Title: N=2 F-Terms Revisited

Date: Jan 24, 2006 02:00 PM

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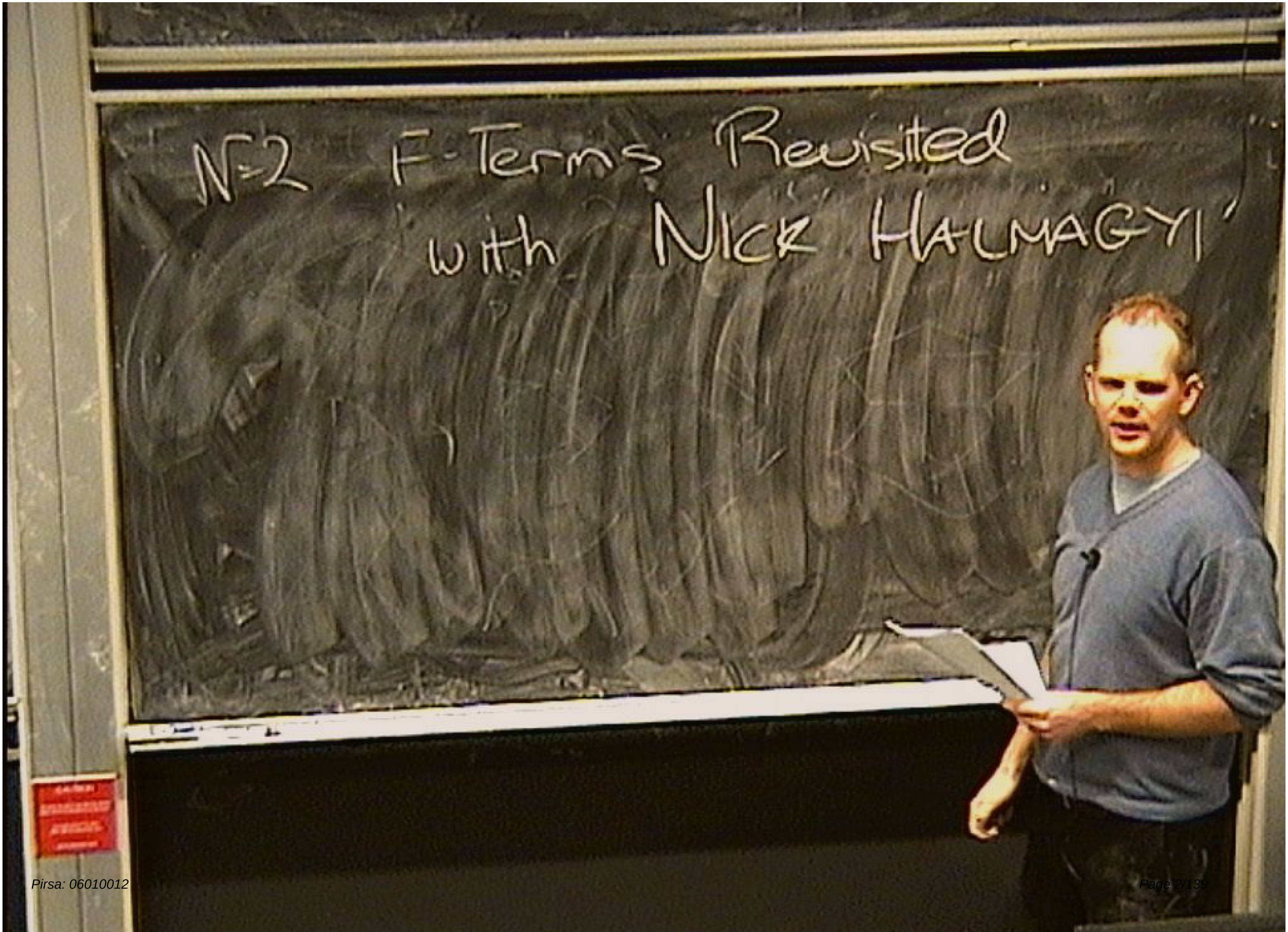
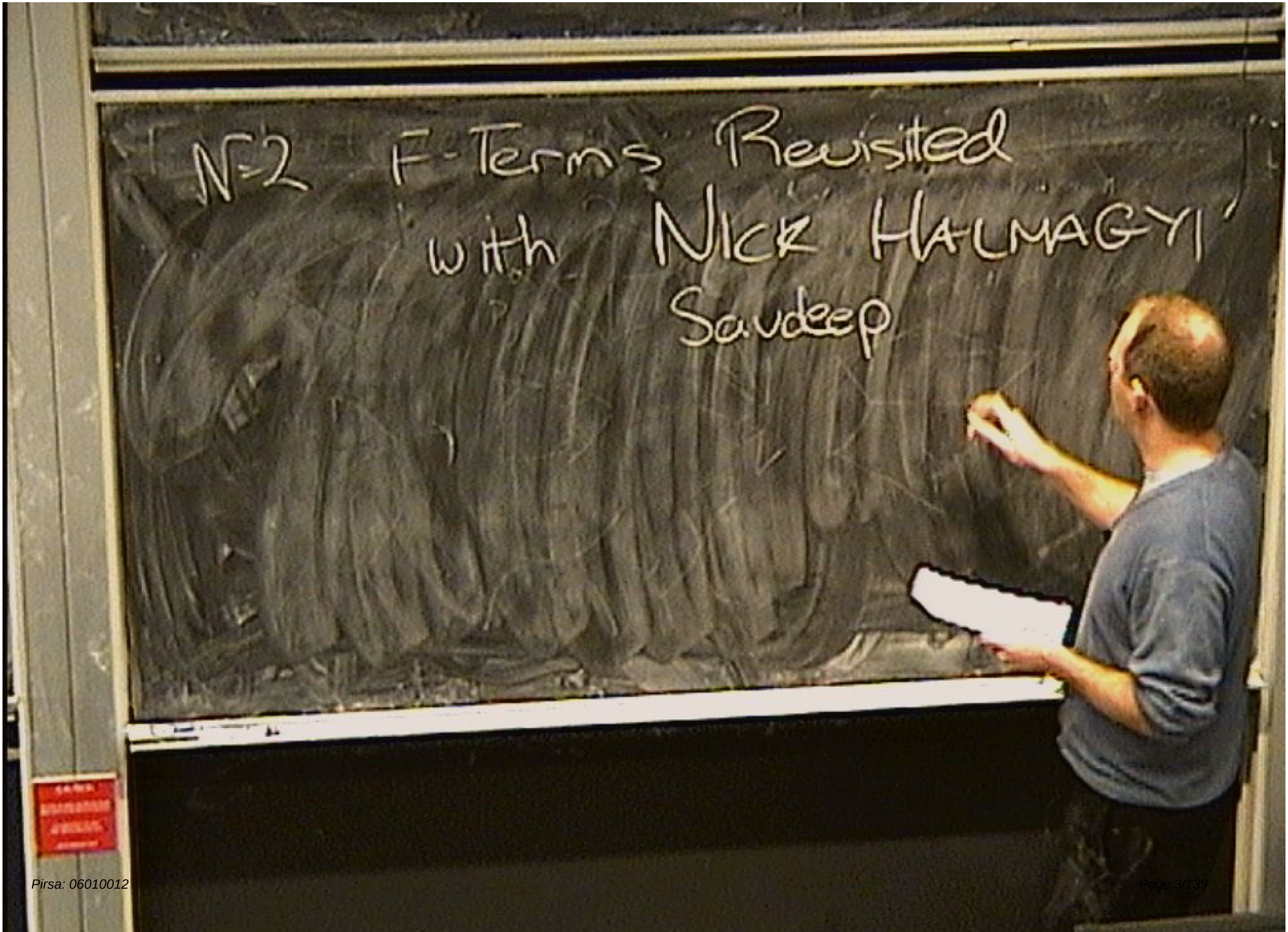
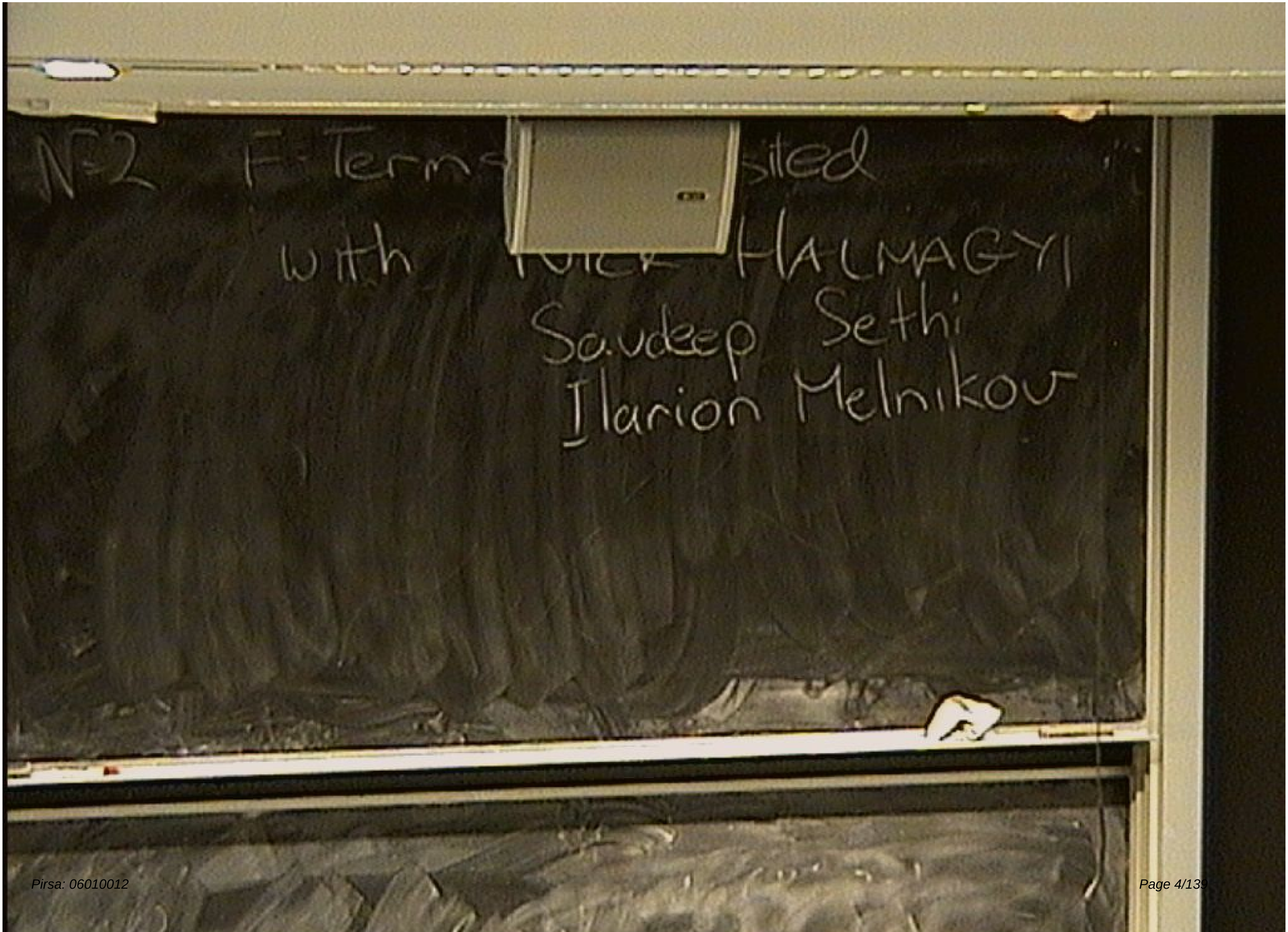
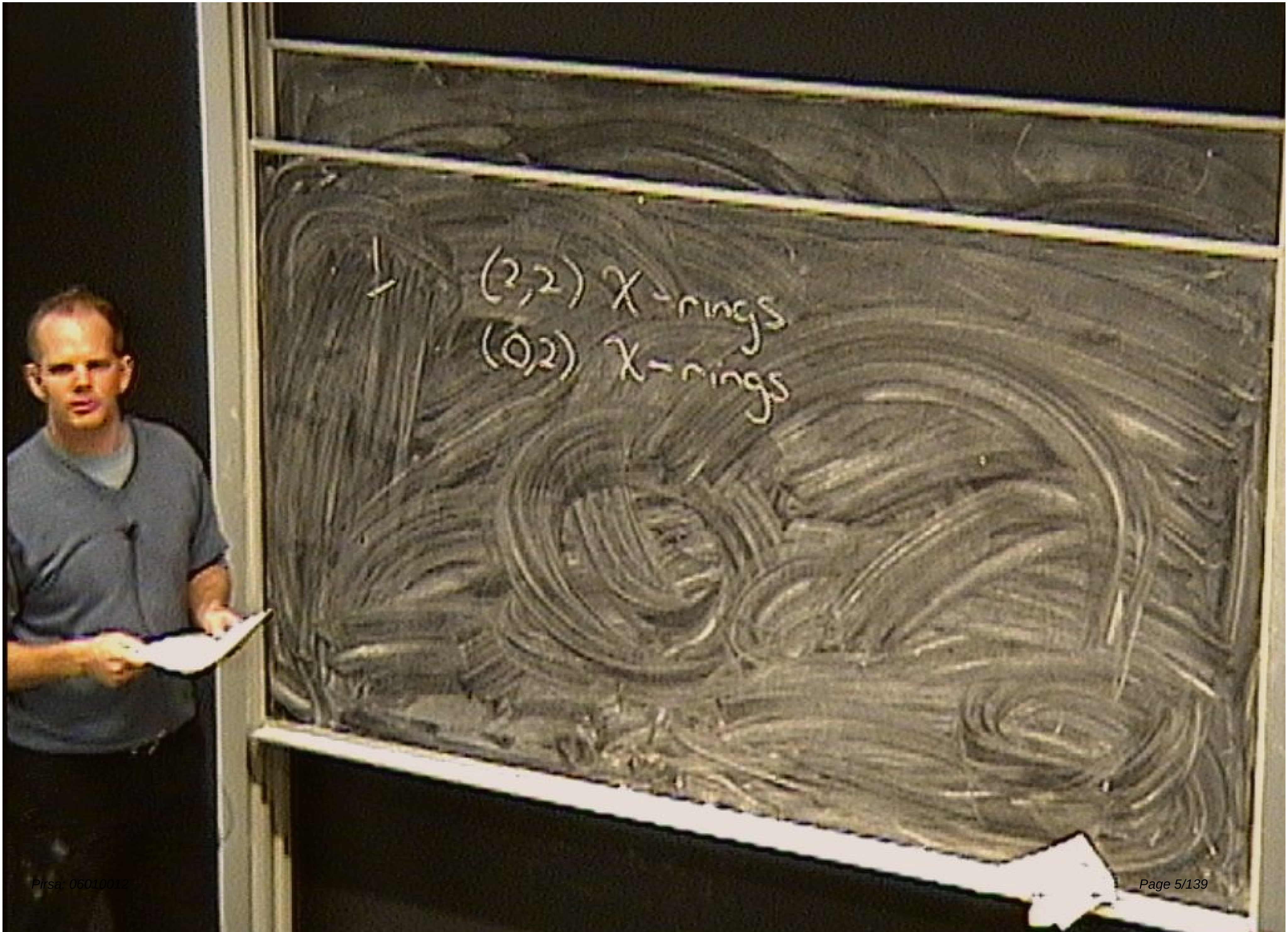
Abstract: N=2 F-Terms Revisited


