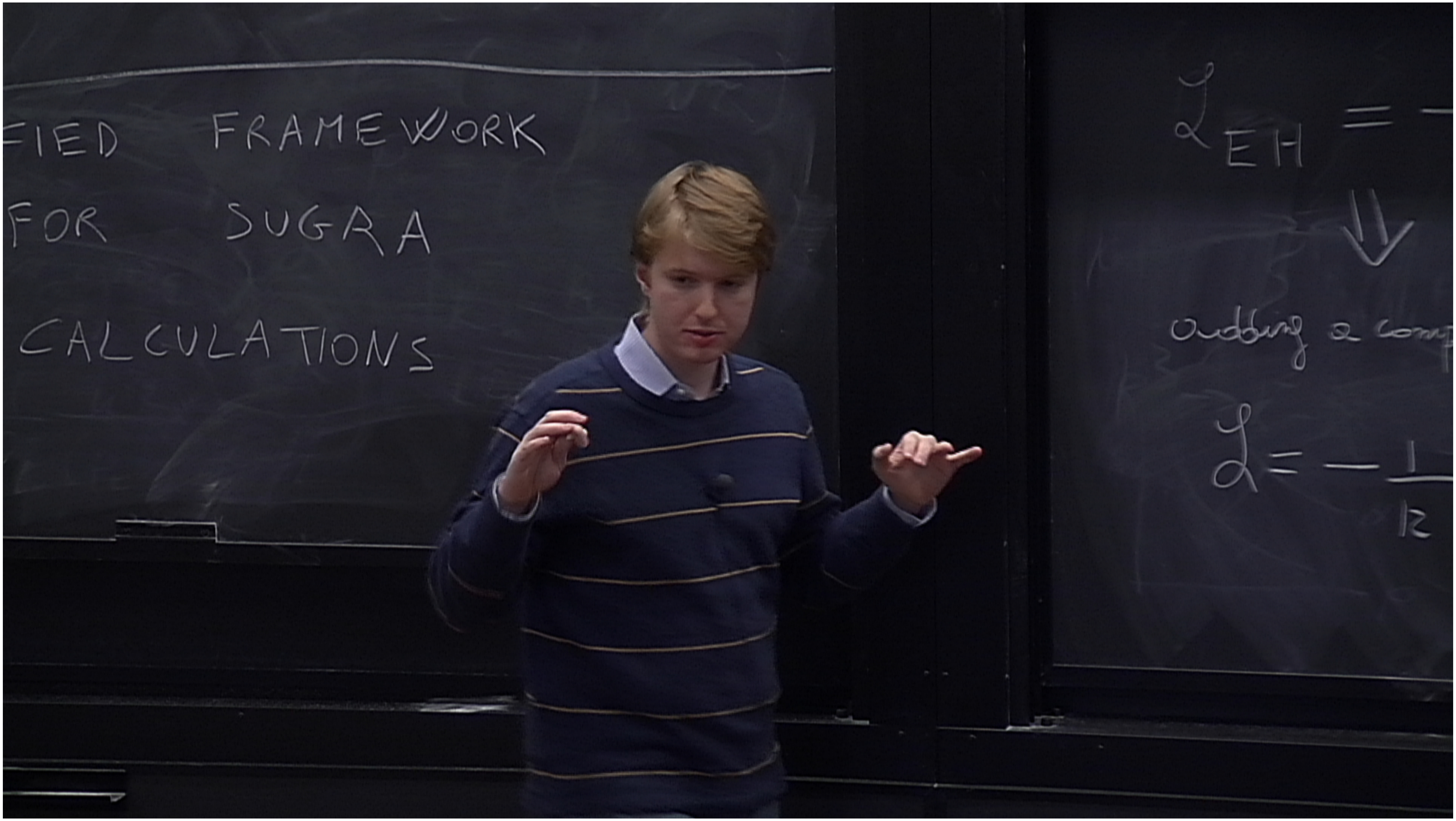
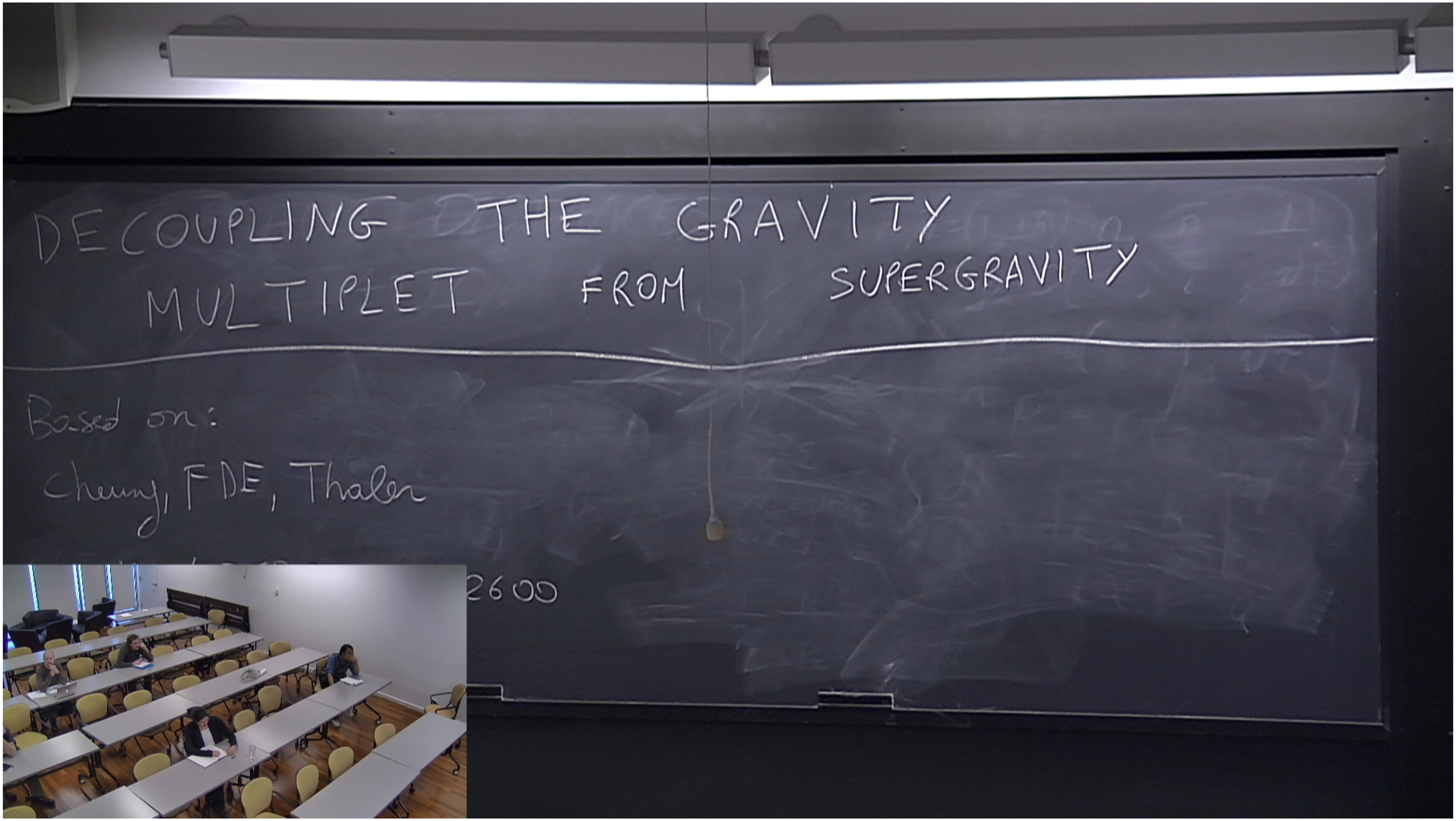
Title: Decoupling the Gravity Multiplet from Supergravity

