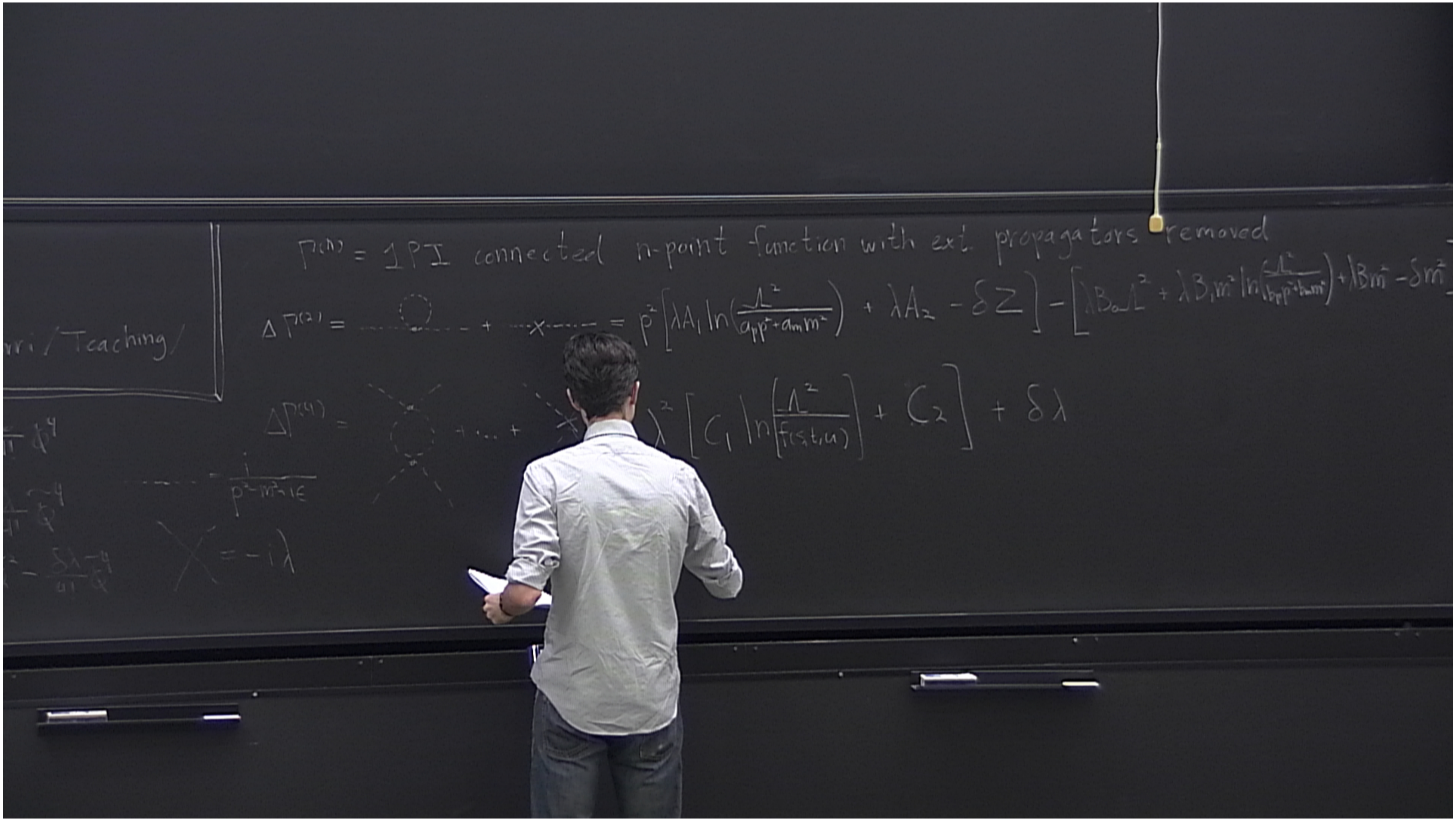
Title: PSI 2015/2016 More/Beyond Standard Model - Lecture 3

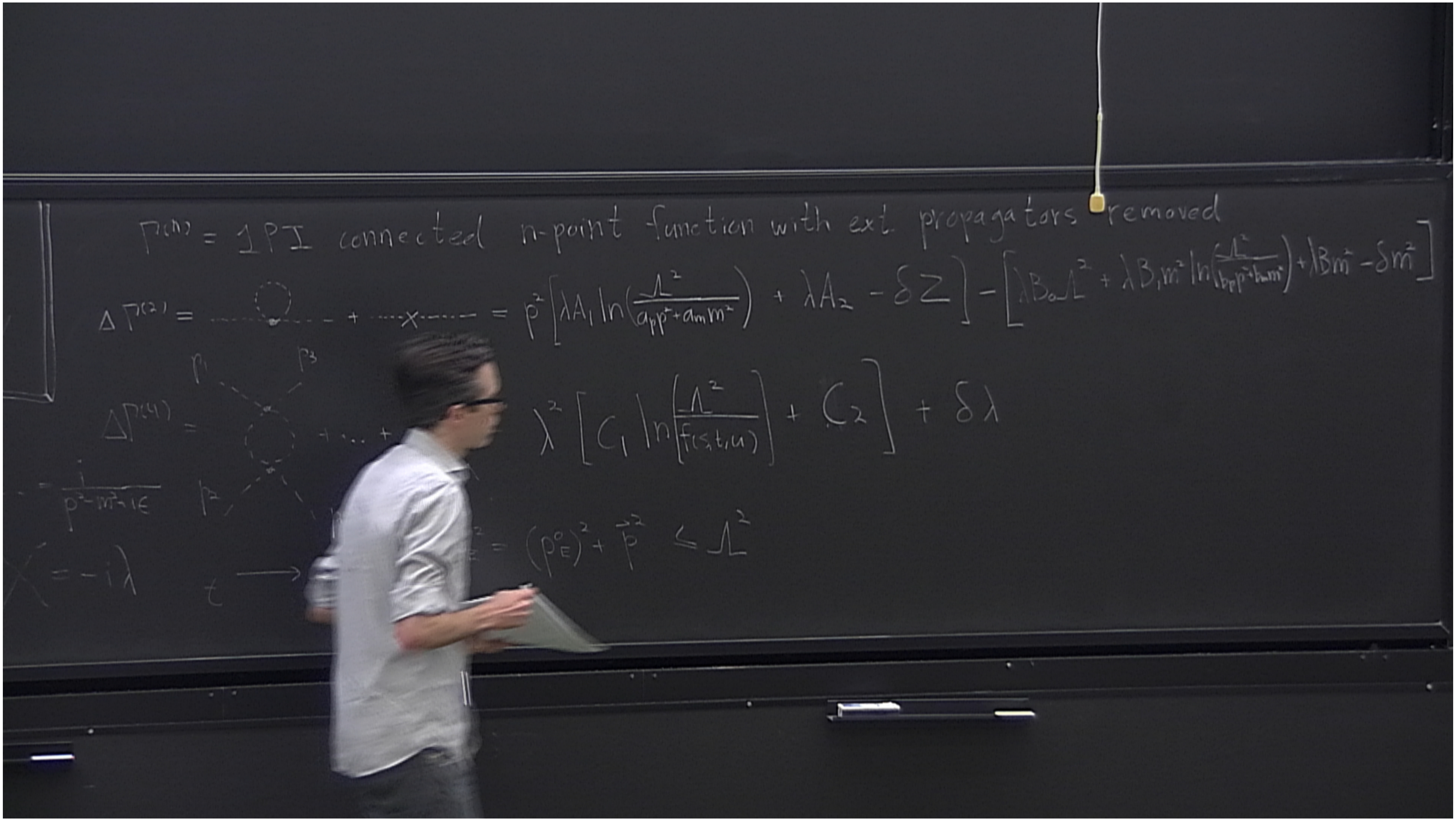
Date: Feb 24, 2016 09:00 AM

URL: http://pirsa.org/16020068

Abstract:



Γ(n) = 1PI connected n-point function with ext. propagators removed
ΔΓ(2) = p²[λA₁ ln(Λ²/(a_p p² + a_m m²)) + λA₂ − δZ] − [λB₀Λ² + λB₁m² ln(Λ²/(b_p p² + b_m m²)) + λB₂m² − δm²]
ΔΓ(4) = + ... + = λ²[C₁ ln(Λ²/f(s,t,u)) + C₂] + δλ
= −iλ
/Teaching/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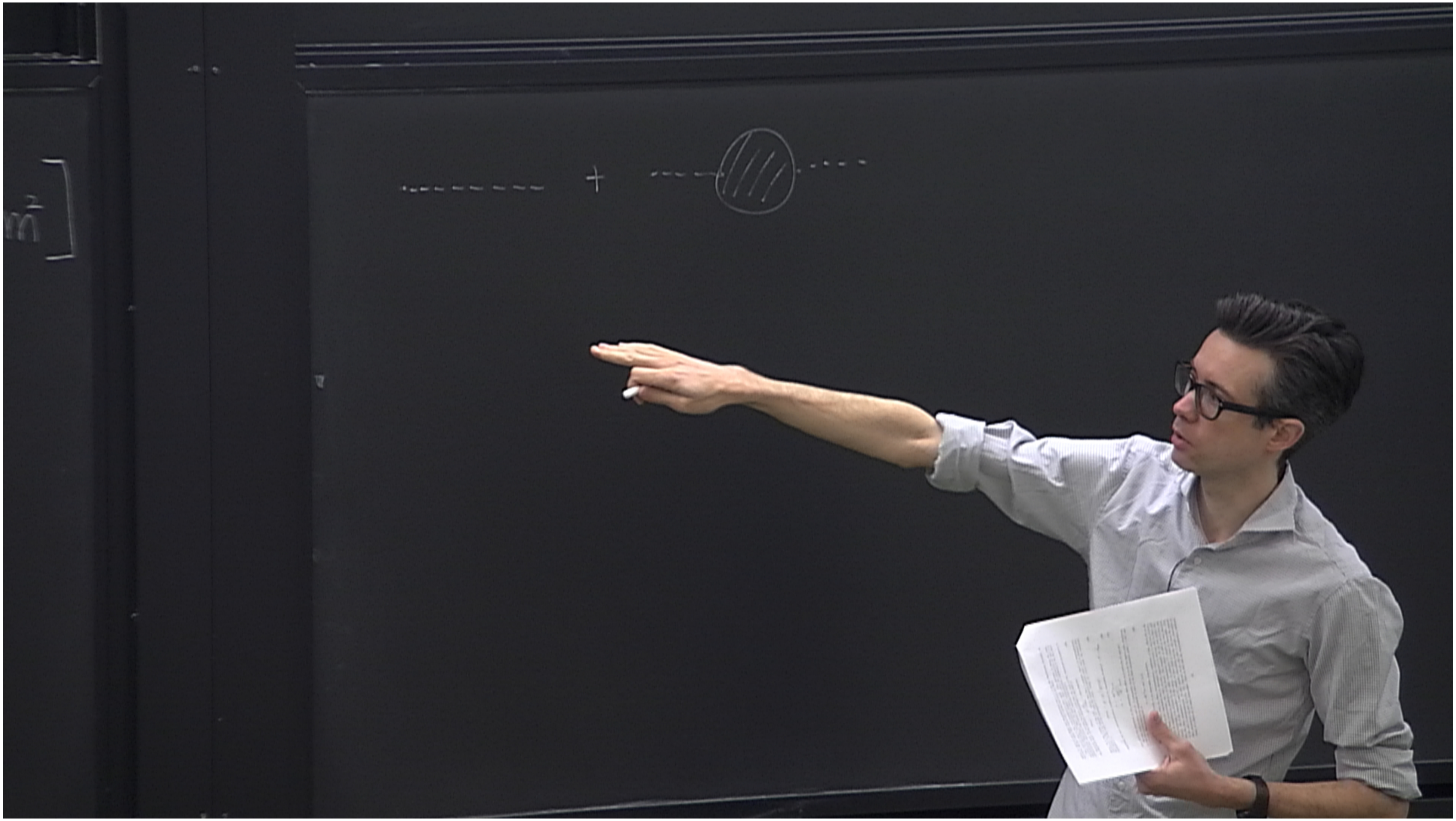
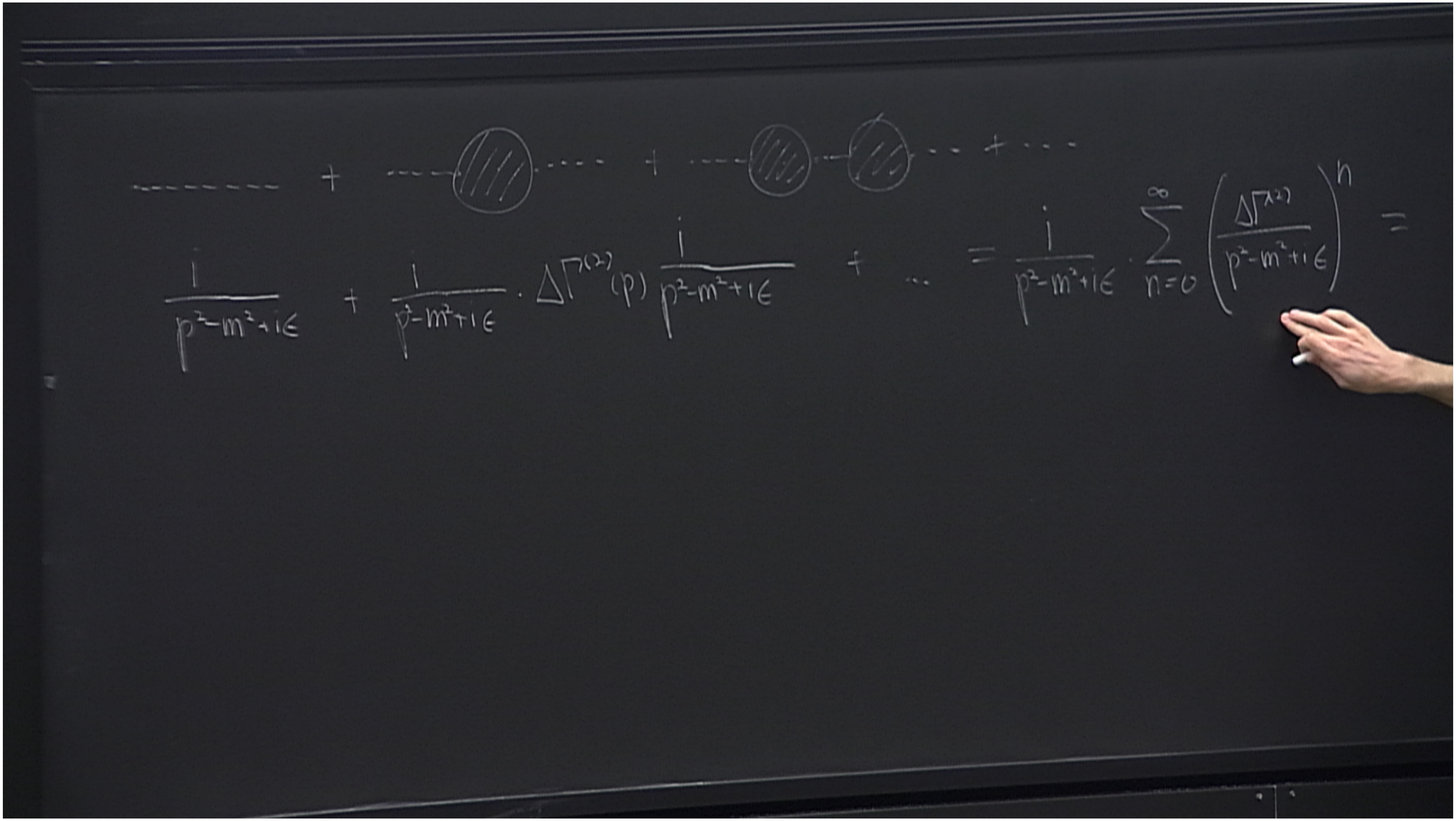
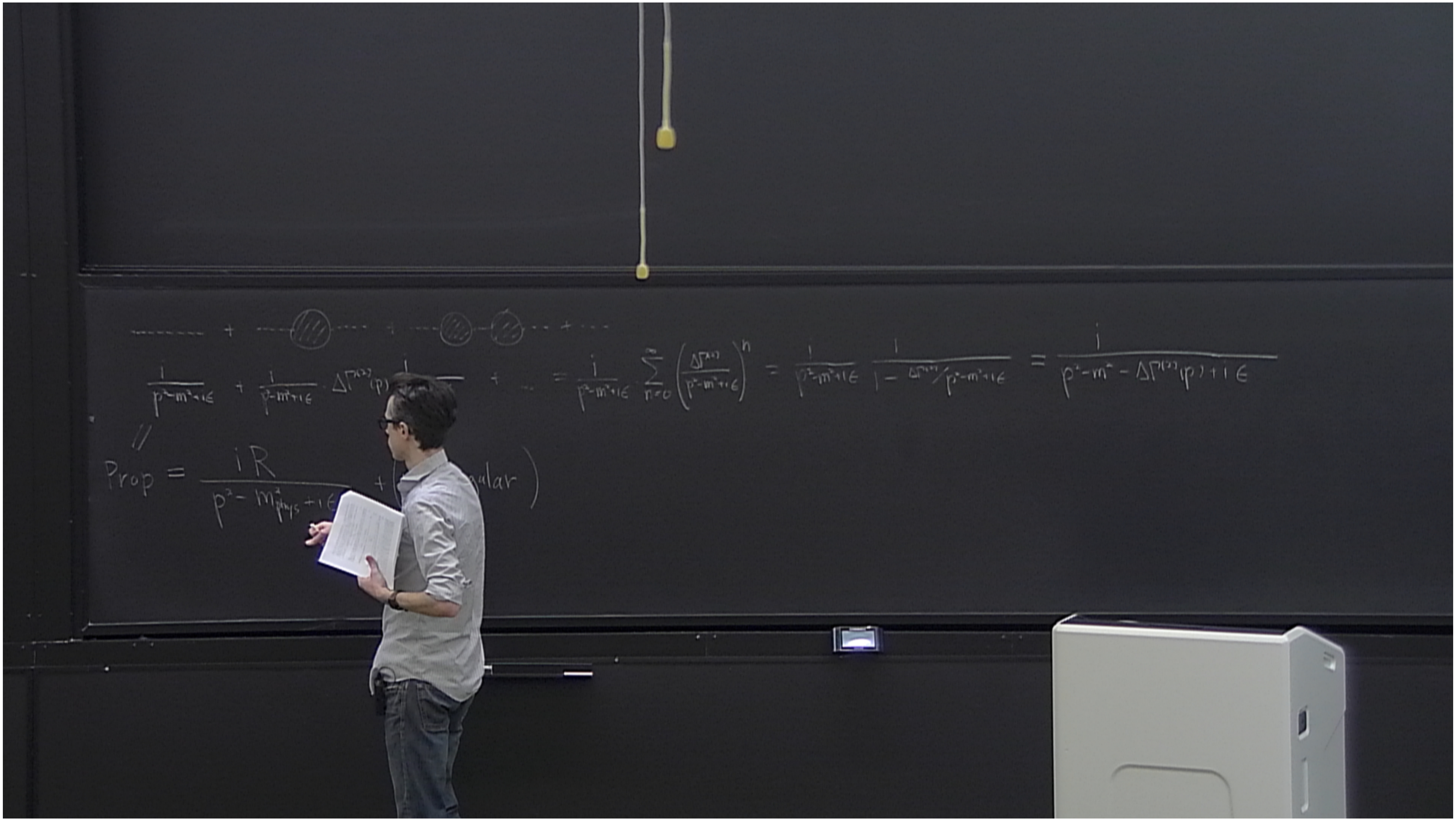
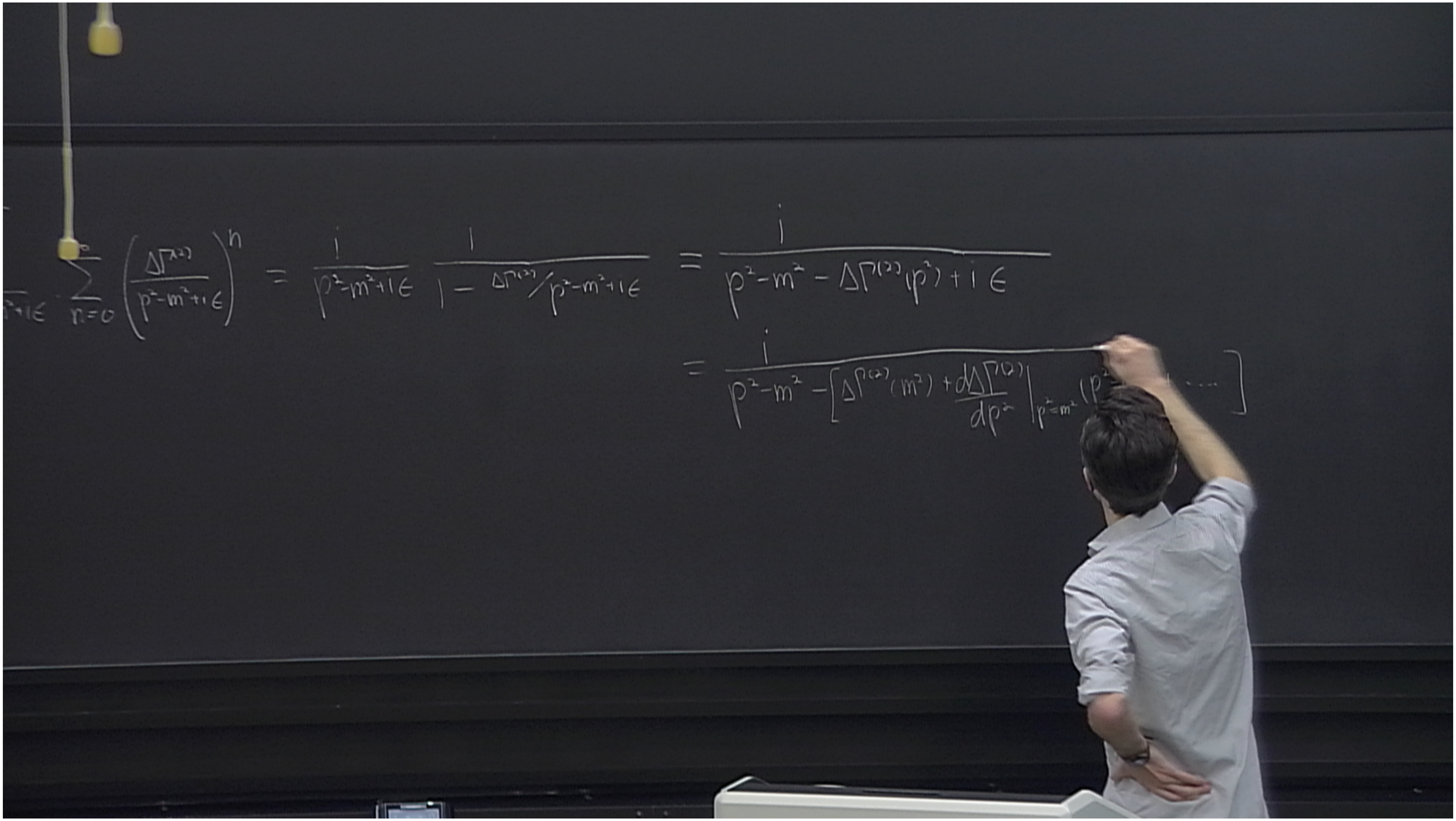
ΔΓ^(4) = λ² [C₁ ln(Λ²/f(s,t,u)) + C₂] + δλ
(p_E^0)² + p⃗² ≤ Λ²
= −iλ