N=2 F-Terms Revisited
with NICK HALMAGYI


N=2 F-Terms Revisited
with NICK HALMAGYI
Sandeep


№2 F-Terms
sited
with
HALMAGYI
Savdeep Sethi
Ilarion Melnikov


(2,2) χ-rings
(0,2) χ-rings

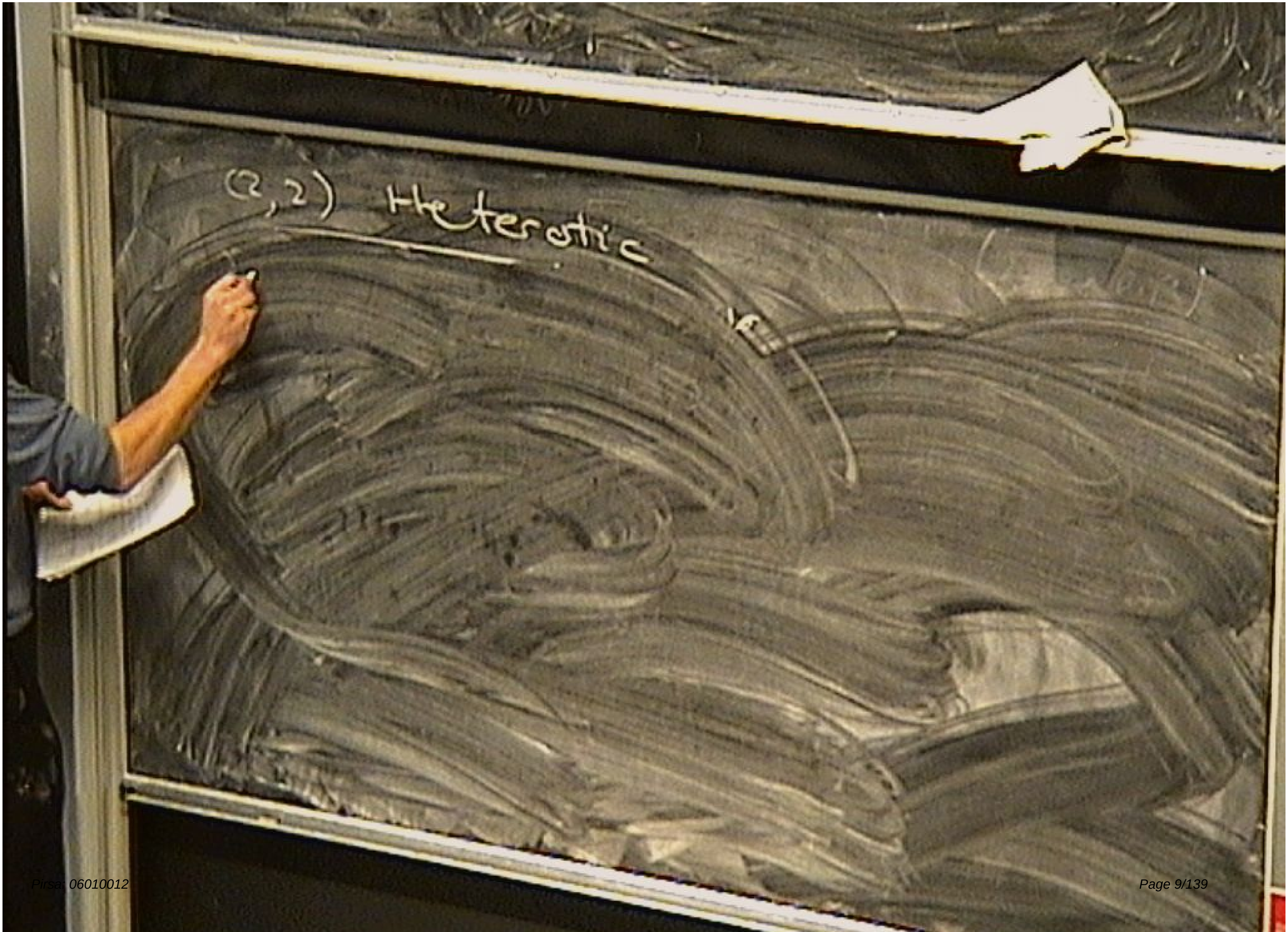
1. (2,2) χ-rings

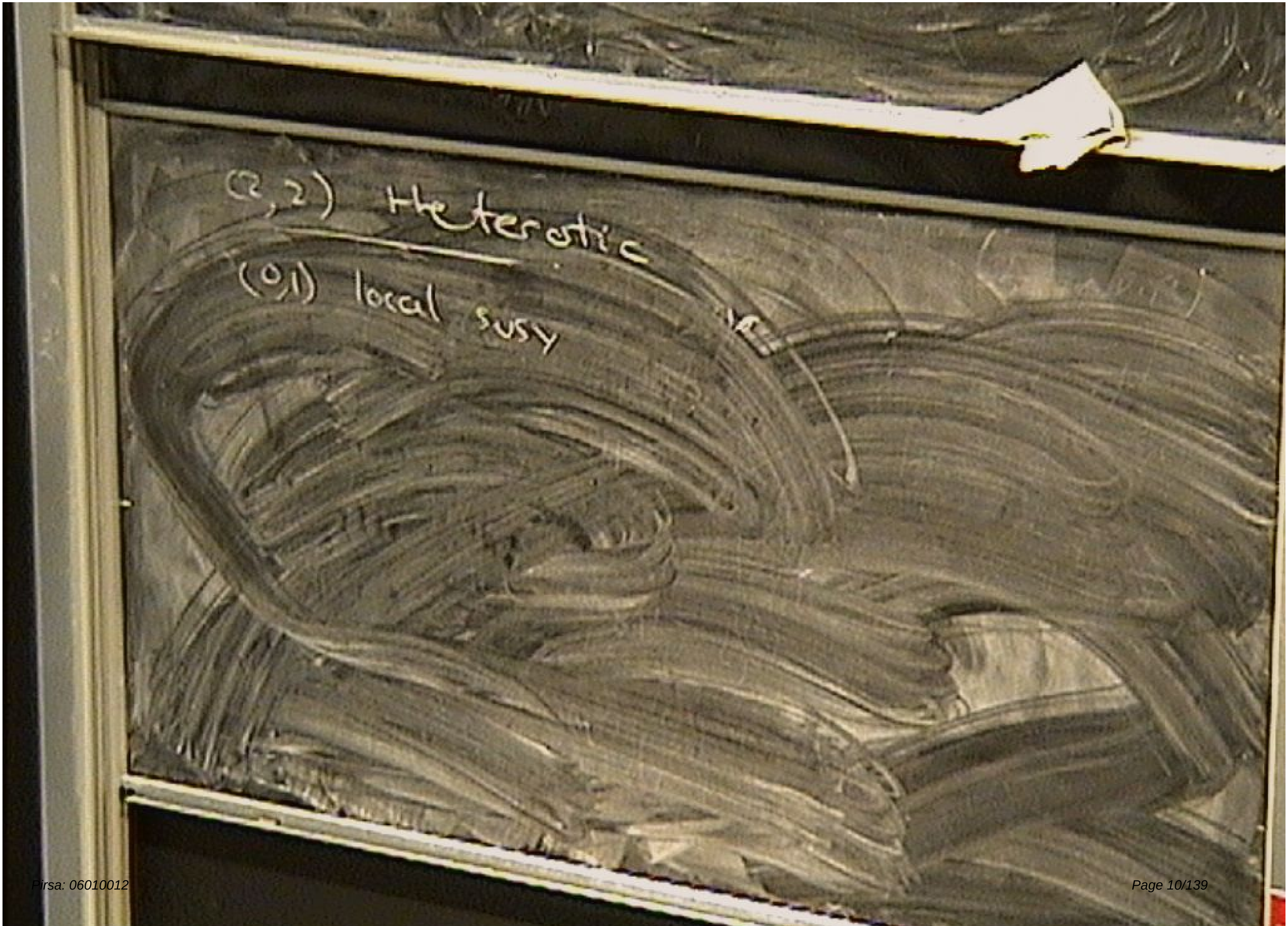
(0,2) χ-rings

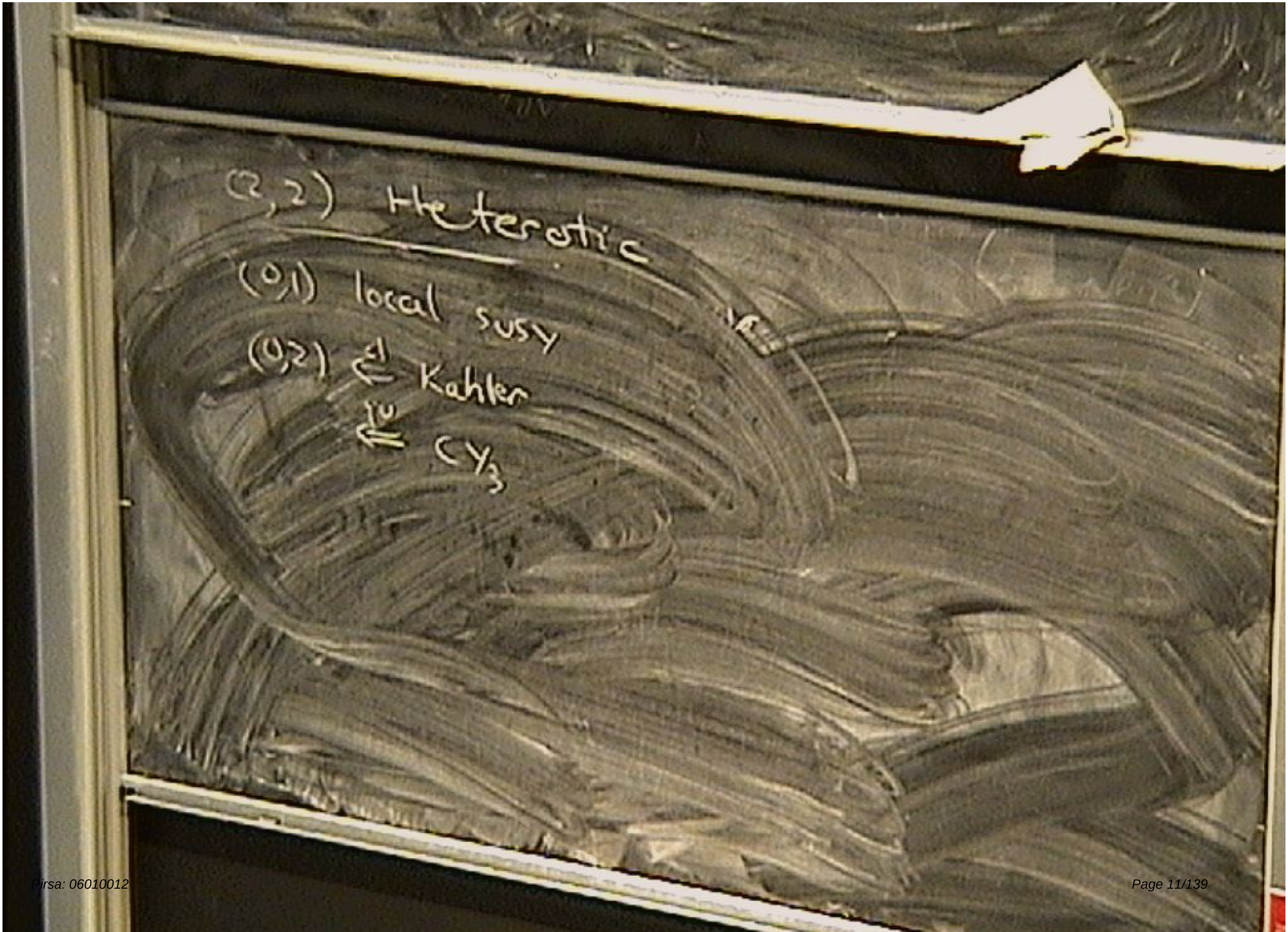
2. Het/IIA duality.

1. $(2,2)$ χ-rings
   $(0,2)$ χ-rings
2. Het/IIA duality
3. $\mathcal{N}=2$ SUGRA in 4d.

1. (2,2) χ-rings
   (0,2) χ-rings
2. Het/IIA duality
3. $\mathcal{N}=2$ SUGRA in 4d.
4. F-terms from worldsheet


