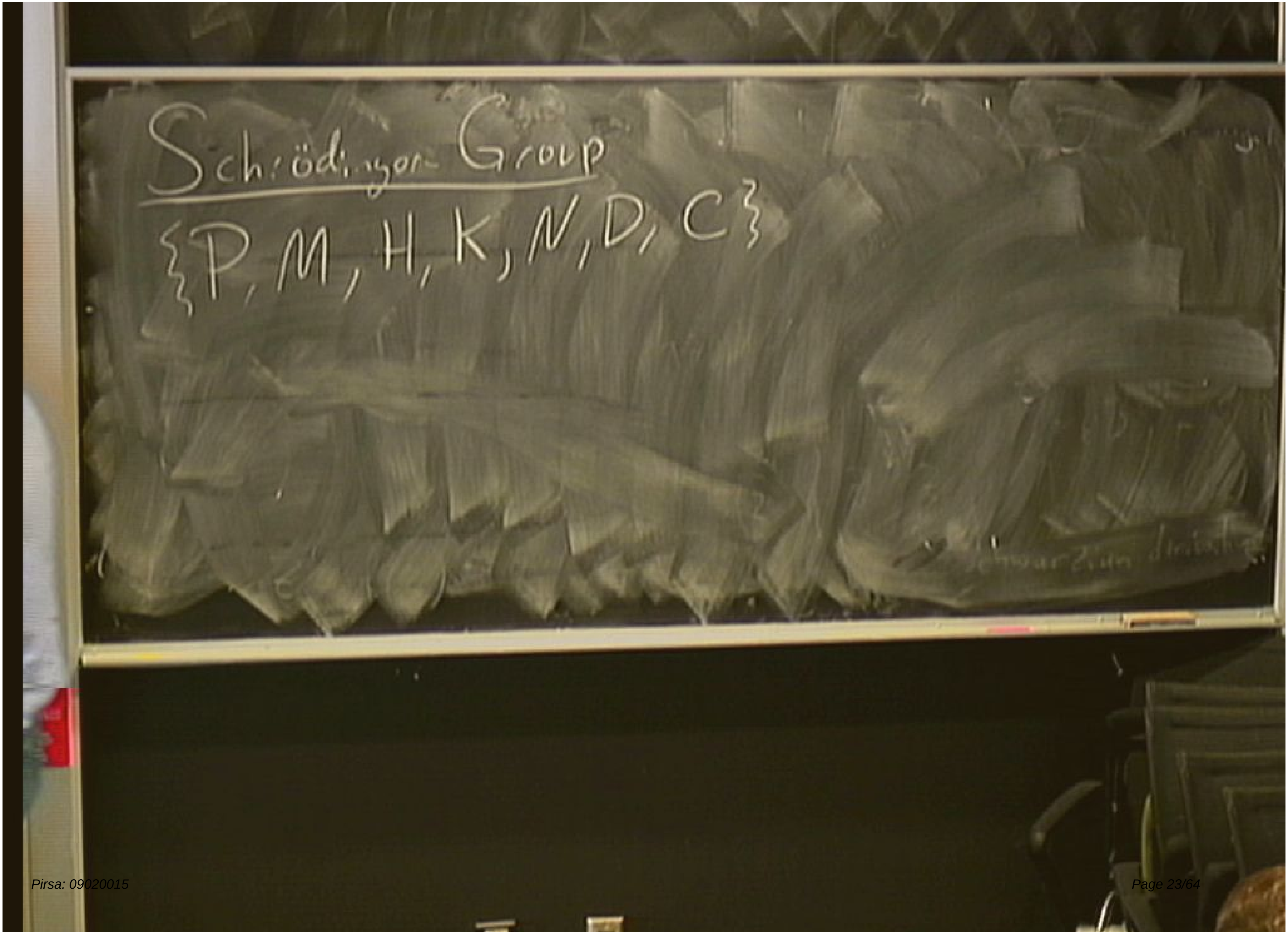
$$\mathcal{L} = i\psi^\dagger \partial_t \psi - \frac{|\nabla \psi|^2}{2m} + (\phi^* \psi \psi + h.c.)$$

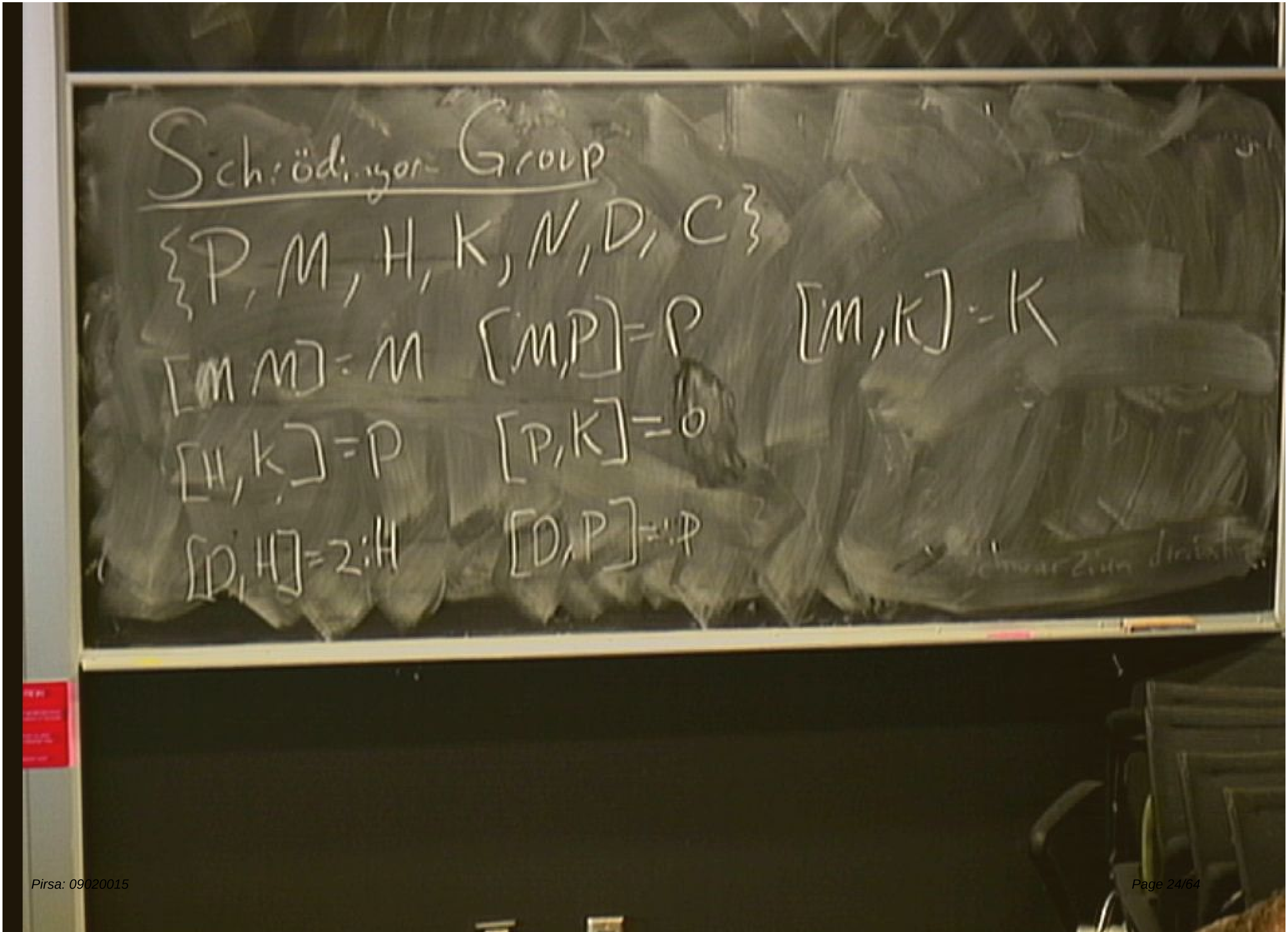
$$i\partial_t \psi - \frac{\nabla^2}{2m}\psi = 0$$

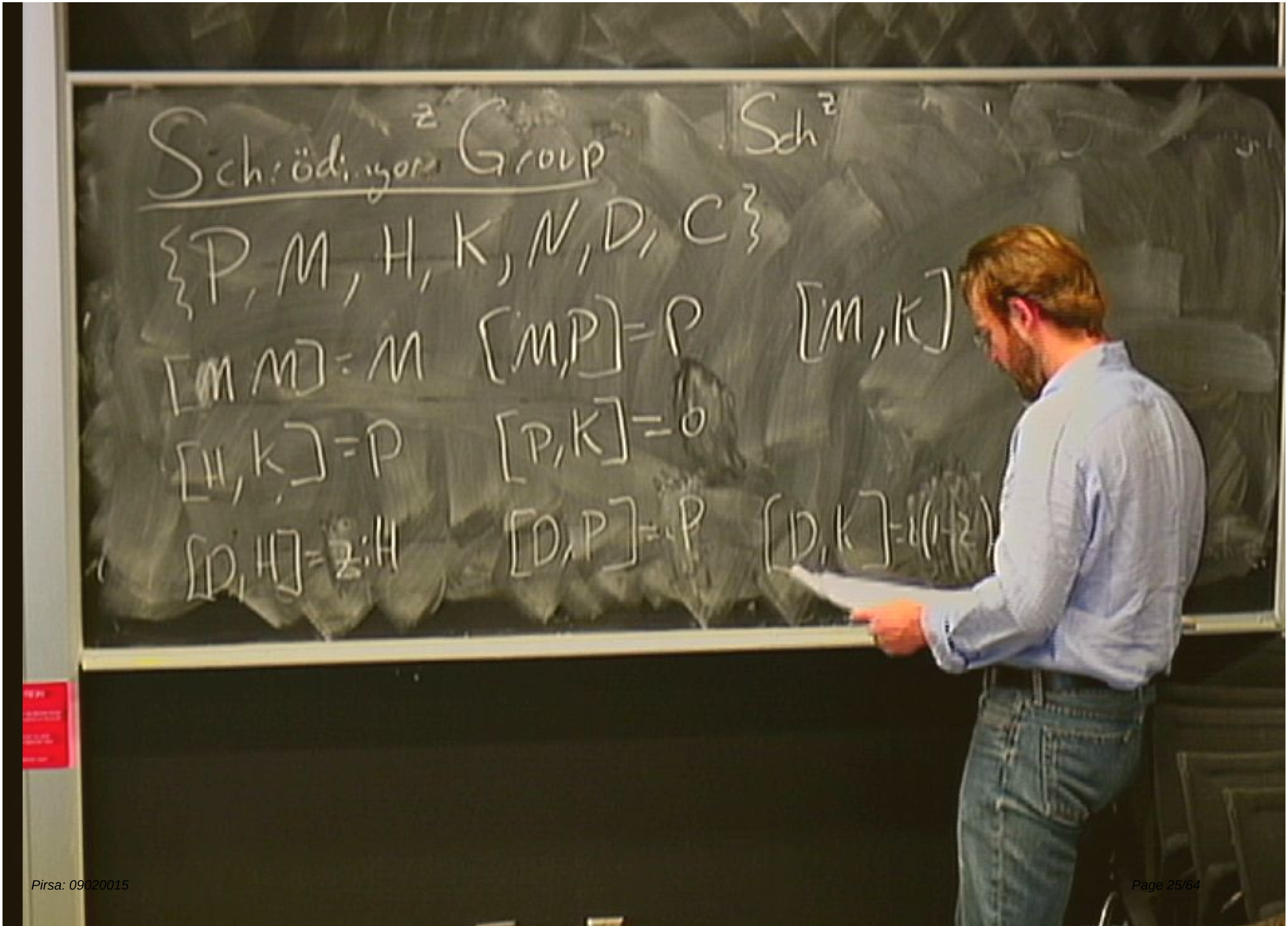

$\mathcal{L} = i\psi^\dagger \partial_t \psi - \frac{|\nabla \psi|^2}{2m} + (\phi^* \psi\psi + h.c.)$
$i\partial_t \psi - \frac{\nabla^2}{2m}\psi = 0$
$x \to \lambda x \quad t \to \lambda^2 t$


L = iψ† ∂t ψ − |∇ψ|²/2m + (φ* ψψ + h.c.)
i∂t ψ − ∇²/2m ψ = 0
x→λx t→λ²t

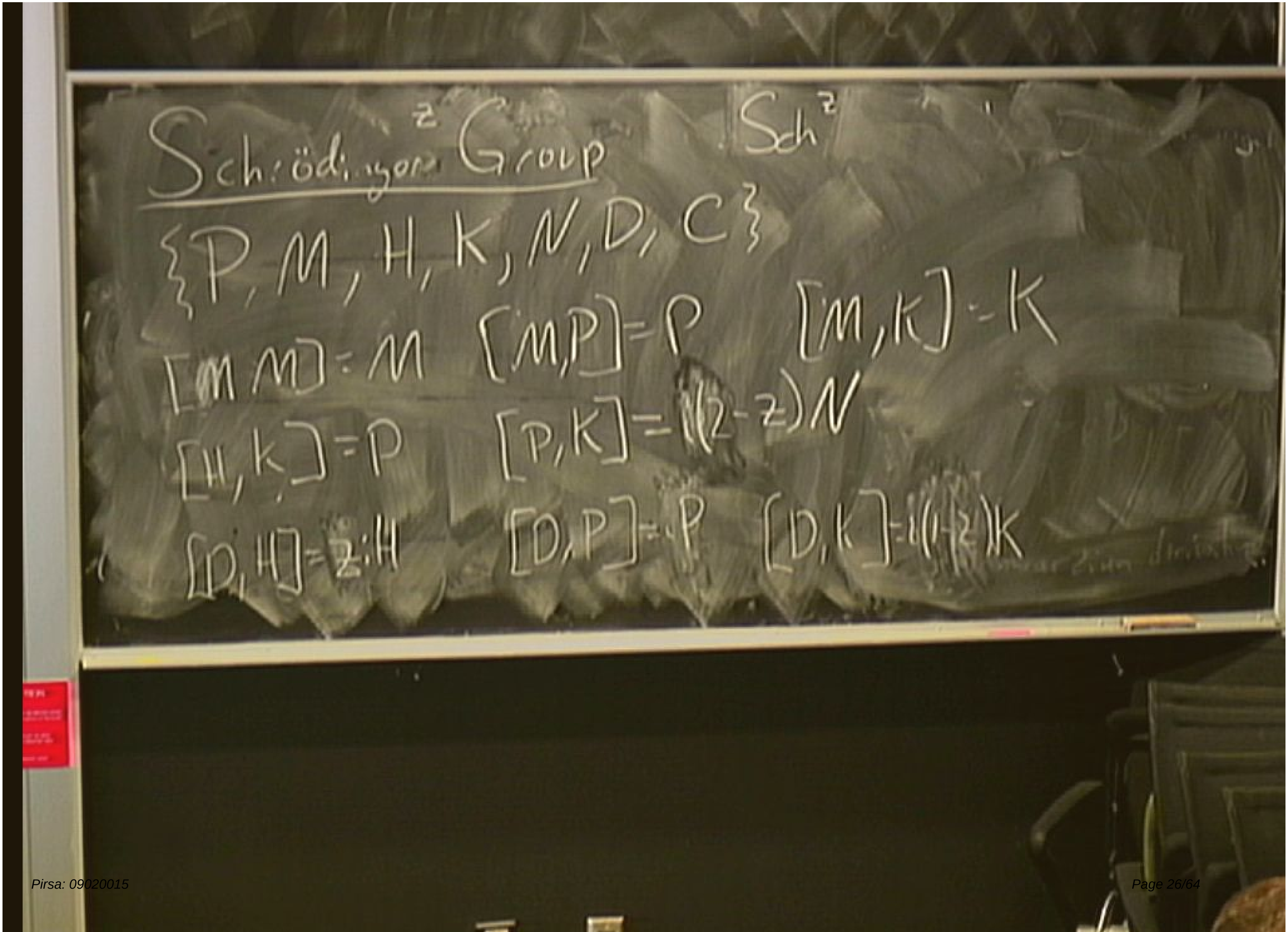

D: x→λx t→λ²t
t→t/(1+ct)