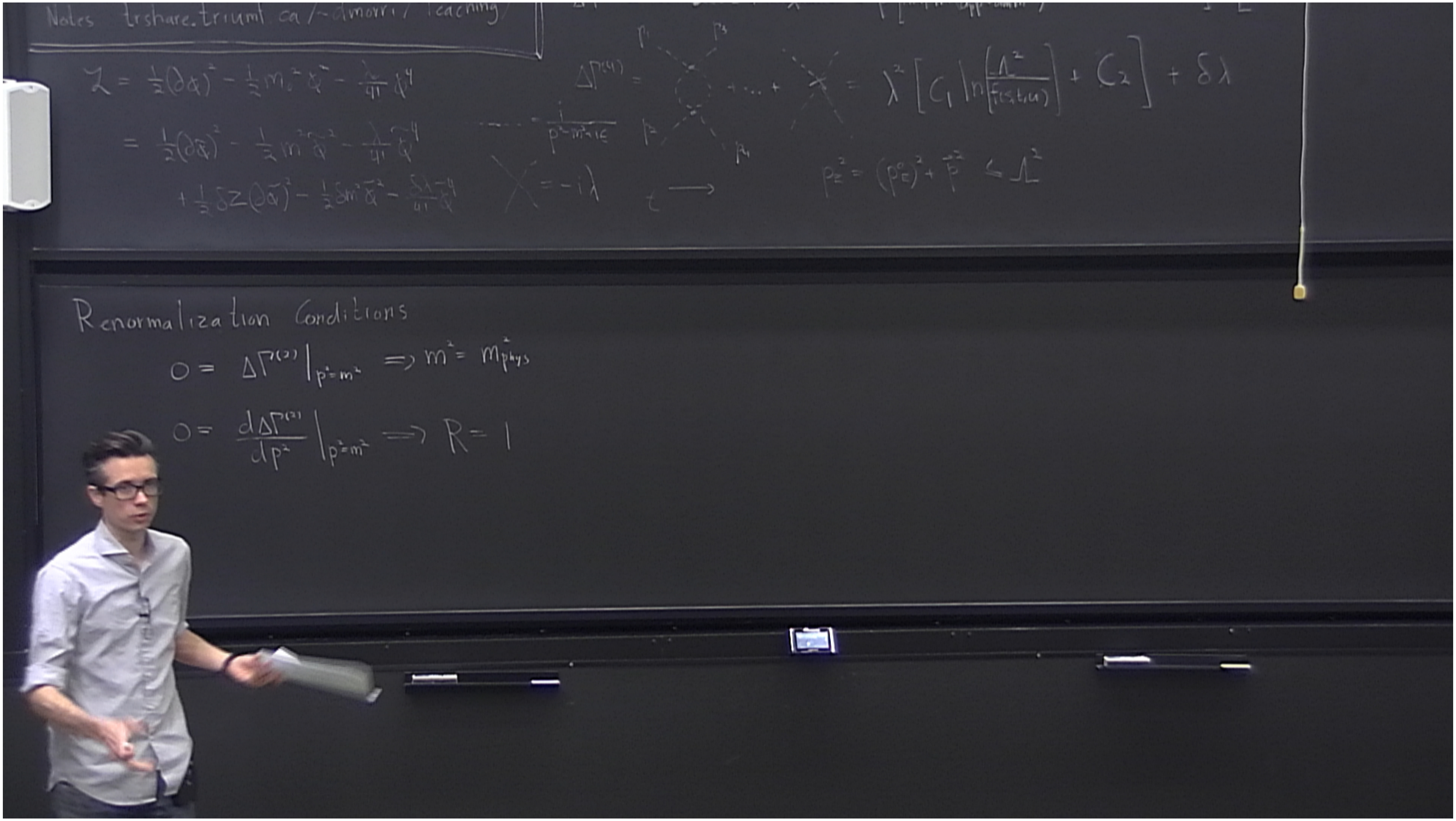


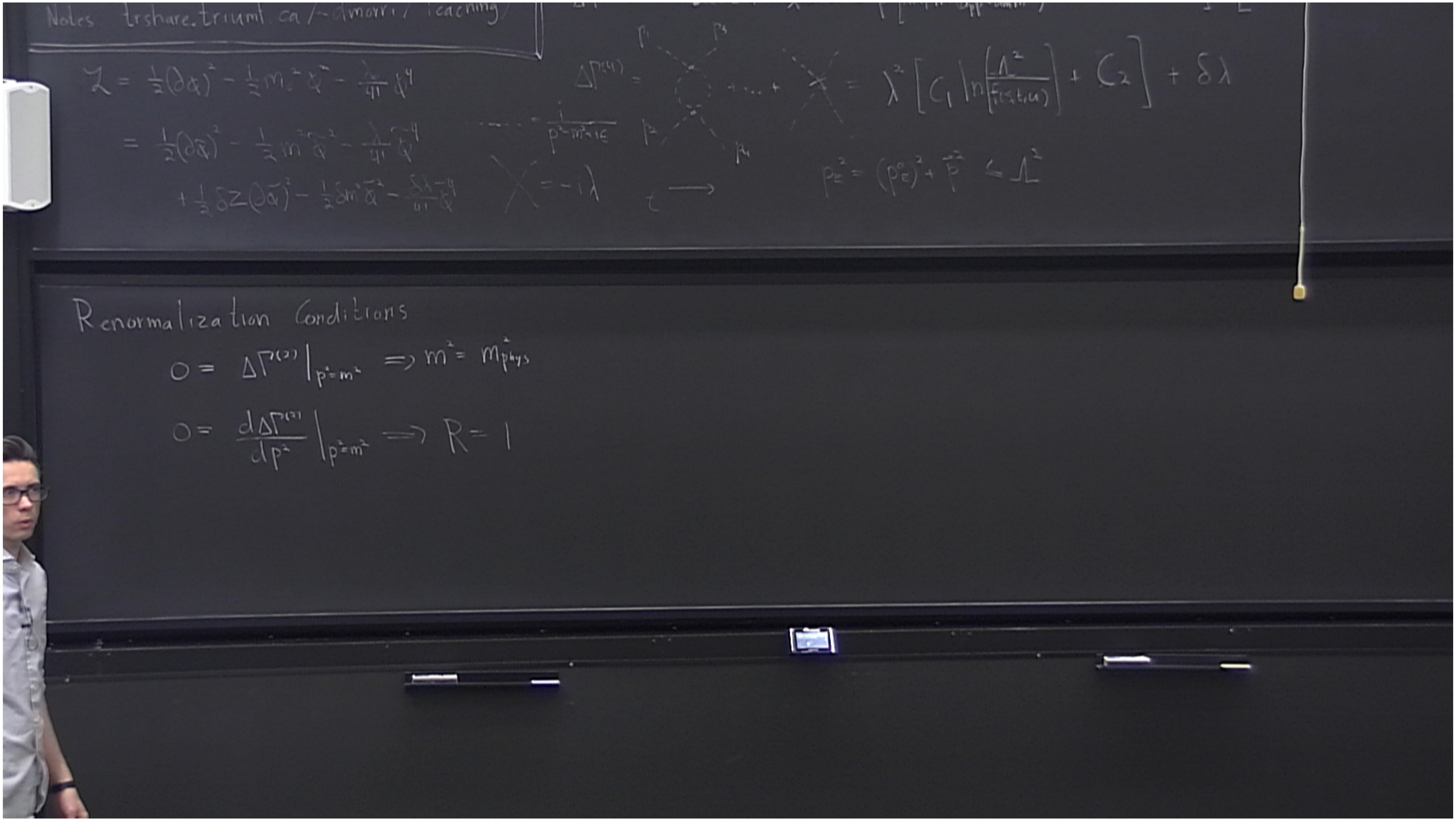

$\frac{i}{p^2-m^2+i\epsilon} + \frac{i}{p^2-m^2+i\epsilon}\cdot\Delta\Gamma^{(2)}(p)\,\frac{i}{p^2-m^2+i\epsilon} + \dots = \frac{i}{p^2-m^2+i\epsilon}\cdot\sum_{n=0}^{\infty}\left(\frac{\Delta\Gamma^{(2)}}{p^2-m^2+i\epsilon}\right)^n =$