(2,2) Heterotic


(2,2) heterotic
(0,1) local susy


(2,2) Heterotic
(0,1) local susy
(0,2) ⇐ Kahler
⇐ CY3

(2,2) Heterotic

(0,1) local susy

(0,2) $\overset{cl}{\Leftarrow}$ Kahler

(2,2) $\overset{qu}{\Leftarrow}$ CY_3

left moving

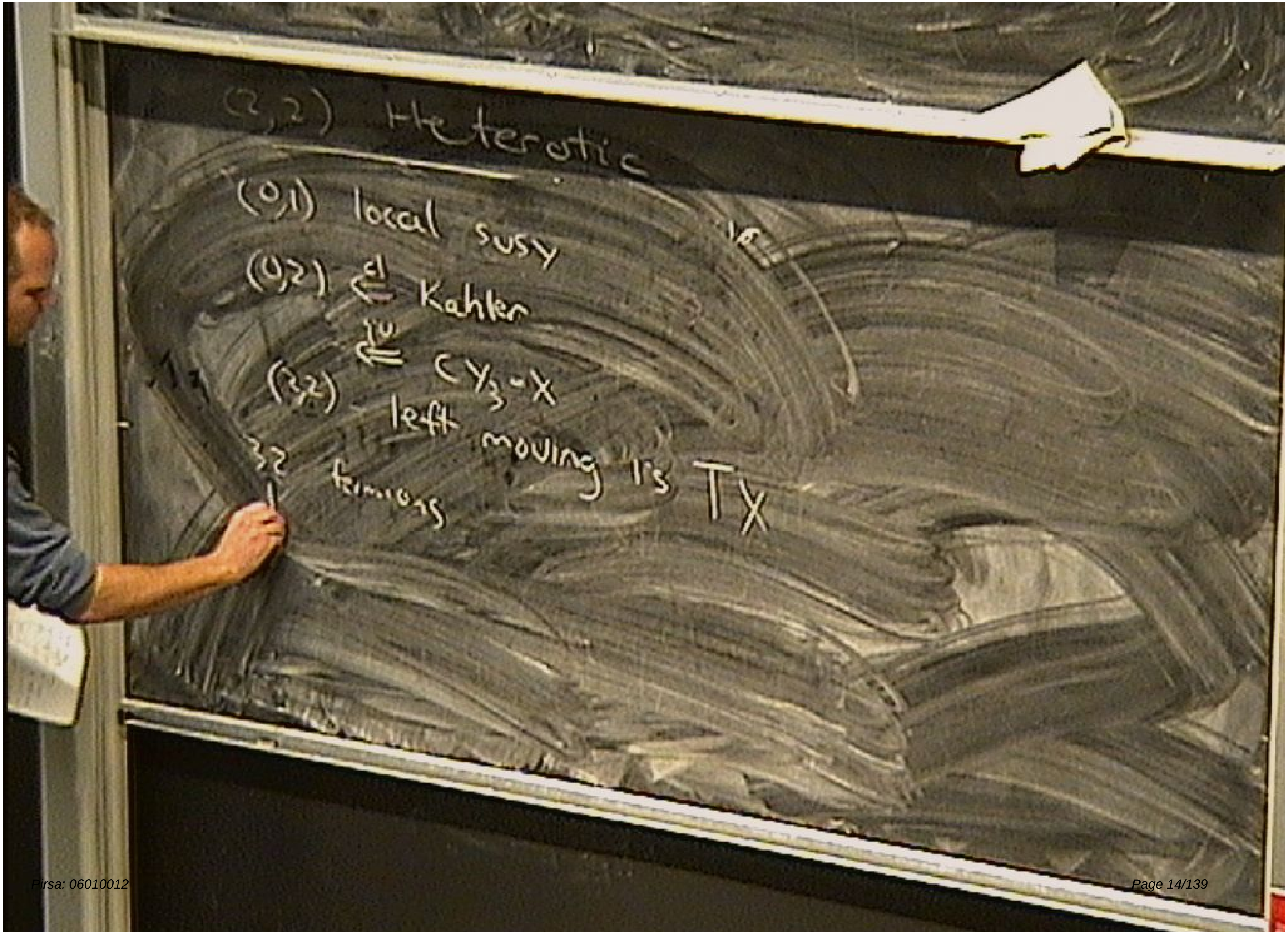