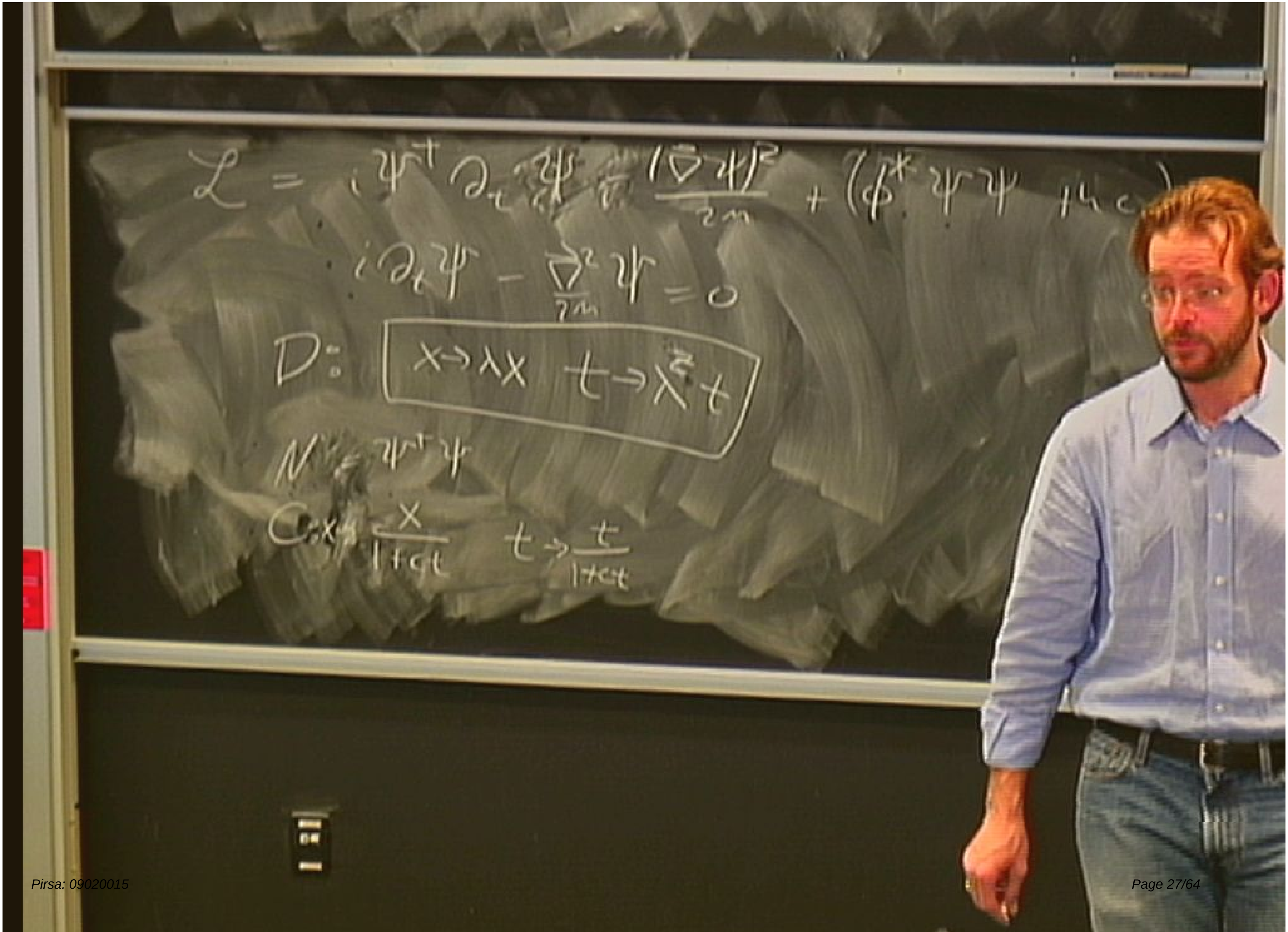

Schrödinger Group
{P, M, H, K, N, D, C}

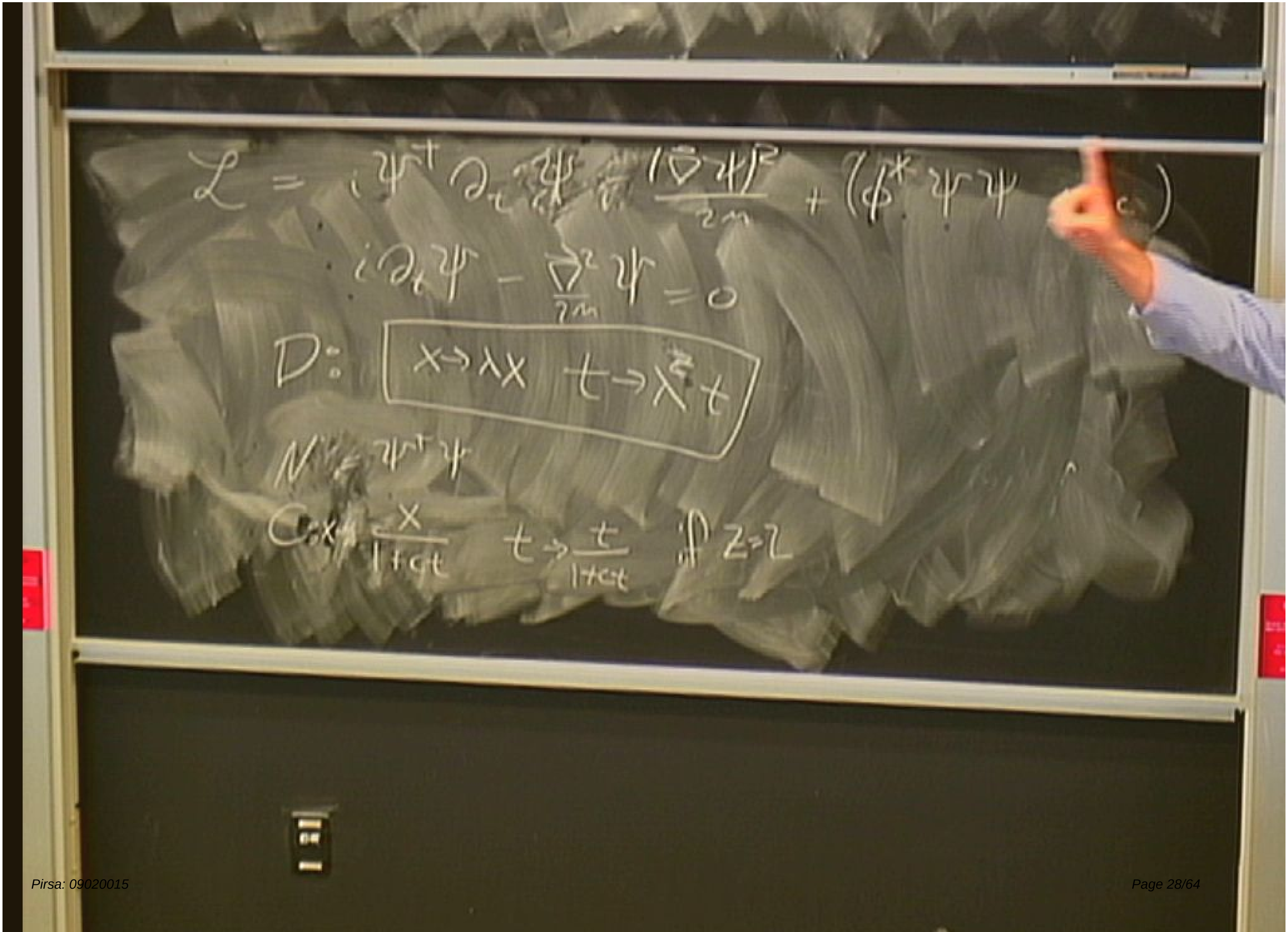

Schrödinger Group
{P, M, H, K, N, D, C}
[M,M]=M
[M,P]=P
[M,K]=-K
[H,K]=P
[P,K]=0
[D,H]=2iH
[D,P]=iP

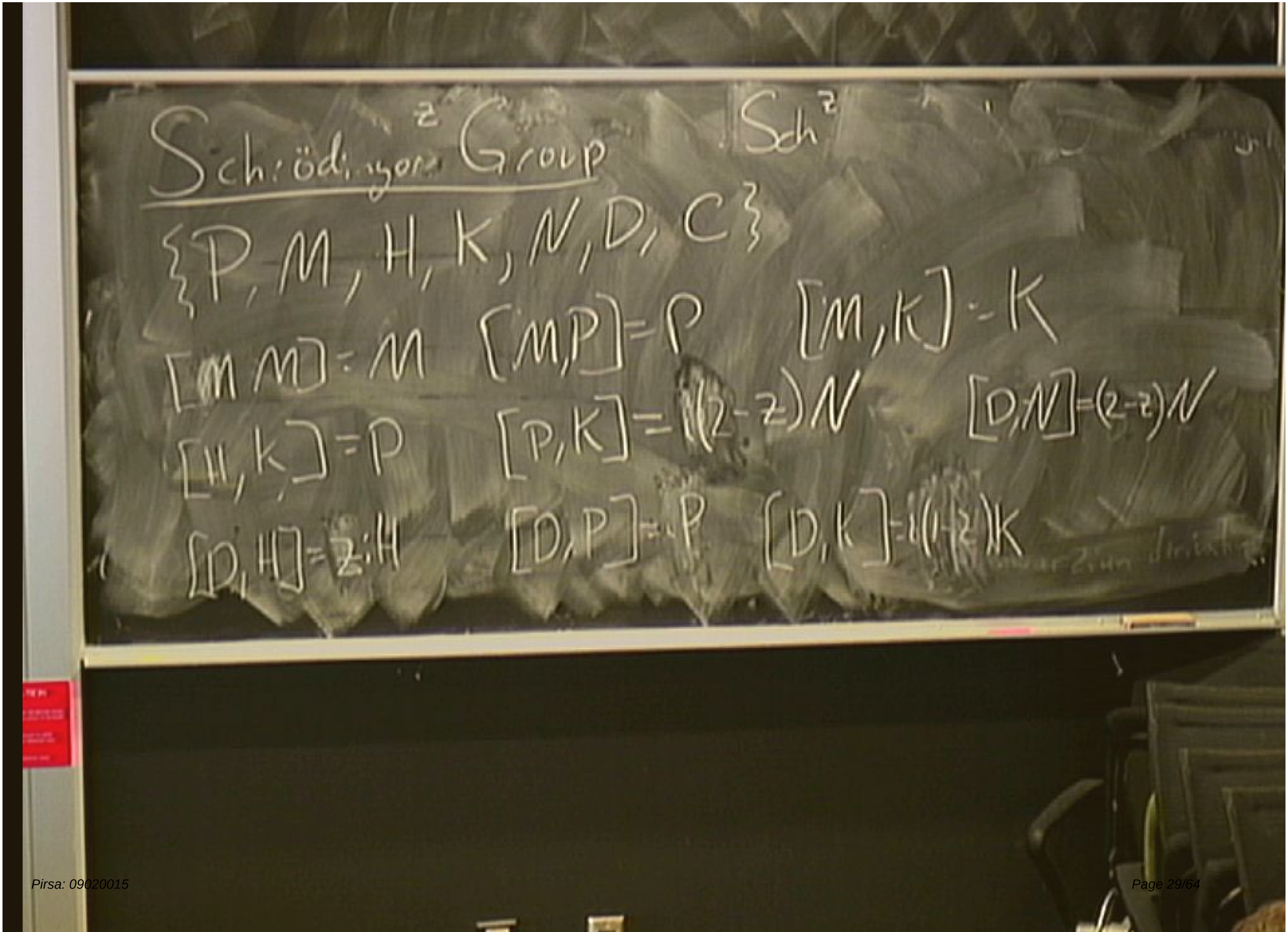


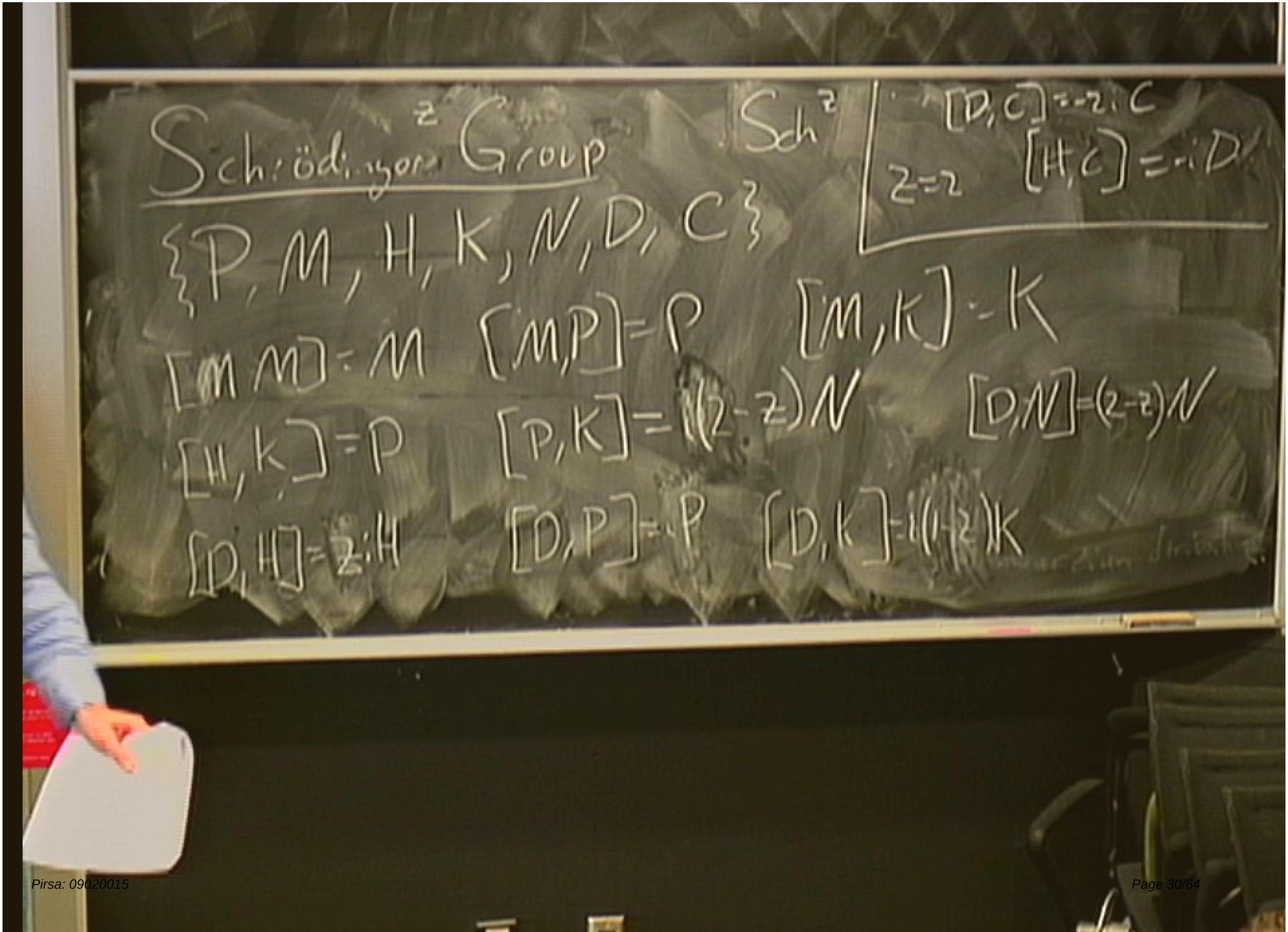
Schrödinger Group
Sch
{P, M, H, K, N, D, C}
[M, M] = M
[M,P] = P
[M,K]
[H,K] = P
[P,K] = 0
[D,P] = iP


Schrödinger^z Group
Sch^z
{P, M, H, K, N, D, C}
[M, M] = M
[M, P] = P
[M, K] = -K
[H, K] = P
[P, K] = -i(2-z)N
[D, H] = z H
[D, P] = -P
[D, K] = i(1-z)K


$\mathcal{L} = i\psi^\dagger \partial_t \psi - \frac{|\nabla \psi|^2}{2m} + (\phi^* \psi\psi + h.c.)$
$i\partial_t \psi - \frac{\nabla^2}{2m}\psi = 0$
$D: \; x \to \lambda x \quad t \to \lambda^z t$
$N: \; \psi^\dagger \psi$
$C: \; x \to \frac{x}{1+ct} \quad t \to \frac{t}{1+ct}$


L = iψ† ∂t ψ − |∇ψ|²/2m + (φ* ψψ + c.c.)
i∂t ψ − ∇²/2m ψ = 0
D: x → λx t → λ² t
N = ψ†ψ
C: x → x/(1+ct) t → t/(1+ct) if z=2


Schrödinger^z Group
Sch^z
{P, M, H, K, N, D, C}
[M M] = M
[M,P] = P
[M,K] = -K
[P,K] = -i(2-z)N
[D,N] = (2-z)N
[H,K] = P
[D,H] = zH
[D,P] = -P
[D,K] = i(1-z)K


Schrödinger^z Group
{P, M, H, K, N, D, C}
[M, M] = M
[M,P] = P
[M,K] = K
[H,K] = P
[P,K] = i(2−z)N
[D,N] = (2−z)N
[D,H] = z i H
[D,P] = i P
[D,K] = i(1−z)K
Sch^z
[D,C] = −2iC
z=2
[H,C] = −iD