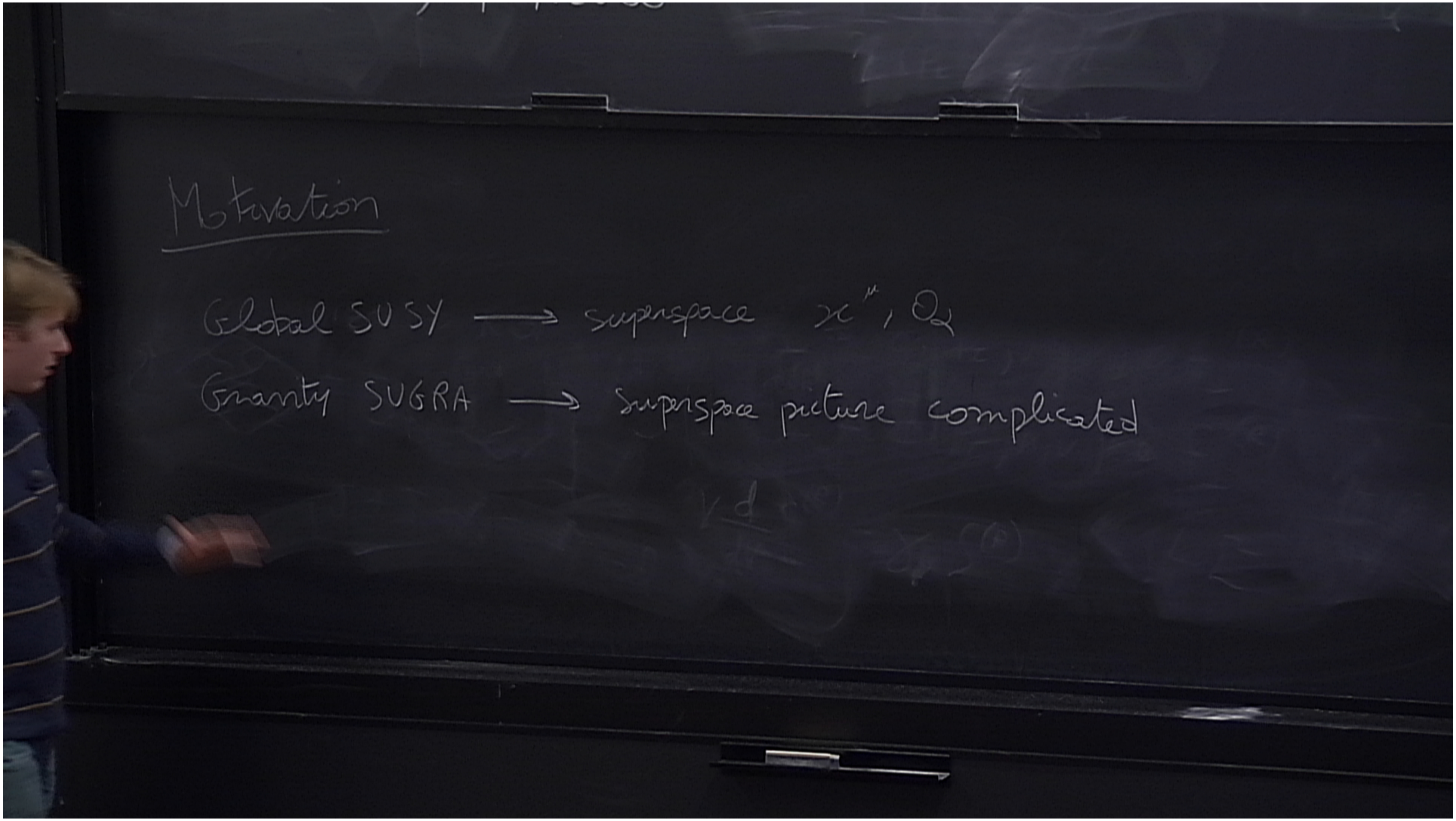
Date: Dec 08, 2011 02:30 PM

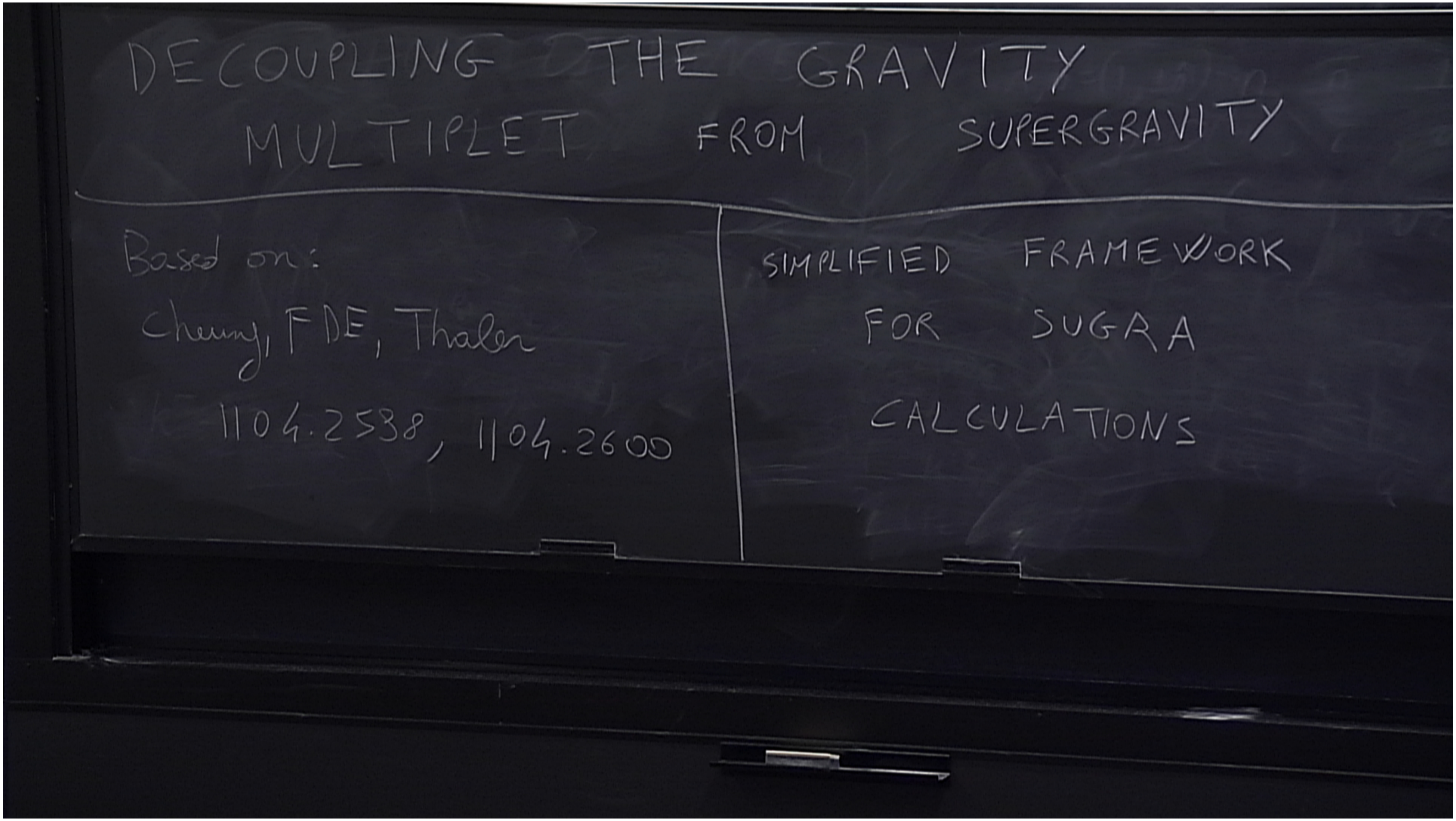
URL: http://pirsa.org/11120051

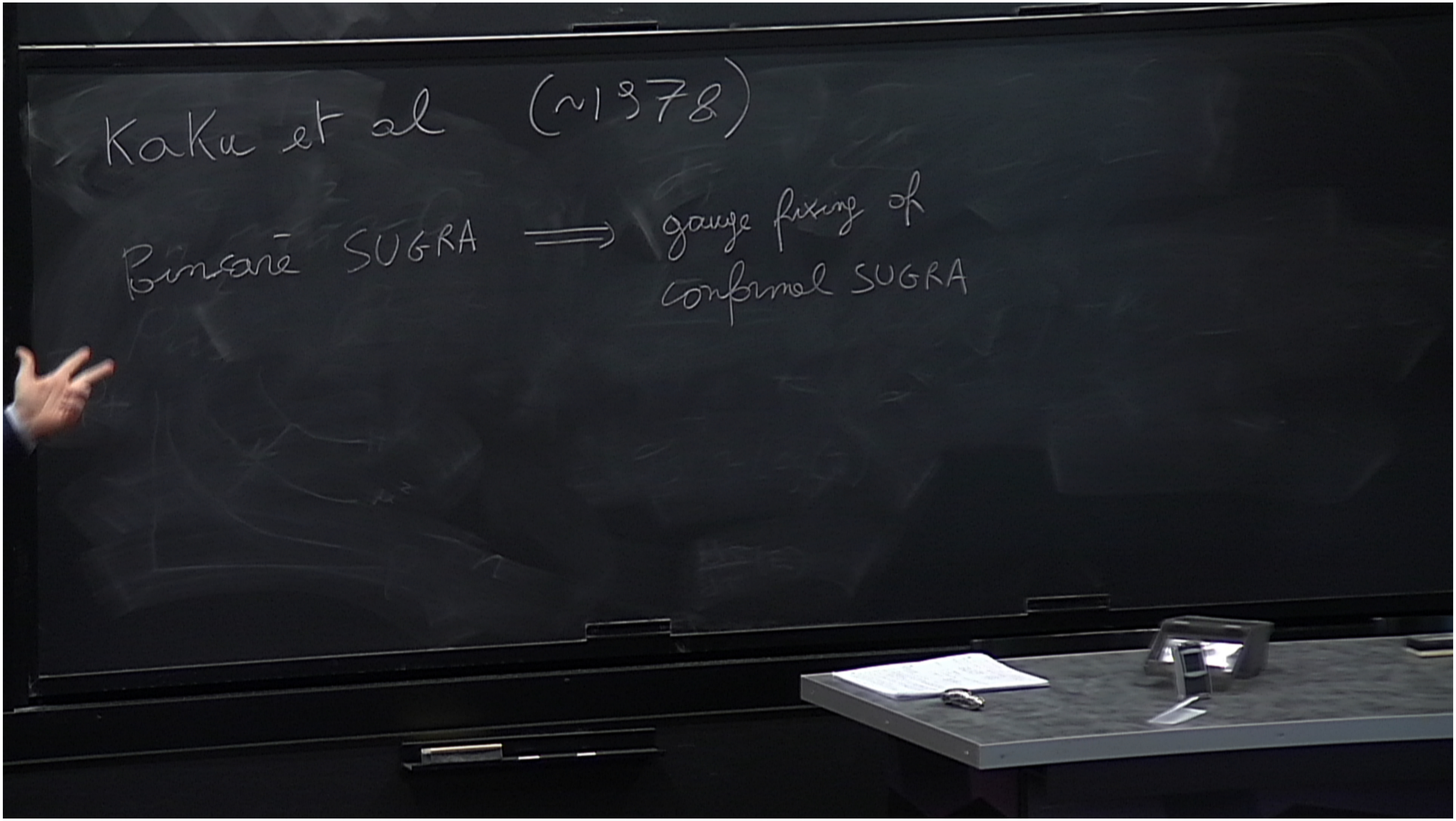
Abstract: The full machinery of supergravity (SUGRA) is required to fully understand many supersymmetric models. For the purpose of understanding phenomenology at colliders and in cosmology, the main concern is to ascertain the effects of SUGRA on the vacuum structure and particle spectrum. Practical calculations often require cumbersome manipulations of component field terms involving the full gravity multiplet. In this talk I will present an alternative gauge fixing for conformal SUGRA which decouples these gravity complications from SUGRA computations. This yields a simplified tree-level action for the matter fields in SUGRA which can be expressed compactly in terms of superfields and a modified conformal compensator. As a concrete application I will finally show the example of the mass spectrum of goldstini arising from a general admixture of F-term, D-term, and almost no-scale supersymmetry breaking.

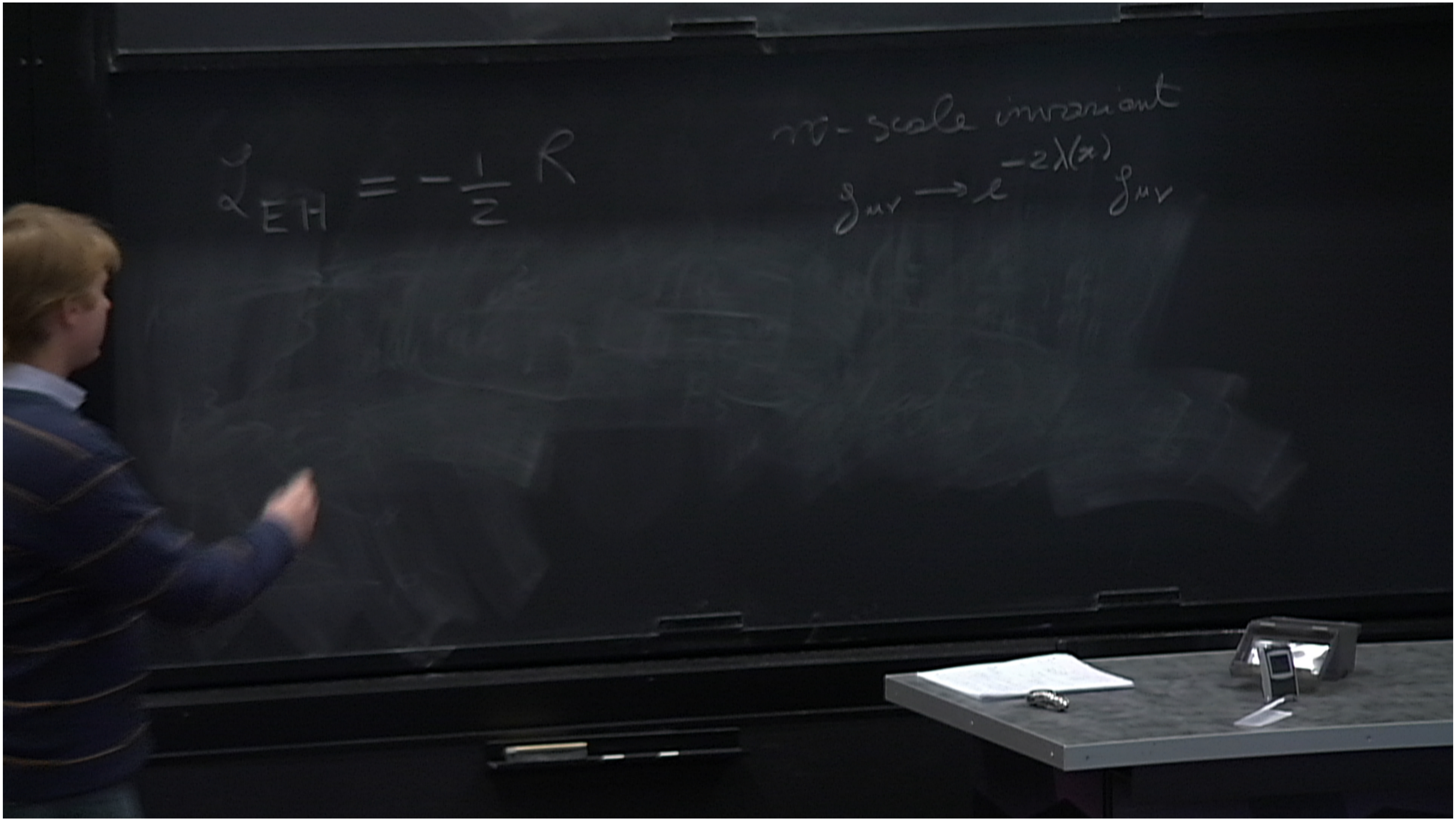

FIED FRAMEWORK
FOR SUGRA
CALCULATIONS

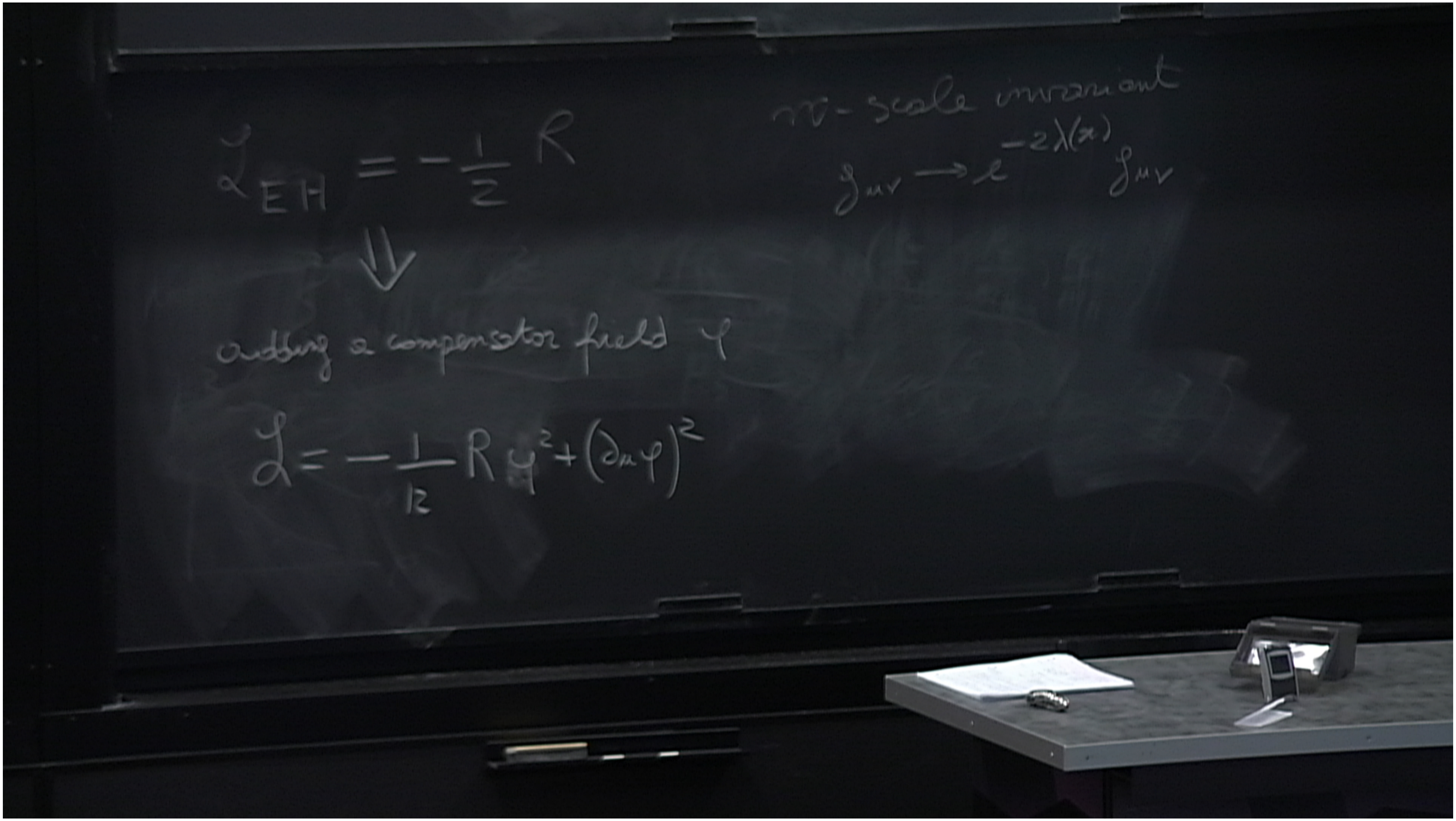

DECOUPLING THE GRAVITY
MULTIPLET FROM SUPERGRAVITY
Based on:
Cheung, FDE, Thaler
2600

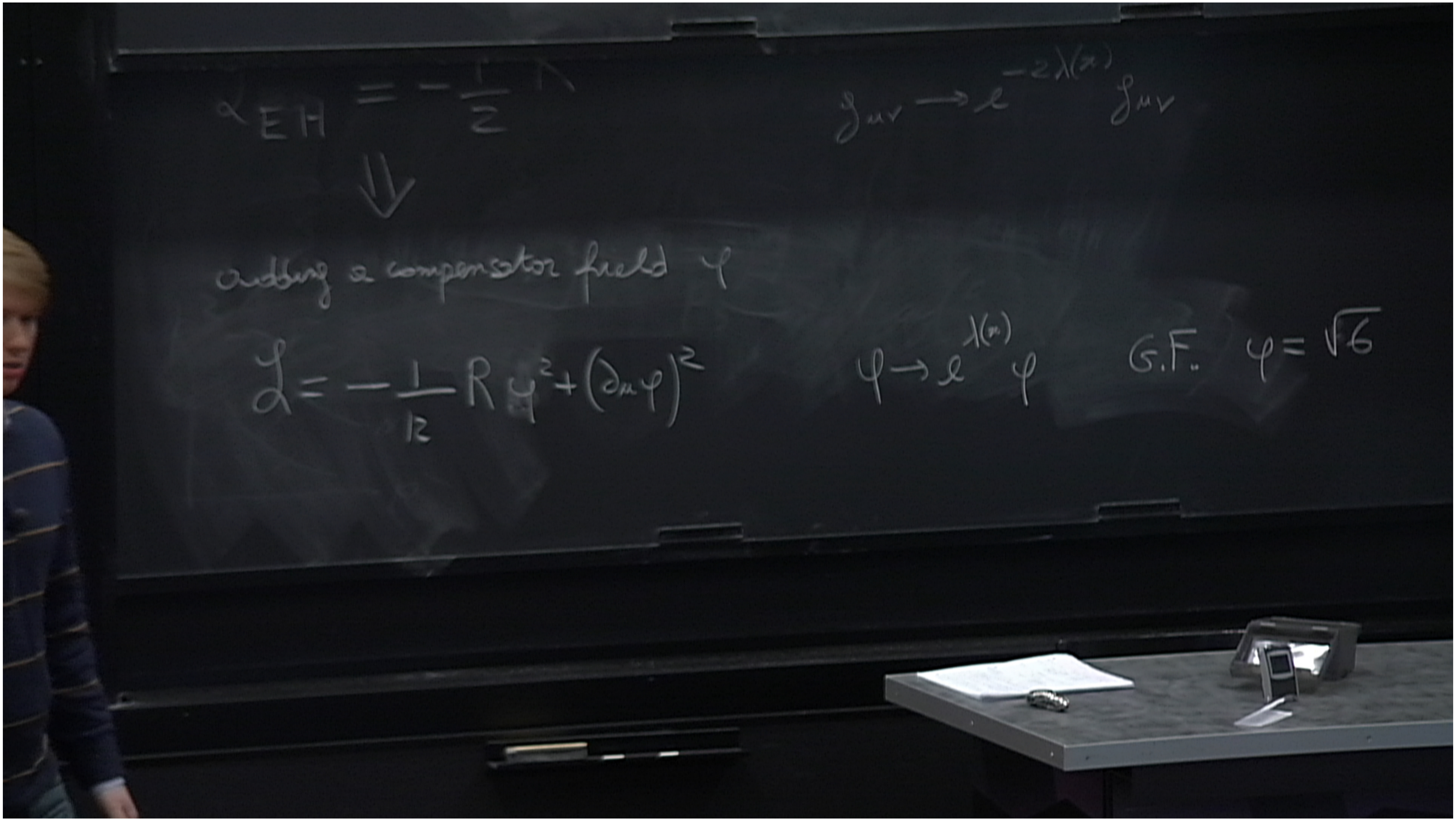

Motivation
Global SUSY $\longrightarrow$ superspace x^μ, θ_α
Gravity SUGRA $\longrightarrow$ superspace picture complicated