(2,2) Heterotic

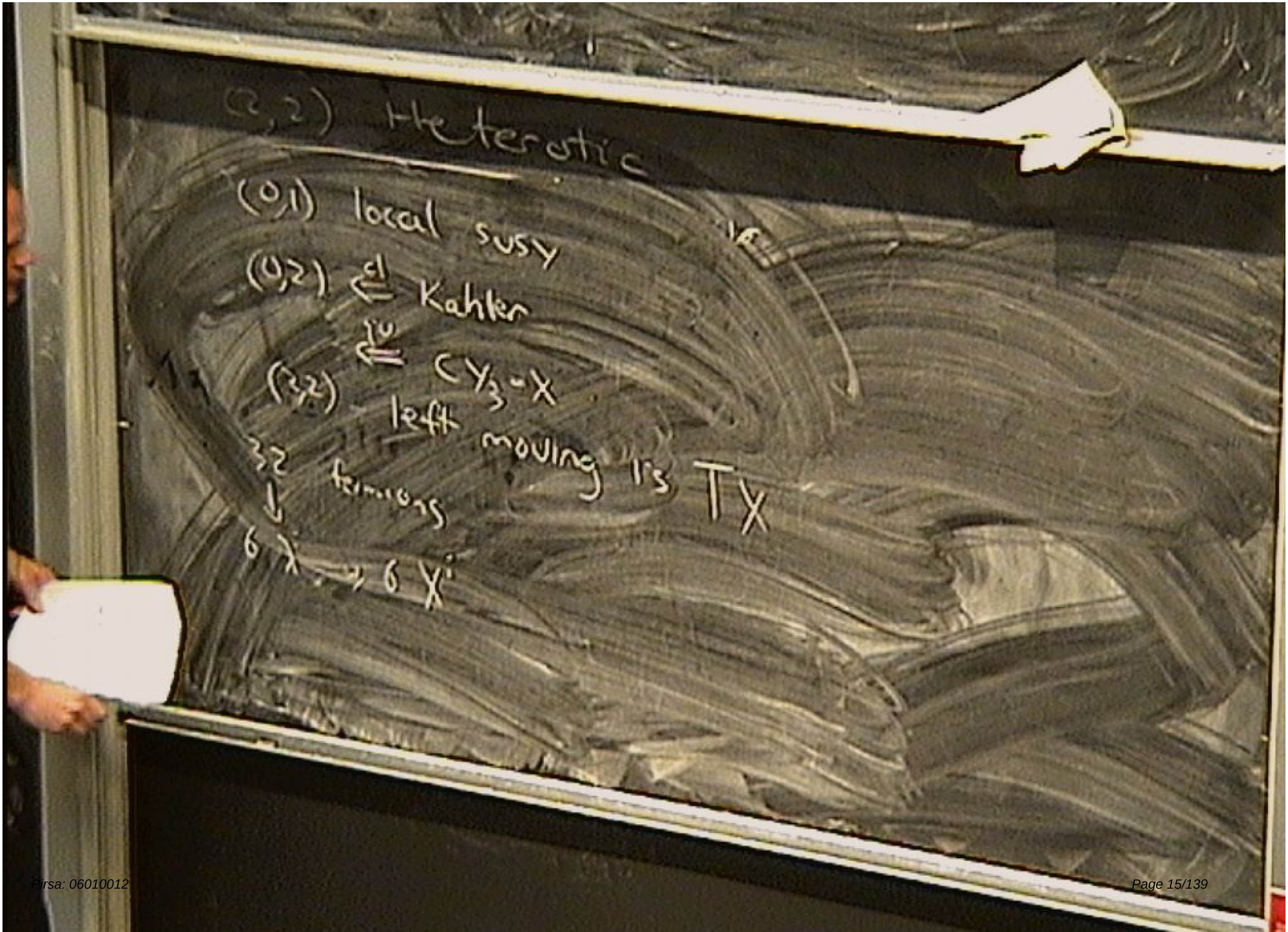
(0,1) local susy

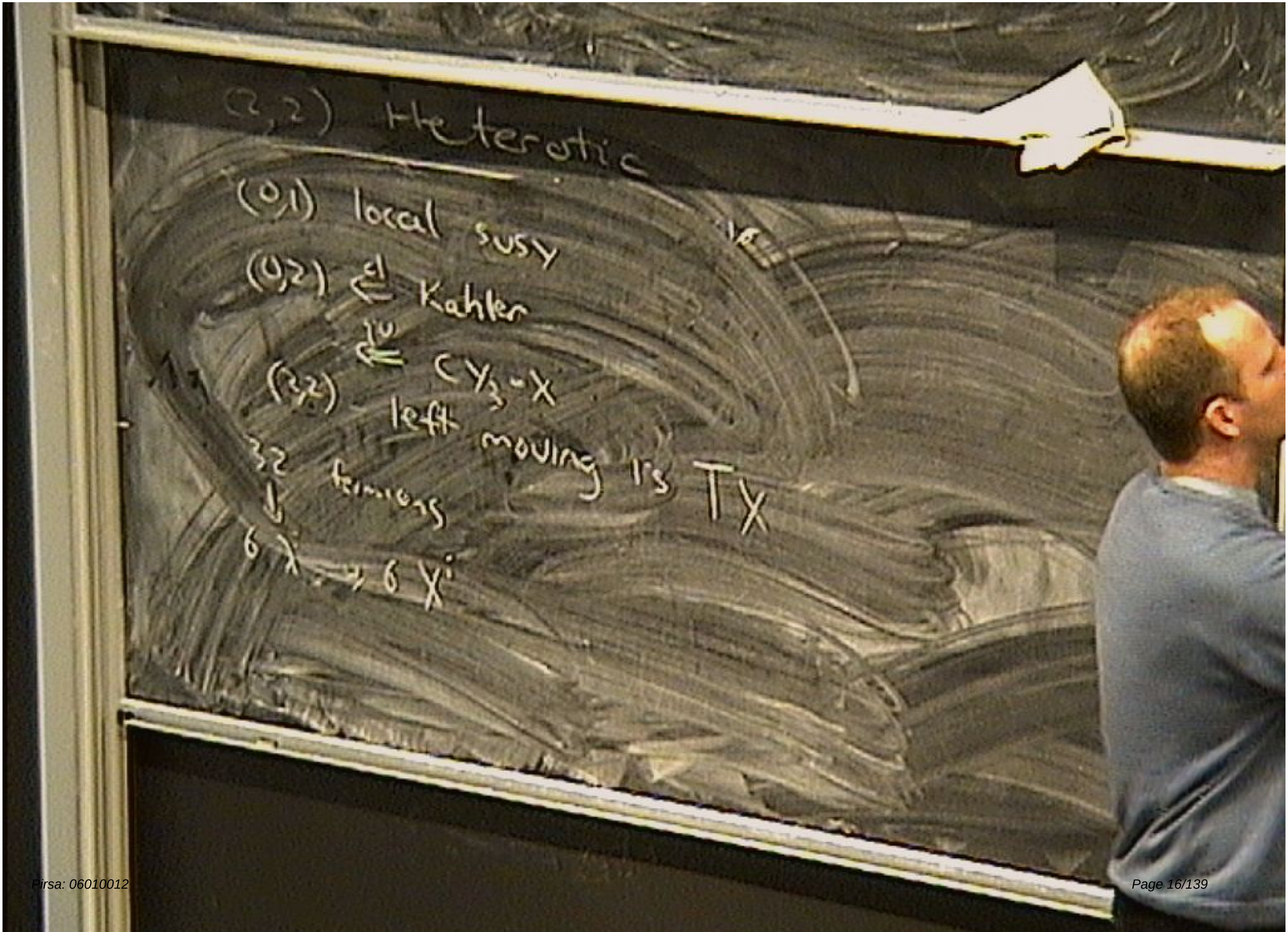
(0,2) $\overset{cl}{\Leftarrow}$ Kahler

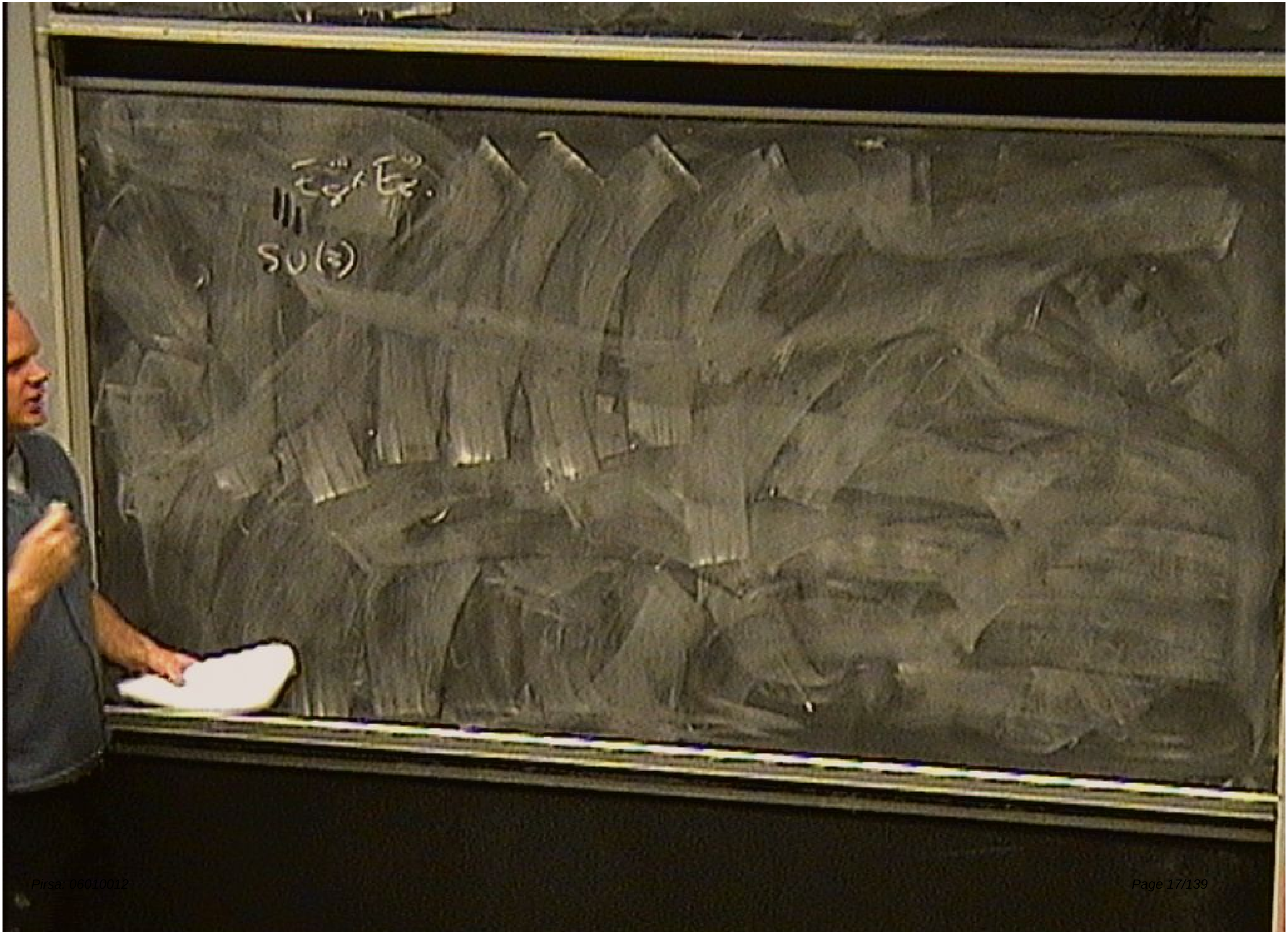
(2,2) $\overset{qu}{\Leftarrow}$ $CY_3 - X$