Schrödinger^z Group

$\{P, M, H, K, N, D, C\}$

Sch^2

$z=2$

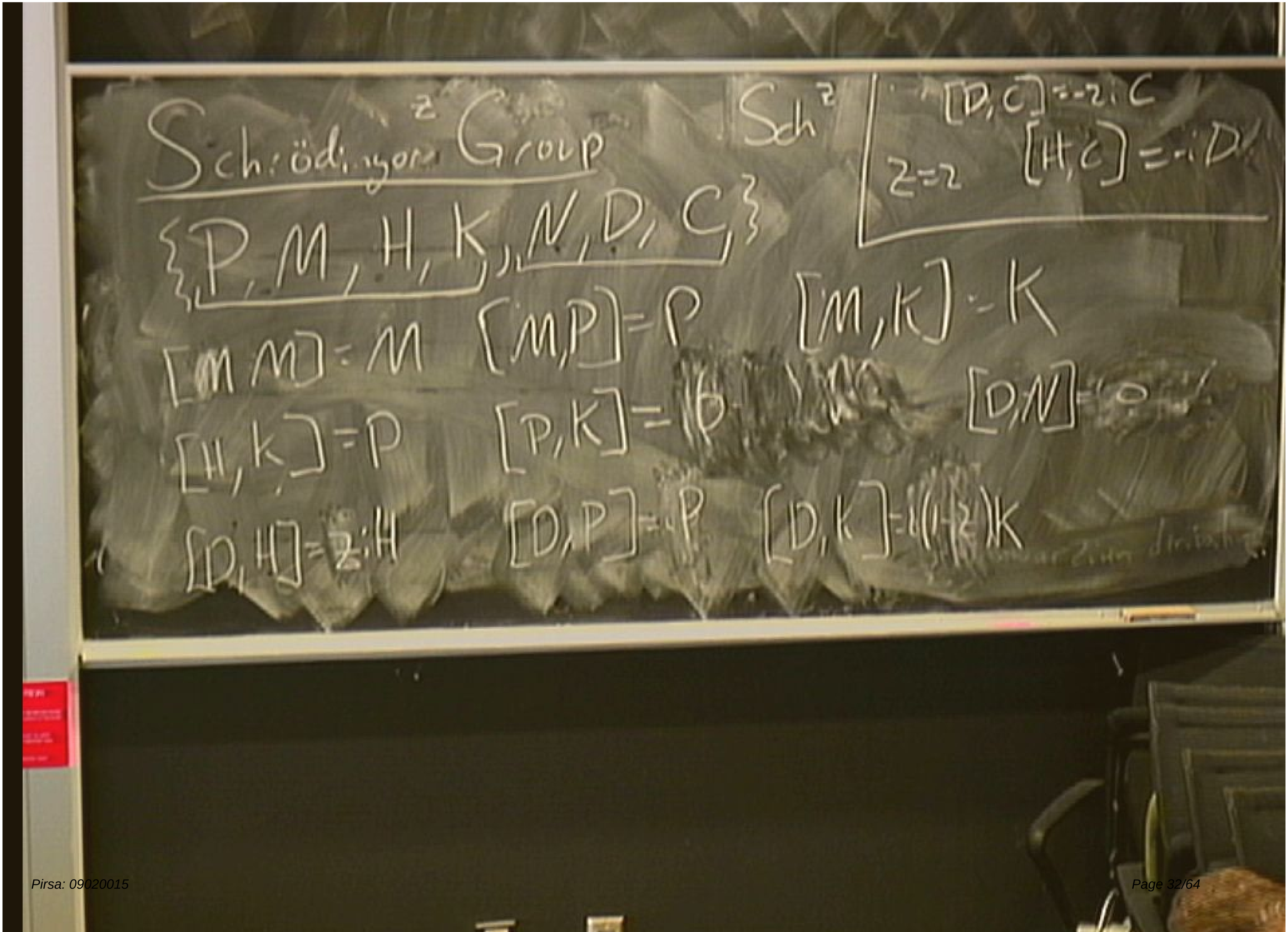
$[D, C] = -2iC$

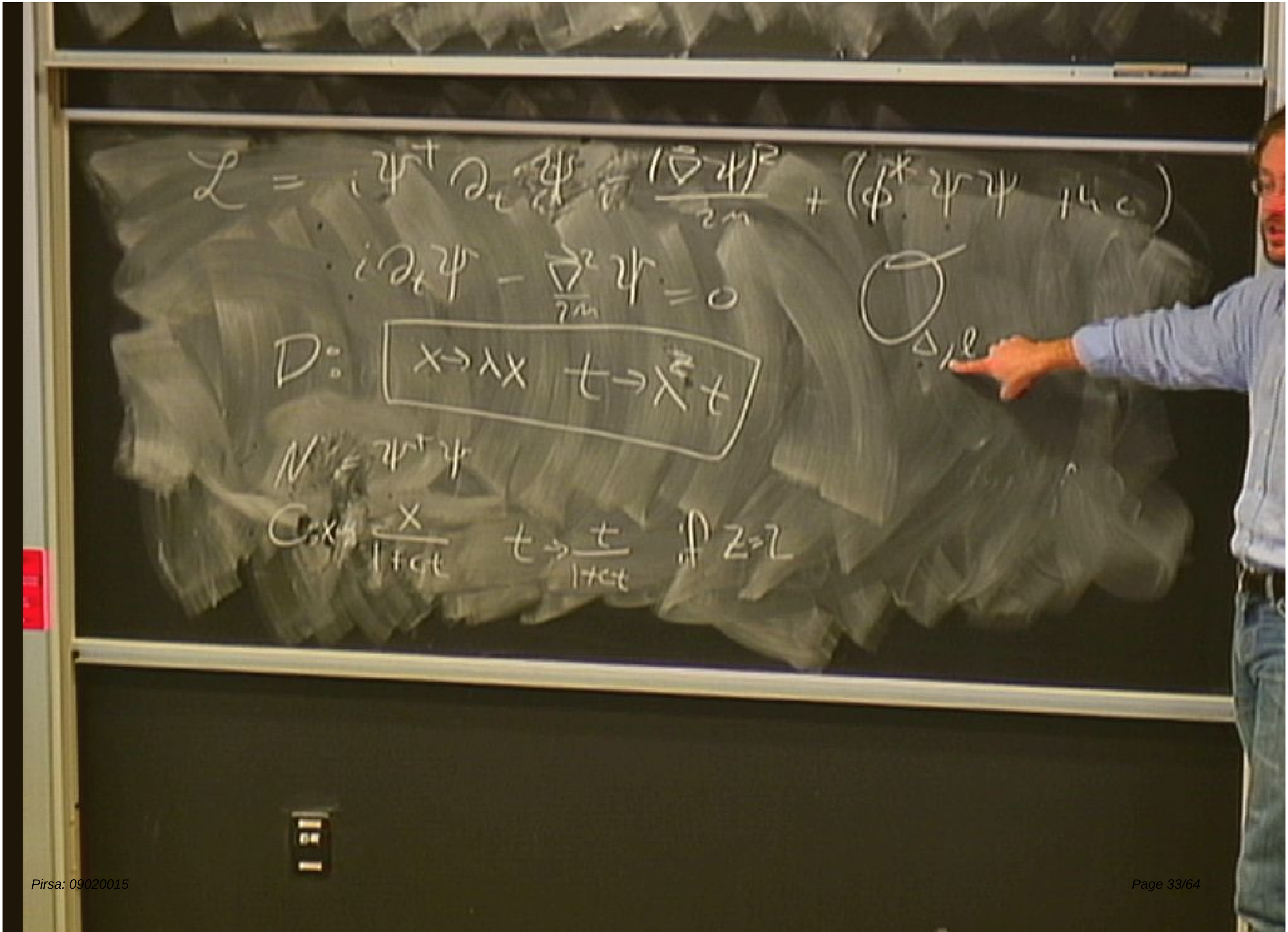
$[H, C] = -iD$

$[M, M] = M \qquad [M, P] = P \qquad [M, K] = K$

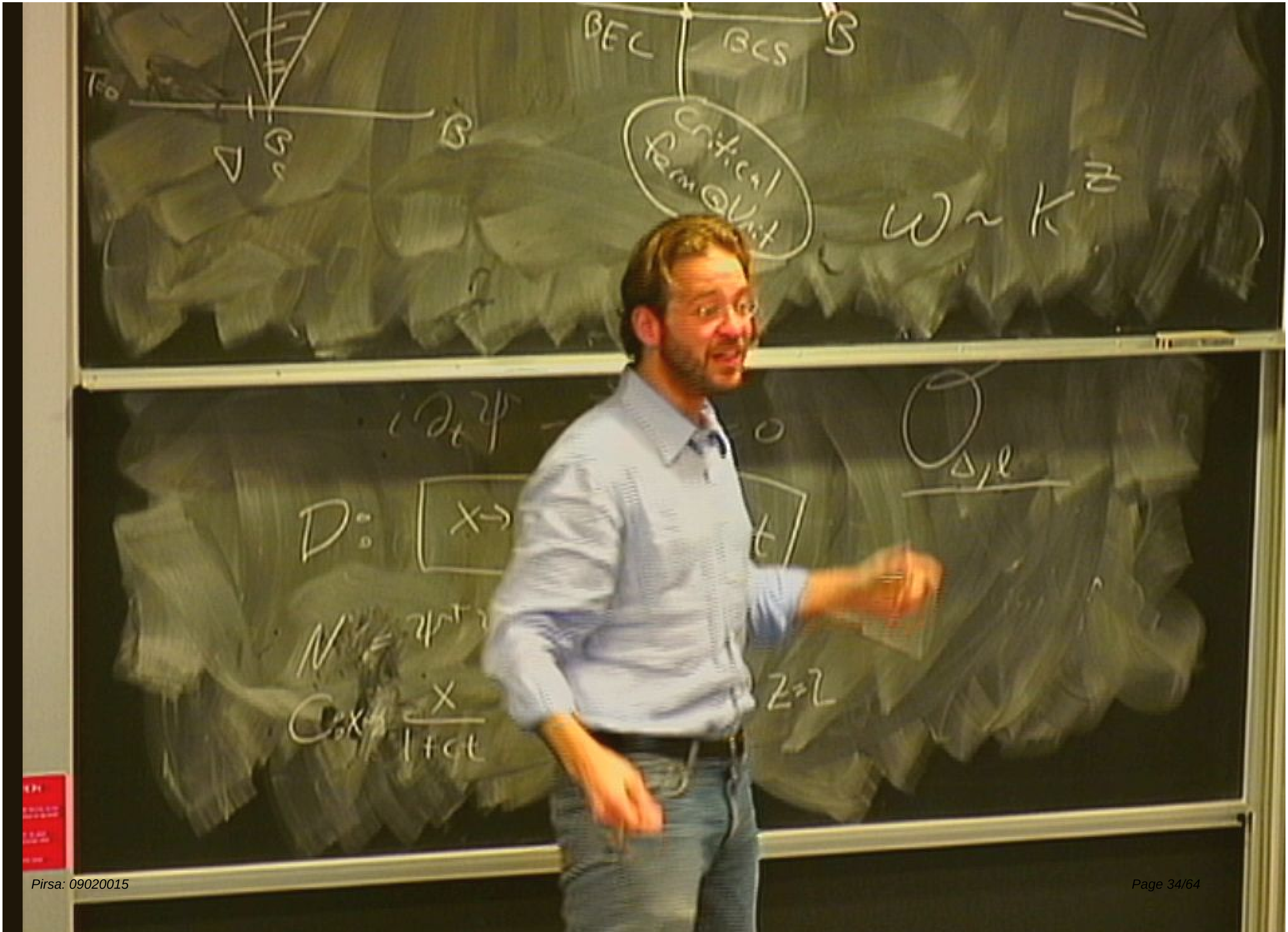
$[H, K] = P \qquad [P, K] = -i(2-z)N \qquad [D, N] = (2-z)N$

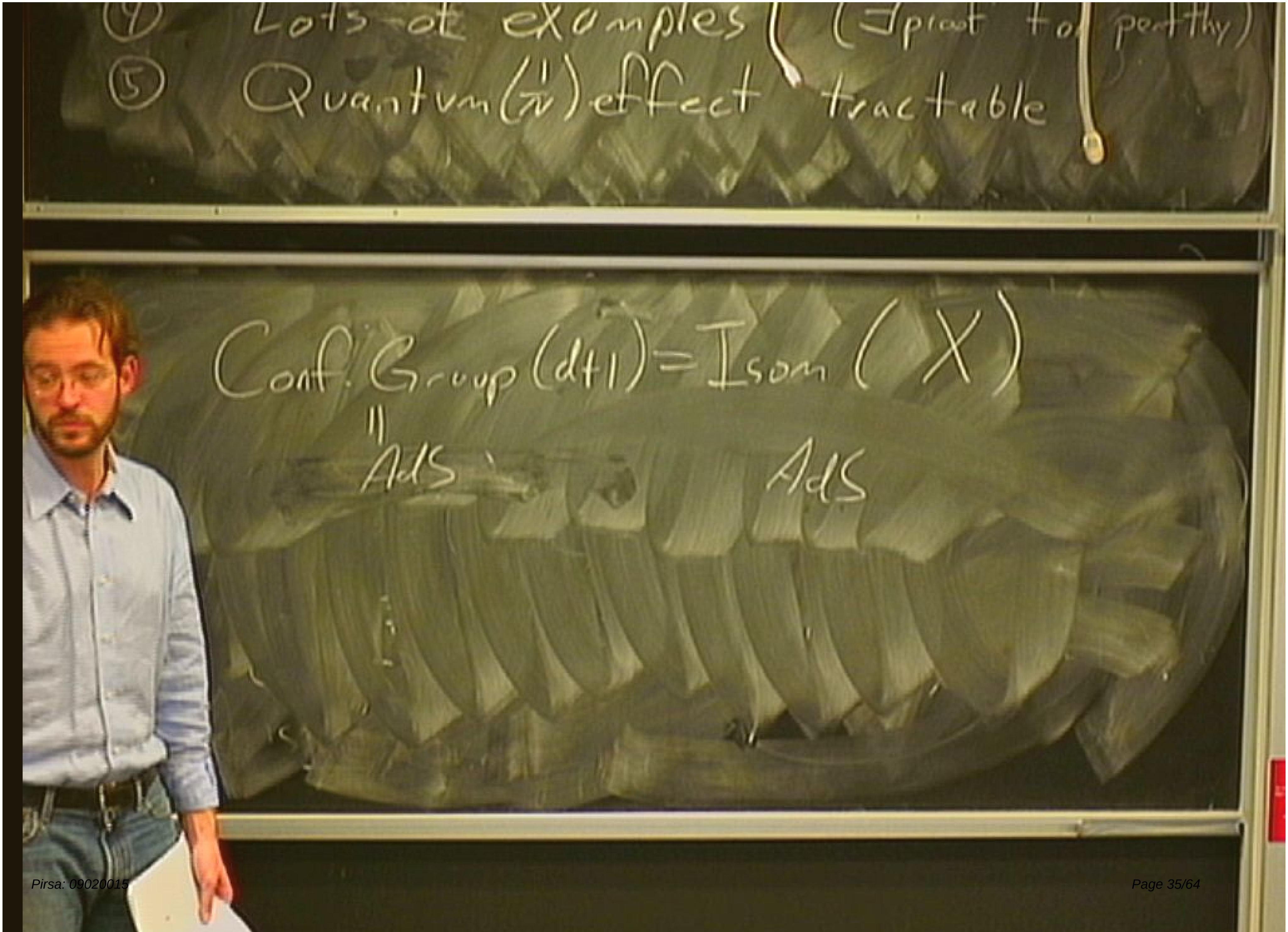
$[D, H] = z\,iH \qquad [D, P] = iP \qquad [D, K] = i(1-z)K$


Schrödinger Group
Sch
[D,C] = -2iC
z=2
[H,C] = -iD
{P, M, H, K, N, D, C}
[M,M] = M
[M,P] = P
[M,K] = K
[D,N] = 0
[H,K] = P
[P,K] =
[D,H] = z iH
[D,P] = iP
[D,K] = i(1-z)K

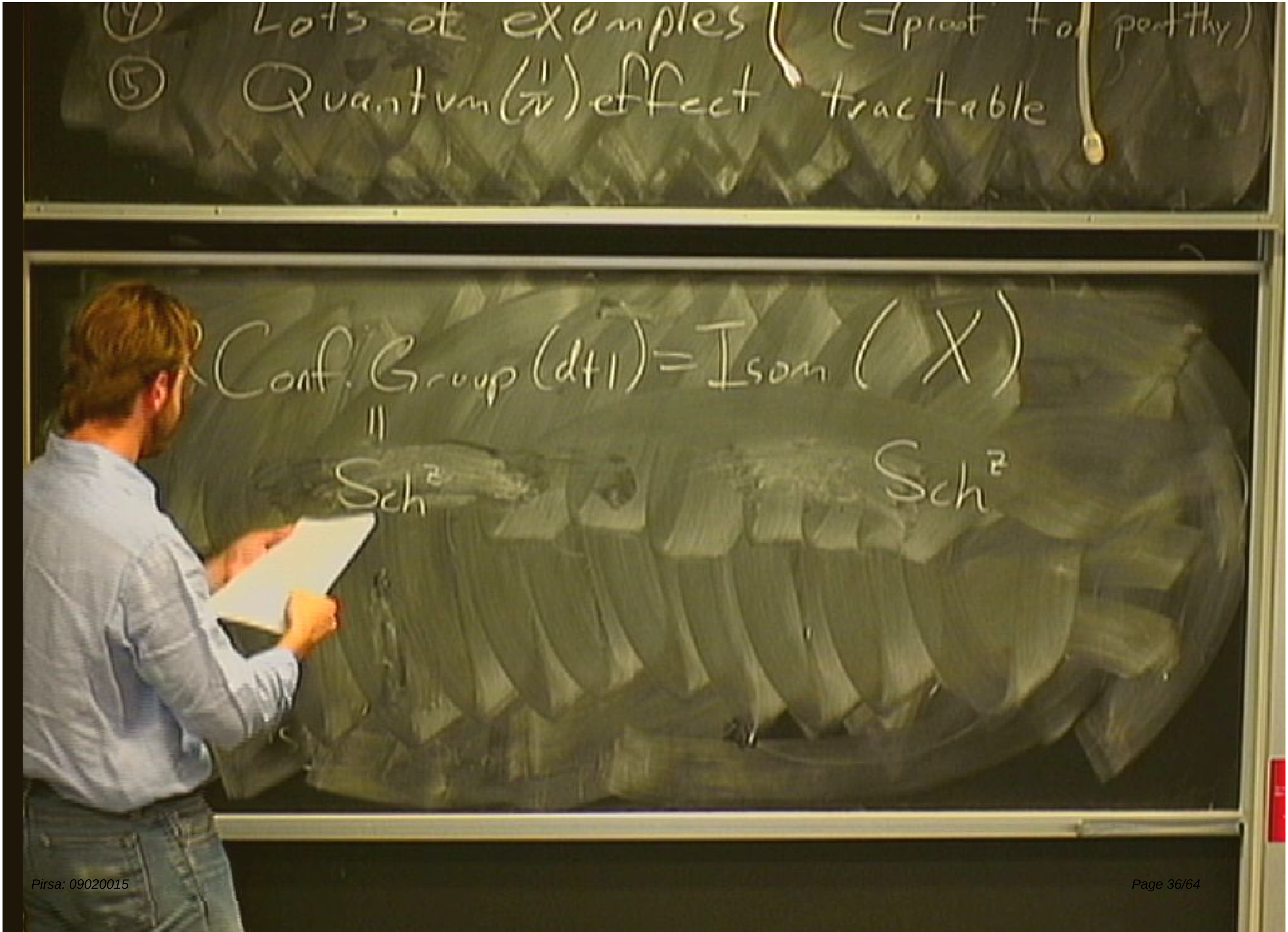


L = iψ† ∂t ψ − |∇ψ|²/2m + (φ* ψψ + h.c.)
i∂tψ − ∇²ψ/2m = 0
D: x → λx t → λ²t
N = ψ†ψ
C: x → x/(1+ct) t → t/(1+ct) if z=2
O Δ,ℓ