$$\sum_{n=0} \left(\frac{\Delta\Gamma^{(2)}}{p^2-m^2+i\epsilon}\right)^n = \frac{i}{p^2-m^2+i\epsilon}\,\frac{1}{1-\Delta\Gamma^{(2)}/p^2-m^2+i\epsilon} = \frac{i}{p^2-m^2-\Delta\Gamma^{(2)}(p)+i\epsilon}$$


Prop =
iR


$\ldots + i\epsilon \sum_{n=0}^{\infty} \left(\frac{\Delta\Gamma^{(2)}}{p^2-m^2+i\epsilon} \right)^n = \frac{i}{p^2-m^2+i\epsilon} \frac{1}{1 - \Delta\Gamma^{(2)} / p^2-m^2+i\epsilon} = \frac{i}{p^2-m^2-\Delta\Gamma^{(2)}(p^2)+i\epsilon}$
$= \frac{i}{p^2-m^2-\left[\Delta\Gamma^{(2)}(m^2) + \frac{d\Delta\Gamma^{(2)}}{dp^2}\Big|_{p^2=m^2}(p^2 \ldots) + \ldots\right]}$


Notes trshare.triumf.ca/~dmorri/teaching/
Renormalization Conditions
0 = ΔΓ^(2) |p²=m² ⇒ m² = m²phys
0 = dΔΓ^(2)/dp² |p²=m² ⇒ R = 1



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Renormalization Conditions
0 = ΔΓ(2) | p²=m² ⟹ m² = m²phys
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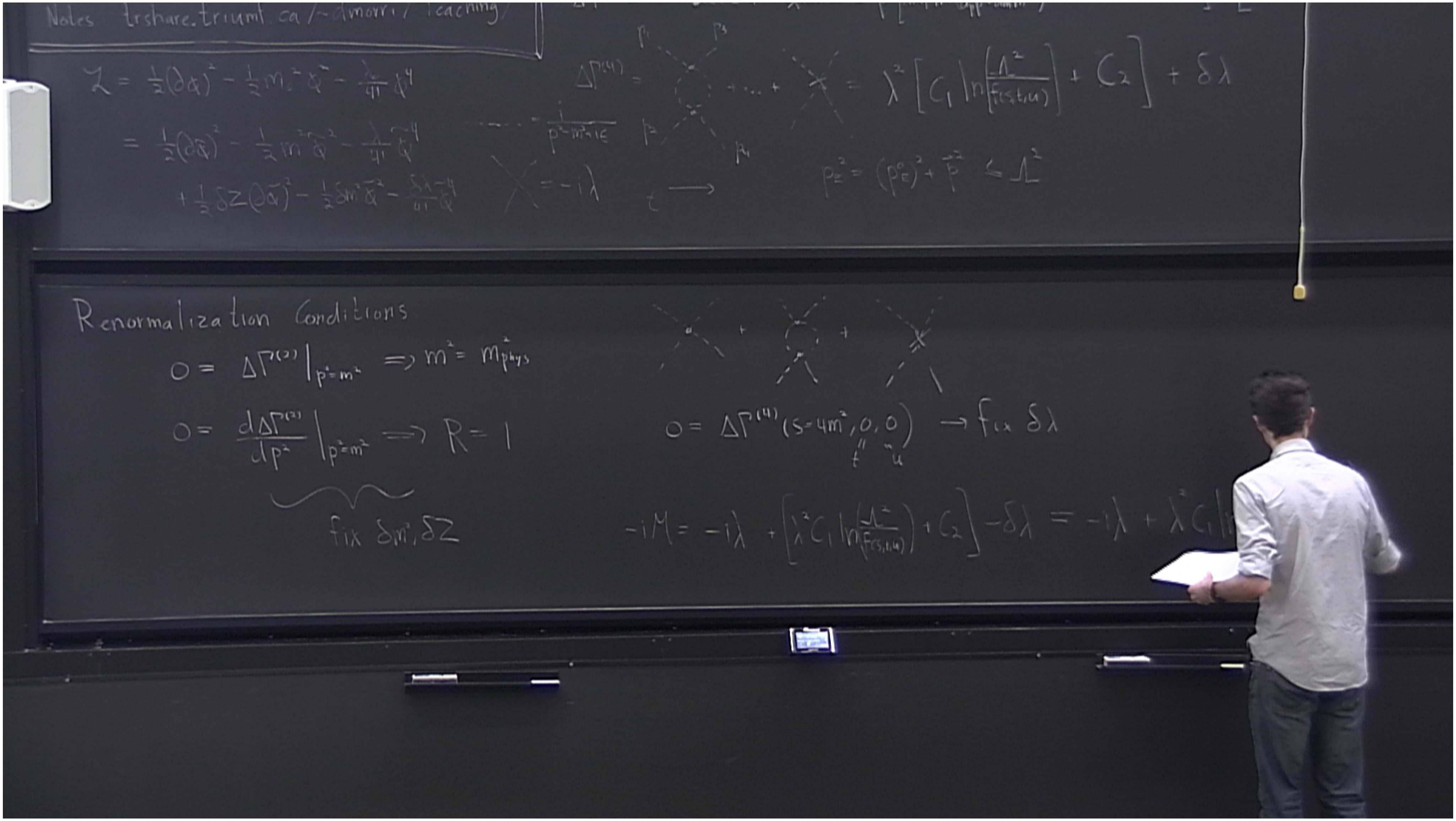
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Renormalization Conditions
0 = ΔΓ(2)|p²=m² ⇒ m² = m²phys
0 = dΔΓ(2)/dp² |p²=m² ⇒ R = 1
fix δm², δZ
0 = ΔΓ(4)(s=4m², 0, 0) → fix δλ
-iM = -iλ + [λ²C1 ln(Λ²/f(s,t,u)) + C2] - δλ = -iλ + λ²C1

Notes trshare.triumf.ca/~dmorri/Teaching/

$$\mathcal{L} = \frac{1}{2}(\partial\phi)^2 - \frac{1}{2}m_0^2\phi^2 - \frac{\lambda_0}{4!}\phi^4$$

$$= \frac{1}{2}(\partial\tilde{\phi})^2 - \frac{1}{2}m^2\tilde{\phi}^2 - \frac{\lambda}{4!}\tilde{\phi}^4$$

$$+ \frac{1}{2}\delta Z(\partial\tilde{\phi})^2 - \frac{1}{2}\delta m^2\tilde{\phi}^2 - \frac{\delta\lambda}{4!}\tilde{\phi}^4$$

$$\frac{i}{p^2 - m^2 + i\epsilon} \qquad = -i\lambda$$

$$\Delta\Gamma^{(4)} = \ldots + \ldots + \ldots = \lambda^2\left[C_1 \ln\left(\frac{\Lambda^2}{f(s,t,u)}\right) + C_2\right] + \delta\lambda$$