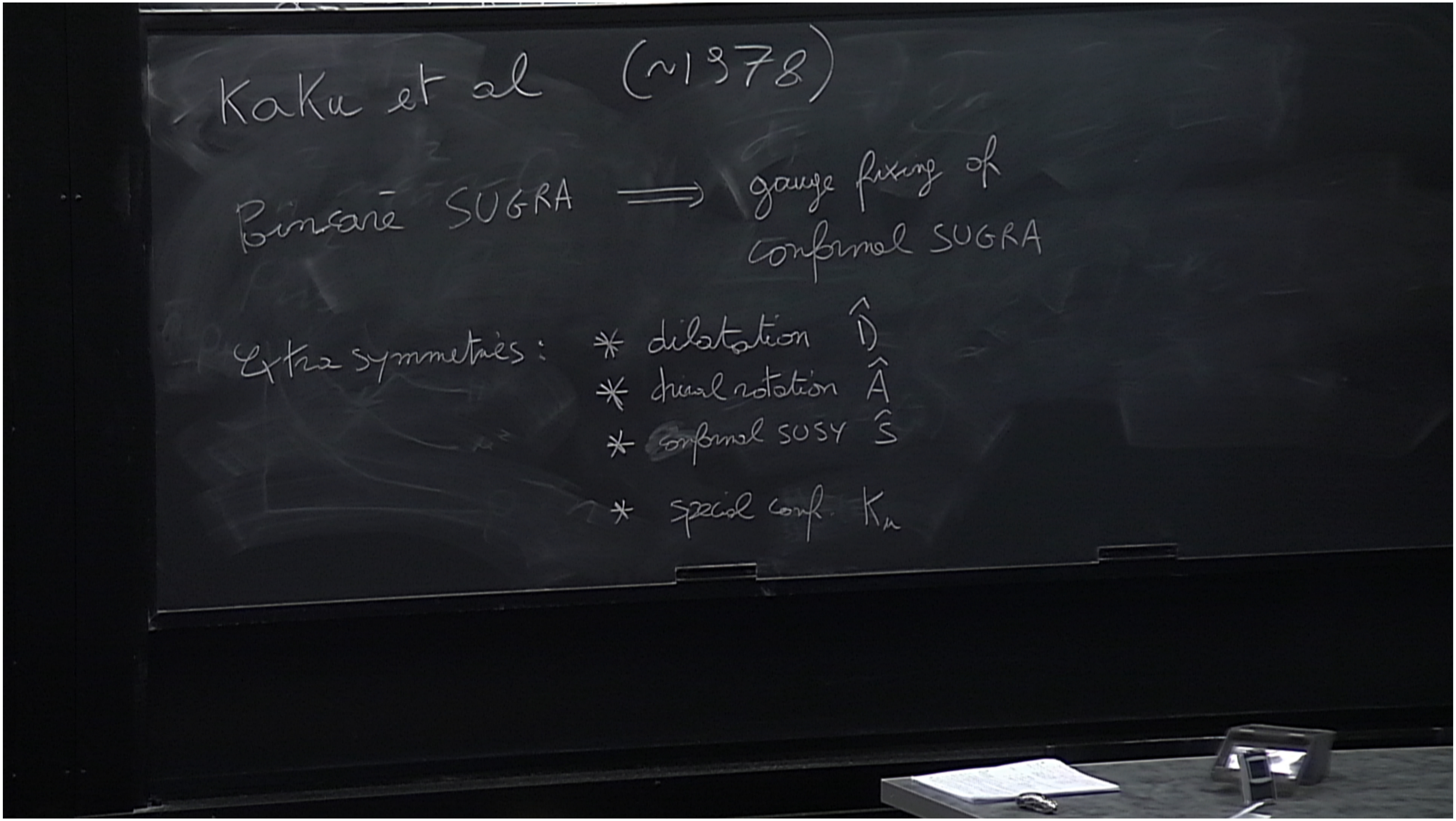

DECOUPLING THE GRAVITY MULTIPLET FROM SUPERGRAVITY
Based on:
Cheung, FDE, Thaler
1104.2538, 1104.2600
SIMPLIFIED FRAMEWORK FOR SUGRA CALCULATIONS

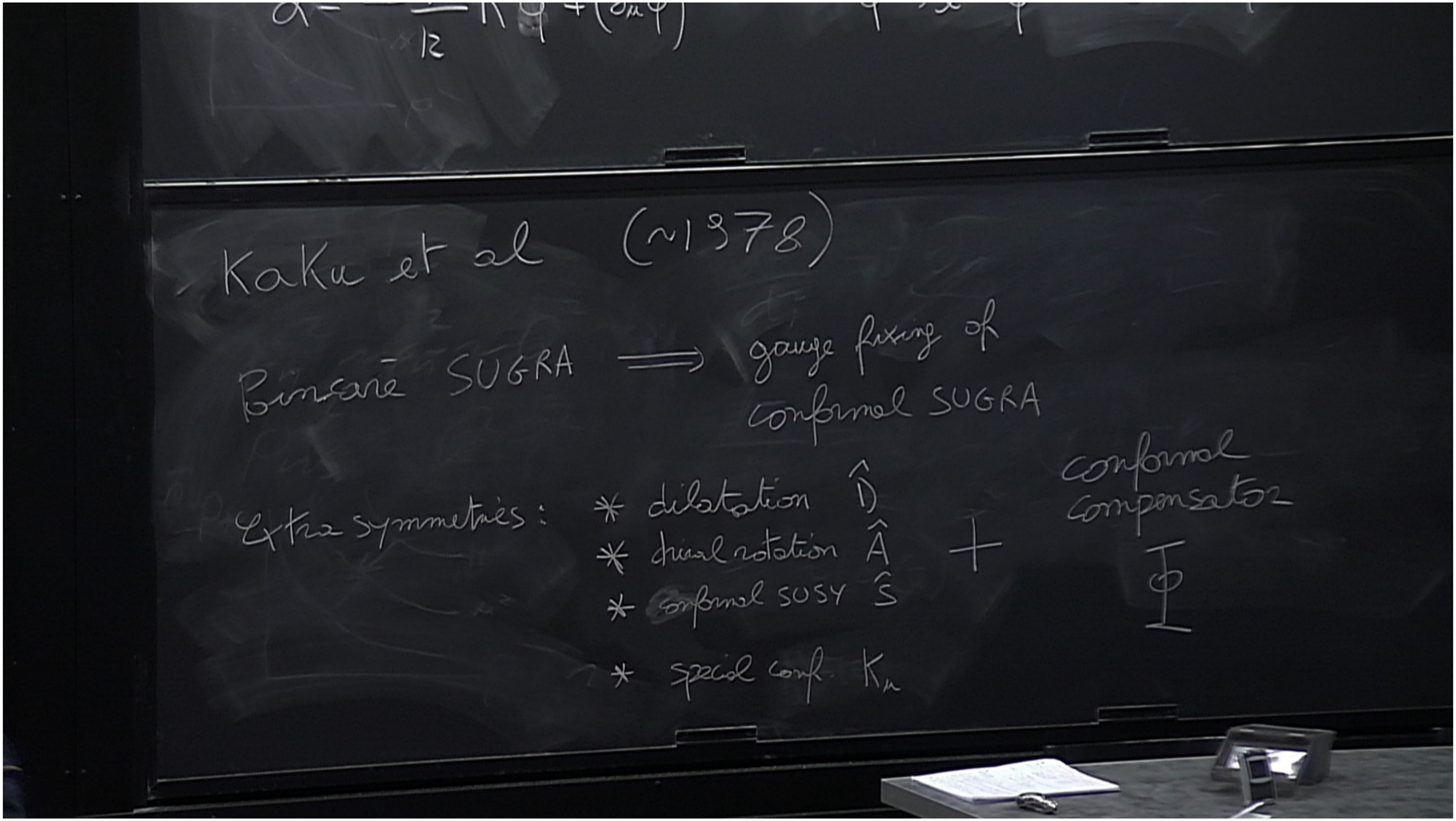

Kaku et al (~1978)
Poincaré SUGRA ⟹ gauge fixing of
conformal SUGRA


$\mathcal{L}_{EH} = -\frac{1}{2} R$
no-scale invariant
$g_{\mu\nu} \to e^{-2\lambda(x)} g_{\mu\nu}$

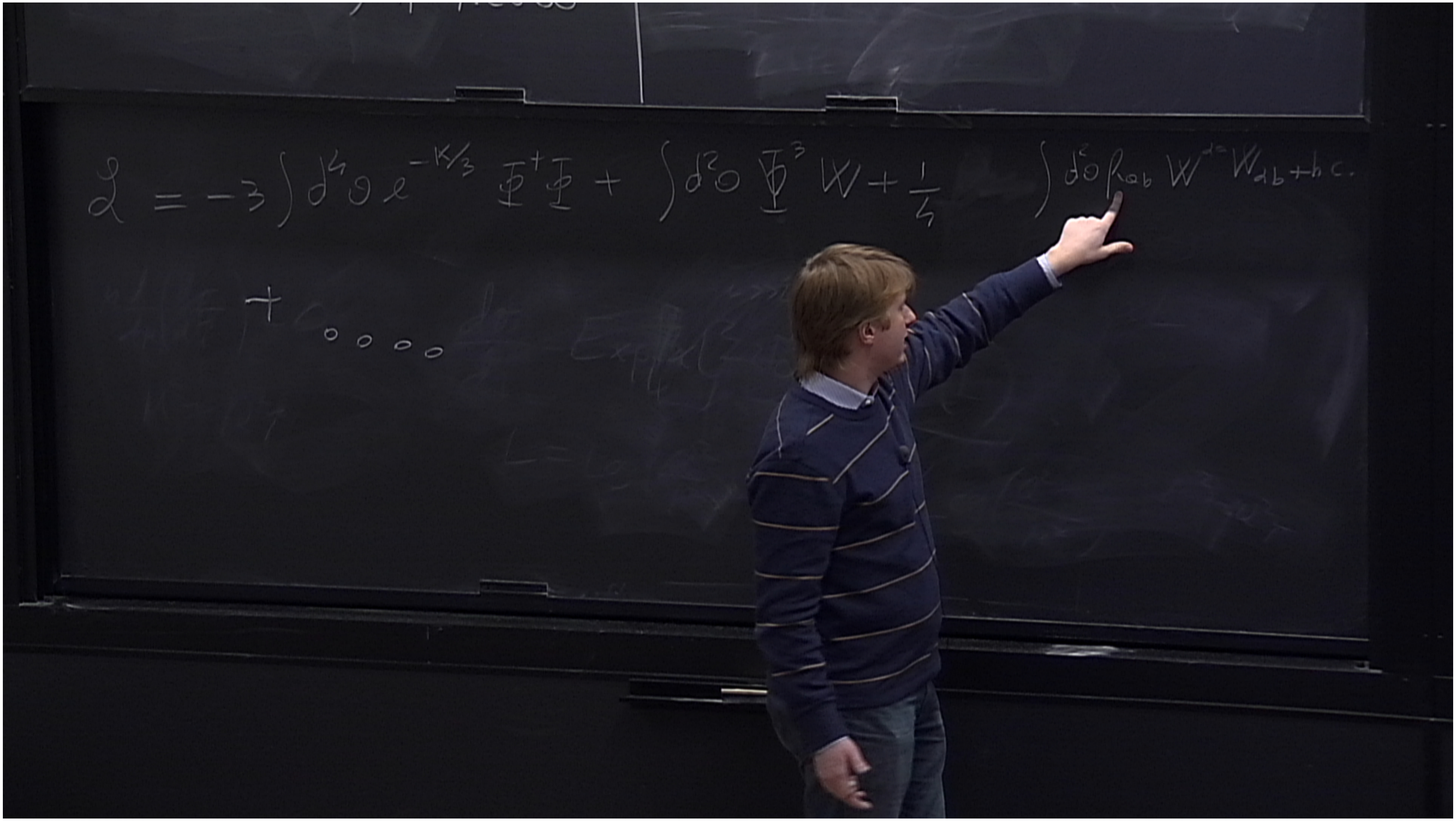

no-scale invariant
$g_{\mu\nu} \to e^{-2\lambda(x)} g_{\mu\nu}$
$\mathcal{L}_{EH} = -\frac{1}{2} R$
$\Downarrow$
adding a compensator field φ
$\mathcal{L} = -\frac{1}{12} R \varphi^2 + (\partial_\mu \varphi)^2$


$\mathcal{L}_{EH} = -\frac{1}{2}\Lambda$
$g_{\mu\nu} \to e^{-2\lambda(x)} g_{\mu\nu}$
$\Downarrow$
adding a compensator field φ
$\mathcal{L} = -\frac{1}{12} R \varphi^2 + (\partial_\mu \varphi)^2$
$\varphi \to e^{\lambda(x)} \varphi$
G.F. $\varphi = \sqrt{6}$


Kaku et al (~1978)
Poincaré SUGRA ⟹ gauge fixing of
conformal SUGRA
Extra symmetries:
* dilatation $\hat{D}$
* chiral rotation $\hat{A}$
* conformal SUSY $\hat{S}$
* special conf. K_μ



Kaku et al (~1978)
Poincaré SUGRA ⟹ gauge fixing of conformal SUGRA
Extra symmetries:
* dilatation $\hat{D}$
* chiral rotation $\hat{A}$
* conformal SUSY $\hat{S}$
* special conf. K_μ
+ conformal compensator Φ