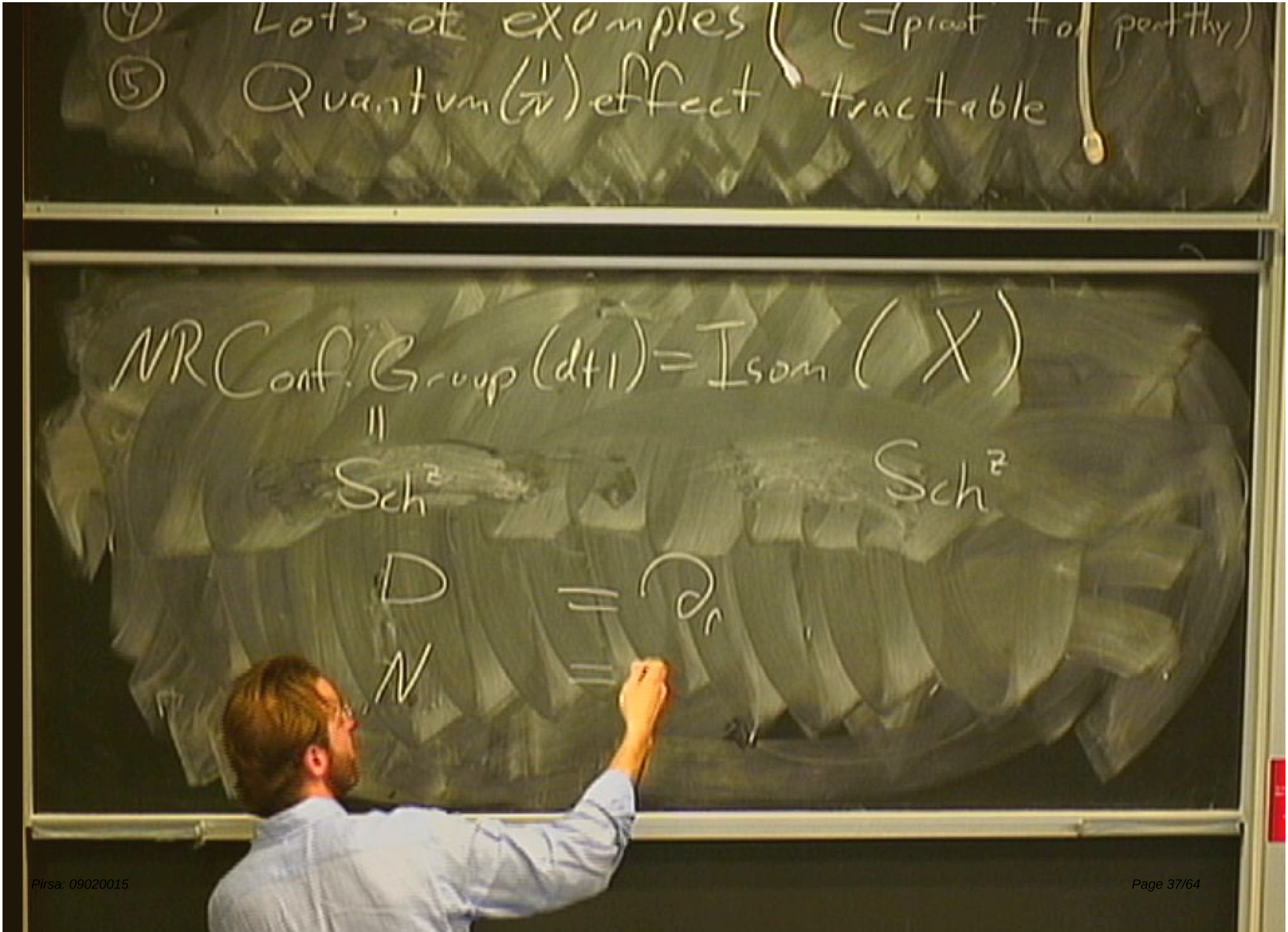

BEC
BCS
ω ~ k^z
Z=2

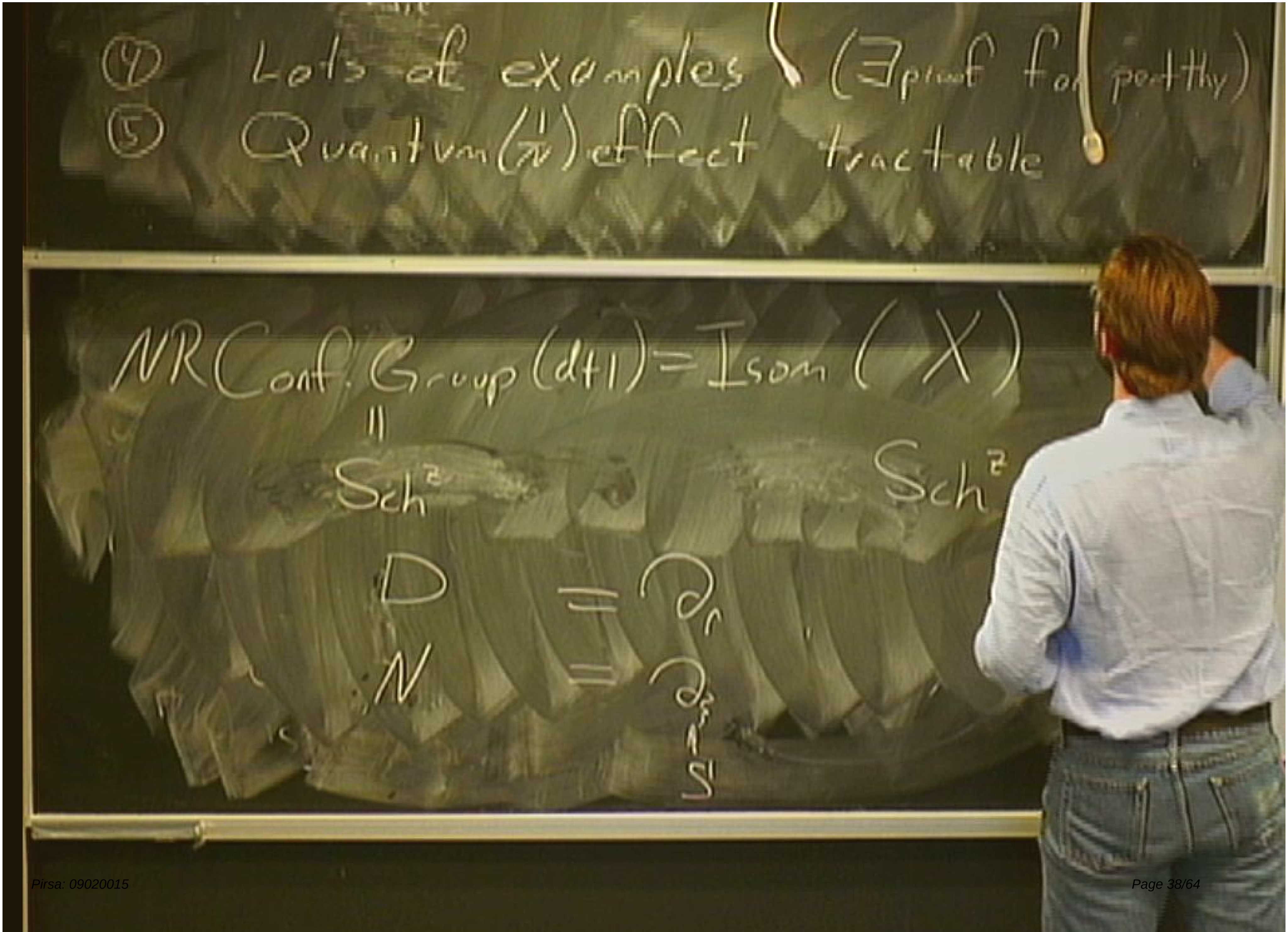


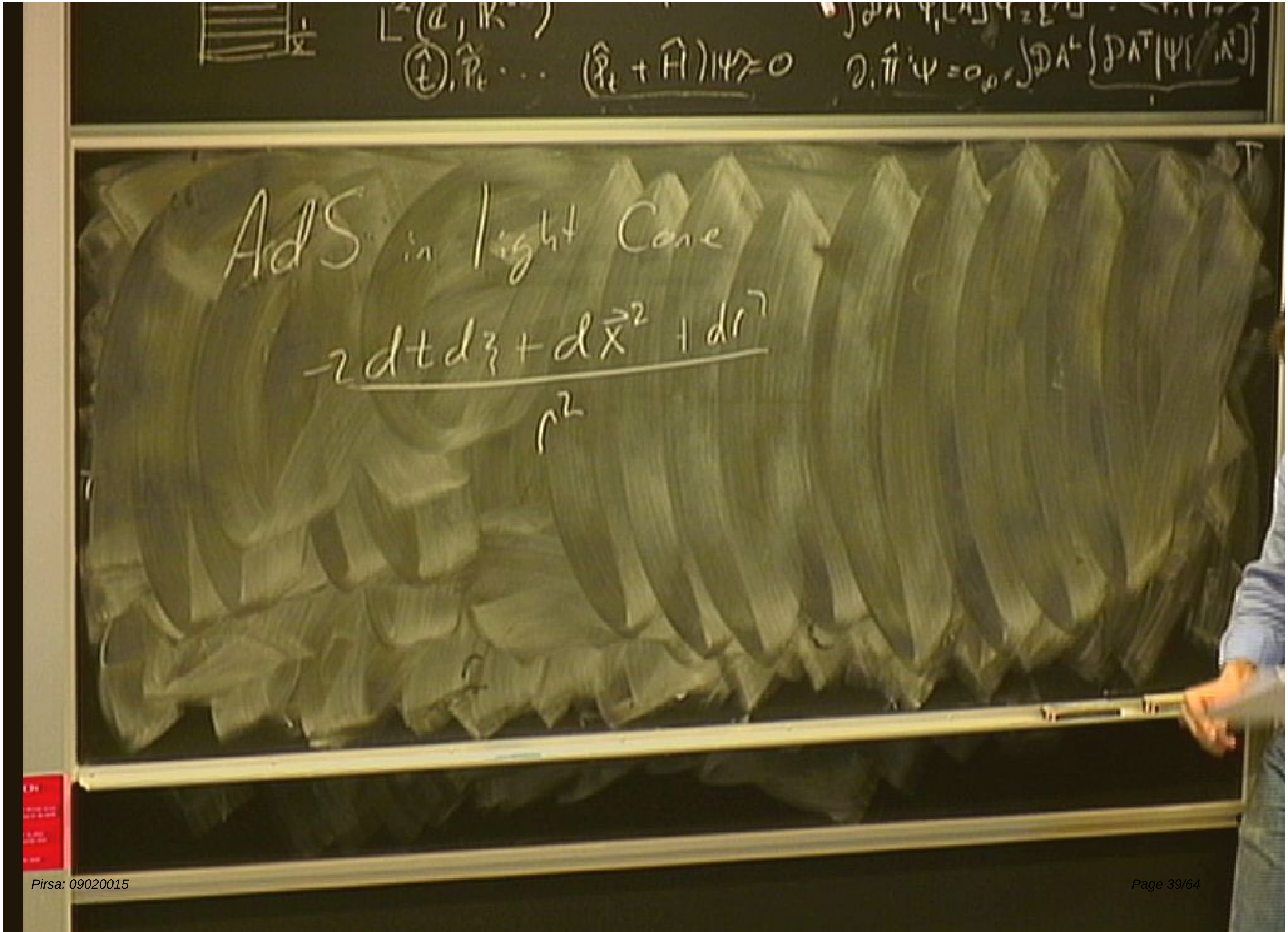
Lots of examples
Quantum effect tractable
Conf. Group (d+1) = Isom (X)
AdS
AdS

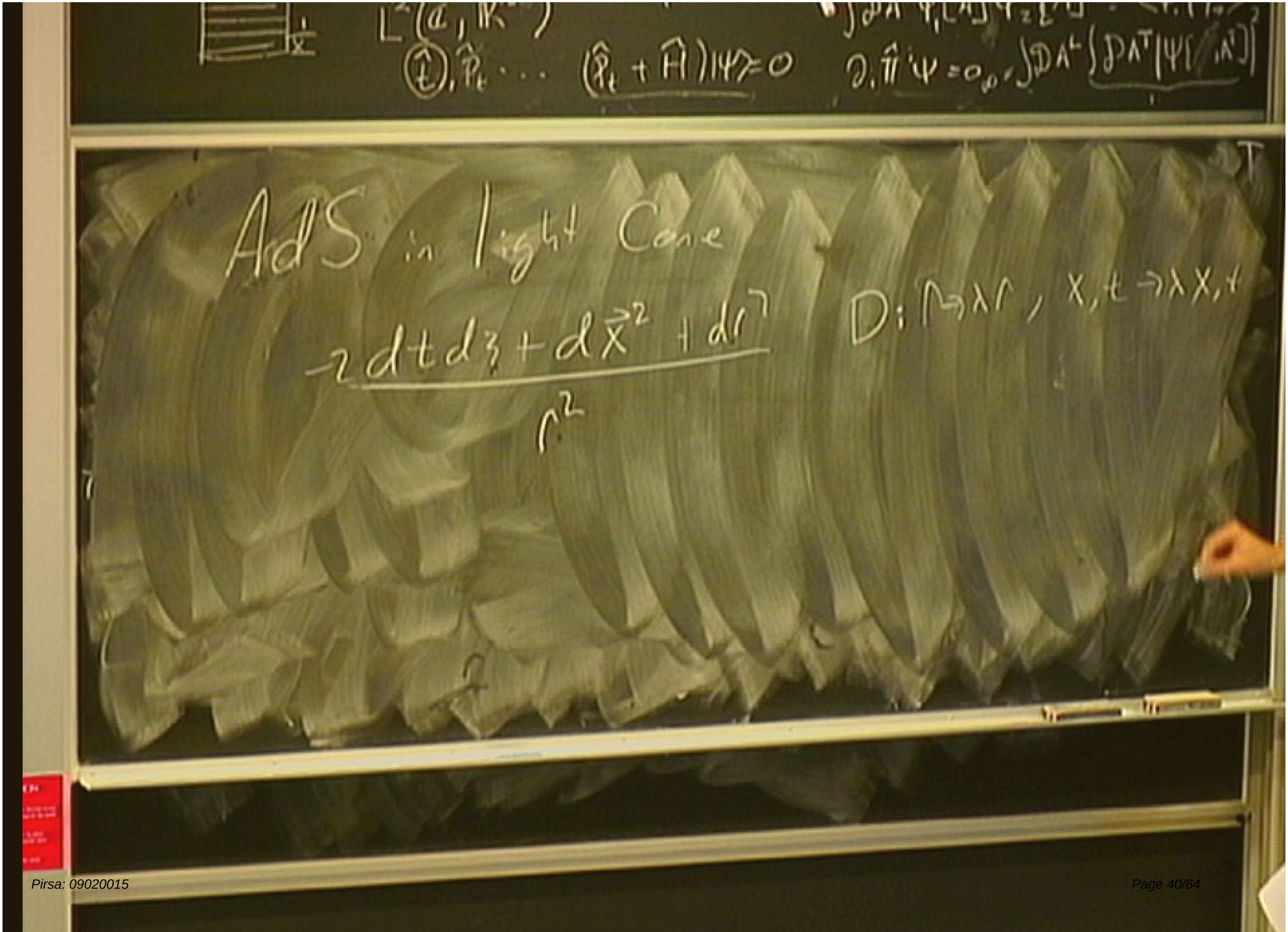


Lots of examples
⑤ Quantum effect tractable
Conf. Group (d+1) = Isom (X)
Sch²
Sch²


④ Lots of examples
⑤ Quantum effect tractable
NR Conf. Group (d+1) = Isom (X)
Sch²
Sch²
D = ∂r
N =


④ Lots of examples (∃ proof for positivity)
⑤ Quantum (1/N) effect tractable
NR Conf. Group (d+1) = Isom (X)
Sch²
Sch²
D = ∂r
N = ∂ξ
S¹


AdS in Light Cone
$\frac{-2\,dt\,dz + d\vec{x}^2 + dr^2}{r^2}$


(P̂_t + Ĥ)|ψ⟩ = 0
AdS in light Cone
−2 dt dz + dx⃗² + dr²
r²
D: r → λr , x, t → λx, t