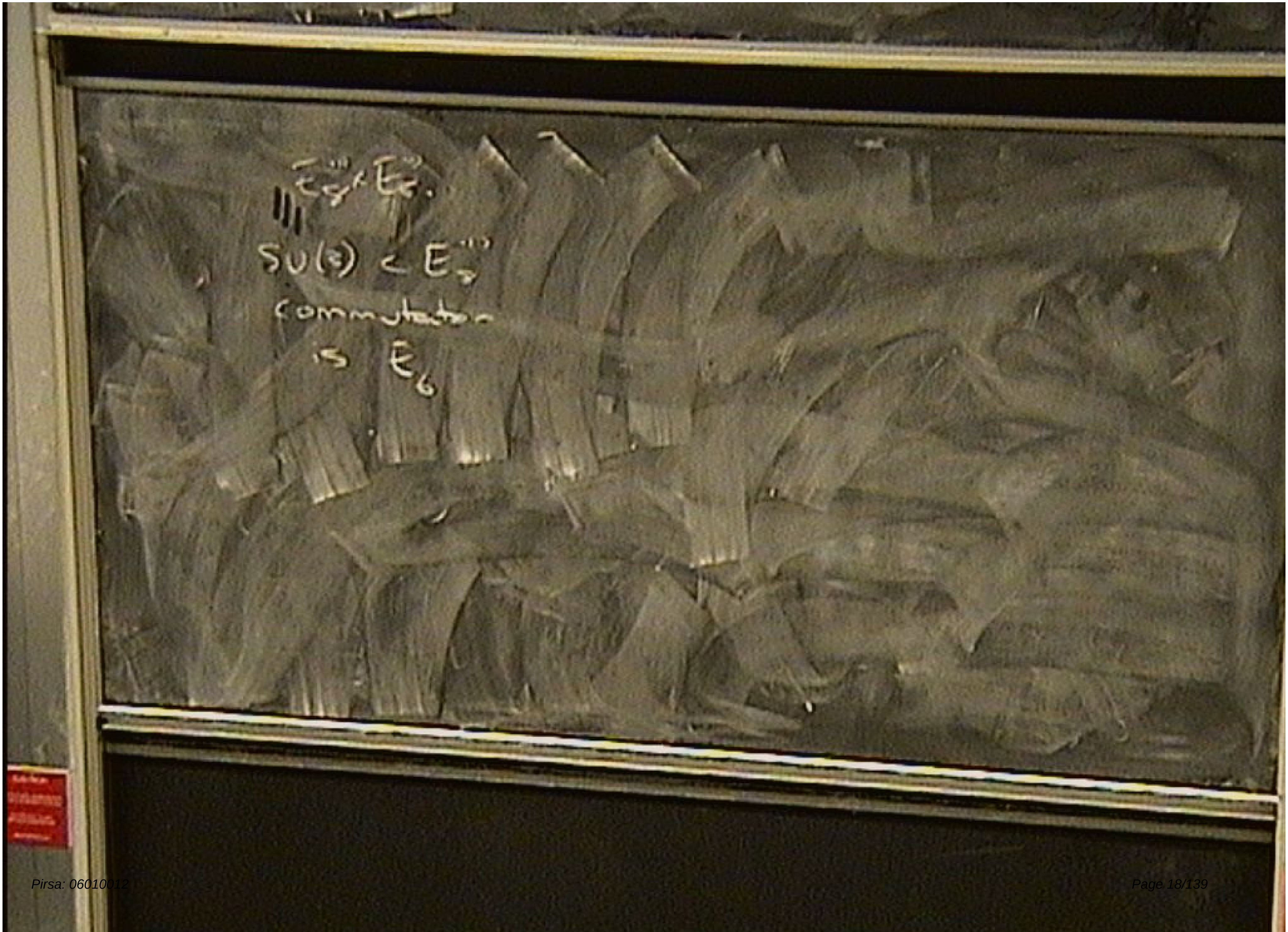
left moving 1's TX

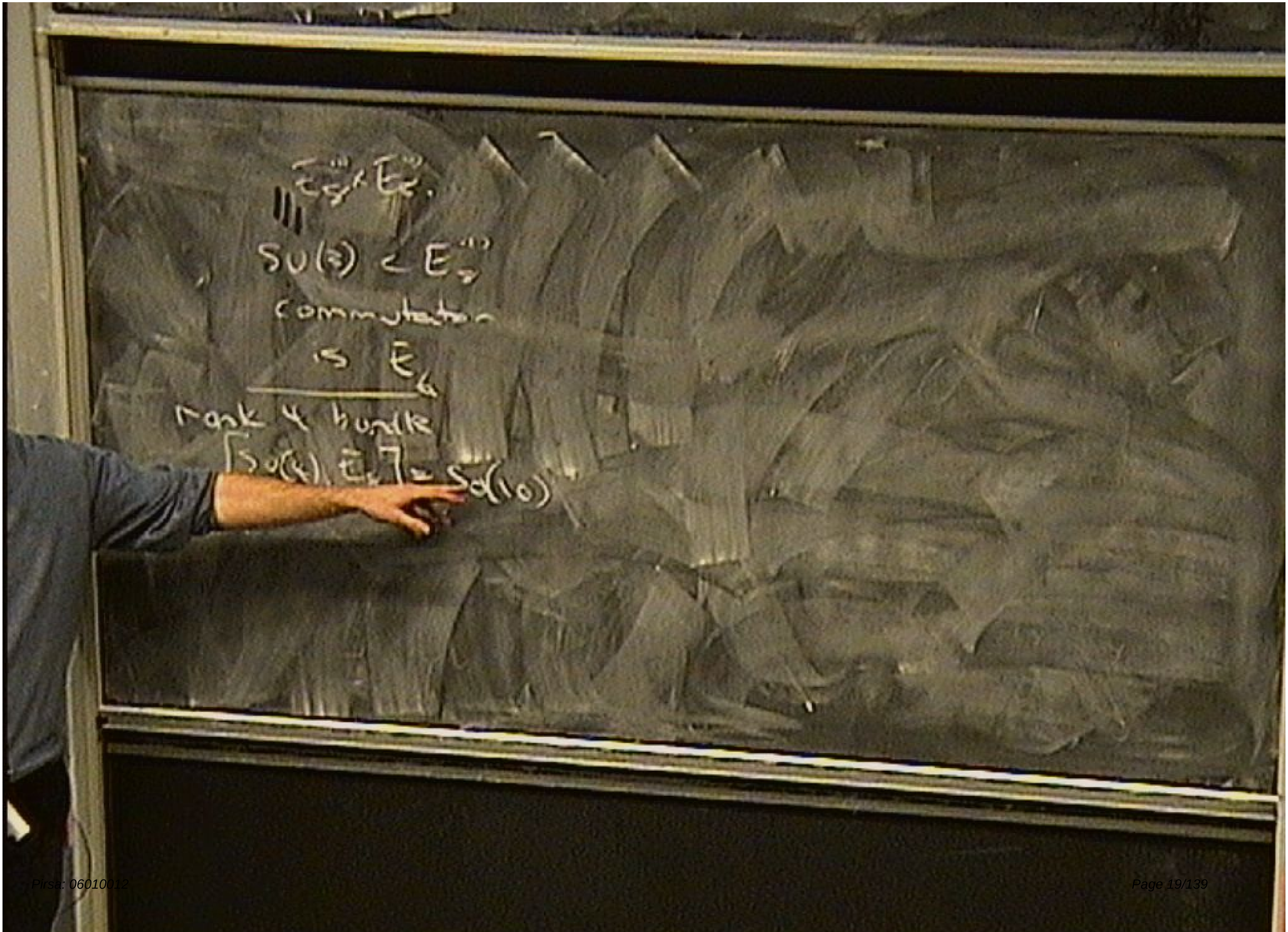

(2,2) Heterotic
(0,1) local susy
(0,2) Kahler
(2,2) CY3 - X
left moving 1's TX
32 fermions


(2,2) Heterotic
(0,1) local susy
(0,2) Kahler
CY3 = X
(2,2) left moving
32 fermions is TX
6 X


(2,2) Heterotic
(0,1) local susy
(0,2) ⇐ Kahler
(2,2) ⇐ CY3 - X
left moving 's TX
32 fermions
6 λ → 6 X^i


SU(3)


$E_8^{(1)} \times E_8^{(1)}$
$SU(3) < E_8^{(1)}$
commutator
is E_6


E8 × E8
SU(3) ⊂ E8
commutator
is E6
rank 4 bundle
[SU(4), E8] = SO(10)