$\mathcal{L} = -3\int d^4\theta\, e^{-K/3}\, \Phi^\dagger \Phi + \int d^2\theta\, \Phi^3 W + \frac{1}{4} \int d^2\theta\, f_{ab} W^{\alpha} W_{\alpha b} + h.c.$
$+ \ldots$

$$\mathcal{L} = -3\int d^4\theta\, e^{-K/3}\, \Phi^\dagger \Phi + \int d^2\theta\, \Phi^3 W + \frac{1}{4}\int d^2\theta\, f_{ab} W^{\alpha a} W_{\alpha b} + h.c.$$

$$+ \ \ldots\ldots$$

Kugo & Uehara NPB 226 (1983)

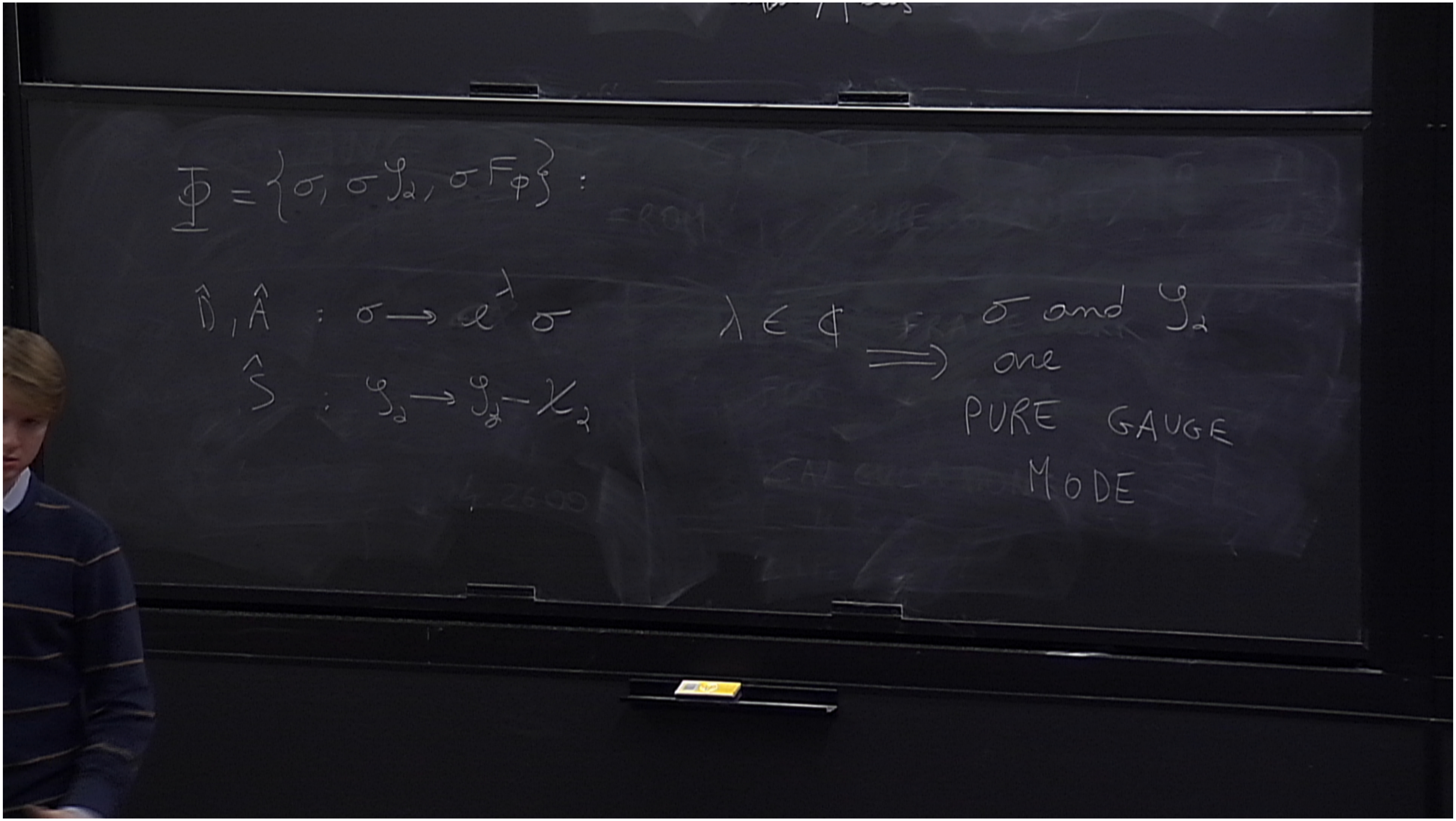
$$\mathcal{L} = -3\int d^4\theta\, e^{-K/3}\, \Phi^\dagger \Phi + \int d^2\theta\, \Phi^3 W + \frac{1}{4}\int d^2\theta\, f_{ab} W^{\alpha a} W_{\alpha b} + h.c.$$

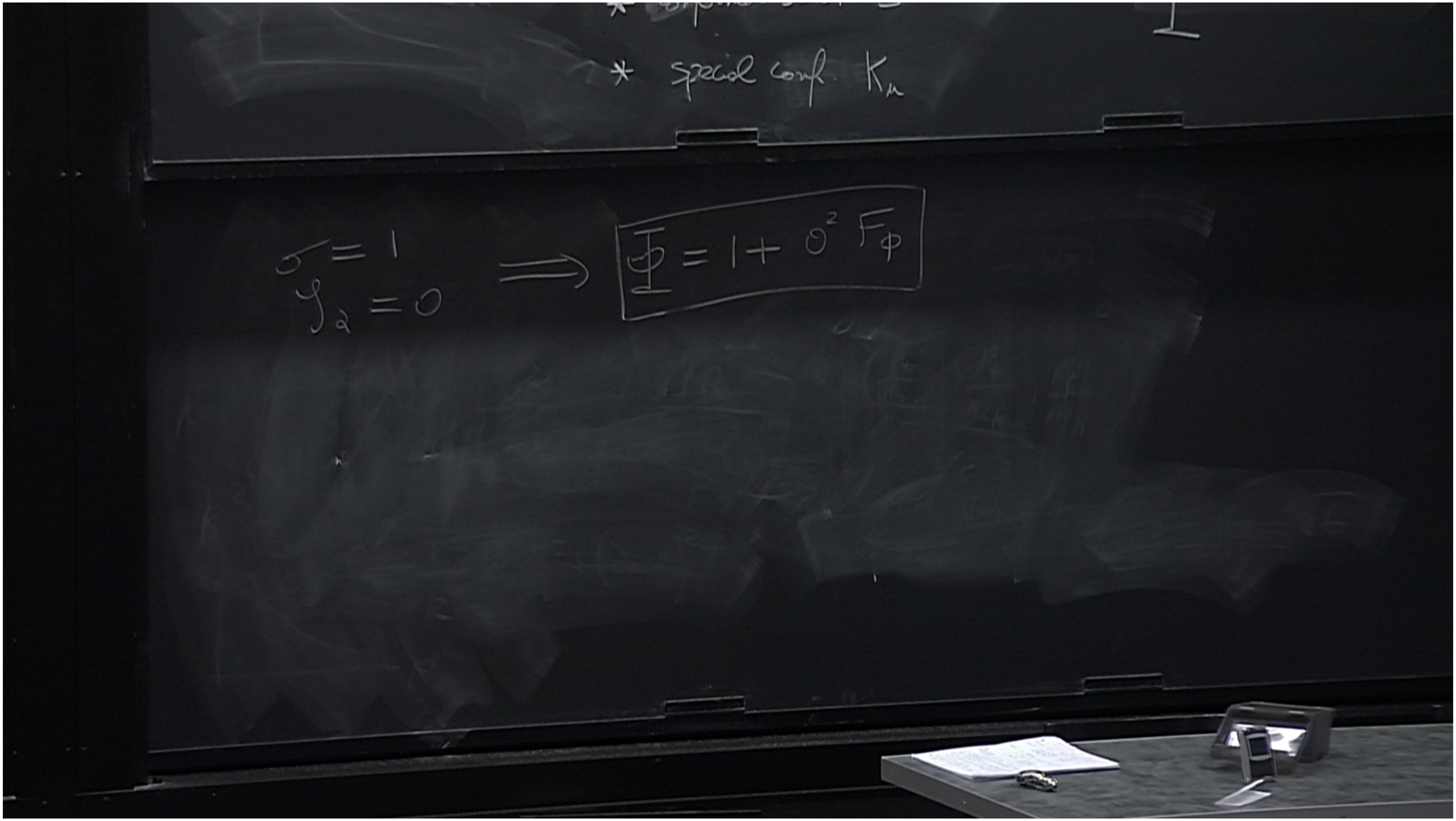
$$+ \circ\circ\circ\circ\circ\circ$$

Kugo & Uehara NPB 226 (1983)

Θ : global SUSY superspace

$\circ\circ\circ\circ$ = graviton, gravitino, auxiliary fields


$\Phi = \{\sigma, \sigma\varphi_2, \sigma F_\phi\}$:
$\hat{D}, \hat{A}$: $\sigma \to e^{\lambda}\sigma$
$\hat{S}$: $\varphi_2 \to \varphi_2 - \chi_2$
$\lambda \in \mathbb{C} \Longrightarrow$ σ and φ_2 one
PURE GAUGE
MODE


* special conf. K_μ
$\sigma = 1$
$\varphi_2 = 0 \Longrightarrow \boxed{\Phi = 1 + \theta^2 F_\phi}$

$$\Phi = 1 + \sigma^2 F_\phi$$

1) $\dfrac{C}{3} \dfrac{R}{2}$

C scalar function of matter fields

$$\langle C \rangle = -3$$

$$\langle C_1 \rangle = \langle C_2 \rangle = 0$$

$\Phi = 1 + \theta^2 F_\Phi$

$\circ\circ\circ\circ\circ\circ$: 1) $\frac{C}{3}\,\frac{R}{2}$ $\quad$ C scalar function of matter fields

$\langle C \rangle = -3 \Longrightarrow$ RS gravitino ✓

$\langle C_1 \rangle = \langle C_2 \rangle = 0$

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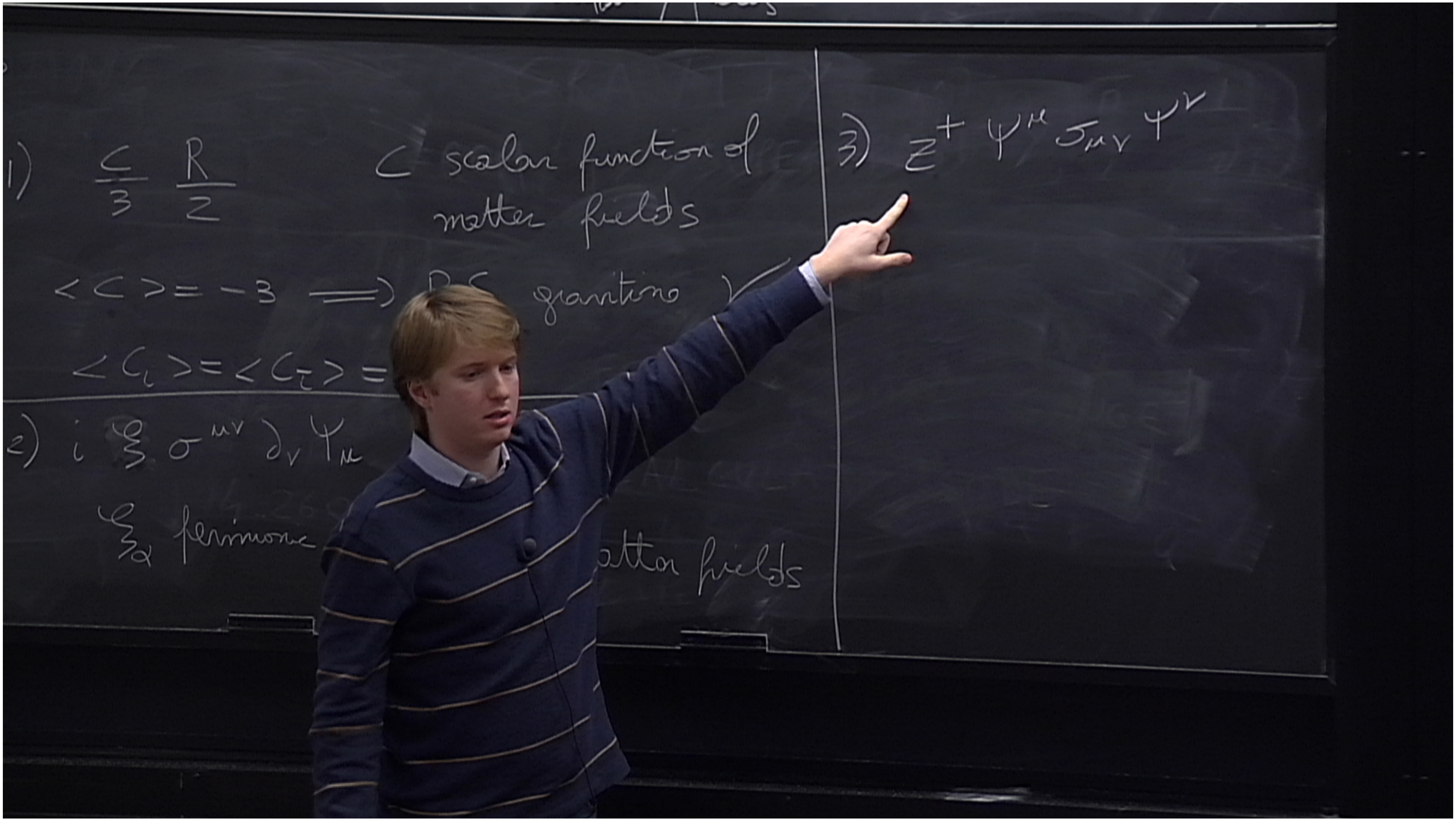
2) $i\,\xi\,\sigma^{\mu\nu}\,\partial_\nu \Psi_\mu$

ξ_α fermionic function of matter fields


1) $\frac{c}{3}$ $\frac{R}{2}$
C scalar function of matter fields
$\langle C \rangle = -3$
gravitino
2) $i \xi \sigma^{\mu\nu} \partial_\nu \psi_\mu$
ξ_α fermionic
fields
3) $Z^+ \psi^\mu \sigma_{\mu\nu} \psi^\nu$