$$p_E^2 = (p_E^0)^2 + \vec{p}^{\,2} \leq \Lambda^2$$

Renormalization Conditions

$$0 = \Delta\Gamma^{(2)}\Big|_{p^2=m^2} \Rightarrow m^2 = m^2_{phys}$$

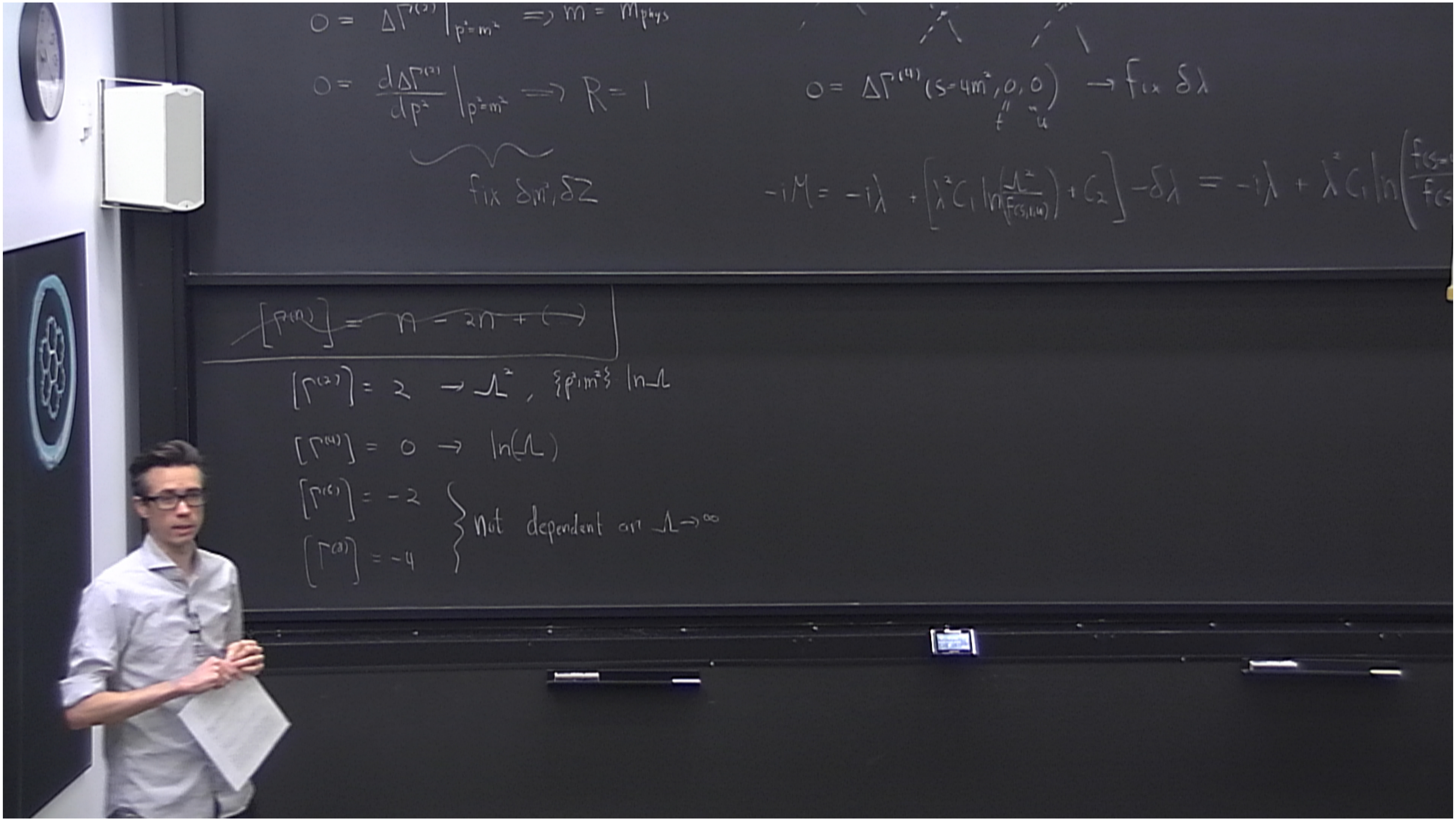
$$0 = \frac{d\Delta\Gamma^{(2)}}{dp^2}\Big|_{p^2=m^2} \Rightarrow R = 1$$

fix $\delta m^2, \delta Z$

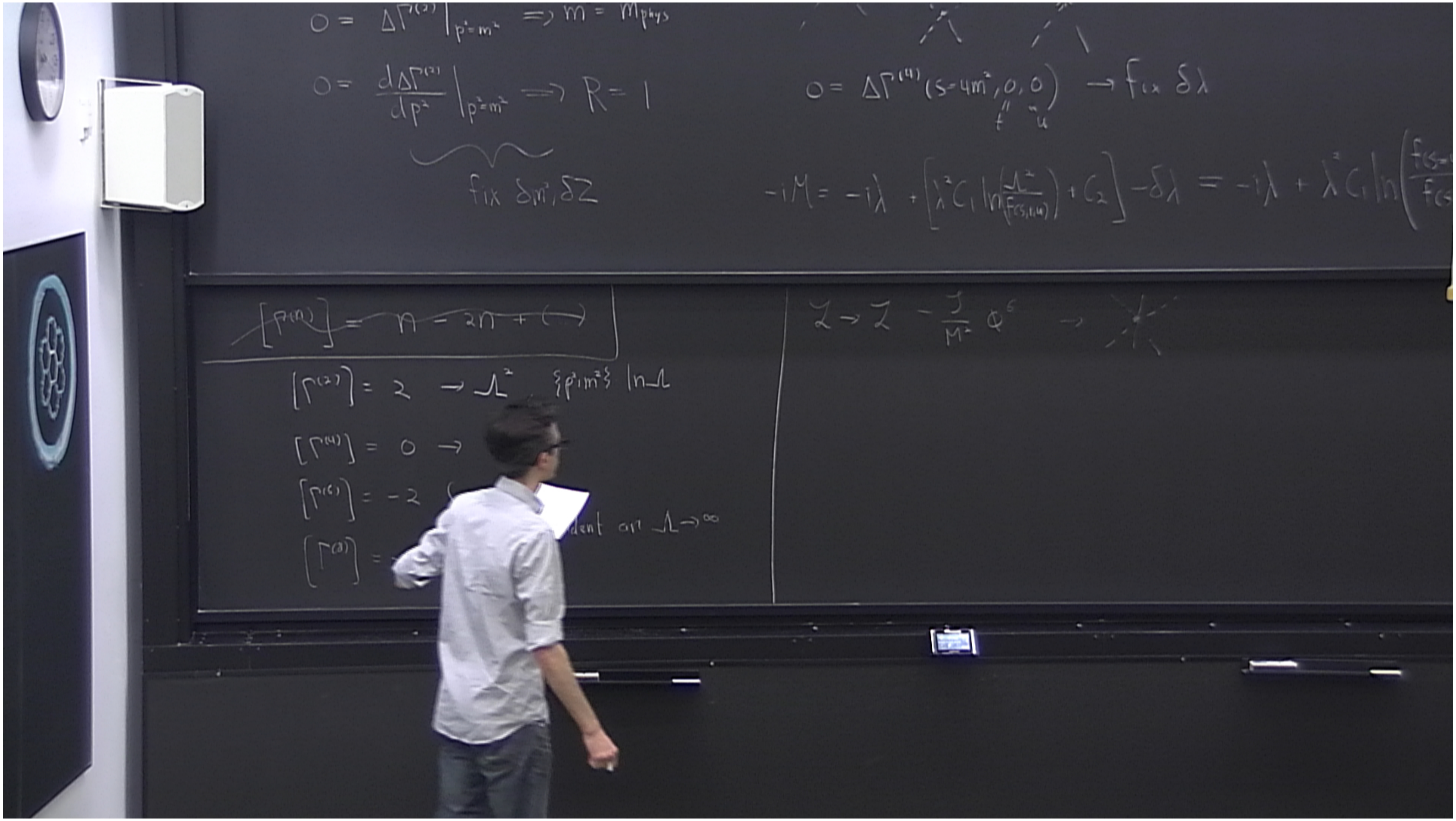
$$0 = \Delta\Gamma^{(4)}(s = 4m^2, 0, 0) \rightarrow \text{fix } \delta\lambda$$

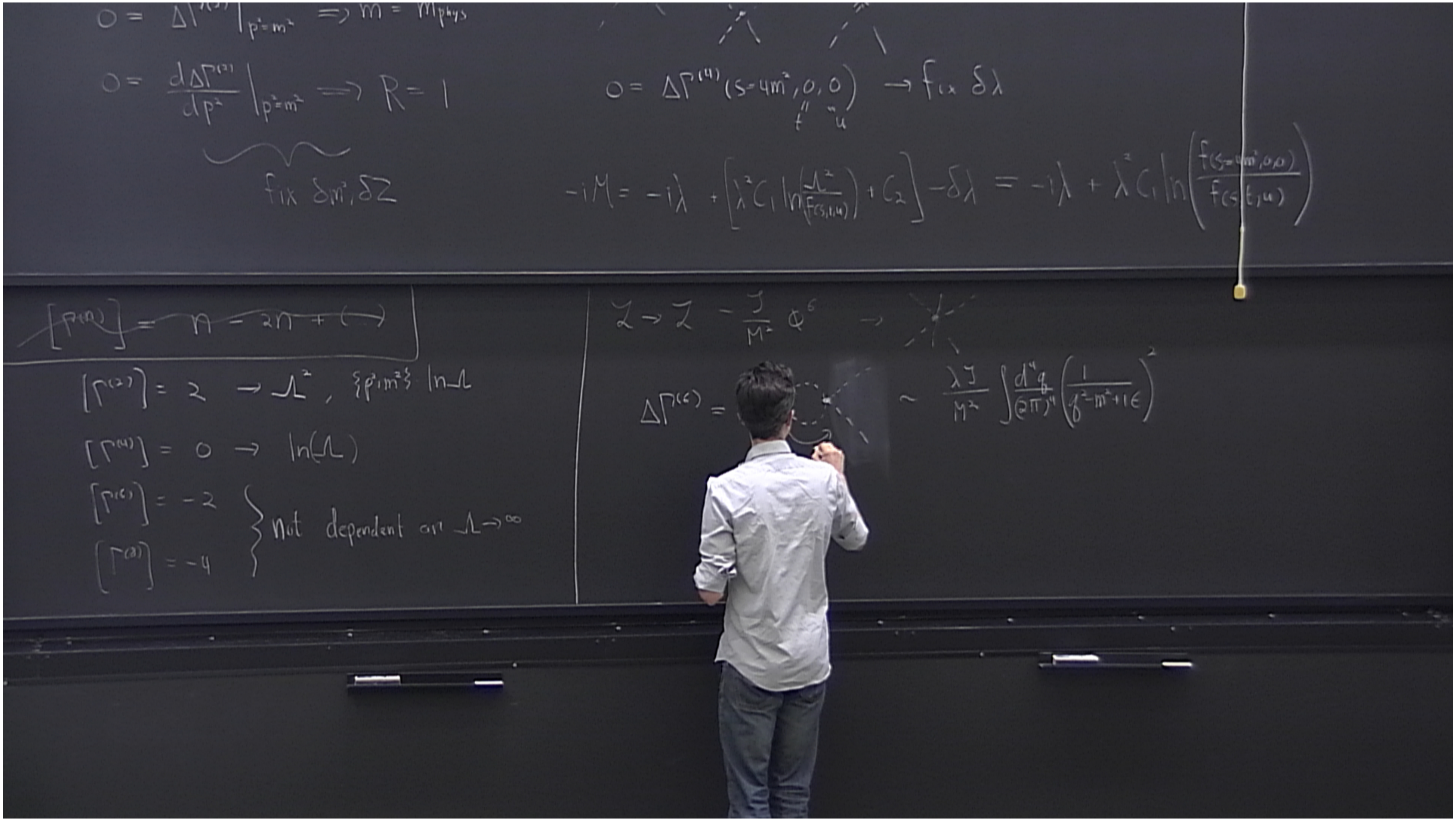
(t, u)