$(\hat{t}), \hat{P}_t \ldots \quad (\hat{P}_t + \hat{H})|\Psi\rangle = 0$

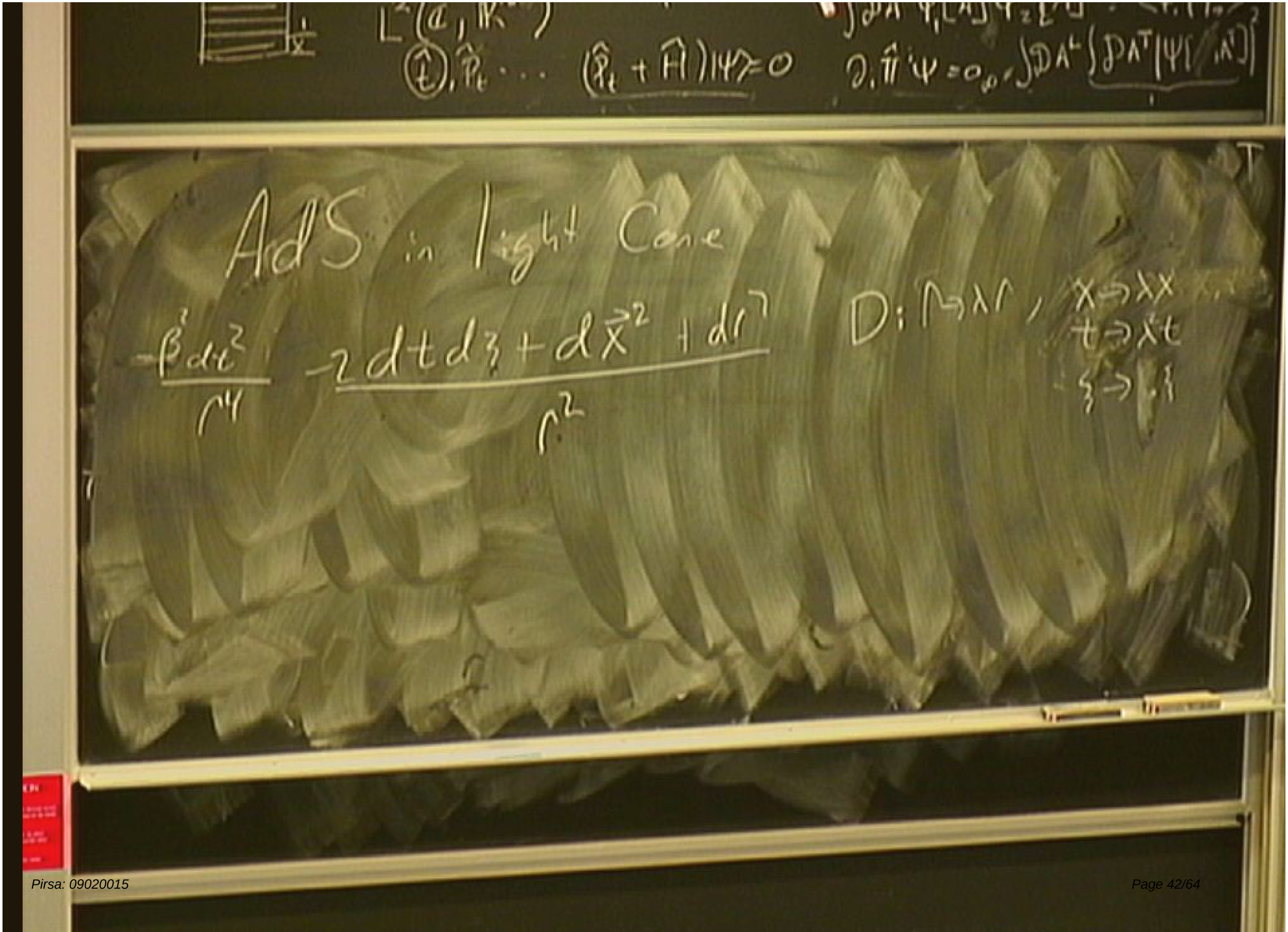
AdS in light Cone

$$\frac{-2\,dt\,d\xi + d\vec{x}^2 + dr^2}{r^2}$$

D: $r \to \lambda r$, $x \to \lambda x$

$t \to \lambda t$

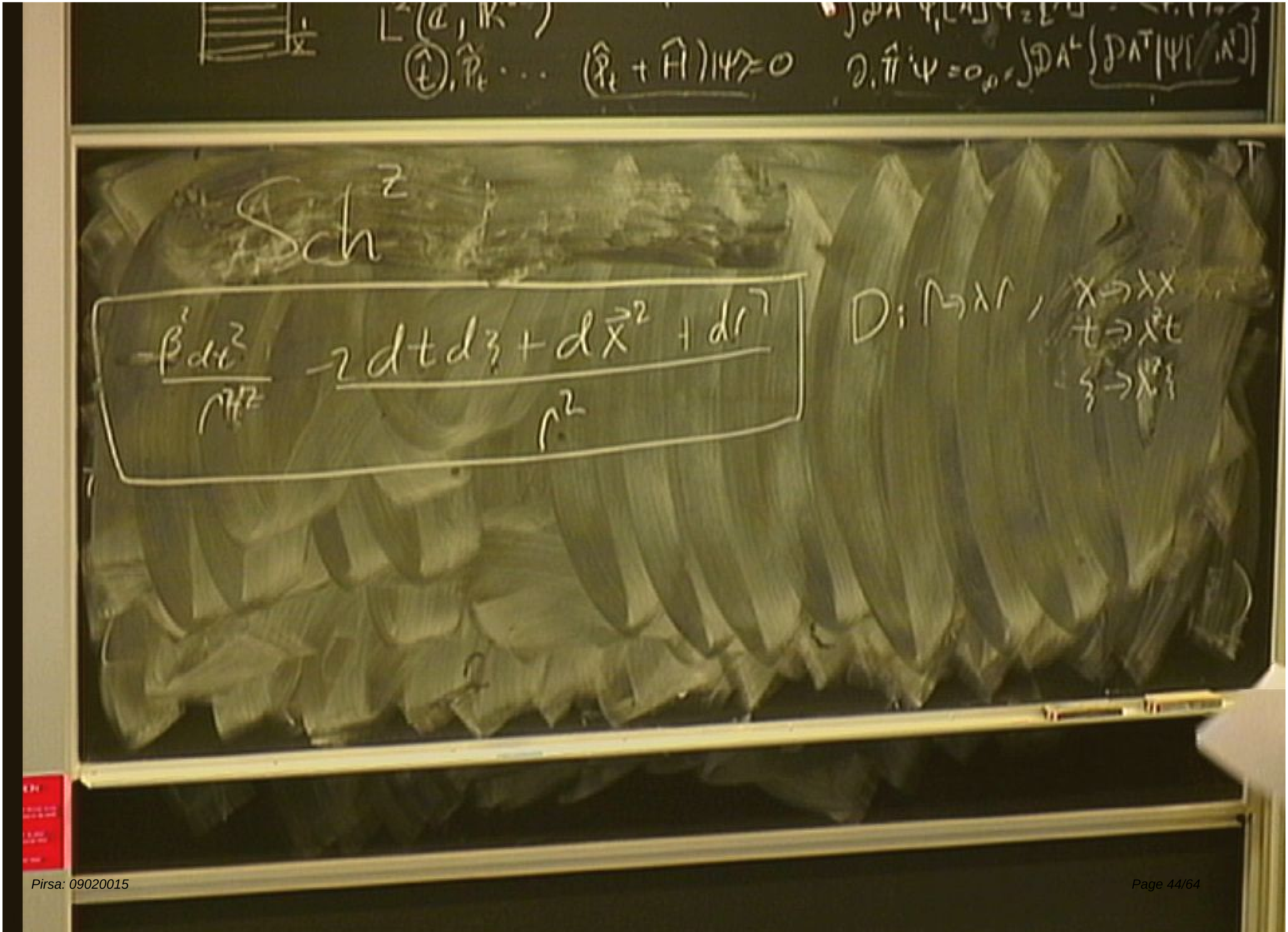
$\xi \to \lambda \xi$

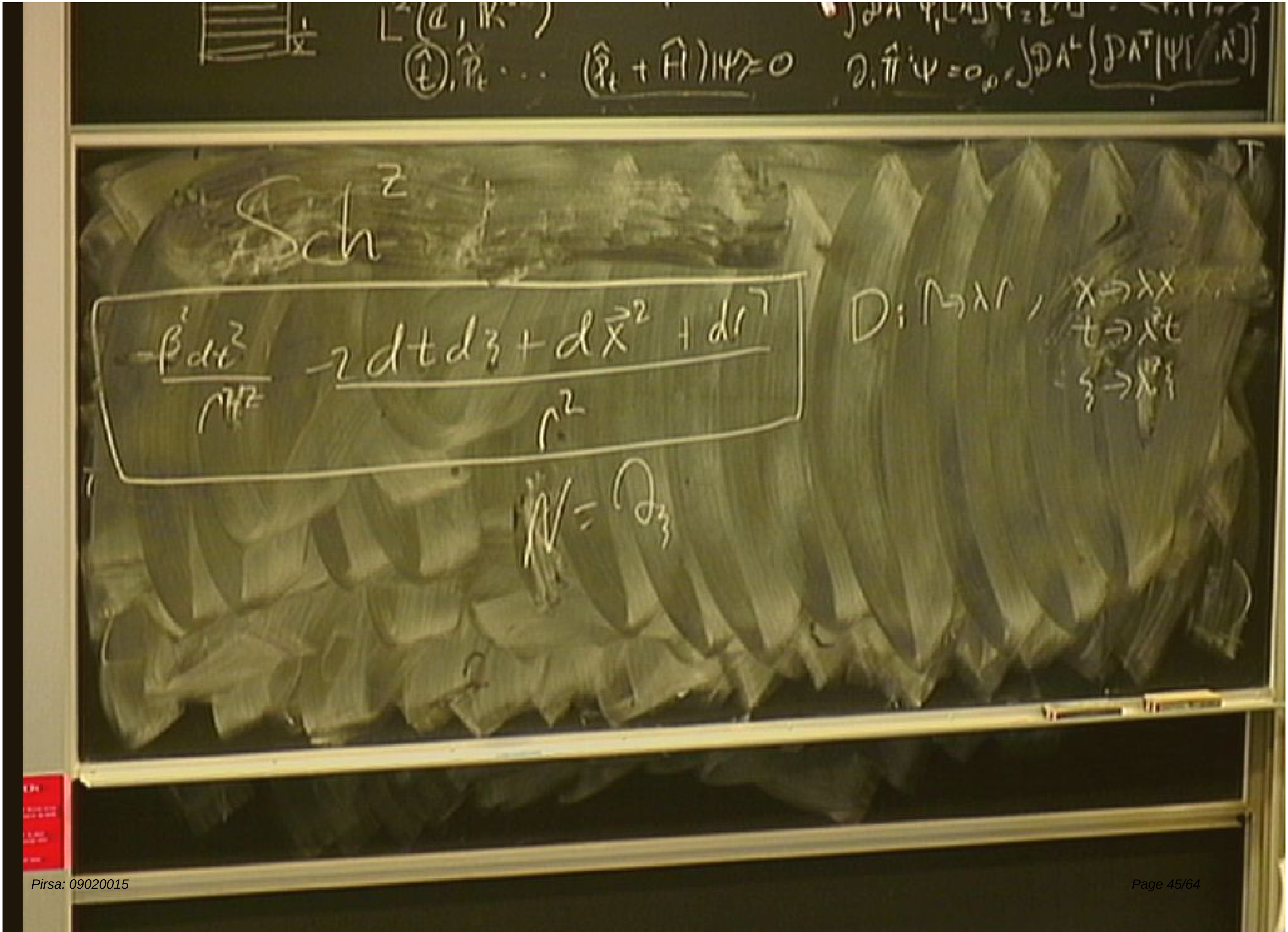

AdS in light Cone
-β²dt²/r⁴ - 2dtdξ + dx⃗² + dr² / r²
D: r→λr, x→λx
t→λ²t
ξ→ξ

AdS in Light Cone

$$-\frac{\beta^2 dt^2}{r^4} - \frac{2\,dt\,d\xi + d\vec{x}^2 + dr^2}{r^2}$$

$D: r \to \lambda r,\quad x \to \lambda x,\quad t \to \lambda^2 t,\quad \xi \to \lambda^0 \xi$


Sch
D:


Sch
N = ∂ξ
D: r→λr, x→λx
t→λ^z t

Sch^z

$$\frac{-\beta^2 dt^2}{r^{2z}} - \frac{2\,dt\,d\xi + d\vec{x}^2 + dr^2}{r^2}$$

$D: r \to \lambda r, \quad x \to \lambda x, \quad t \to \lambda^z t, \quad \xi \to \lambda^{2-z} \xi$

$N = \partial_\xi$

$K: x \to x - vt, \quad \xi \to \xi + \frac{1}{2}(2\vec{v}\cdot\vec{x} \ldots$

$L^2(\mathbb{Q}, \mathbb{R}^{\dots})$

$(\hat{t}), \hat{p}_t \dots \quad (\hat{p}_t + \hat{H})|\psi\rangle = 0 \qquad \partial_i \hat{\pi}^i \psi = 0$

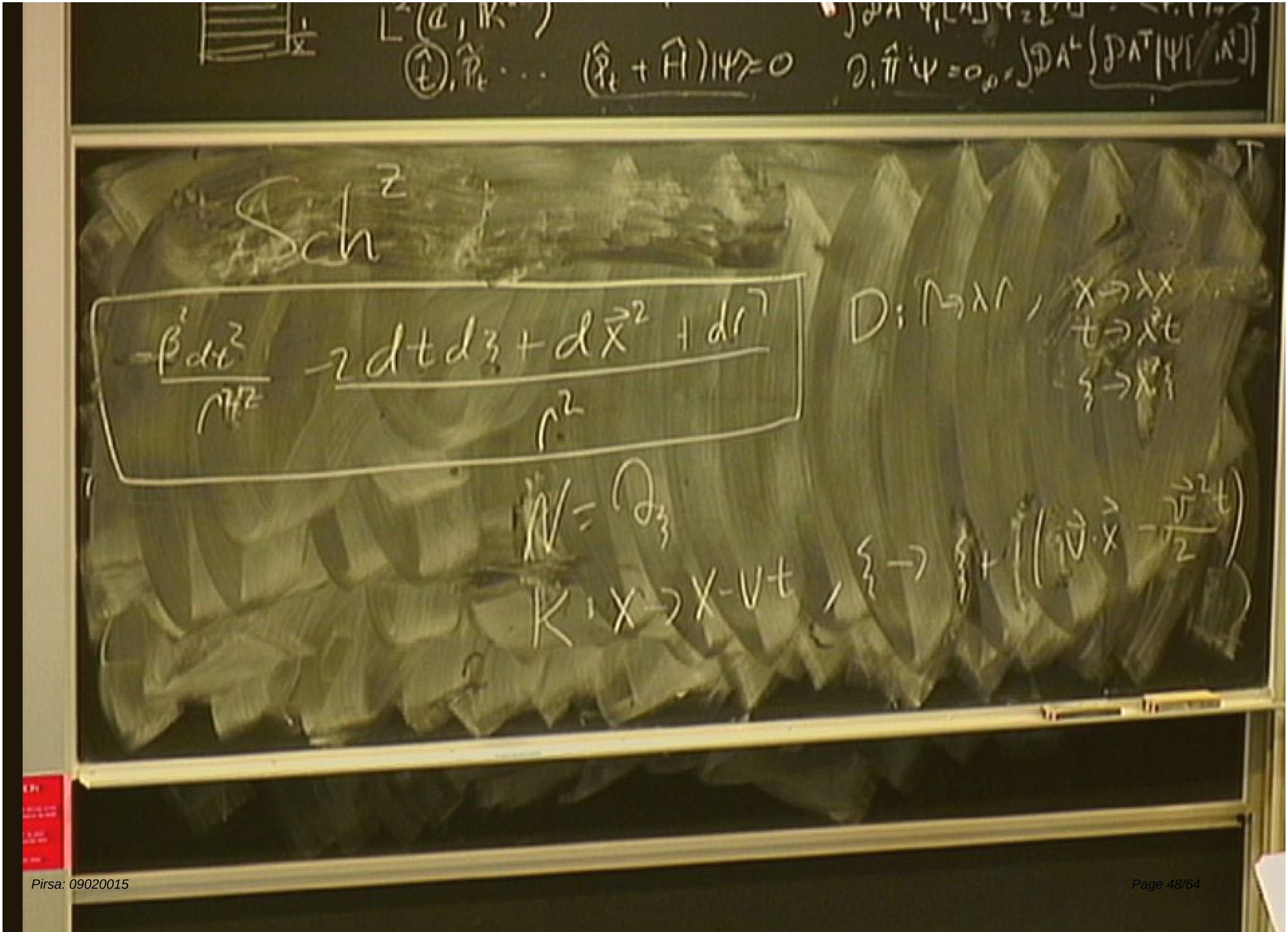
Sch^z

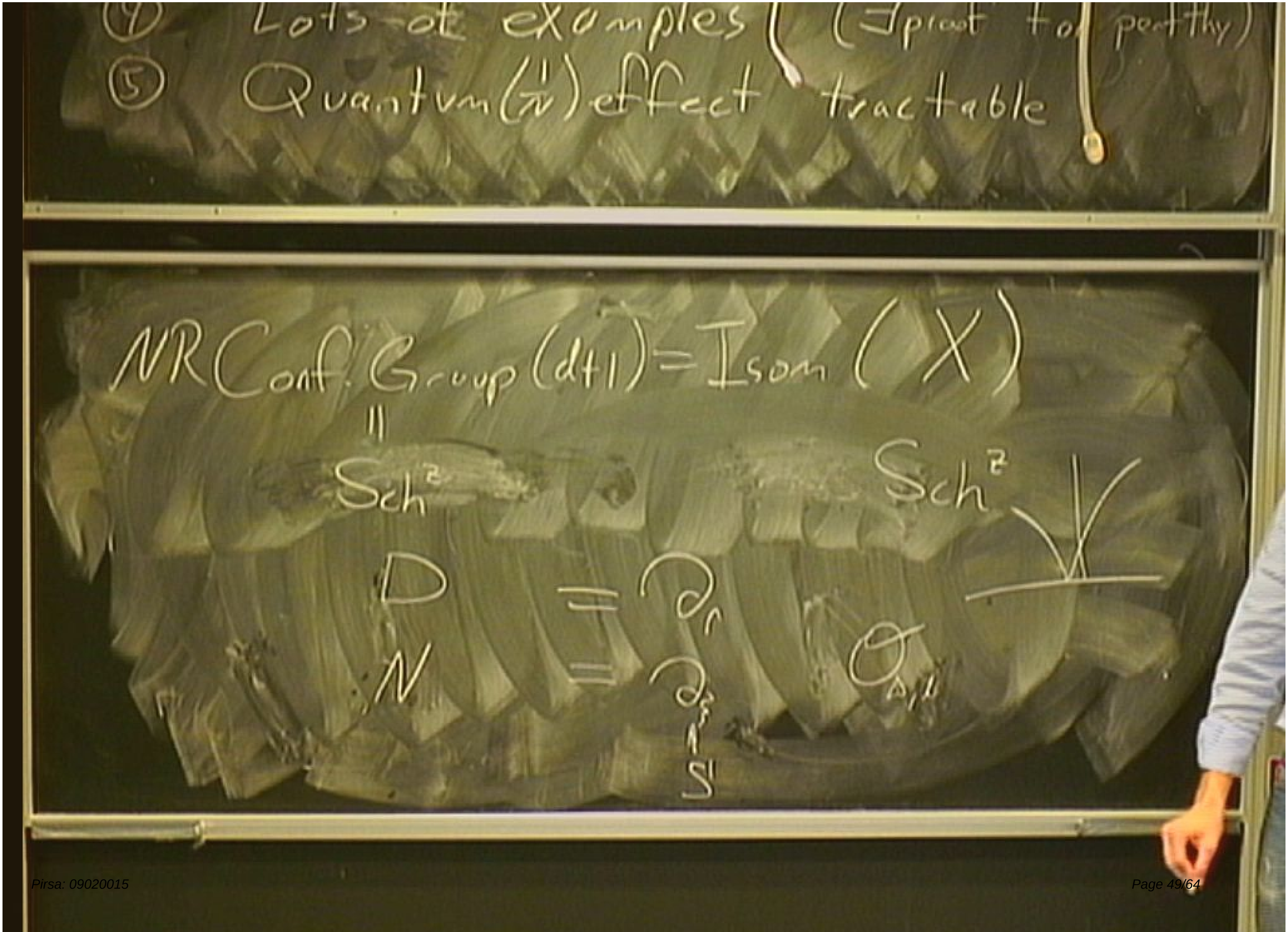
$$-\frac{\beta^2 dt^2}{r^{2z}} - \frac{2\,dt\,d\xi + d\vec{x}^2 + dr^2}{r^2}$$