$\Phi = 1 + \theta^2 F_\phi$

ooooo : 1) $\frac{C}{3} \frac{R}{2}$ C scalar function of matter fields

$\langle C \rangle = -3 \Longrightarrow$ RS gravitino ✓

$\langle C_1 \rangle = \langle C_2 \rangle = 0$

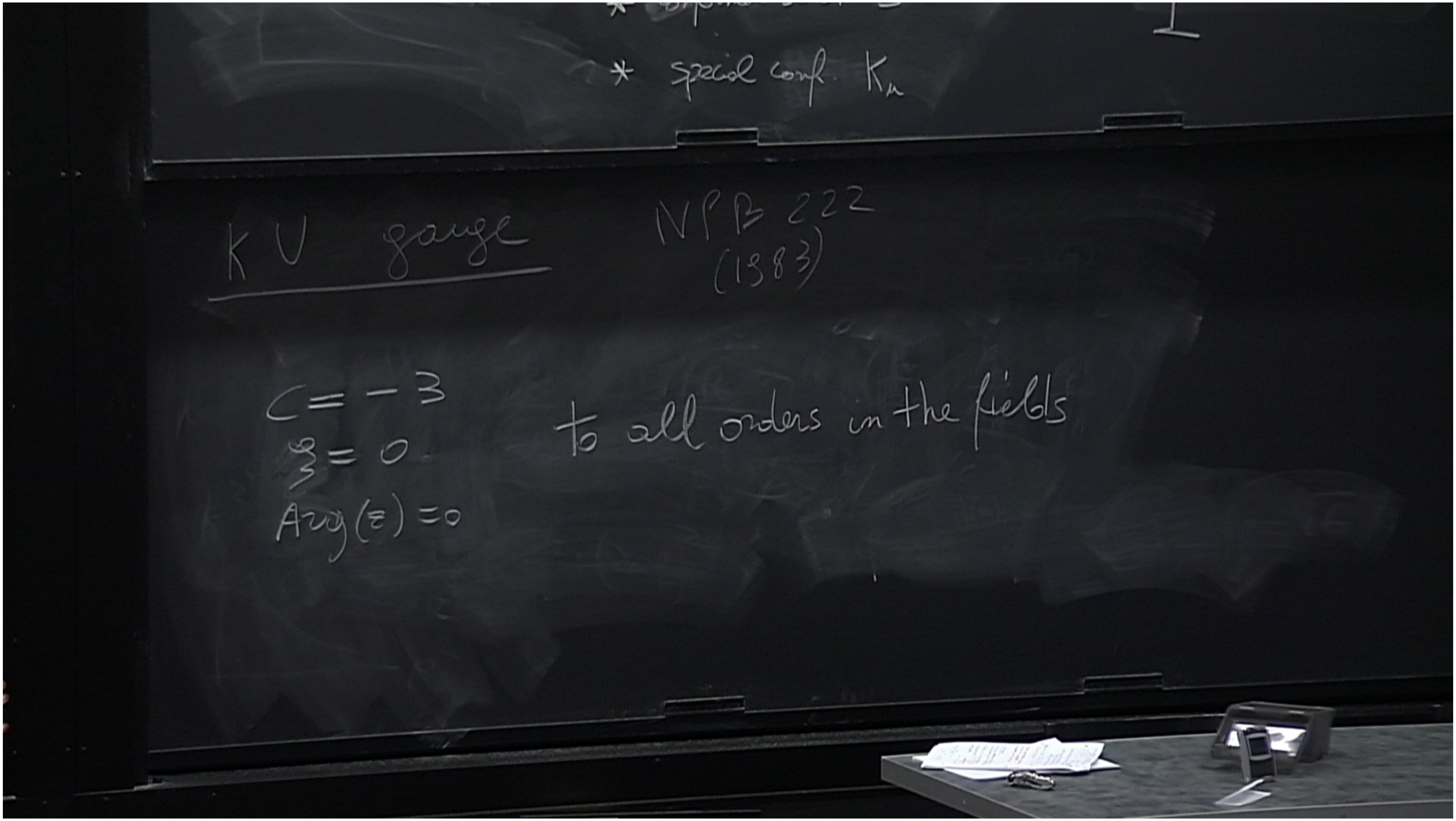
$\boxed{\langle K_i \rangle \chi^i}$

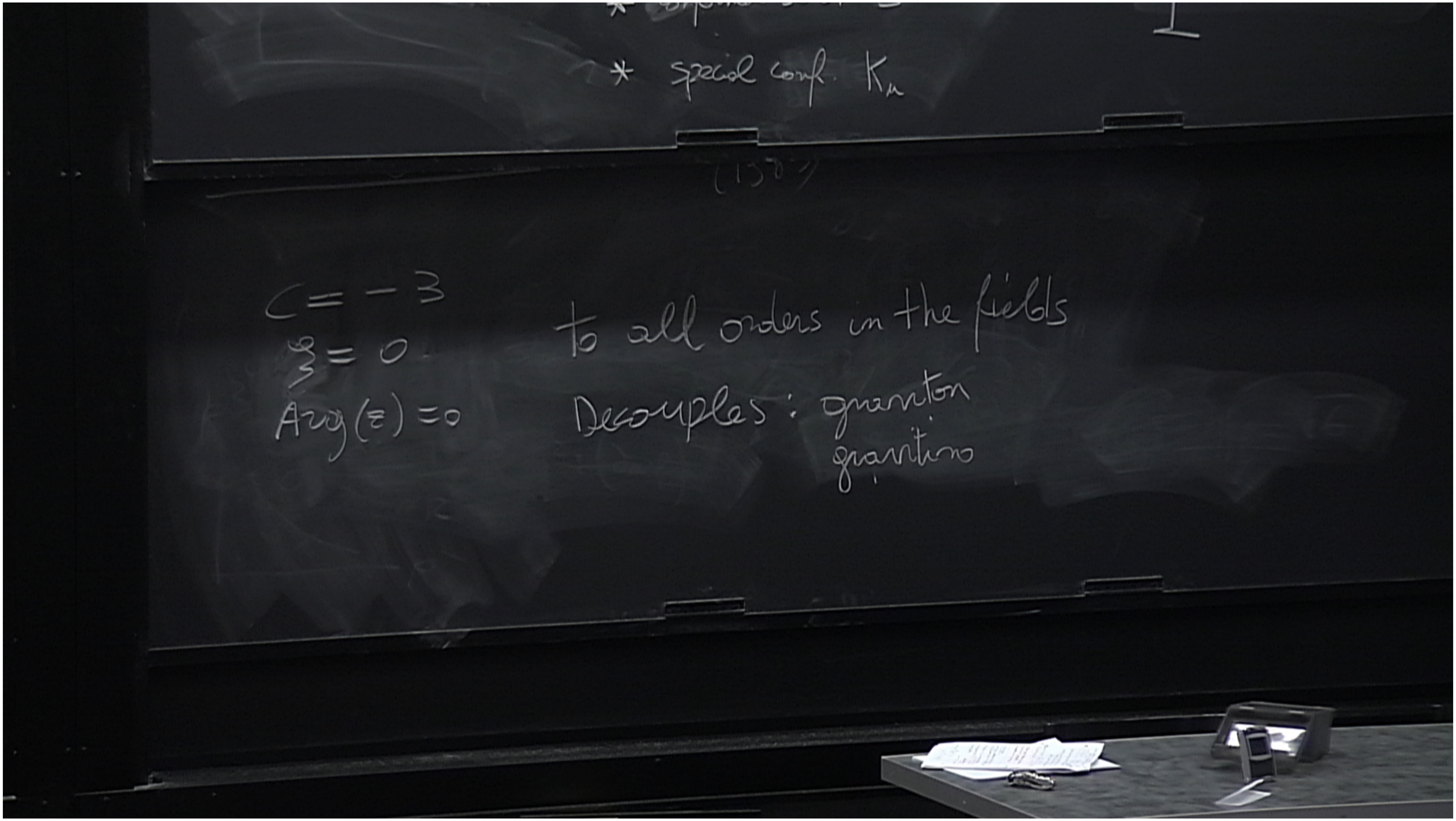
2) $i \xi \sigma^{\mu\nu} \partial_\nu \psi_\mu$

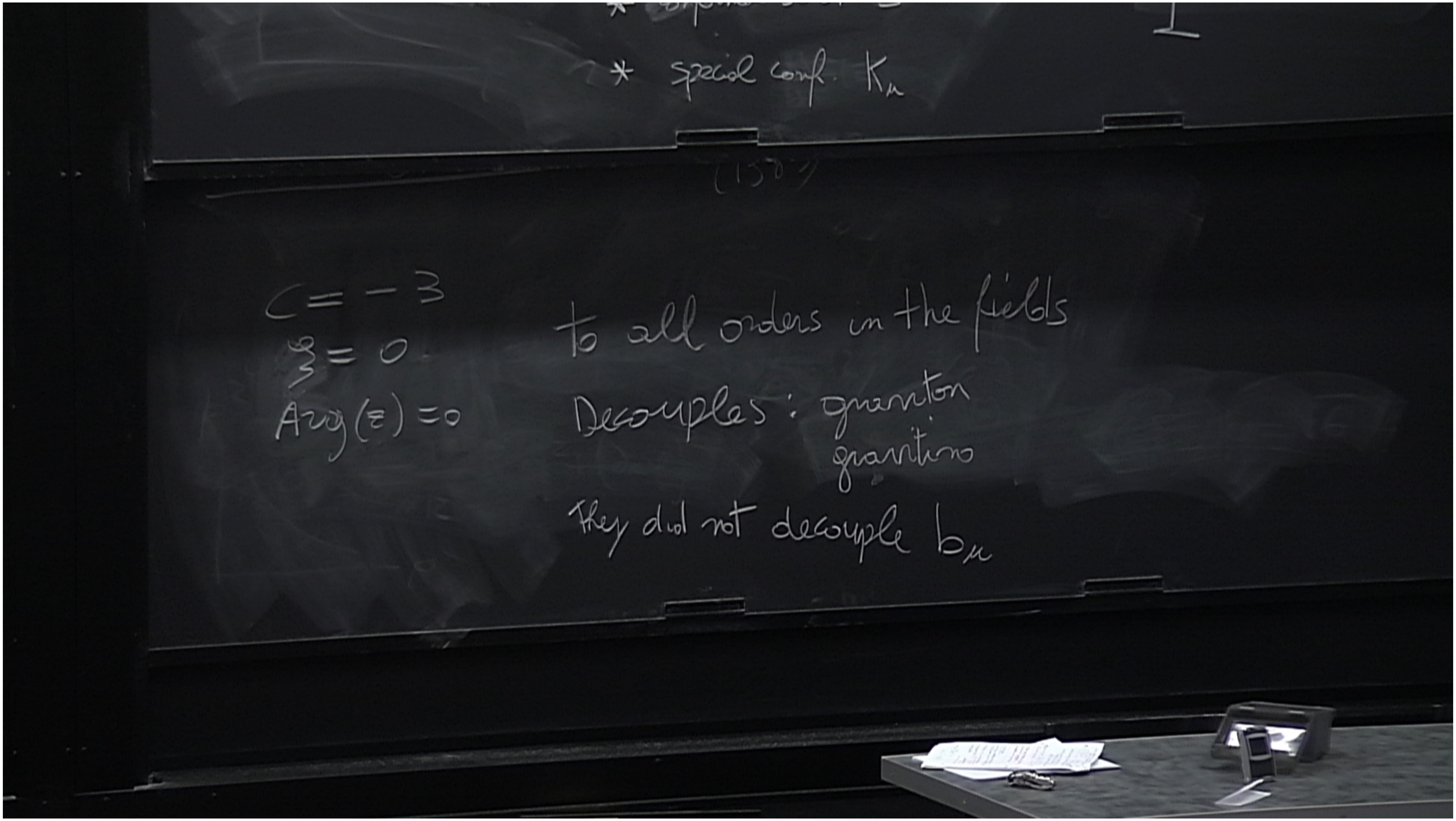
ξ_α fermionic function of matter fields

3) $z^\dagger \psi^\mu \sigma_{\mu\nu} \psi^\nu$

$\mathrm{Arg}(z) = 0$


* special conf. K_μ
KV gauge
NPB 222
(1983)
c = -3
ξ = 0
Arg(z) = 0
to all orders in the fields


* special conf. K_μ
$c = -3$
$\xi = 0$
$\mathrm{Arg}(z) = 0$
to all orders in the fields
Decouples: graviton
gravitino


* special conf. Kμ
C = −3
ξ = 0
Arg(ε) = 0
to all orders in the fields
Decouples: graviton
gravitino
They did not decouple bμ

* chiral rotation +

$\Phi \Longrightarrow$ weight 1

* conformal SUSY $\hat{S}$

* special conf. K_μ

KU gauge

NPB 222 (1983)

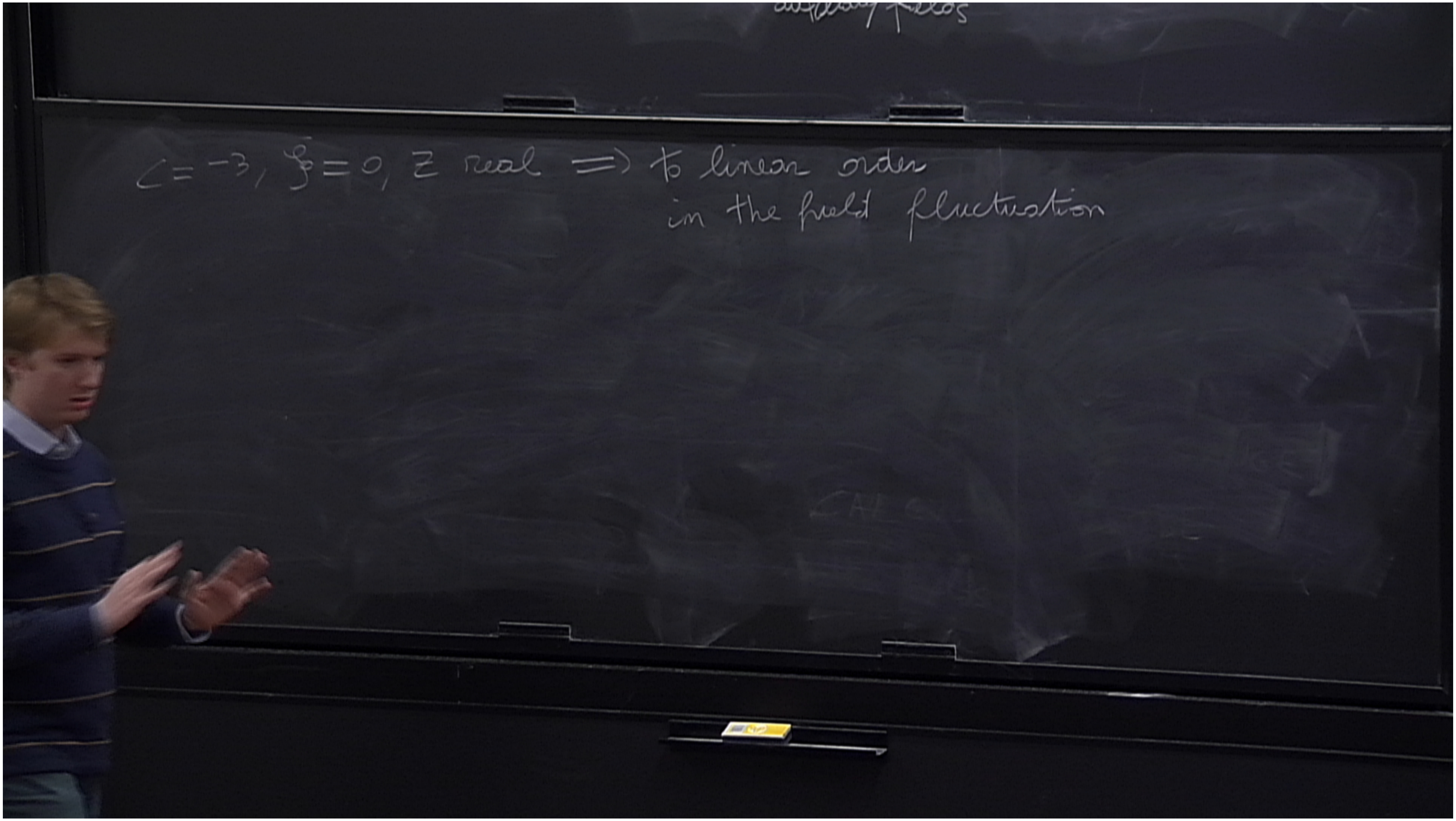
$$D_\mu \sigma = \partial_\mu \sigma - \frac{i}{2} \sigma b_\mu$$