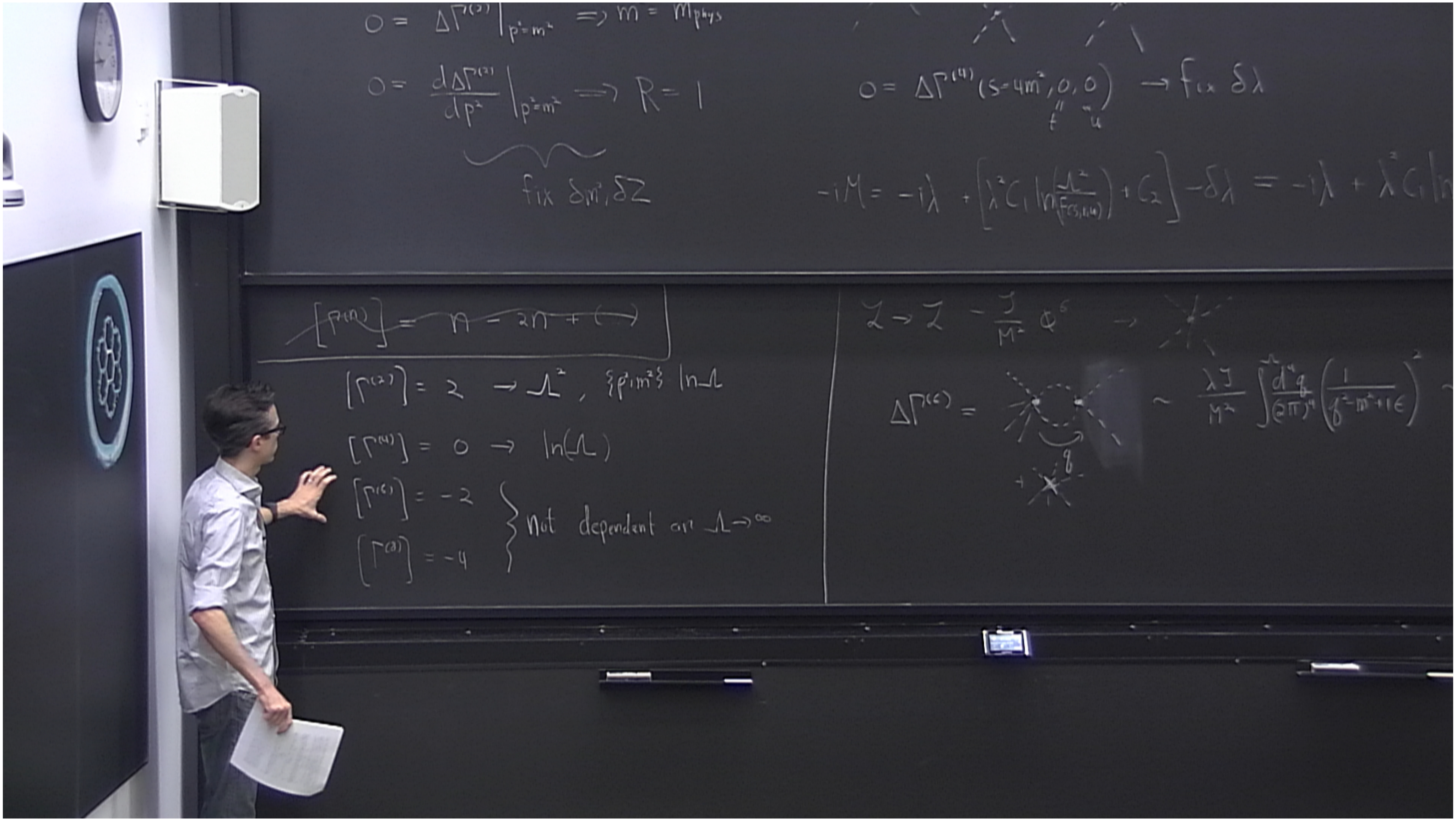
$$-i\mathcal{M} = -i\lambda + \left[\lambda^2 C_1 \ln\left(\frac{\Lambda^2}{f(s,t,u)}\right) + C_2\right] - \delta\lambda = -i\lambda + \lambda^2 C_1 \ln\left(\frac{f(s=4m^2,0,0)}{f(s,t,u)}\right)$$