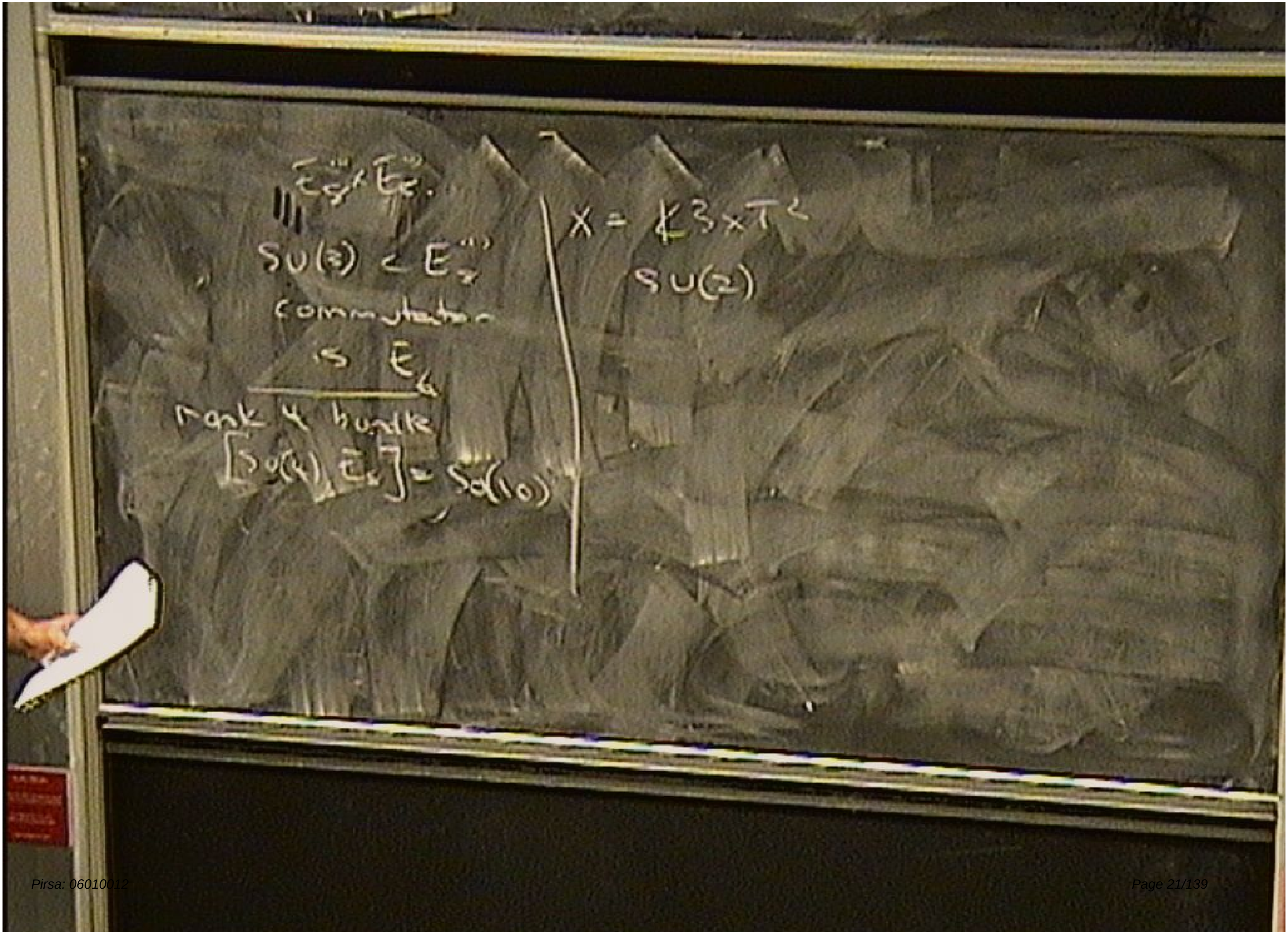
$E_8^{(1)} \times E_8^{(2)}$

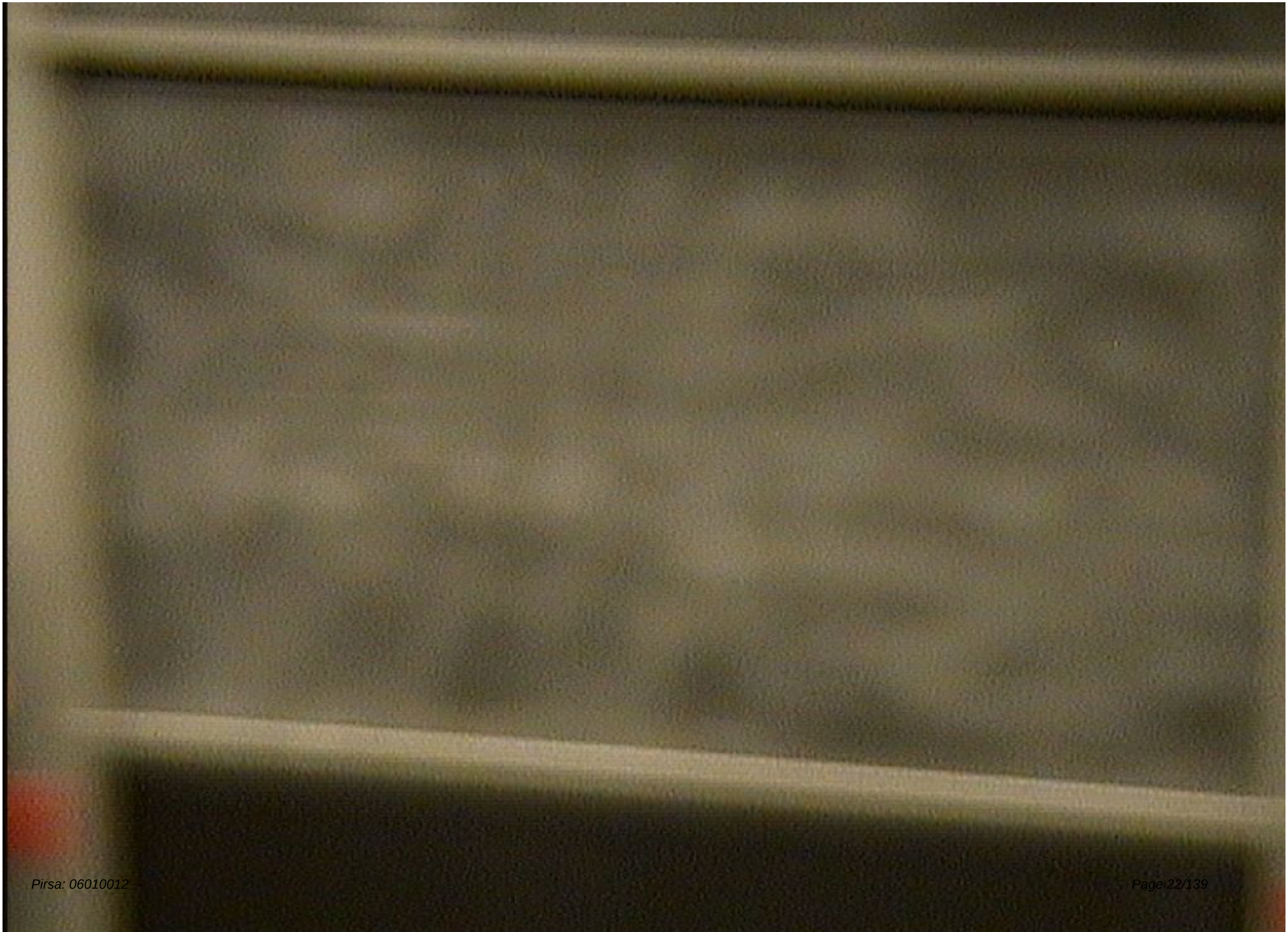
$SU(3) \subset E_8^{(1)}$

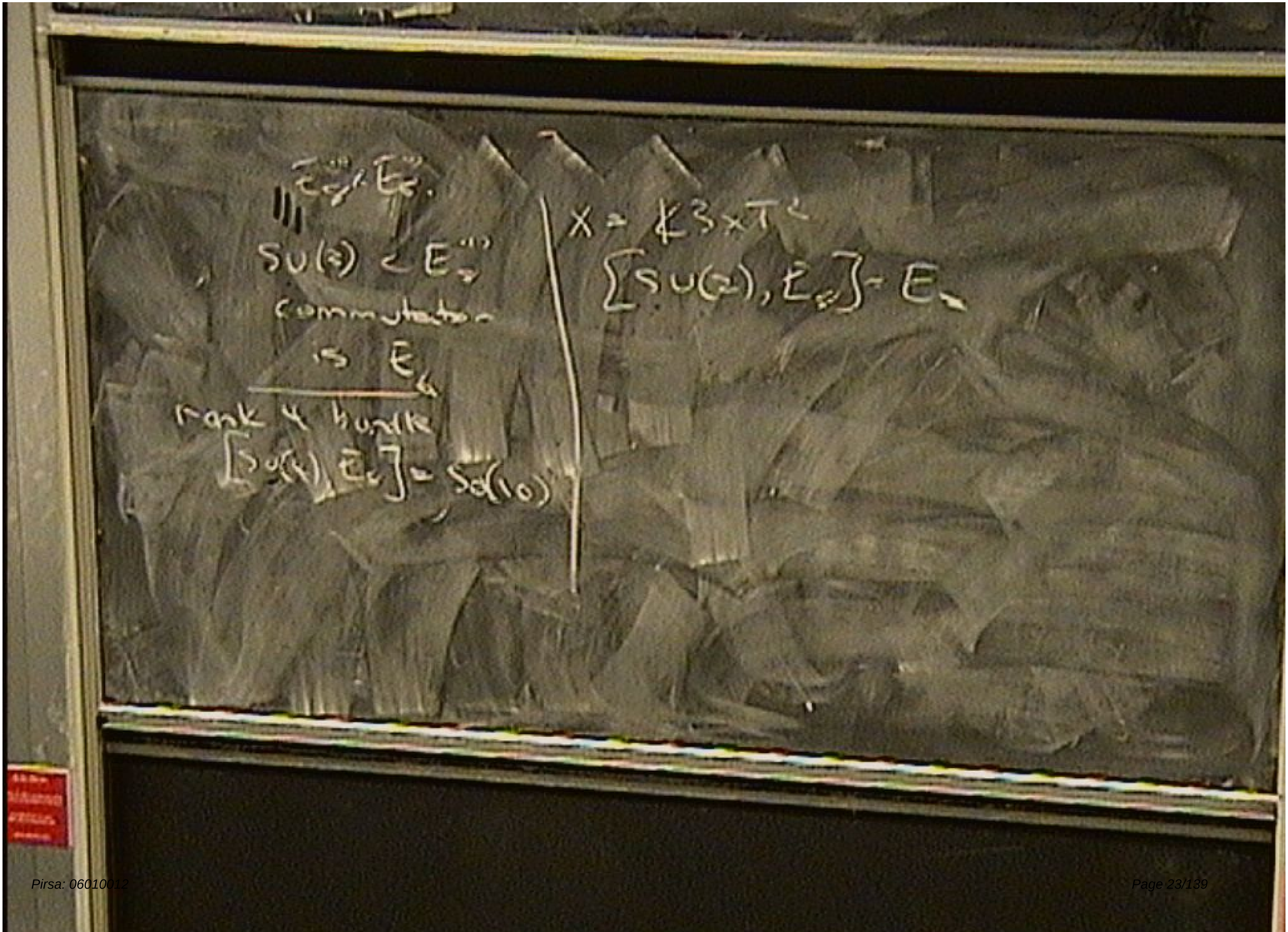
commutator is E_6

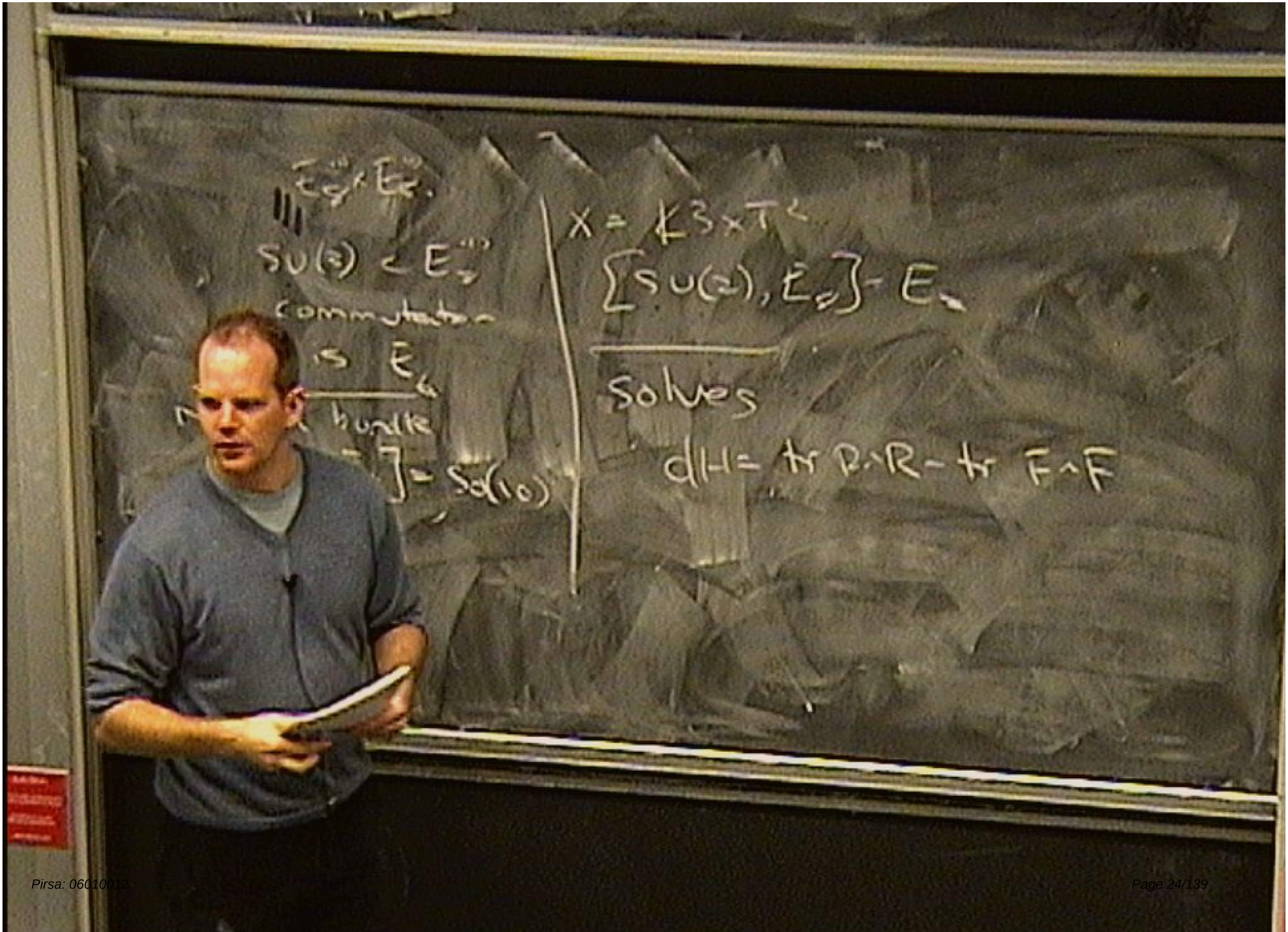
rank 4 bundle

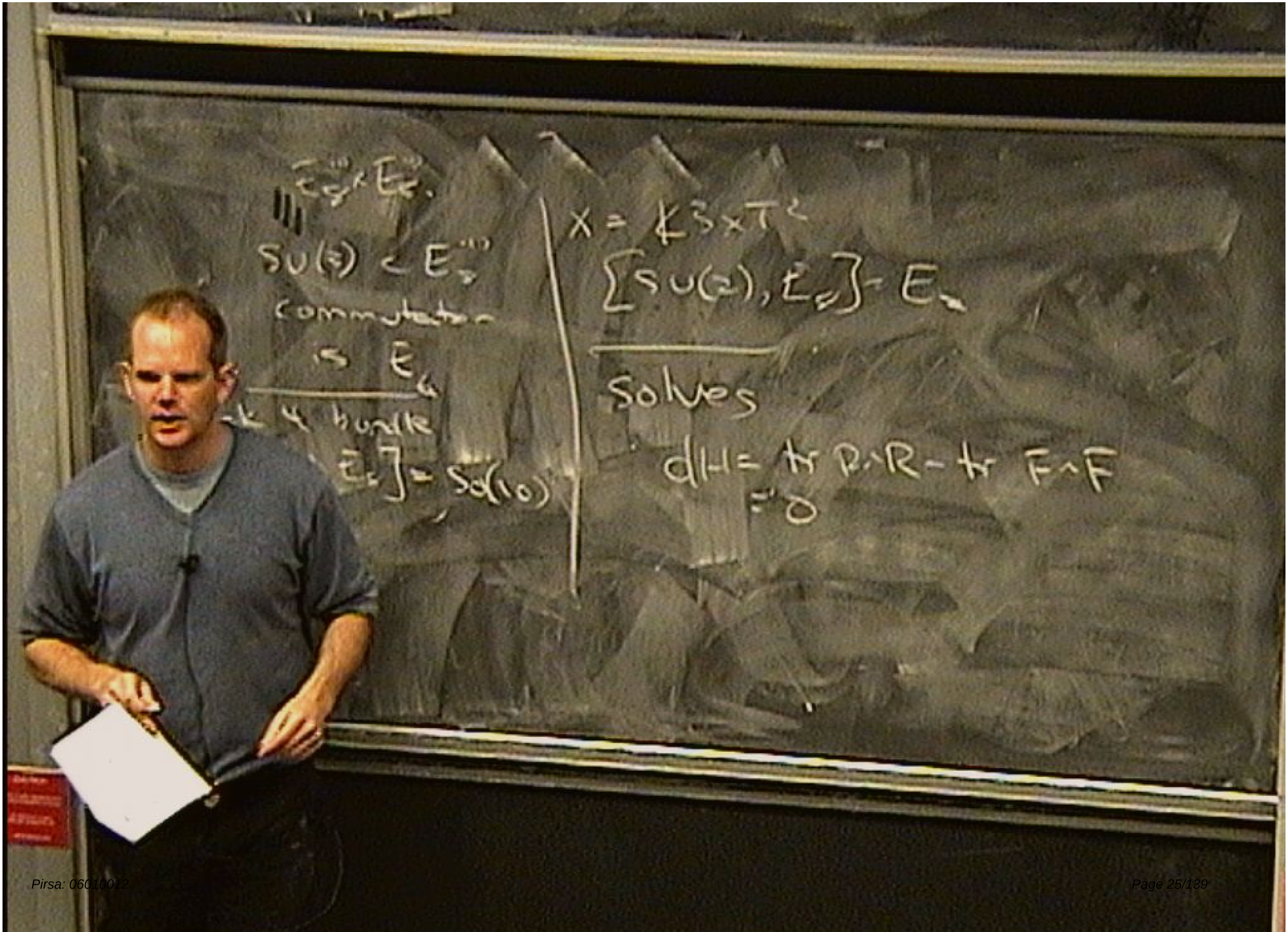
$[SU(4), E_8] = SO(10)$


E8 × E8
SU(3) < E8
commutator
is E6
rank 4 bundle
[SU(4), E8] = SO(10)
X = K3 × T2
SU(2)




E8 × E8
SU(2) ⊂ E8
commutator
is E7
rank 4 bundle
[SU(4), E8] = SO(10)