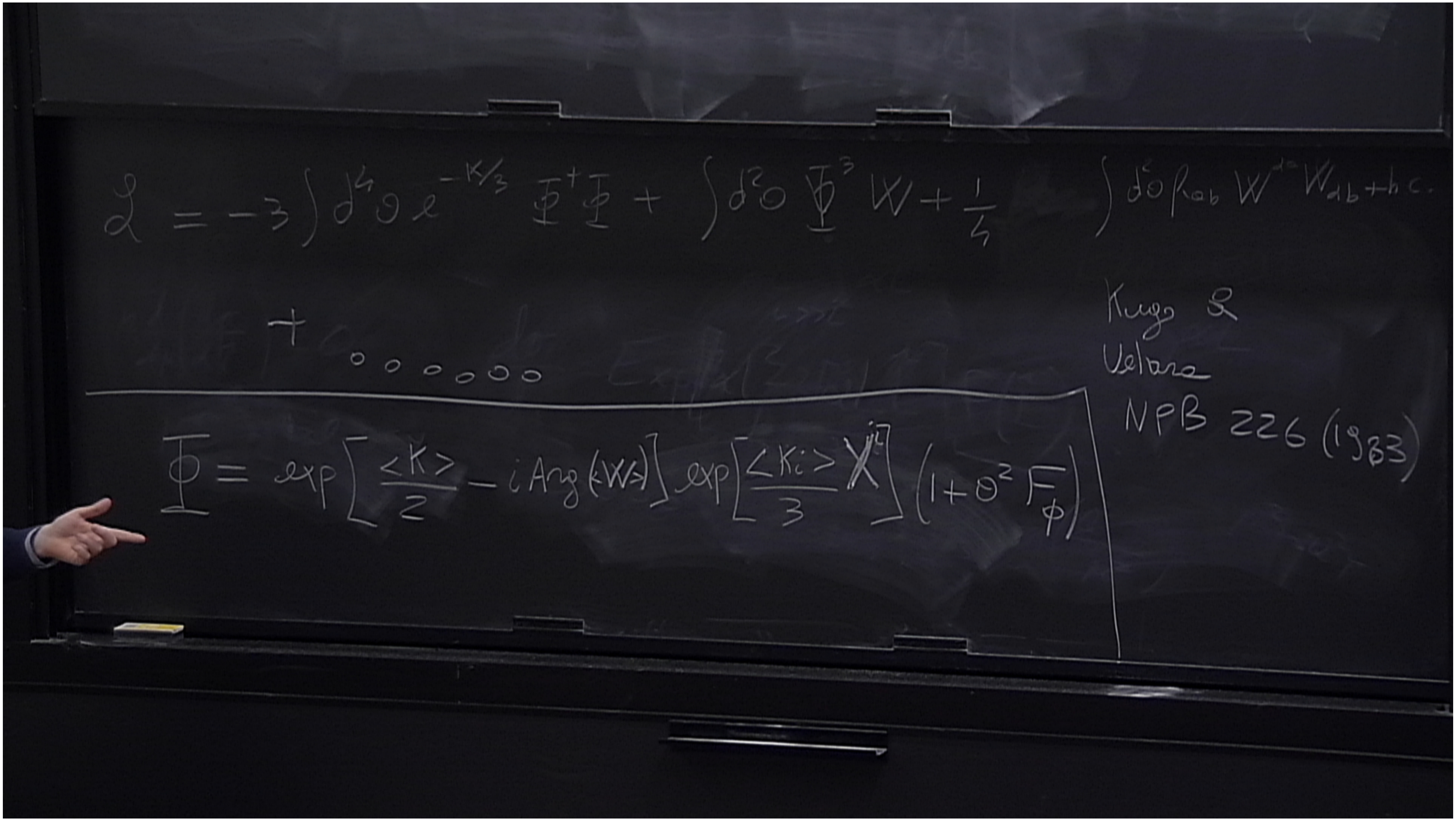
$C = -3$

$\xi = 0$

$\mathrm{Arg}(z) = 0$

$$\Phi = \{\sigma, \sigma \chi, \sigma F_\phi\}$$


c = −3, ξ = 0, Z real ⟹ to linear order
in the field fluctuation


$\mathcal{L} = -3\int d^4\theta\, e^{-K/3}\,\Phi^\dagger\Phi + \int d^2\theta\,\Phi^3 W + \frac{1}{4}\int d^2\theta\, f_{ab} W^{\alpha a} W_{\alpha b} + h.c.$
$+ \ldots$
$\Phi = \exp\left[\frac{\langle K\rangle}{2} - i\,\mathrm{Arg}\langle W\rangle\right]\exp\left[\frac{\langle K_i\rangle X^i}{3}\right](1+\theta^2 F_\phi)$
Kugo & Uehara NPB 226 (1983)

* chiral rotation +
* conformal SUSY $\hat{S}$
* special conf. K_μ

$\Phi \Longrightarrow$ weight 1

$c = -3$

$\xi = 0$

$\mathrm{Arg}(\varepsilon) = 0$

$$D_\mu \sigma = \partial_\mu \sigma - \frac{i}{2}\sigma b_\mu$$

$$\Phi = \{\sigma, \sigma\psi, \sigma F_\phi\}$$

$$\boxed{\Phi = W^{-1/3}\,\tilde{\Phi} \qquad \tilde{\Phi} = \{1, G_i\chi^i, F_\phi\}}$$

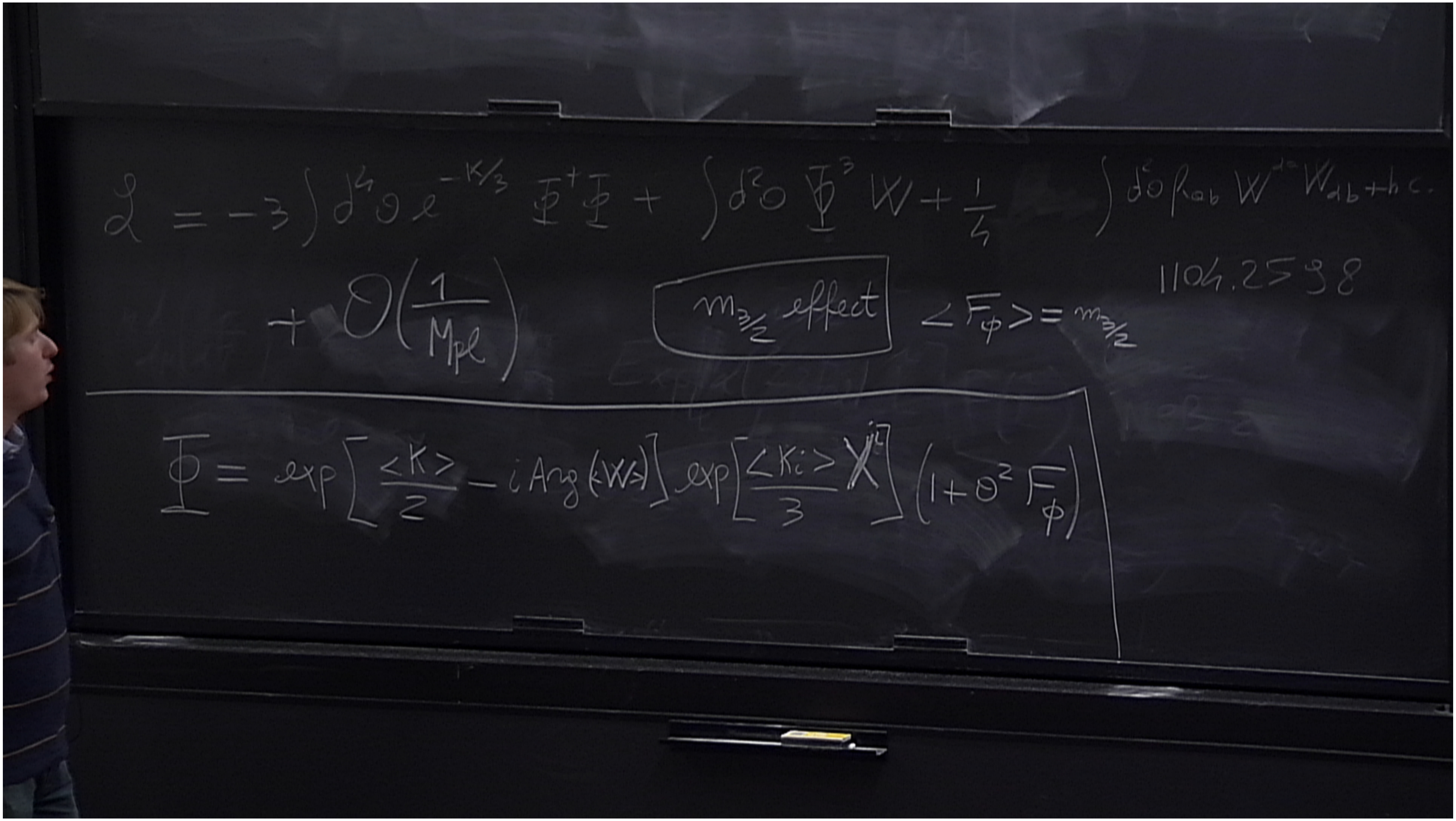
$$\mathcal{L} = -3\int d^4\theta\, e^{-K/3}\,\Phi^\dagger\Phi + \int d^2\theta\, \Phi^3 W + \frac{1}{4}\int d^2\theta\, f_{ab} W^{\alpha a} W_\alpha^{b} + h.c.$$

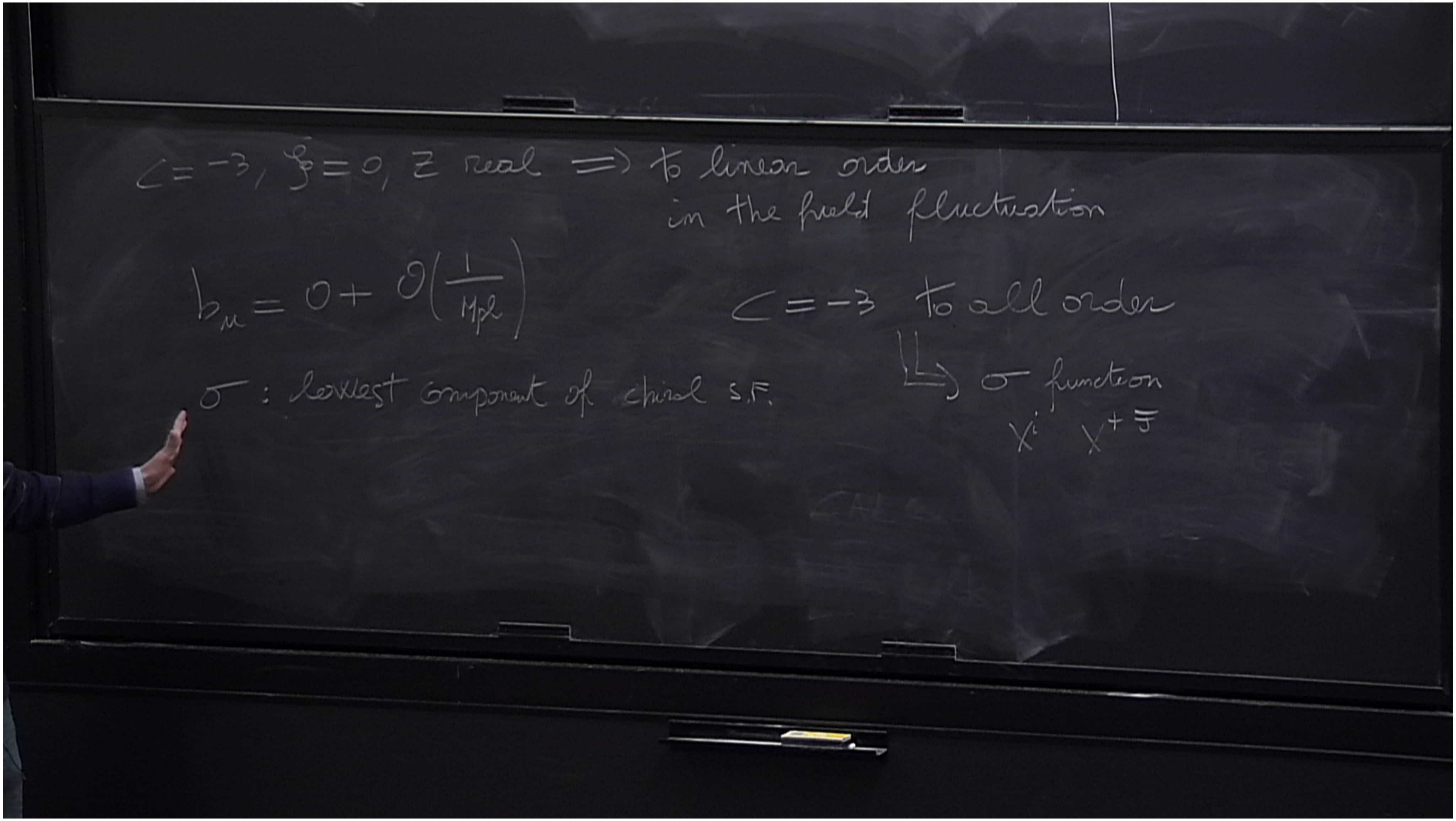
$$+\ \mathcal{O}\left(\frac{1}{M_{Pl}}\right)$$