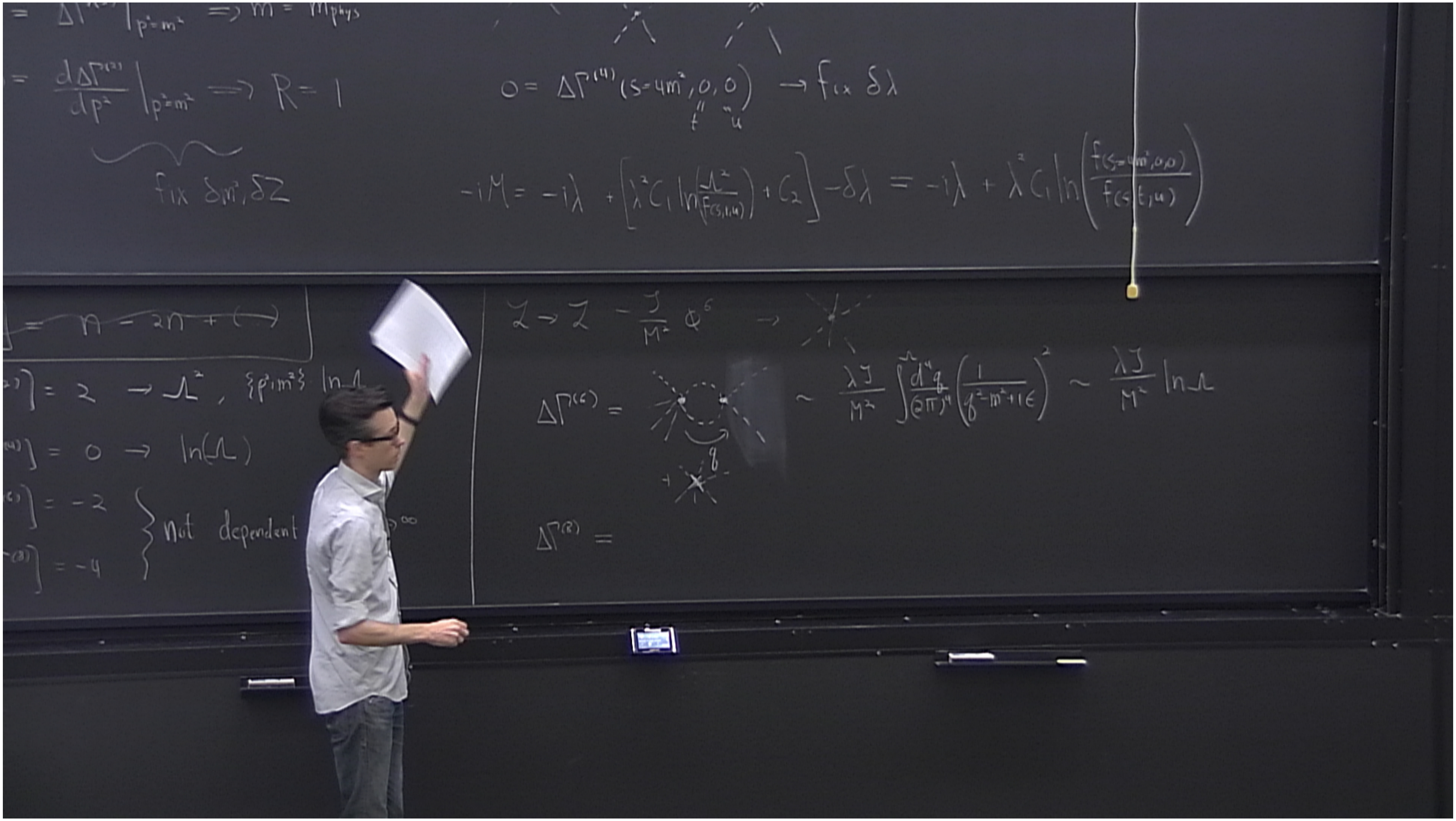


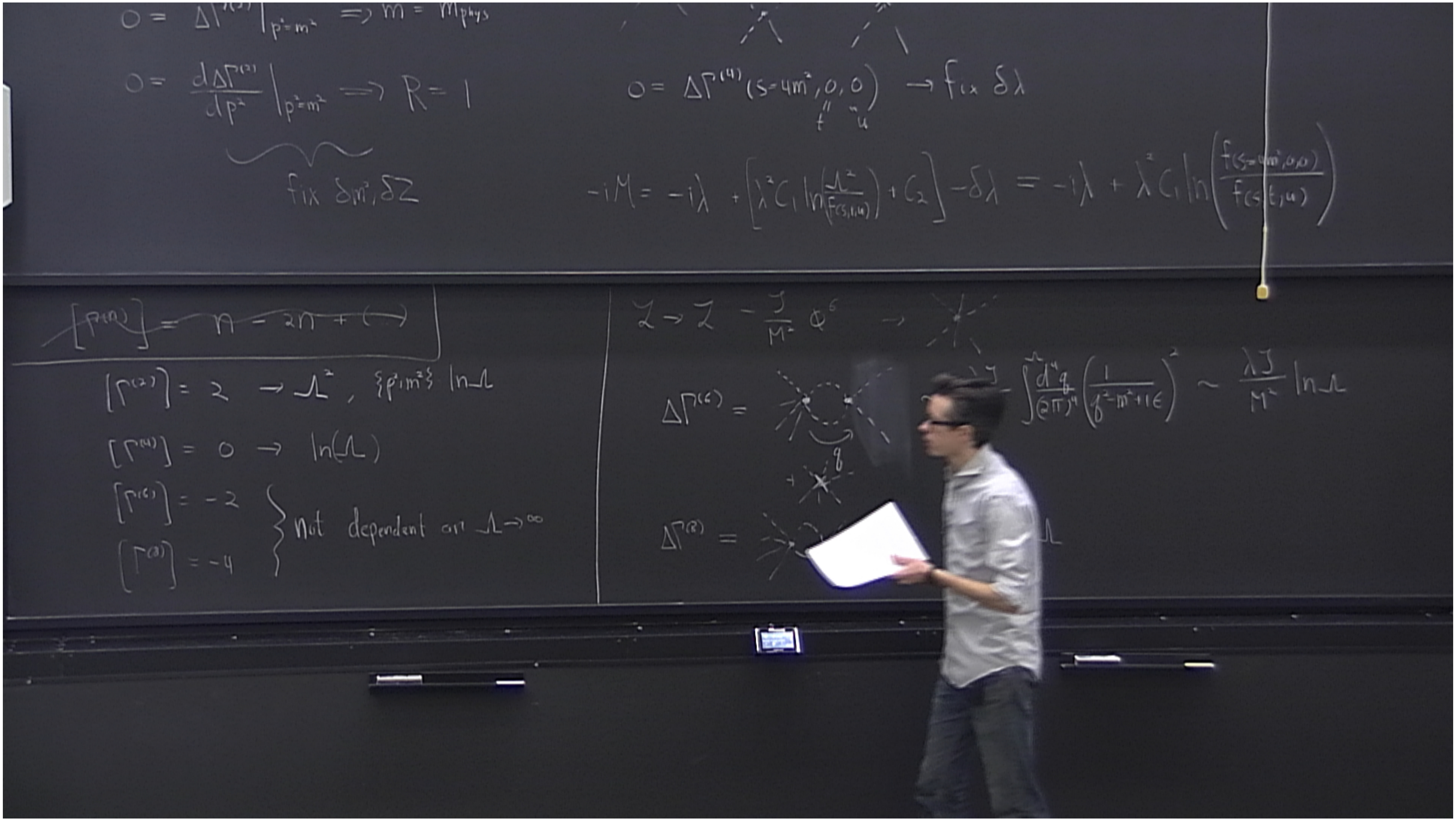
fix δm², δZ
fix δλ
not dependent on Λ→∞


fix δm², δZ
→ fix δλ
dent on Λ→∞

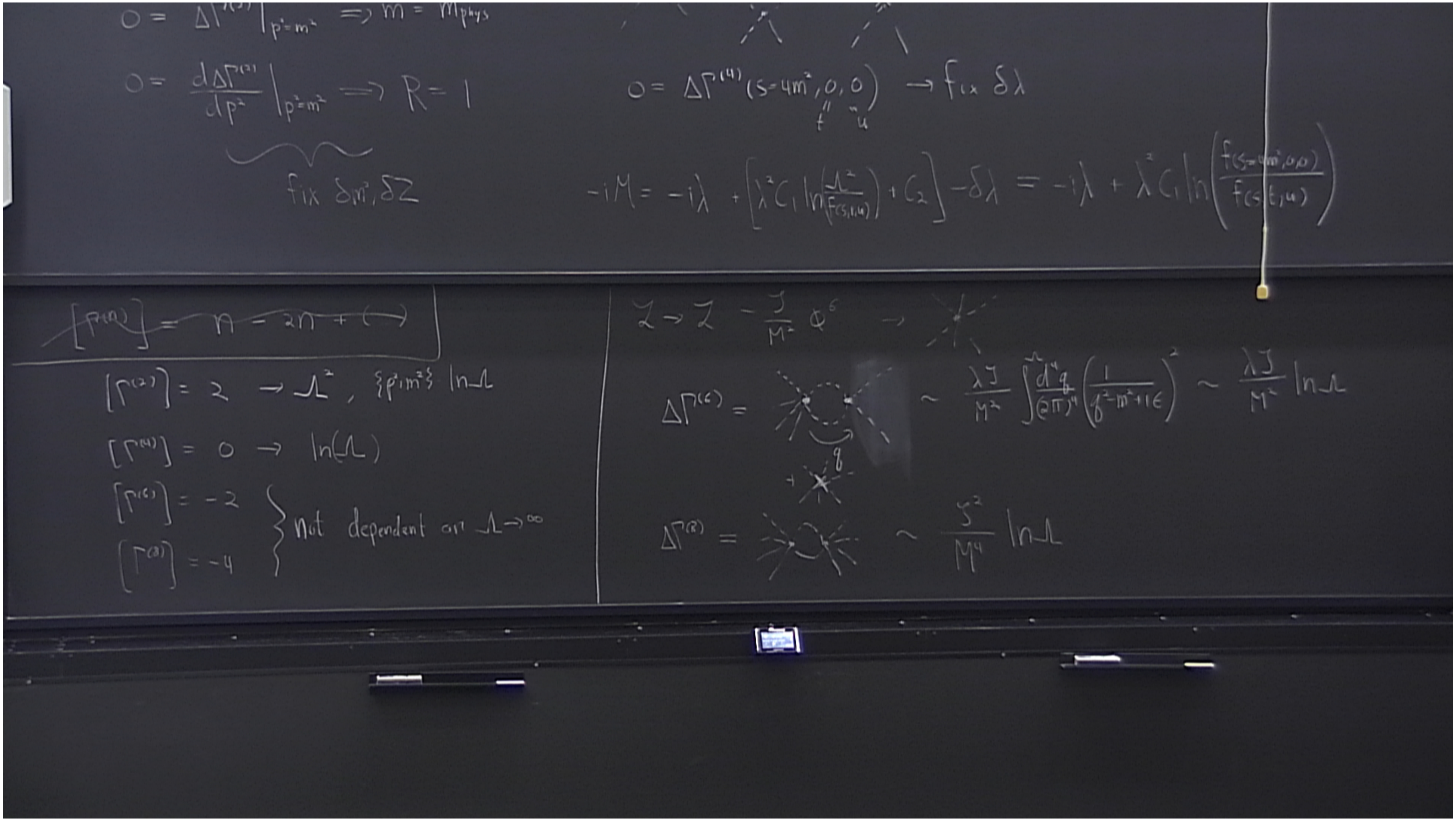

O = dΔΓ^(2)/dp² |p²=m² ⇒ R = 1
fix δm², δZ
O = ΔΓ^(4)(s=4m², 0, 0) → fix δλ
[Γ^(2)] = 2 → Λ², {p², m²} ln Λ
[Γ^(4)] = 0 → ln(Λ)
[Γ^(6)] = −2
[Γ^(8)] = −4
not dependent on Λ→∞
ℒ → ℒ − J/M² φ⁶
ΔΓ^(6) =

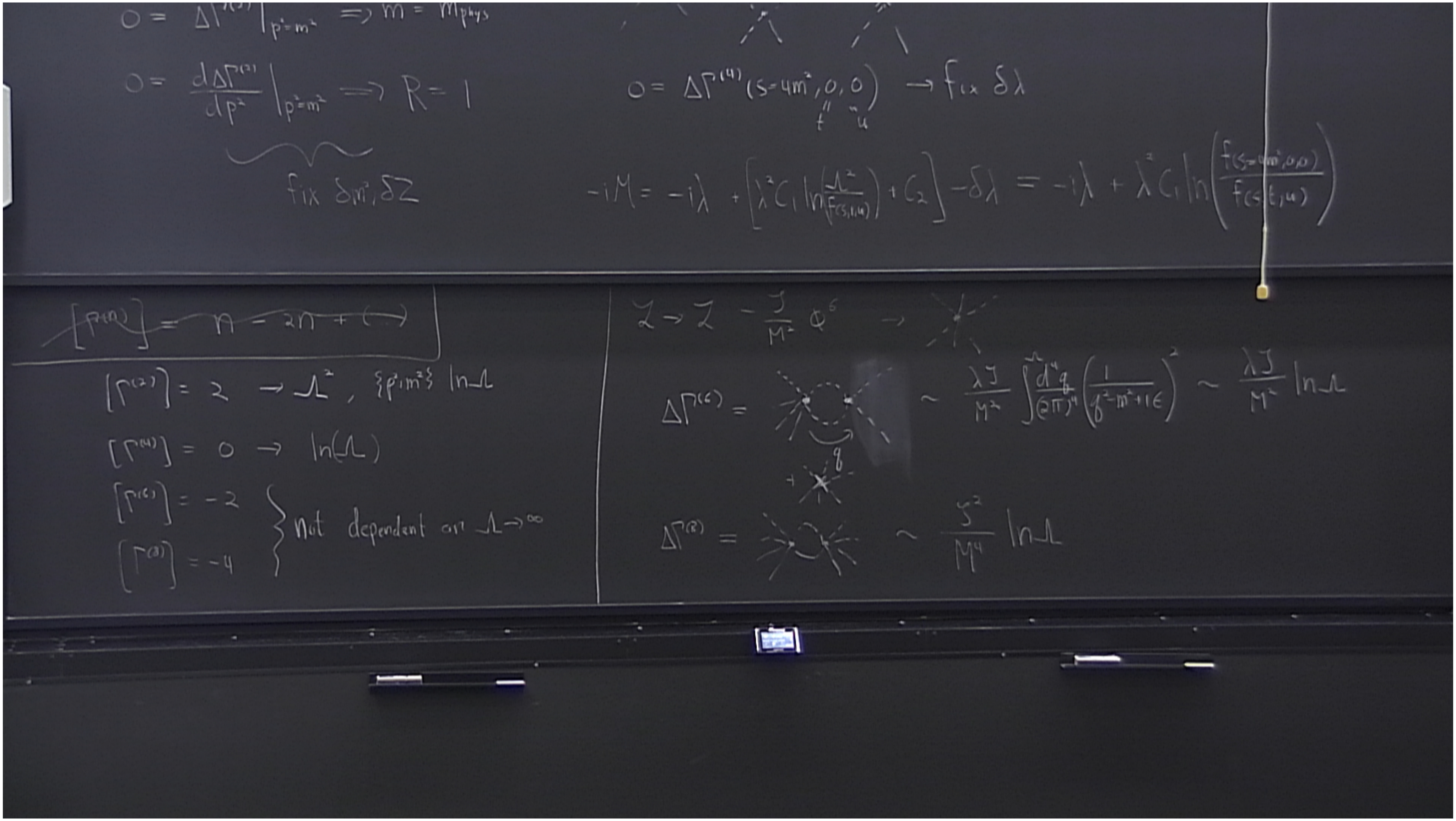

fix δm², δZ
→ fix δλ
R = 1
not dependent on Λ→∞


→ fix δλ
fix δm², δZ
not dependent



fix δm², δZ
[Γ^(2)] = 2 → Λ², {p², m²} ln Λ
[Γ^(4)] = 0 → ln(Λ)
[Γ^(6)] = −2
[Γ^(8)] = −4
not dependent on Λ → ∞
ΔΓ^(6) =
ΔΓ^(8) =