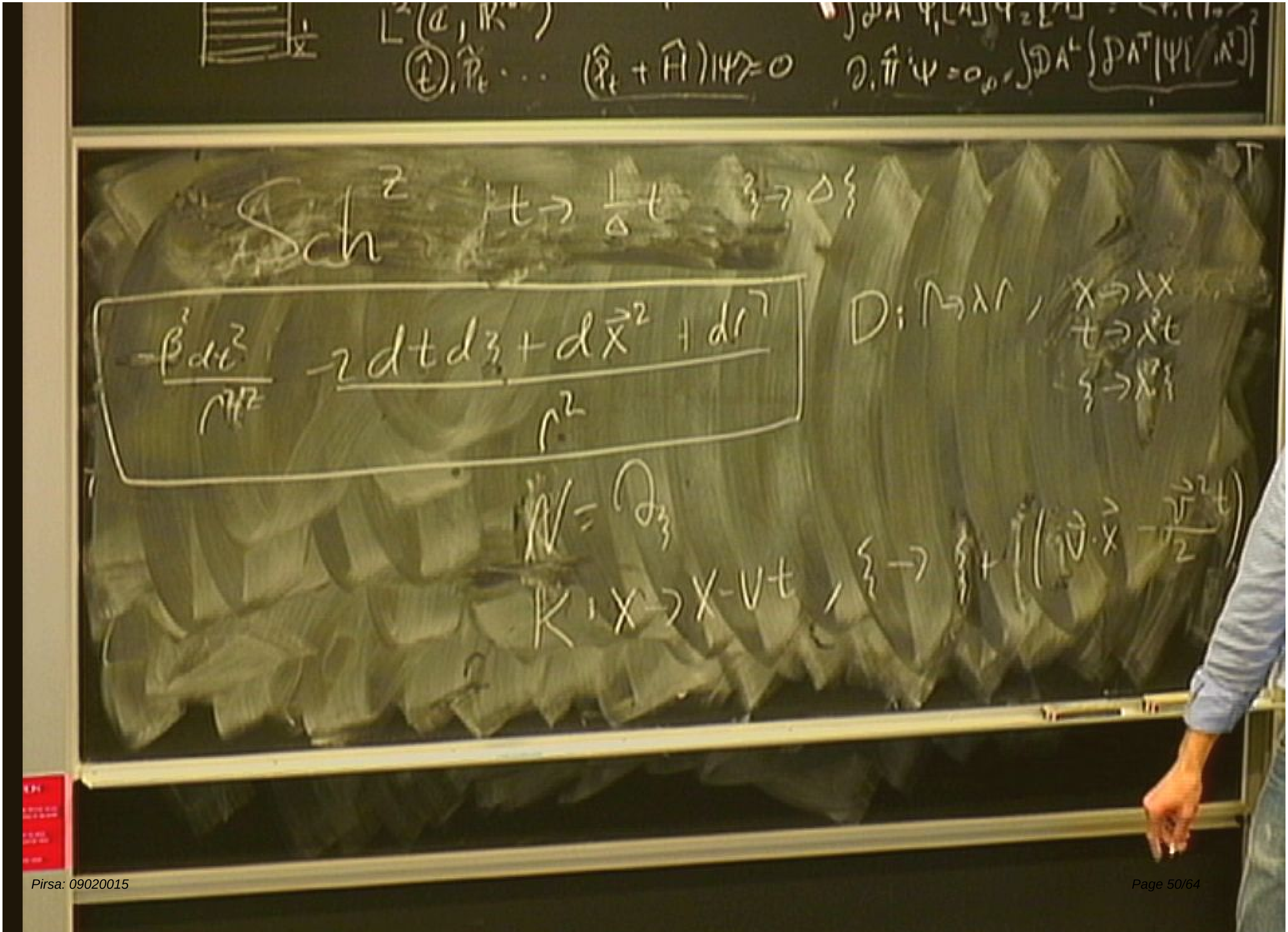
$D: r \to \lambda r, \quad x \to \lambda x, \quad t \to \lambda^z t, \quad \xi \to \lambda^{2-z} \xi$

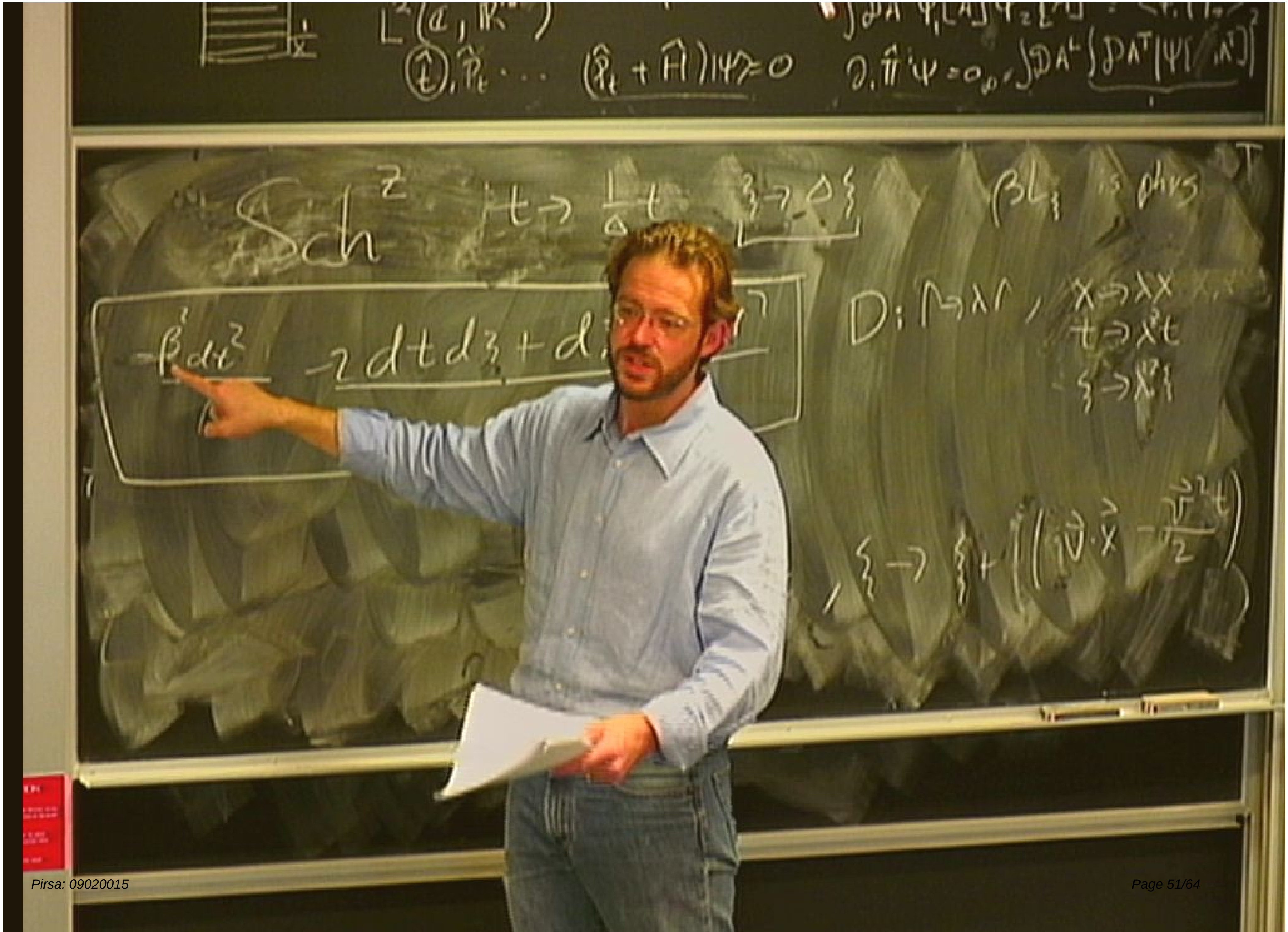
$N = \partial_\xi$

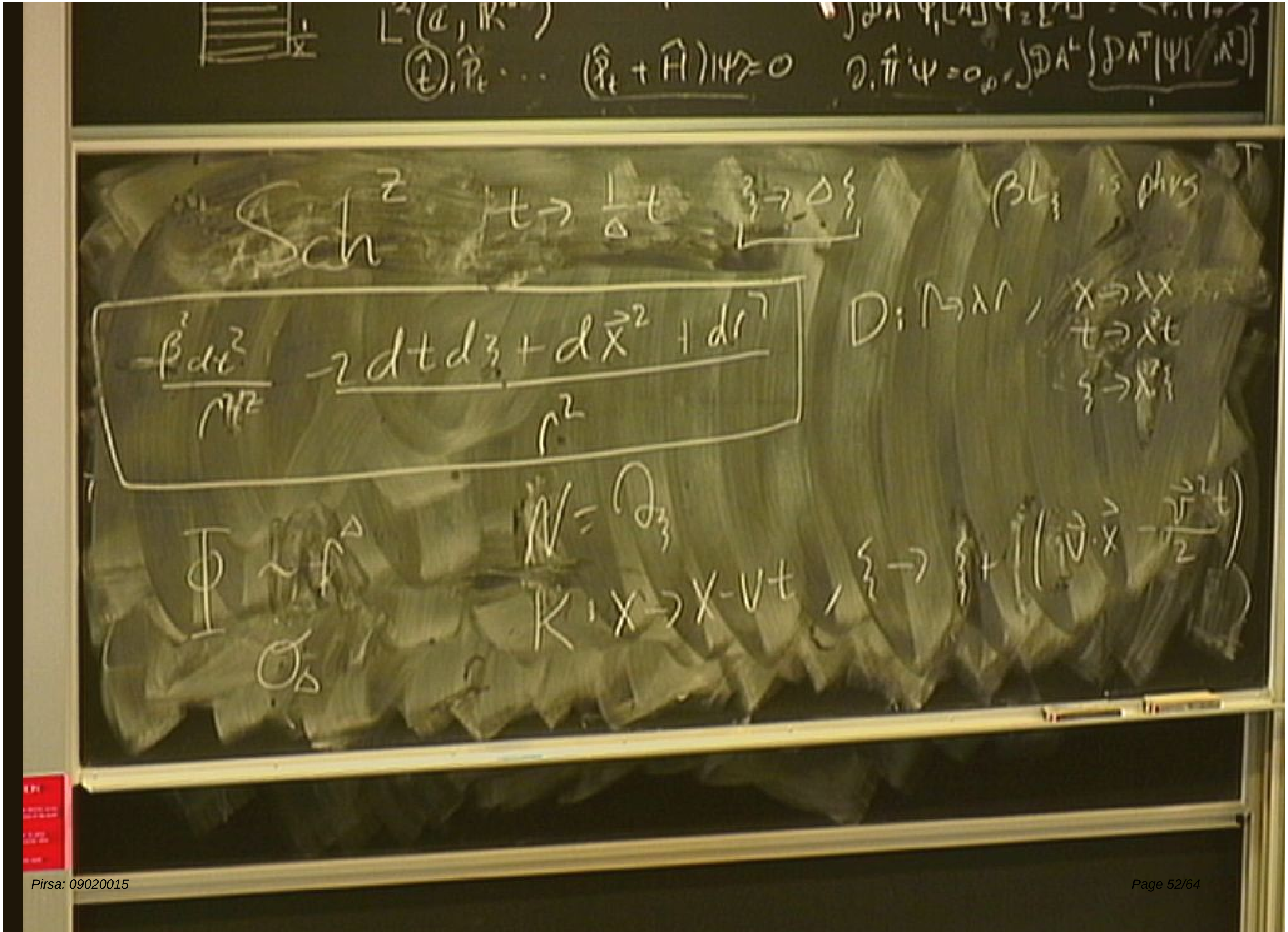
$K: x \to x - vt, \quad \xi \to \xi + \frac{1}{2}\left(2\vec{v}\cdot\vec{x} - \frac{\vec{v}^2 t}{2}\right)$


Sch
D: r → λr, x → λx
t → λ²t
K: x → x − vt
N = ∂ξ

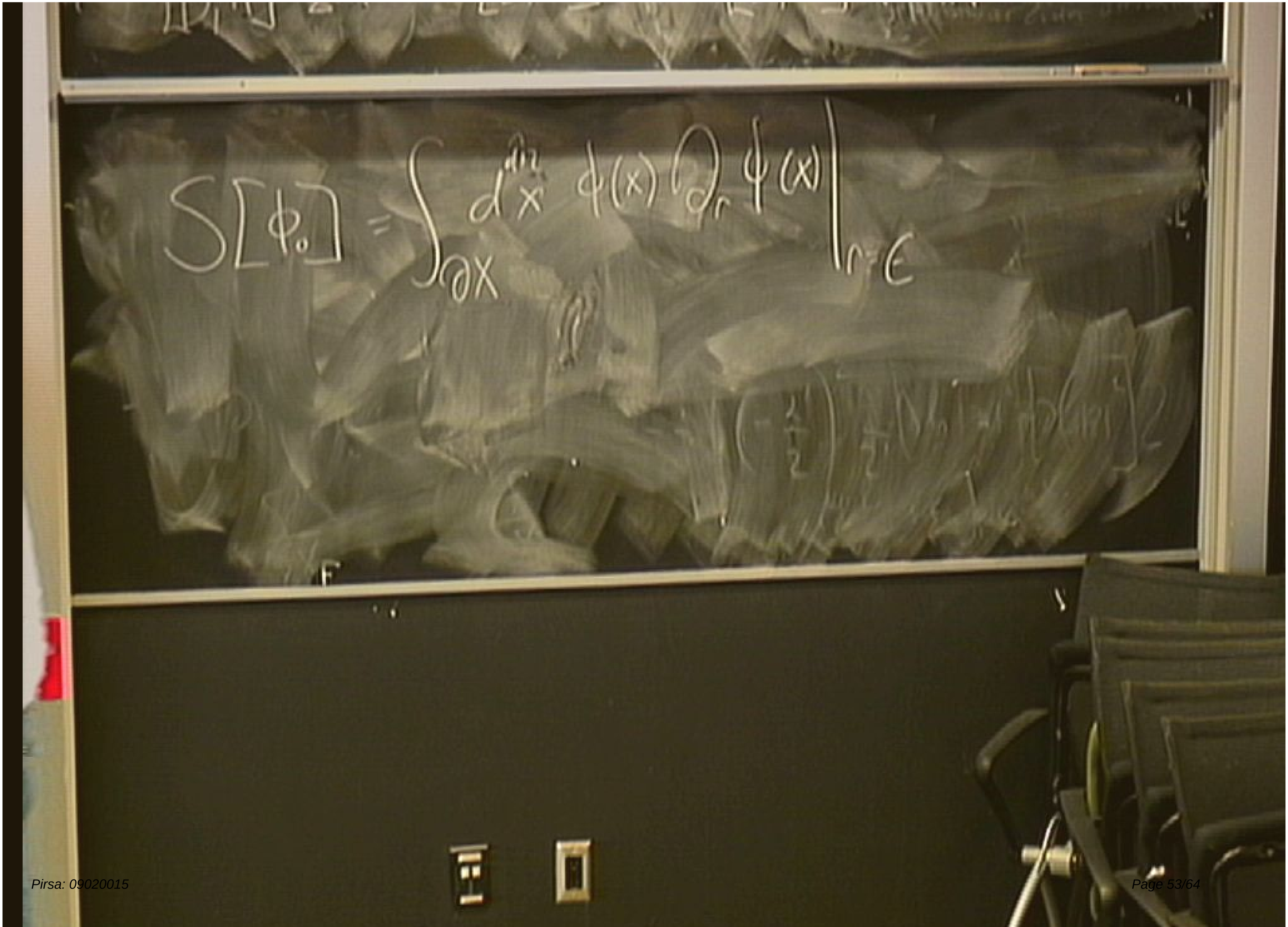

④ Lots of examples
⑤ Quantum (ħ) effect tractable
NR Conf. Group (d+1) = Isom (X)
Sch²
Sch²
D = ∂r
N = ∂ξ
S¹

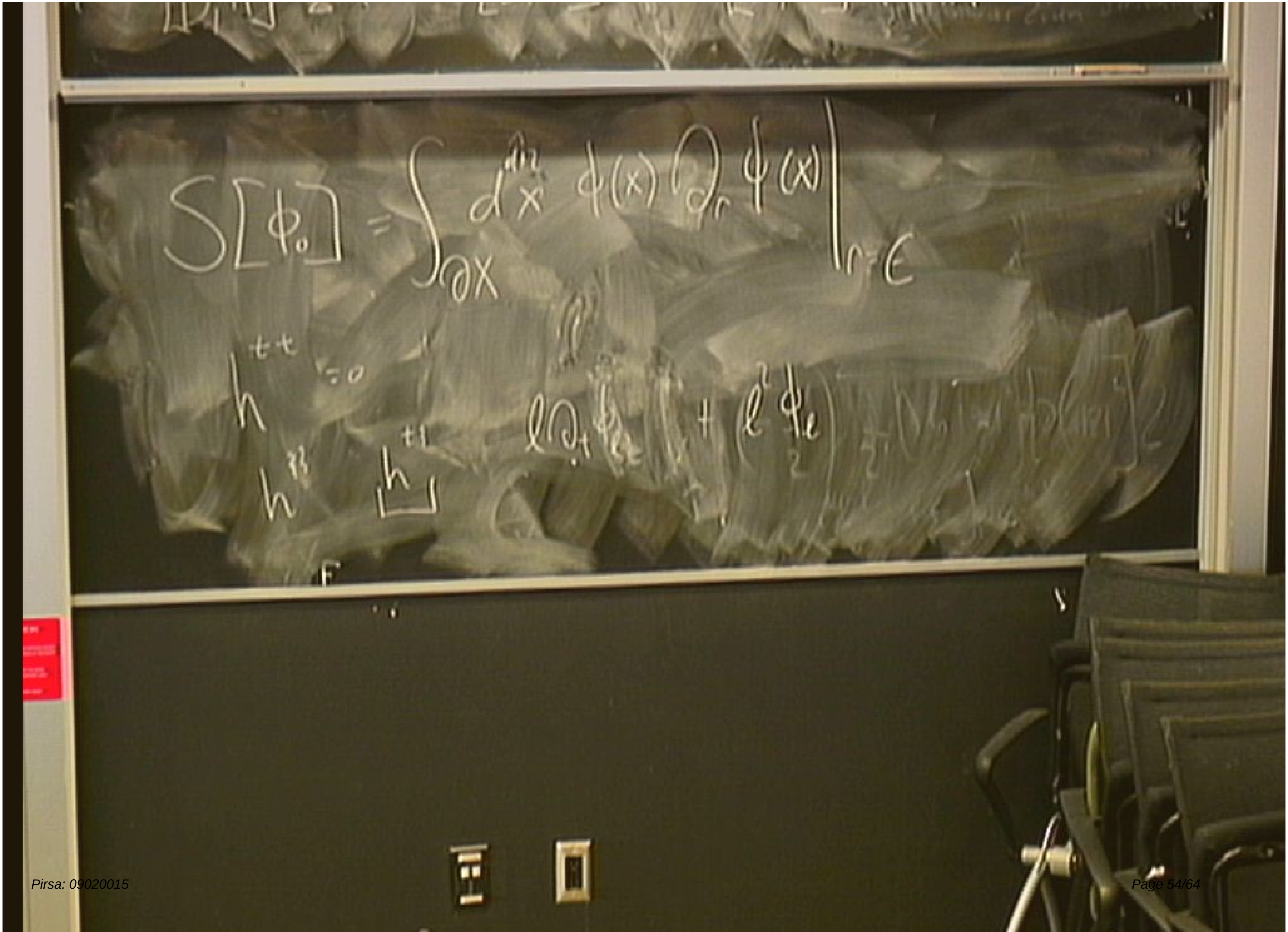

Sch
t → (1/Δ) t   ξ → Δξ
D: r → λr , x → λx
t → λ²t
ξ → λ⁰ξ
N = ∂ξ
K: x → x − vt , ξ → ξ + (v·x − v²t/2)