Kugo & Uehara

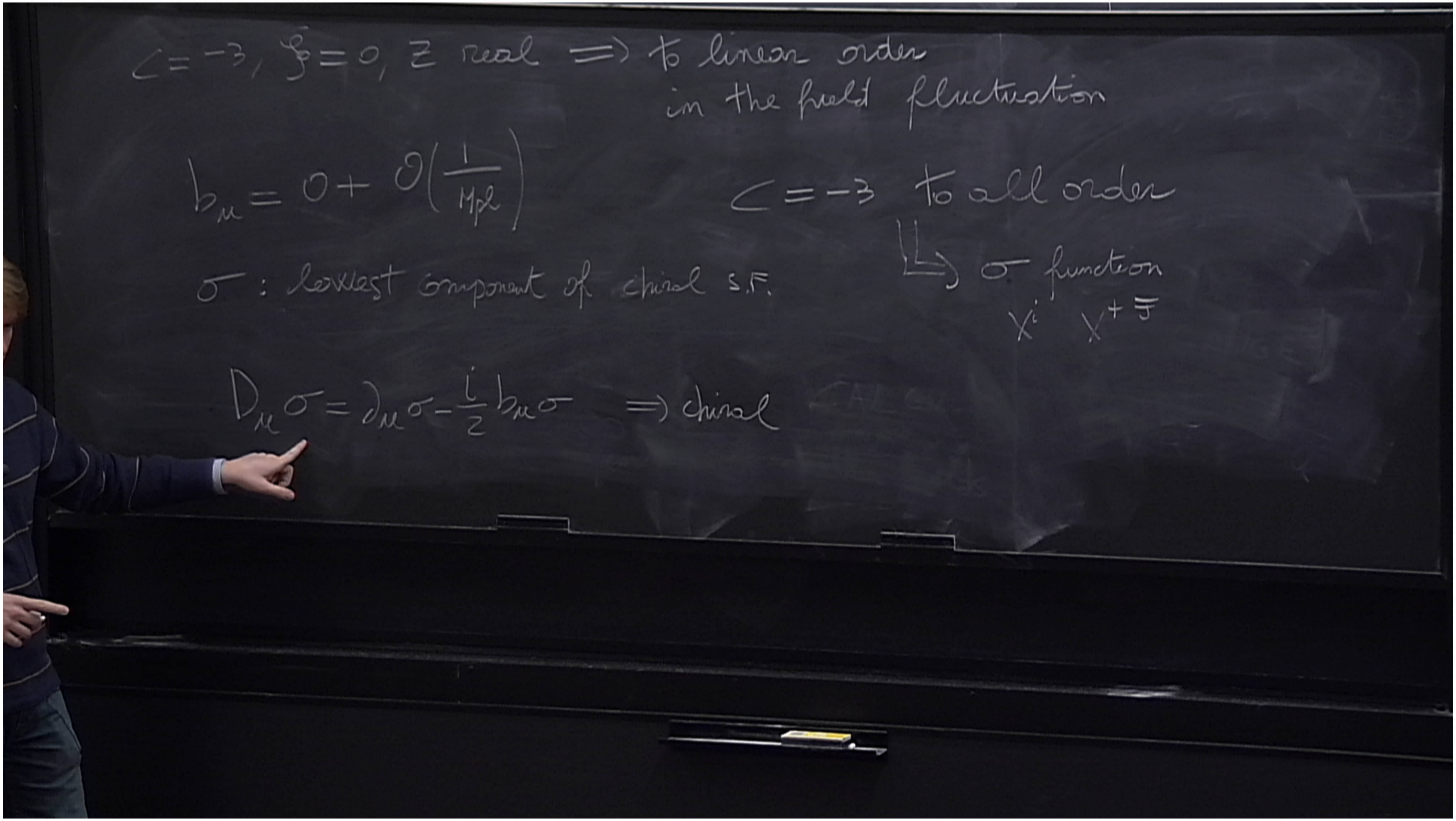
NPB 226 (1983)

$$\Phi = \exp\left[\frac{\langle K\rangle}{2} - i\,\mathrm{Arg}\langle W\rangle\right]\exp\left[\frac{\langle K_i\rangle X^i}{3}\right]\left(1+\theta^2 F_\phi\right)$$


$\mathcal{L} = -3\int d^4\theta\, e^{-K/3}\, \bar{\Phi}^\dagger \Phi + \int d^2\theta\, \Phi^3 W + \frac{1}{4}\int d^2\theta\, f_{ab} W^{\alpha a} W_{\alpha b} + h.c.$
1104.2598
$+\, \mathcal{O}\left(\frac{1}{M_{pl}}\right)$
$m_{3/2}$ effect
$\langle F_\phi \rangle = m_{3/2}$
$\Phi = \exp\left[\frac{\langle K \rangle}{2} - i\,\mathrm{Arg}(\langle W \rangle)\right] \exp\left[\frac{\langle K_i \rangle X^i}{3}\right]\left(1 + \theta^2 F_\phi\right)$



$c = -3,\ \xi = 0,\ Z$ real $\Longrightarrow$ to linear order
in the field fluctuation
$b_\mu = 0 + \mathcal{O}\left(\frac{1}{M_{pl}}\right)$
$c = -3$ to all order
$\hookrightarrow$ σ function
$X^i \quad X^{+} F$
σ : lowest component of chiral s.F.


$c = -3,\ \xi = 0,\ Z$ real $\Longrightarrow$ to linear order
in the field fluctuation
$b_\mu = 0 + \mathcal{O}\left(\frac{1}{M_{pl}}\right)$
$c = -3$ to all order
$\Longrightarrow$ σ function
$\chi^i \quad \chi^{+}$
σ : lowest component of chiral s.F.
$D_\mu \sigma = \partial_\mu \sigma - \frac{i}{2} b_\mu \sigma$ $\Longrightarrow$ chiral

$c = -3$, $\xi = 0$, Z real $\Longrightarrow$ to linear order in the field fluctuation

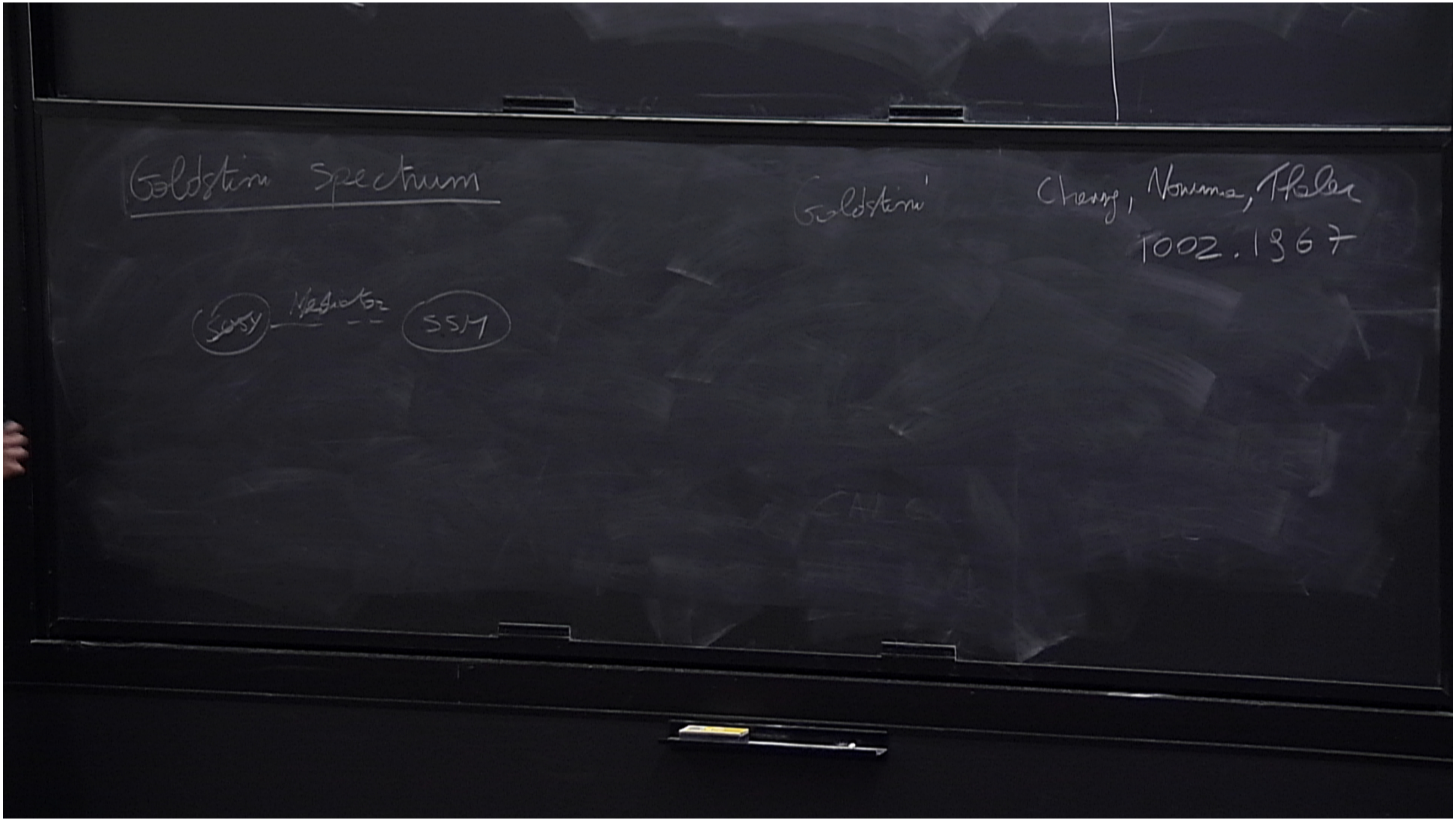
$$b_\mu = 0 + \mathcal{O}\left(\frac{1}{M_{pl}}\right)$$

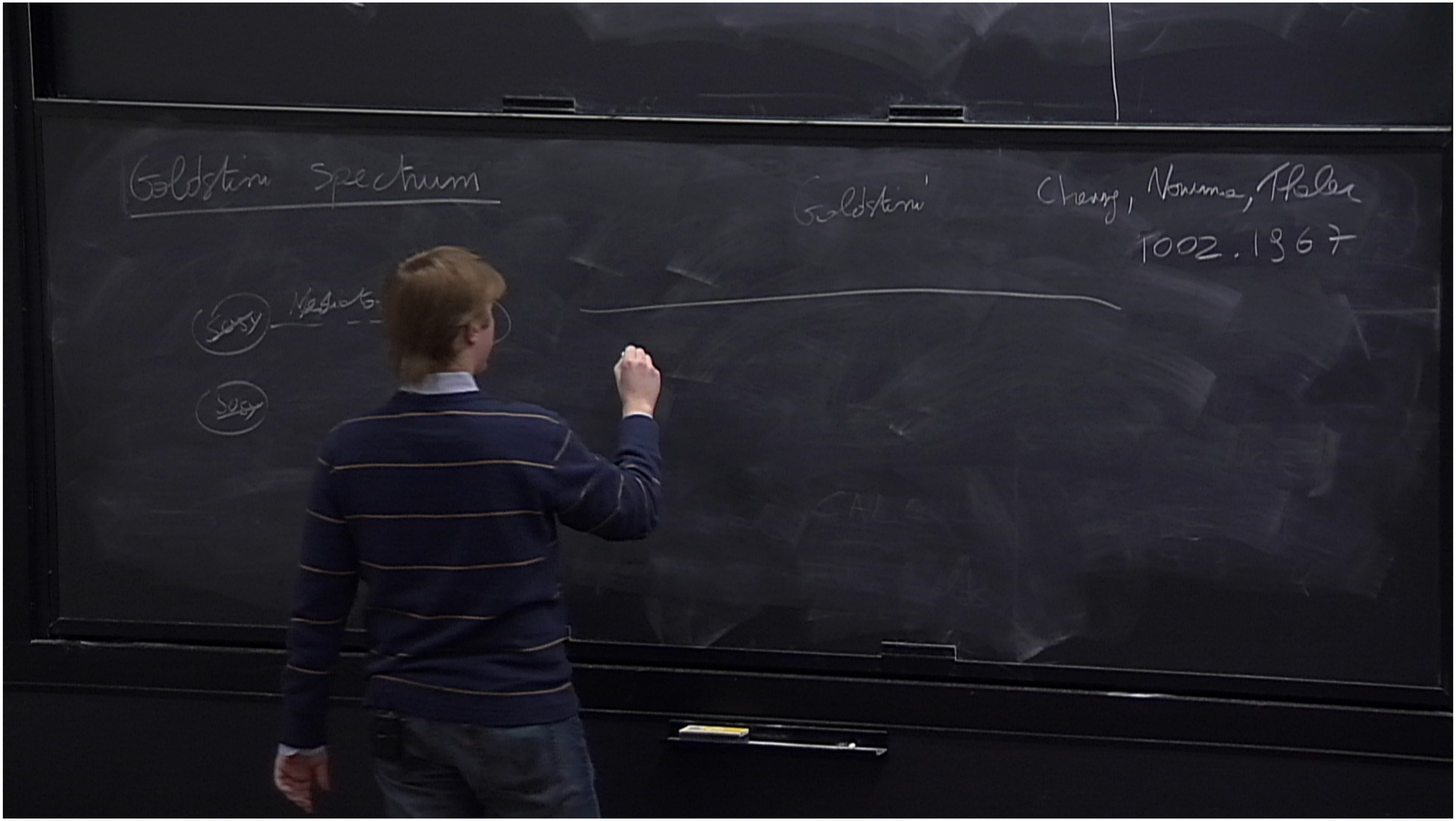
$c = -3$ to all order

$\Longrightarrow$ σ function X^i $X^{+\bar{J}}$

σ : lowest component of chiral S.F.

$$D_\mu \sigma = \partial_\mu \sigma - \frac{i}{2} \cancel{b_\mu} \sigma \quad \Longrightarrow \text{chiral}$$