0 = ΔΓ^(2)|p²=m² ⇒ m = m_phys
0 = dΔΓ^(2)/dp² |p²=m² ⇒ R = 1
fix δm², δZ
0 = ΔΓ^(4)(s=4m², 0, 0) → fix δλ
-iM = -iλ + [λ²C₁ ln(Λ²/f(s,t,u)) + C₂] - δλ = -iλ + λ²C₁ ln(f(s=4m²,0,0)/f(s,t,u))
[Γ^(2)] = 2 → Λ², {p², m²} lnΛ
[Γ^(4)] = 0 → ln(Λ)
[Γ^(6)] = -2
[Γ^(8)] = -4
not dependent on Λ→∞
L → L - J/M² φ⁶
ΔΓ^(6) = ~ λJ/M² ∫ d⁴q/(2π)⁴ (1/(q²-m²+iε))² ~ λJ/M² lnΛ
q
ΔΓ^(8) = ~ J²/M⁴ lnΛ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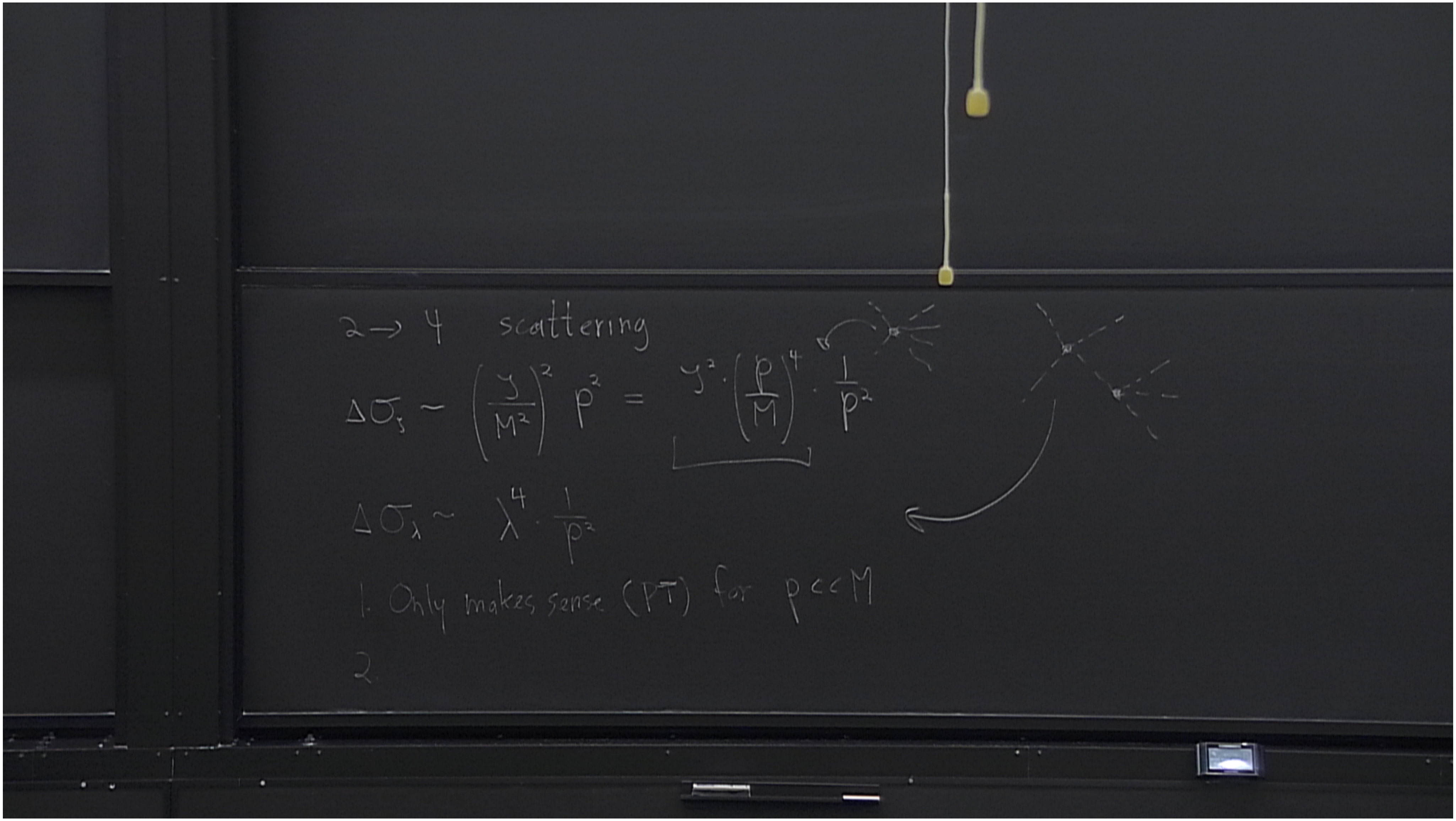
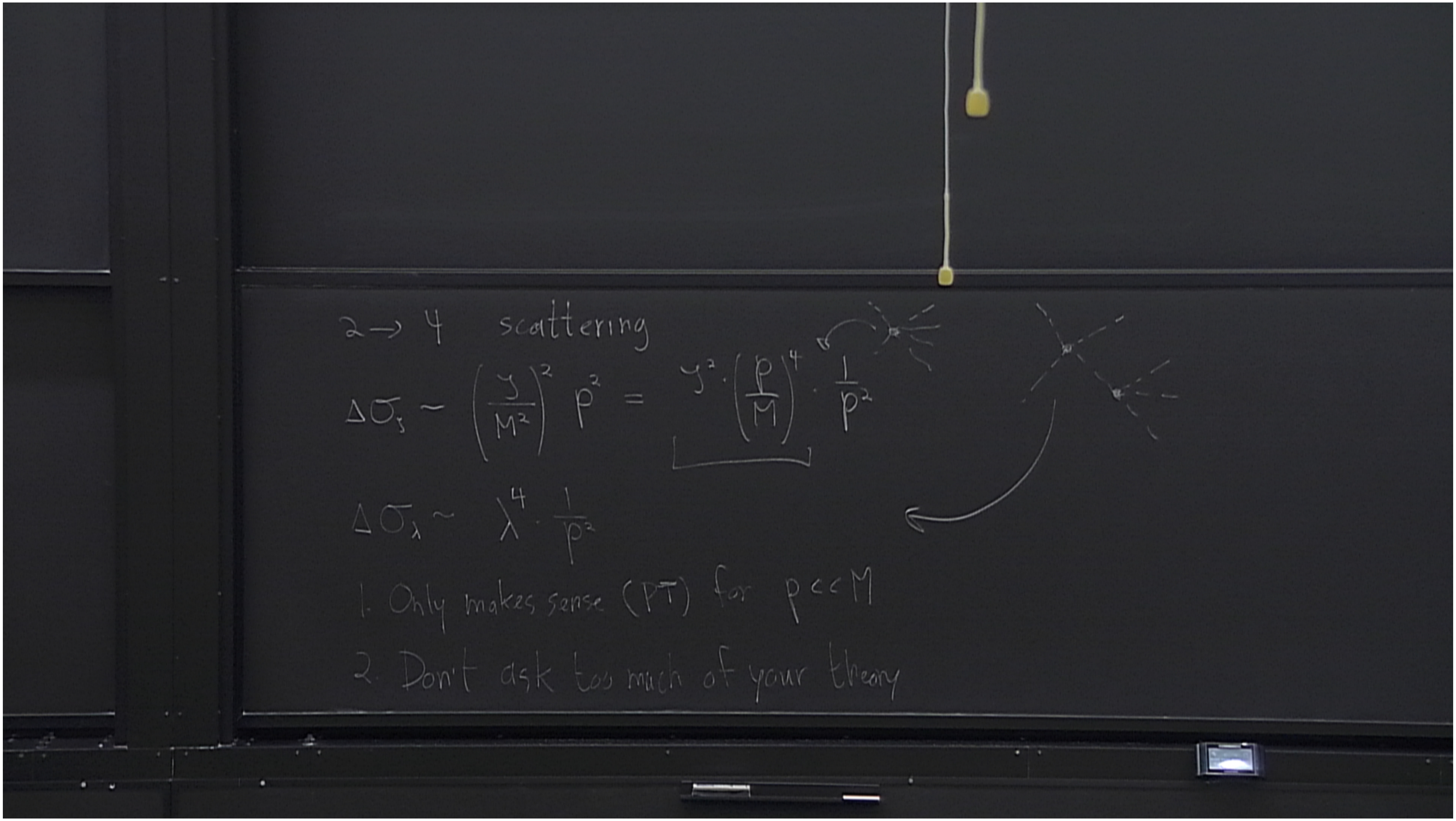
0 = ΔΓ^(4)(s=4m², 0, 0) → fix δλ
t u
−iM = −iλ + [λ² C₁ ln(Λ²/f(s,t,u)) + C₂] − δλ = −iλ + λ² C₁ ln(f(s=4m²,0,0)/f(s,t,u))
[Γ^(n)] = n − 2n + (...)
[Γ^(2)] = 2 → Λ², {p², m²} ln Λ
[Γ^(4)] = 0 → ln(Λ)
[Γ^(6)] = −2
[Γ^(8)] = −4
not dependent on Λ→∞
L → L − J/M² φ⁶ →
ΔΓ^(6) = ~ λJ/M² ∫^Λ d⁴q/(2π)⁴ (1/(q²−m²+iε))² ~ λJ/M² ln Λ
q
+
ΔΓ^(8) = ~ J²/M⁴ ln Λ


2 → 4 scattering
$\Delta\sigma_y \sim \left(\frac{y}{M^2}\right)^2 p^2 = y^2 \cdot \left(\frac{p}{M}\right)^4 \cdot \frac{1}{p^2}$
$\Delta\sigma_\lambda \sim \lambda^4 \cdot \frac{1}{p^2}$
1. Only makes sense (PT) for $p \ll M$
2.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$\Delta\sigma_\lambda \sim \lambda^4 \cdot \frac{1}{p^2}$
1. Only makes sense (PT) for $p \ll M$
2. Don't ask too much of your theory