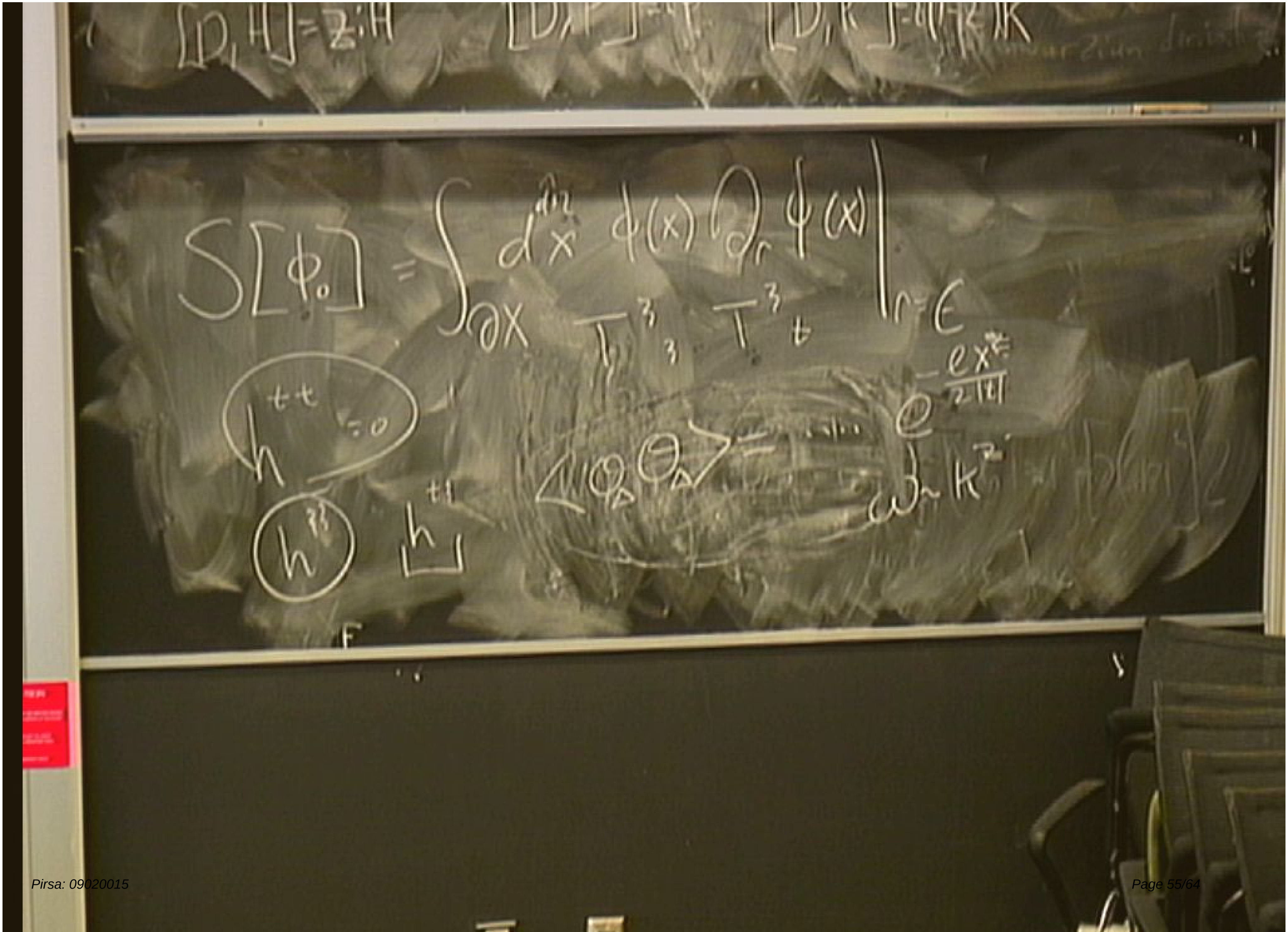


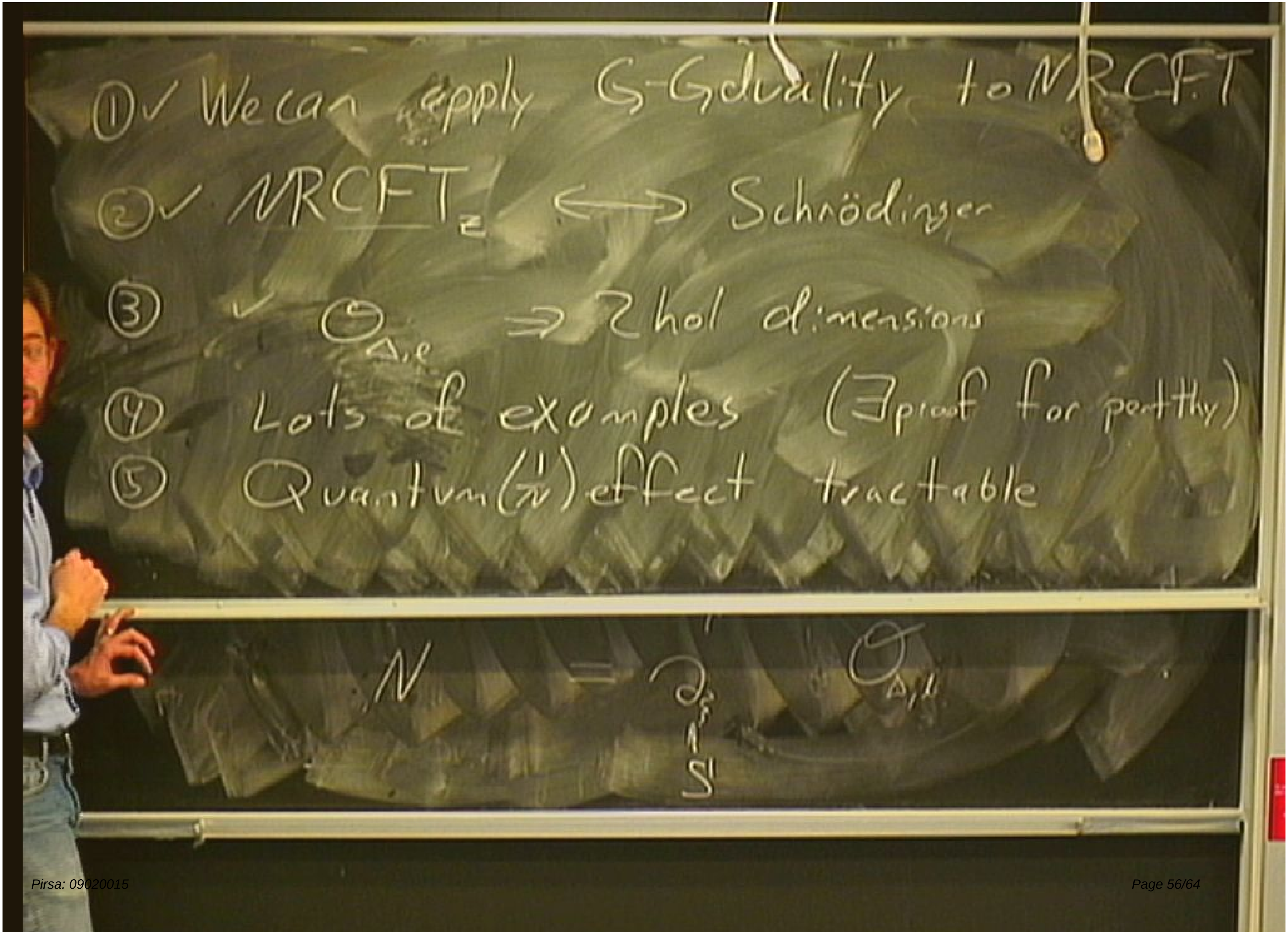


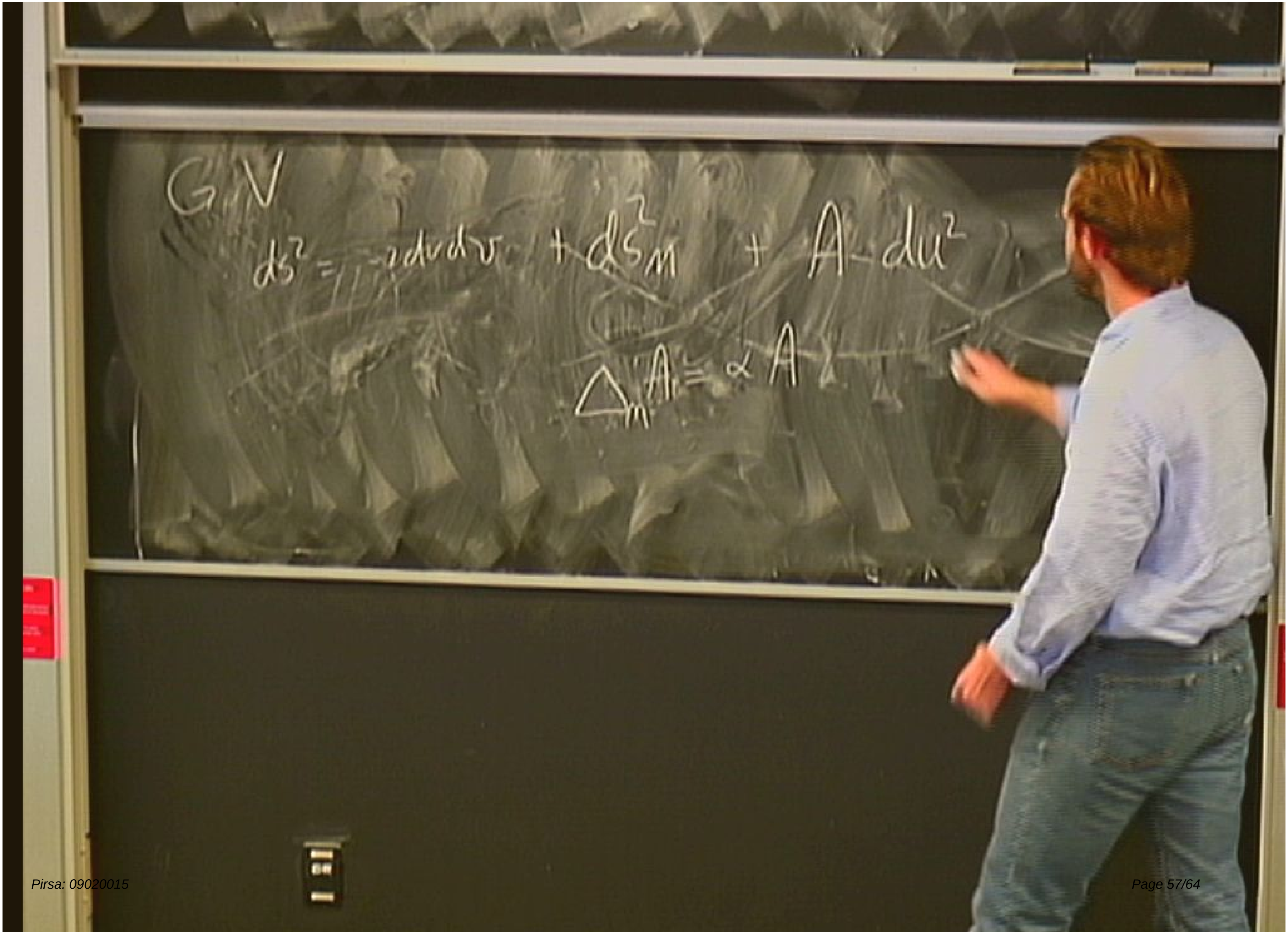
Sch
N = ∂ξ
K: x → x - vt

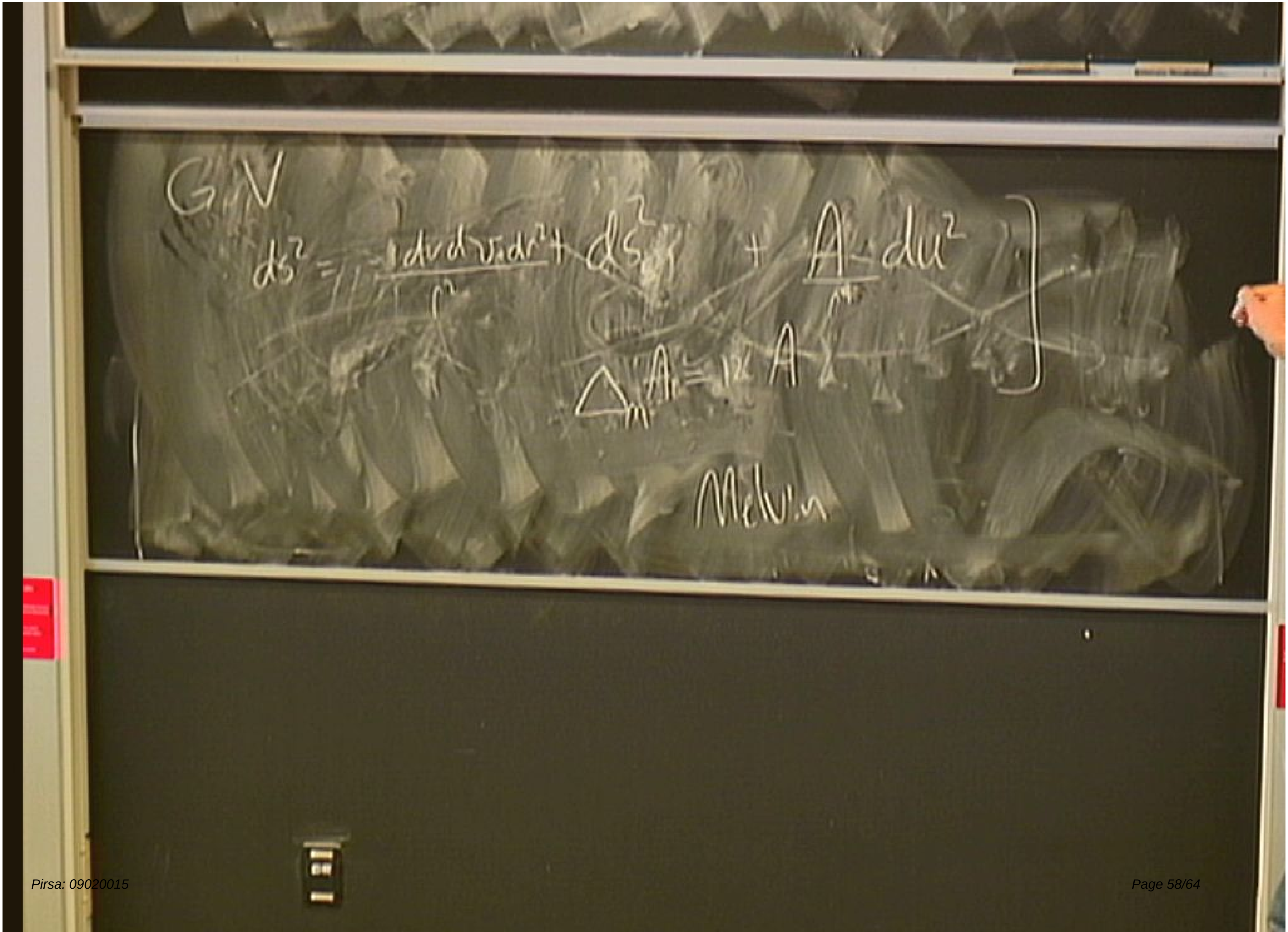

$S[\phi_0] = \int_{\partial X} d^n x \, \phi(x) \, \partial_r \phi(x) \Big|_{r=\epsilon}$