Goldstino spectrum
Goldstini
Cheung, Nomura, Thaler
1002.1967
SUSY
Mediator
SSM


Goldstino spectrum
Goldstini
Cheung, Nomura, Thaler
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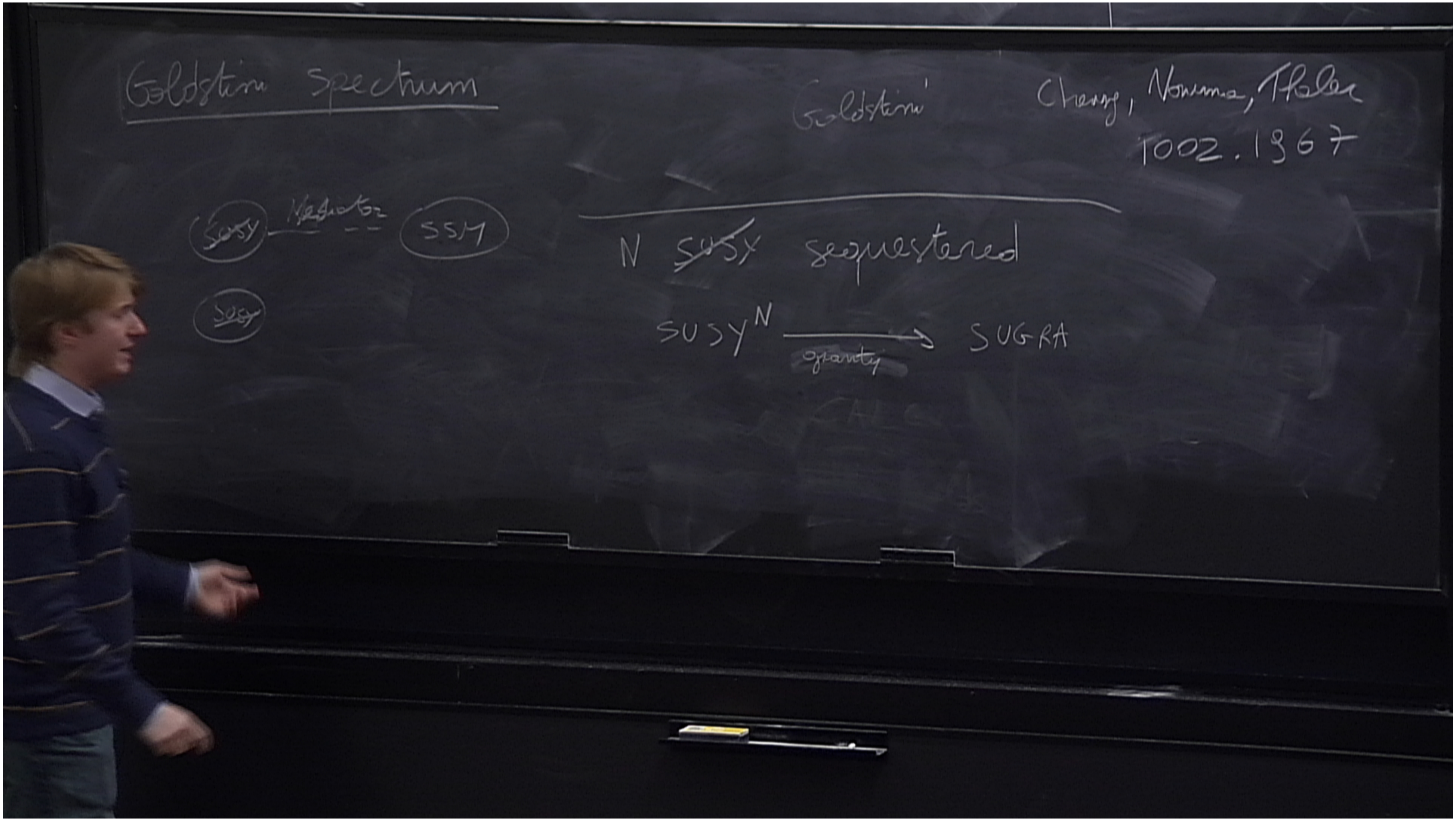
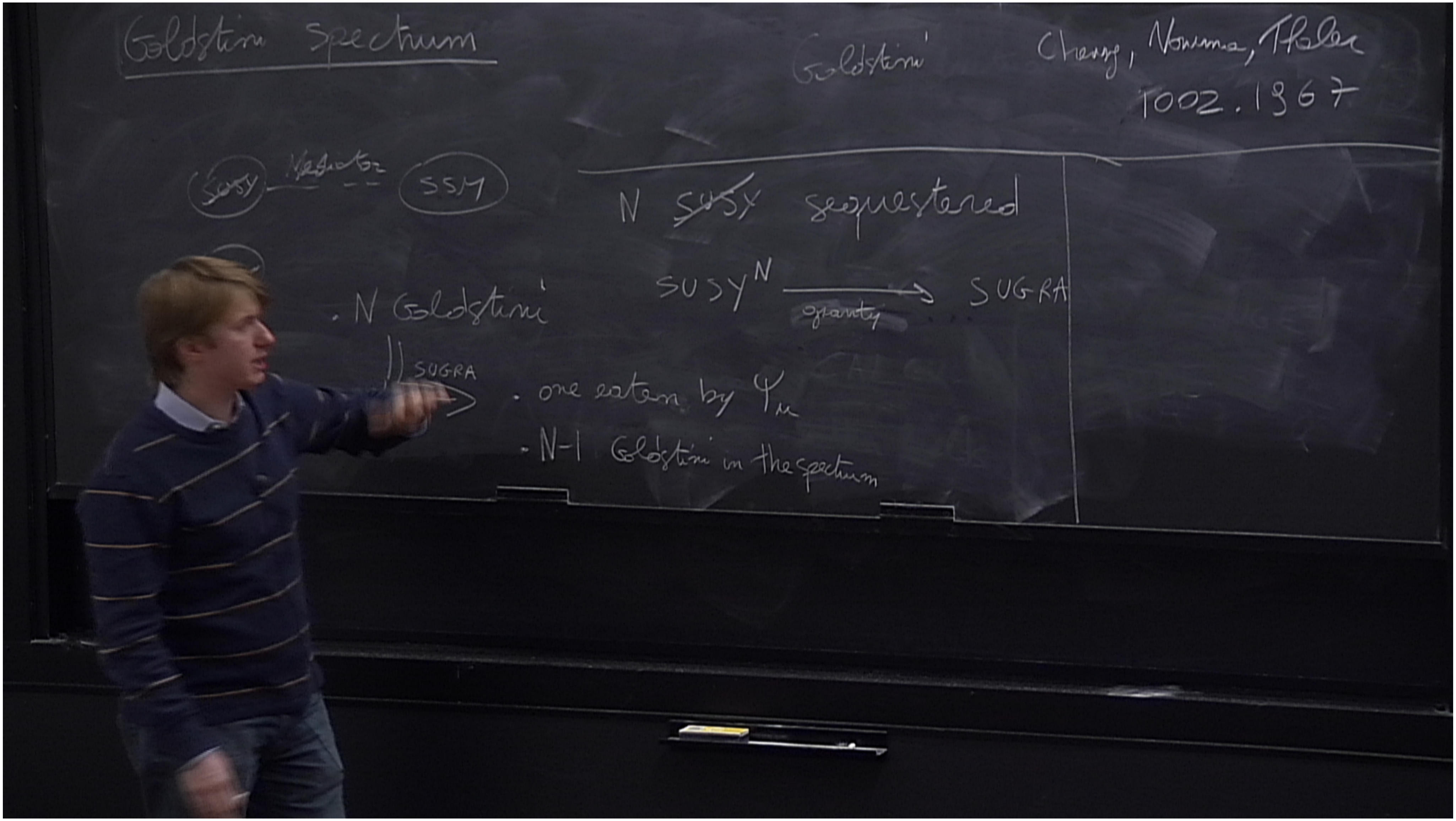
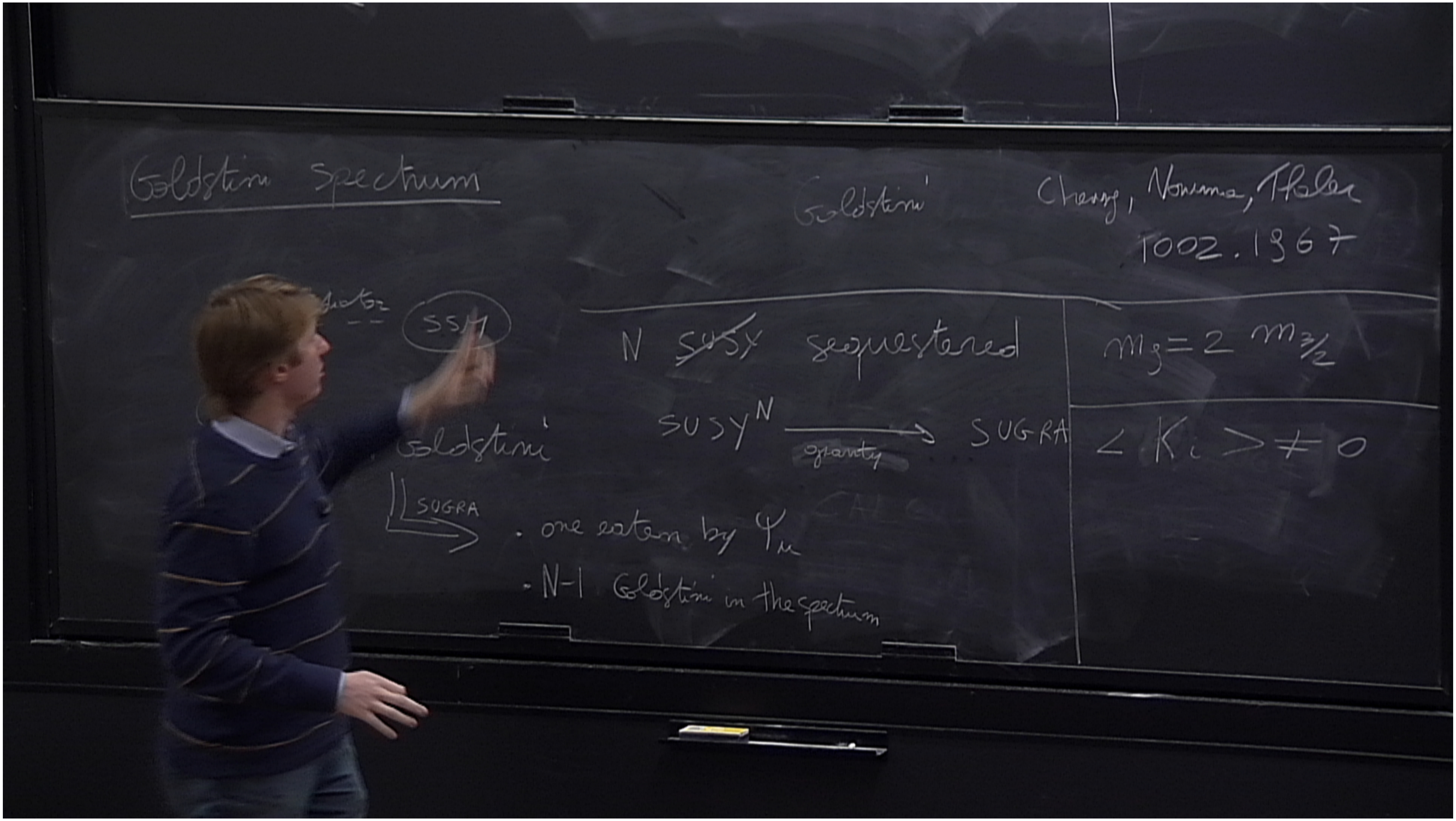
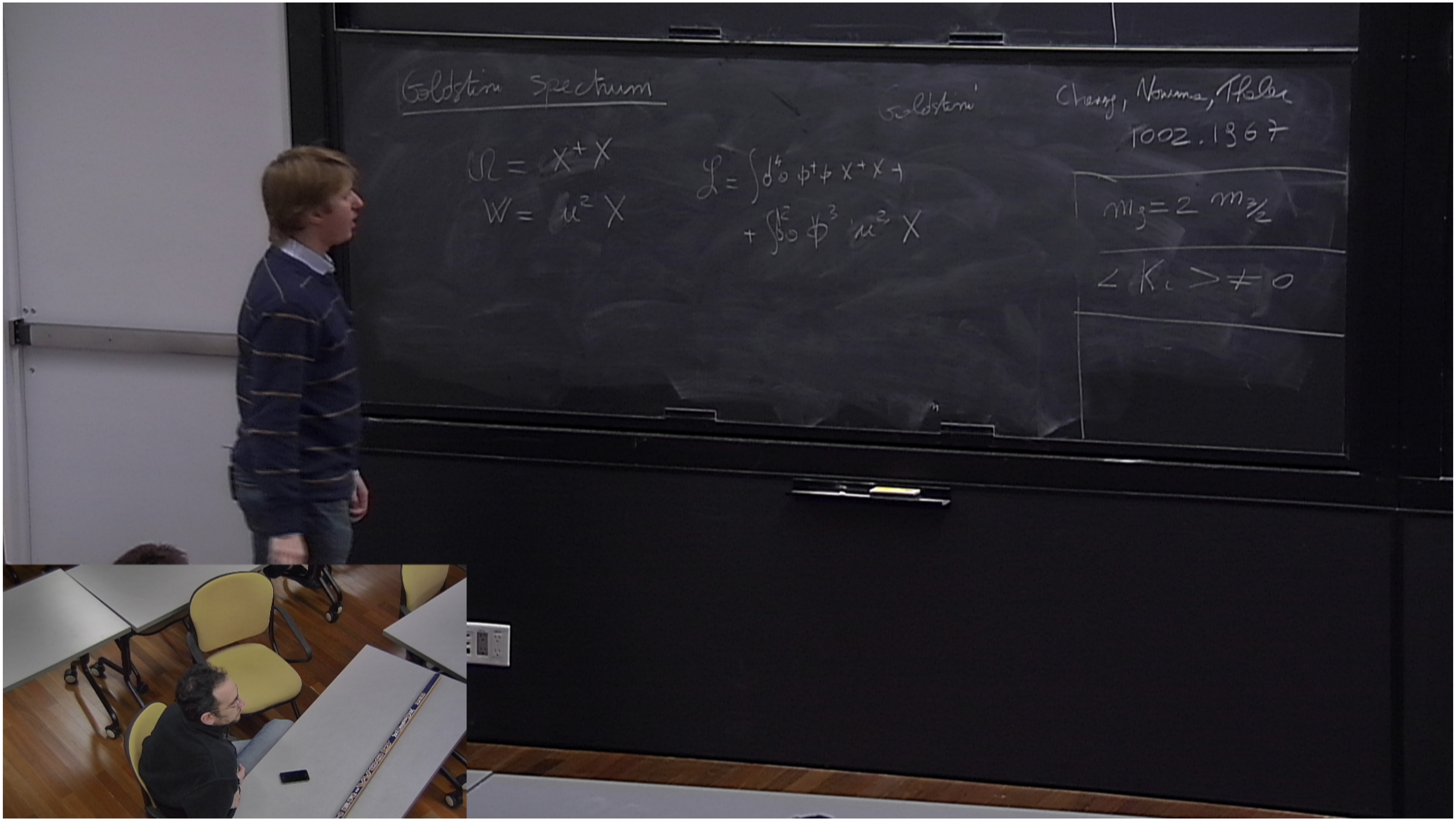

Goldstini spectrum
Goldstini'
Cheung, Nomura, Thaler
1002.1967
SUSY
Mediator
SSM
SUSY
N SUSY sequestered
SUSY^N
gravity
SUGRA


Goldstino spectrum
Goldstini
Cheung, Nomura, Thaler
1002.1967
SUSY
SSM
N SUSY sequestered
SUSY^N
gravity
SUGRA
. N Goldstini
SUGRA
. one eaten by ψ_μ
. N-1 Goldstini in the spectrum


Goldstini spectrum
Goldstini
Cheung, Nomura, Thaler
1002.1967
N SUSY sequestered
m_g = 2 m_3/2
SUSY^N → SUGRA
gravity
< K_i > ≠ 0
Goldstini
SUGRA
. one eaten by ψ_μ
. N-1 Goldstini in the spectrum


Goldstino spectrum
Goldstini
Cheung, Nomura, Thaler
1002.1967
$\Omega = X^+ X$
$W = \mu^2 X$
$\mathcal{L} = \int d^4\theta \, \phi^+ \phi \, X^+ X +$
$+ \int d^2\theta \, \phi^3 \mu^2 X$
$m_3 = 2 \, m_{3/2}$
$\langle K_i \rangle \neq 0$