X = K3 × T2
[SU(2), E8] = E7


X = K3 × T²
{SU(2), E₈} = E₇
solves
dH = tr R∧R − tr F∧F
SU(3) ⊂ E₈
commutator
is E₆
= SO(10)



SU(3) ⊂ E8
commutator
is E6
4 bundle
] = SO(10)
X = K3 × T2
[SU(2), E8] = E7
Solves
dH = tr R∧R − tr F∧F
= 0

(2,2) χ-ring.

(2,2) χ-ring.

Primary

G

(2,2) χ-ring.

Primary

$$G^{-}_{+1/2}|\phi\rangle = G^{+}_{+1/2}|\phi\rangle = 0$$

(2,2) χ-ring.

Primary

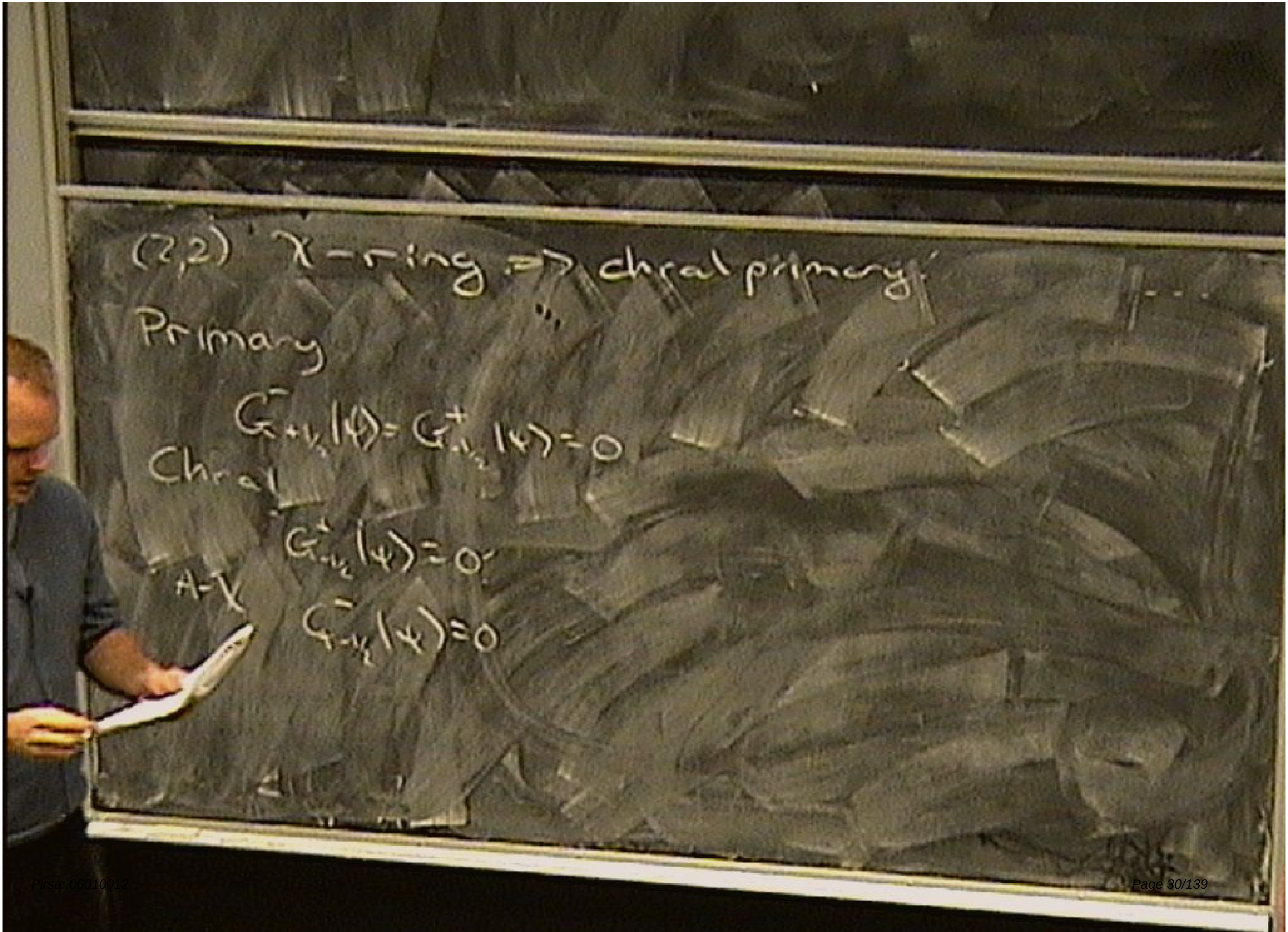
$$G^-_{+1/2}|\psi\rangle = G^+_{+1/2}|\psi\rangle = 0$$