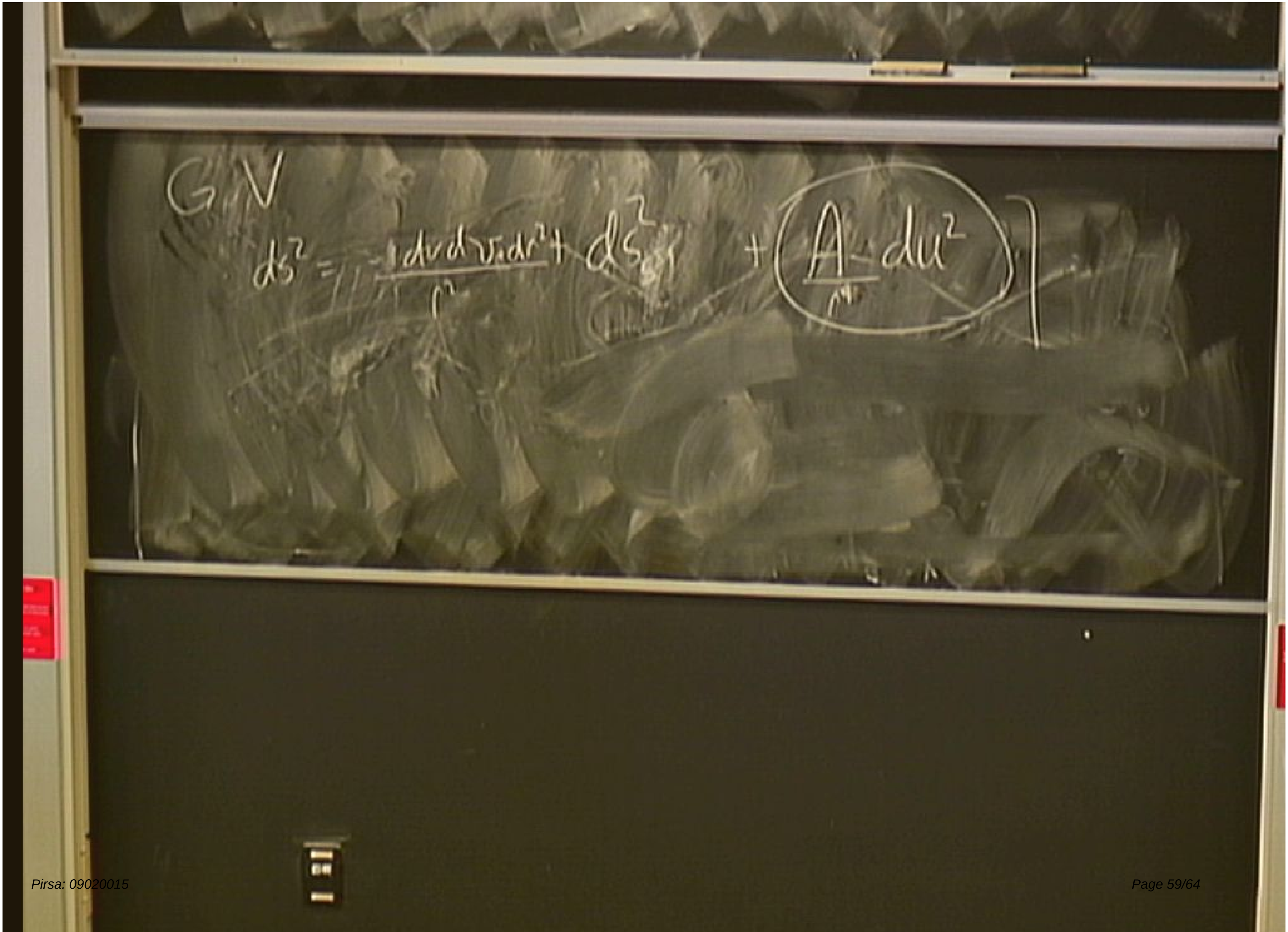

S[φ0] = ∫∂X dd+1x φ(x) ∂r φ(x) |r=ε

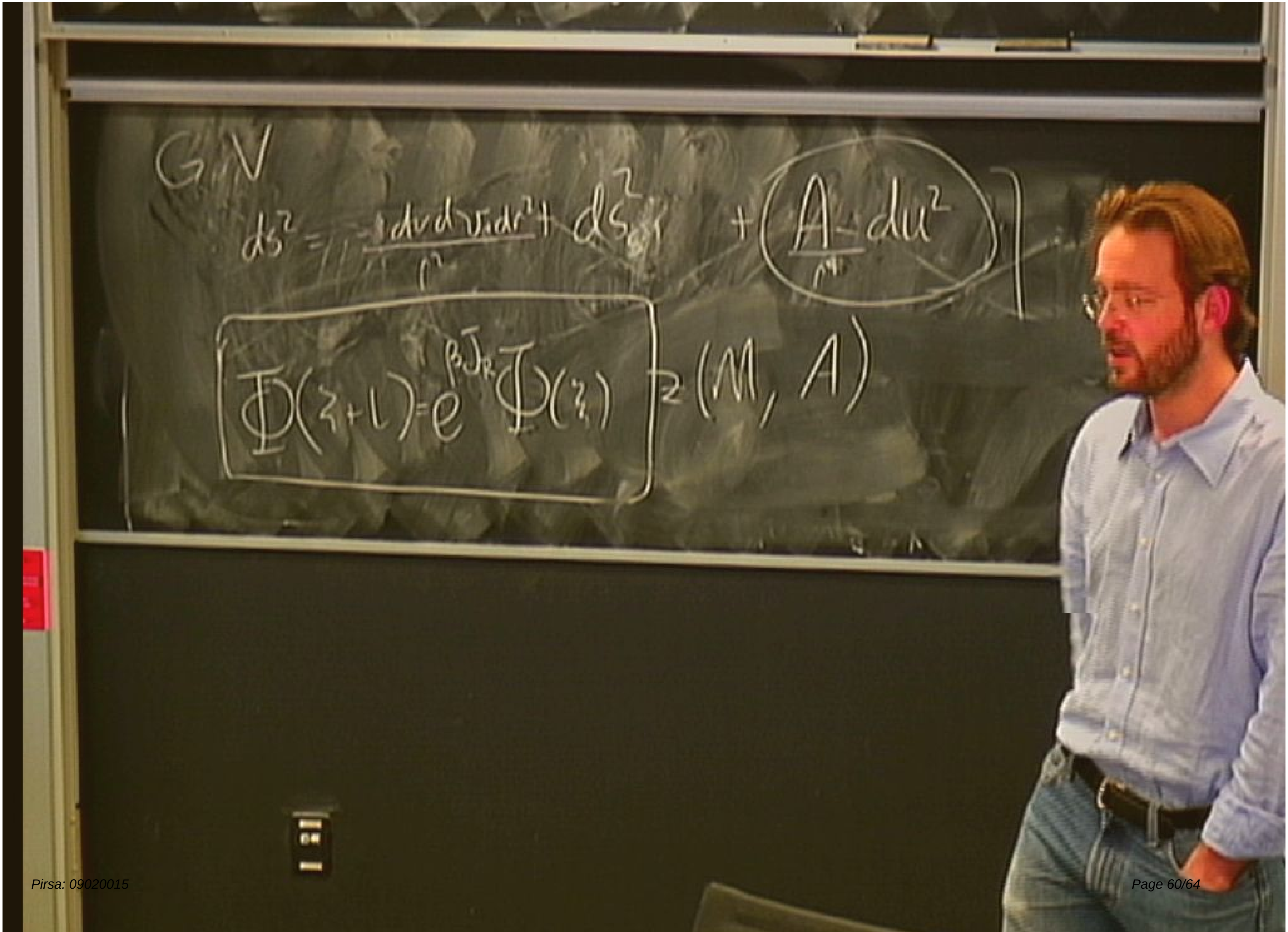

[D, H] = z i H
[D, P] = i P
[D, K] =
S[φ₀] = ∫∂X d x φ(x) ∂r φ(x) | r=ε
T 3 3
T 3 t
h tt = 0
h 33
h t1
⟨O O⟩ =
ω ~ k²


① ✓ We can apply G-G duality to NRCFT
② ✓ NRCFT_z ⟷ Schrödinger
③ ✓ O_{Δ,ℓ} ⇒ 2 hol dimensions
④ Lots of examples (∃ proof for pert thy)
⑤ Quantum (1/N) effect tractable
N = ∂_ξ O_{Δ,ℓ}
S¹


GN
ds² = -2dudv + ds²_M + A du²
Δ_M A = α A


GN
Melvin


GV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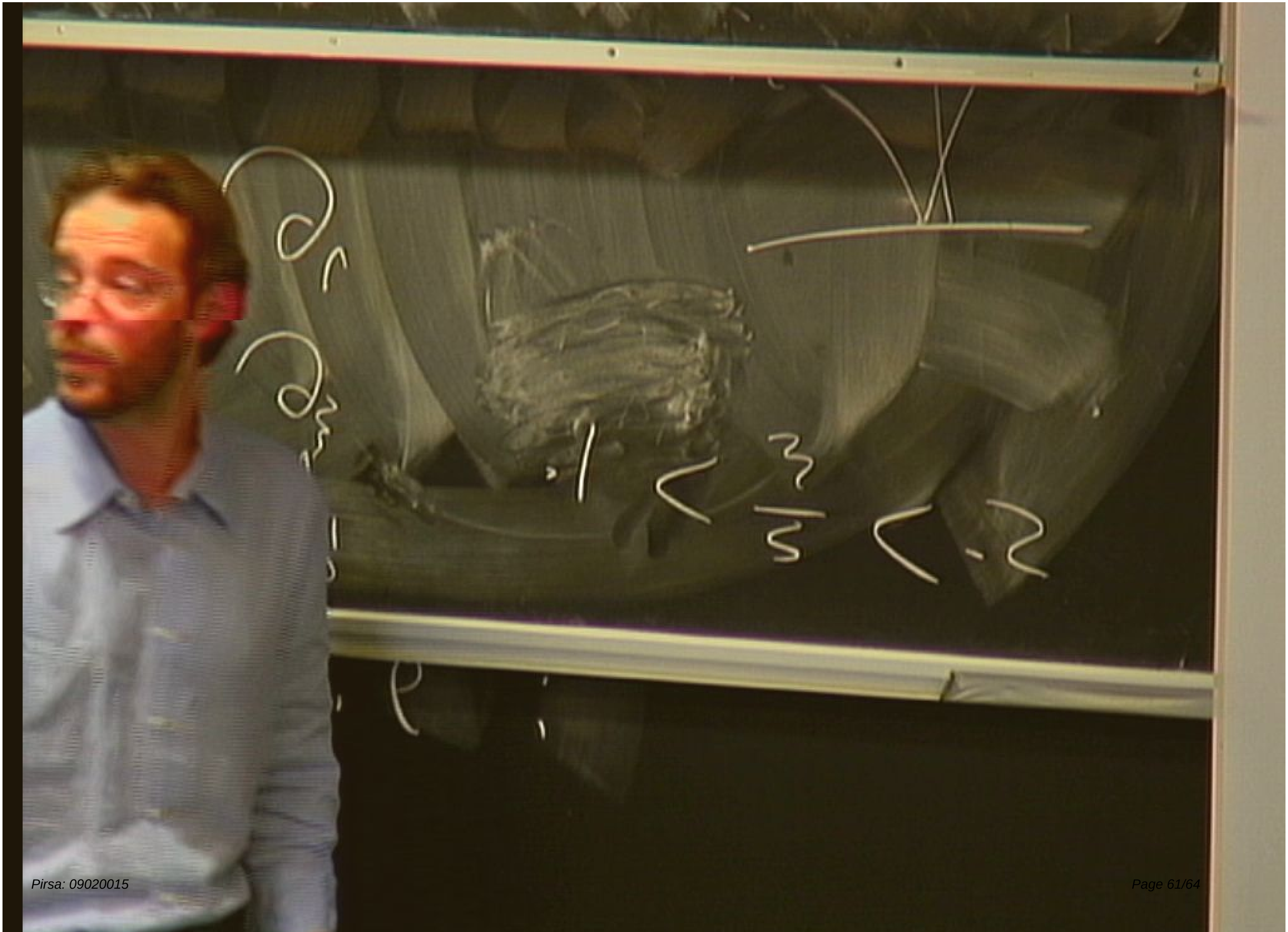

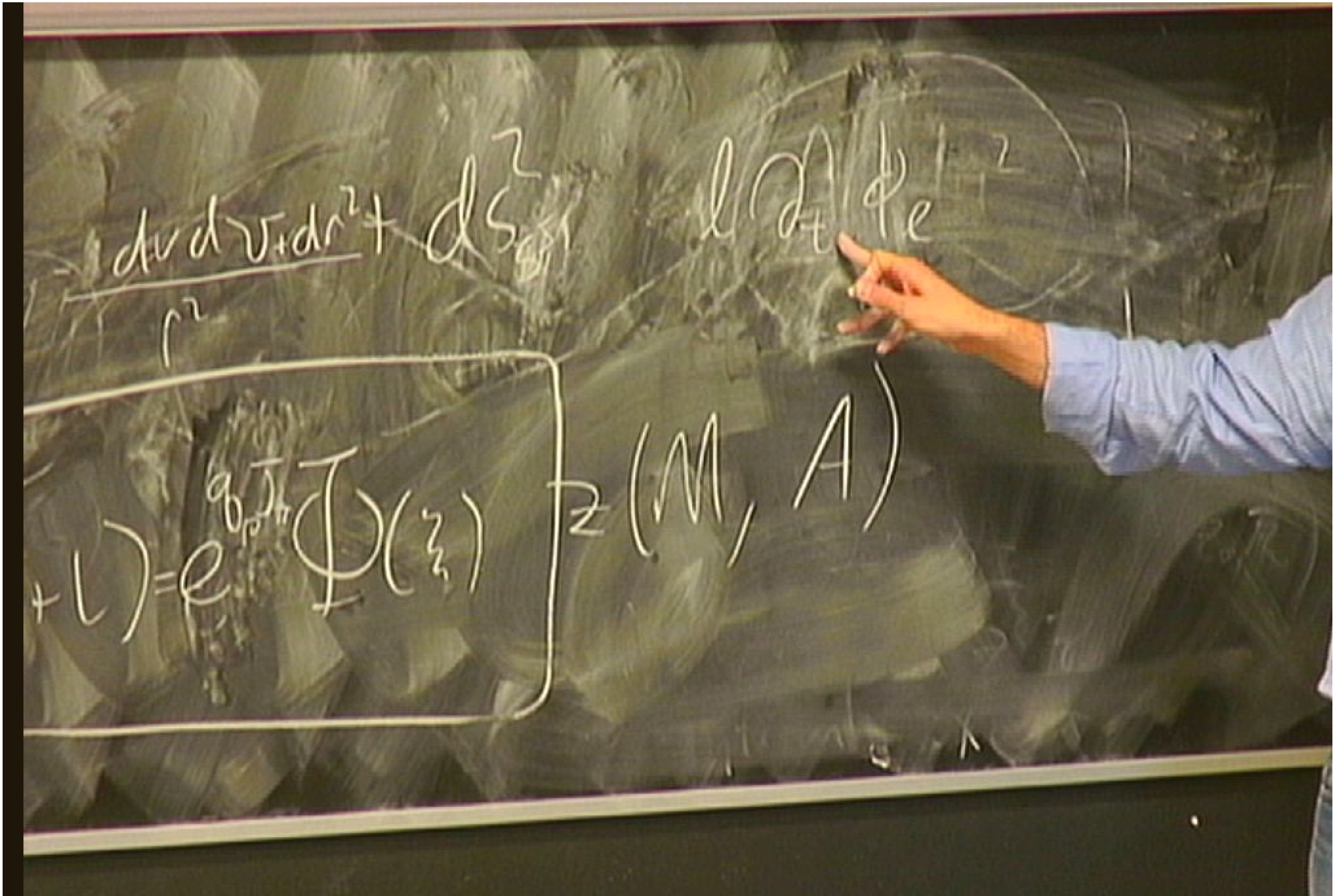

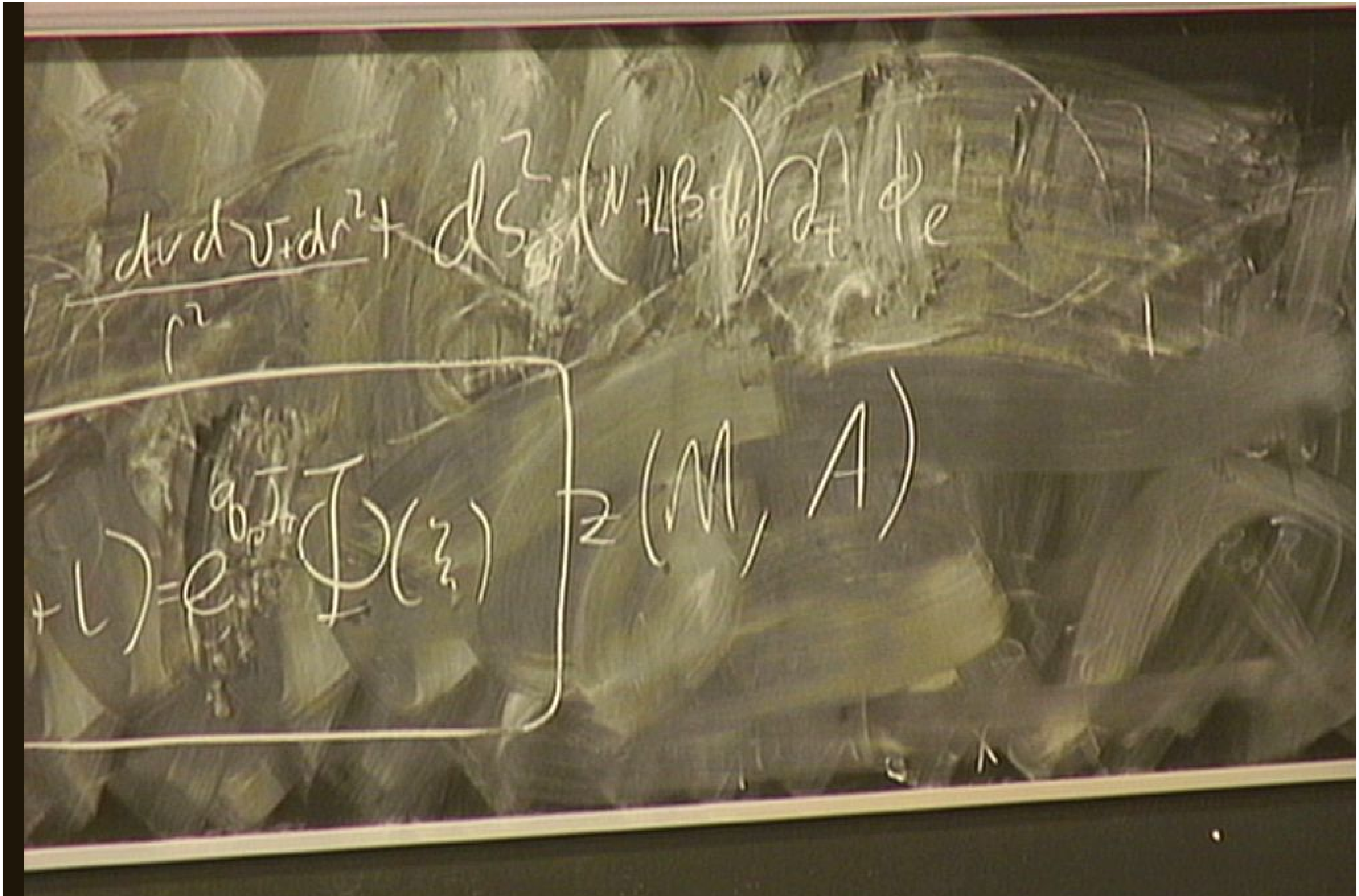
(M, A)