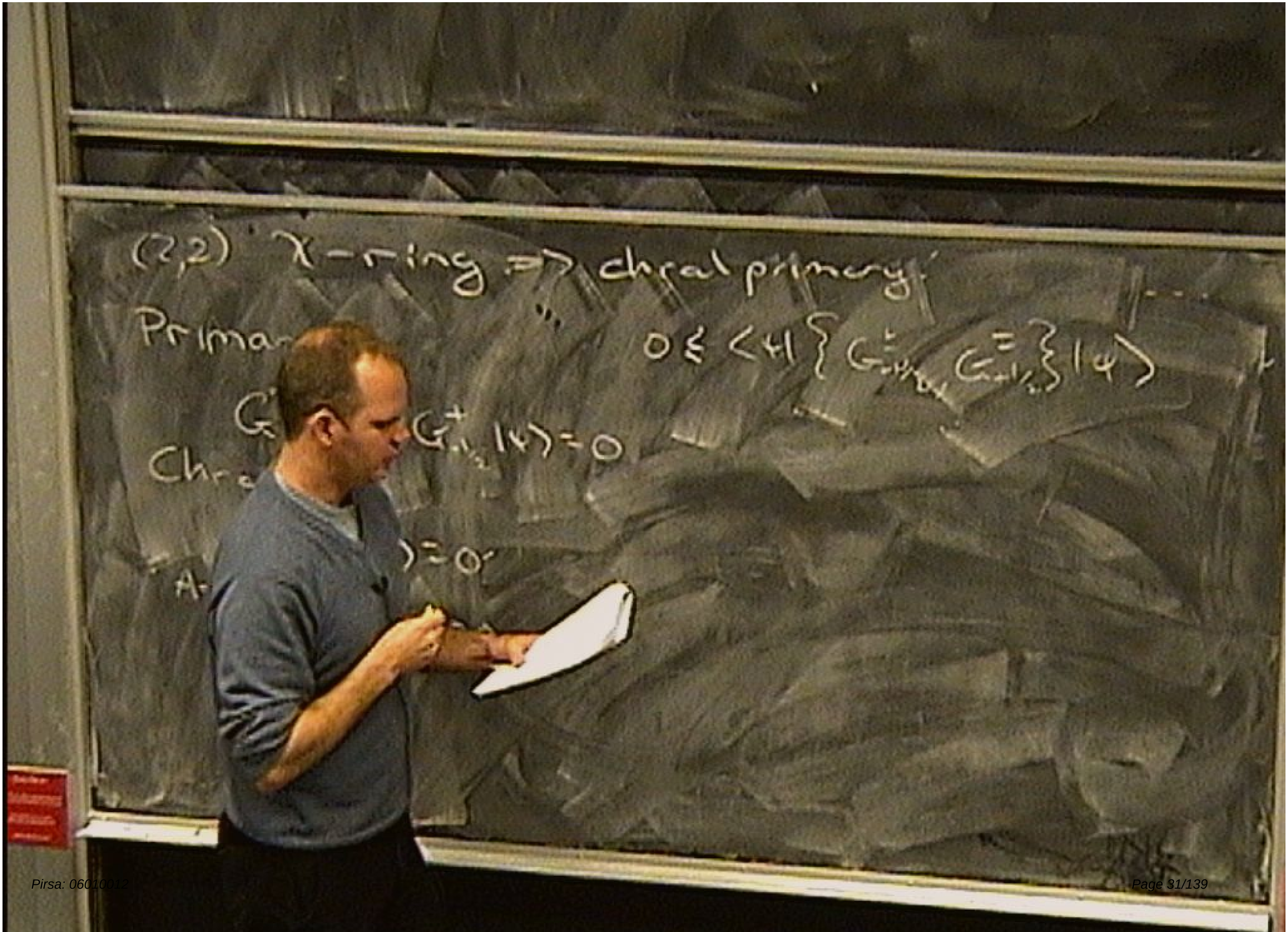
Chiral

$$G^+_{-1/2}|\psi\rangle = 0$$

A-χ

$$G^-_{-1/2}|\psi\rangle = 0$$


(2,2) χ-ring ⇒ chiral primary
Primary
$G^-_{+1/2}|\psi\rangle = G^+_{+1/2}|\psi\rangle = 0$
Chiral
$G^+_{-1/2}|\psi\rangle = 0$
A-χ
$G^-_{-1/2}|\psi\rangle = 0$



(2,2) χ-ring ⇒ chiral primary

(2,2) χ-ring $\Rightarrow$ chiral primary ...

Primary $\qquad 0 \le \langle\psi| \{G^+_{-1/2}, G^-_{+1/2}\} |\psi\rangle$

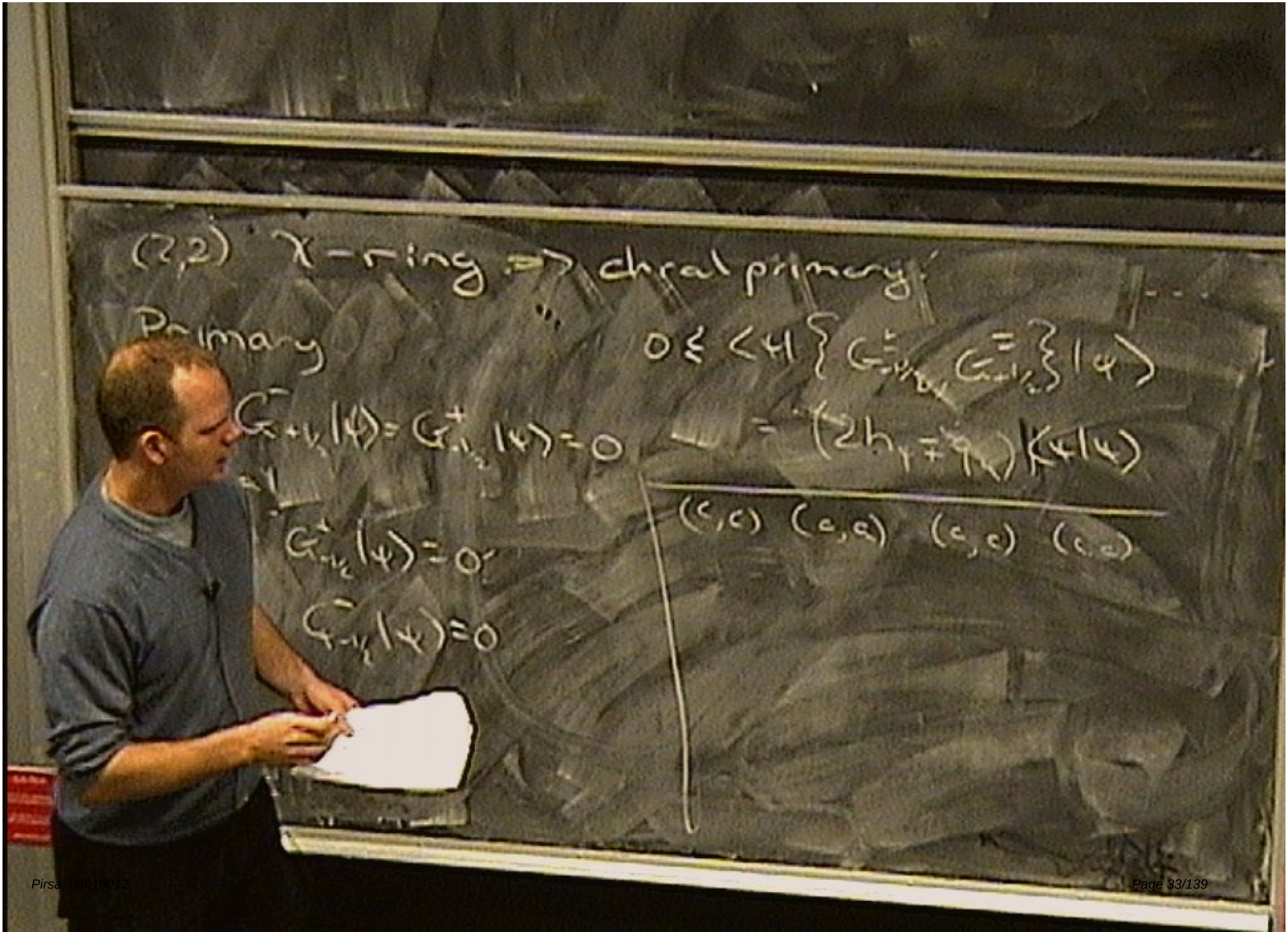
$$G^-_{+1/2}|\psi\rangle = G^+_{+1/2}|\psi\rangle = 0 \qquad = (2h_\psi \mp q_\psi)\langle\psi|\psi\rangle$$

Chiral

$$G^+_{-1/2}|\psi\rangle = 0$$

A-χ

$$G^-_{-1/2}|\psi\rangle = 0$$


(2,2) χ-ring ⟹ chiral primary
Primary
0 ≤ ⟨ψ| {G±−1/2, G∓+1/2} |ψ⟩
G−+1/2 |ψ⟩ = G++1/2 |ψ⟩ = 0
= (2hψ ∓ qψ) ⟨ψ|ψ⟩
(c,c) (c,a) (a,c) (c,a)
G+−1/2 |ψ⟩ = 0
G−−1/2 |ψ⟩ = 0

(2,2) χ-ring $\Rightarrow$ chiral primary ...

Primary

$$G^{-}_{+1/2}|\phi\rangle = G^{+}_{+1/2}|\phi\rangle = 0$$

$$0 \le \langle\phi|\{G^{\pm}_{-1/2}, G^{\mp}_{+1/2}\}|\phi\rangle = (2h_\phi \mp q_\phi)\langle\phi|\phi\rangle$$

Chiral

$$G^{+}_{-1/2}|\phi\rangle = 0$$

A-χ

$$G^{-}_{-1/2}|\phi\rangle = 0$$

(c,c) (a,a) (a,c) (c,a)

(2,2) χ-ring $\Rightarrow$ chiral primary

Primary

$$G^-_{+1/2}|\psi\rangle = G^+_{+1/2}|\psi\rangle = 0$$

$$0 \le \langle\psi|\{G^+_{-1/2}, G^-_{+1/2}\}|\psi\rangle = (2h_\psi \mp q_\psi)\langle\psi|\psi\rangle$$

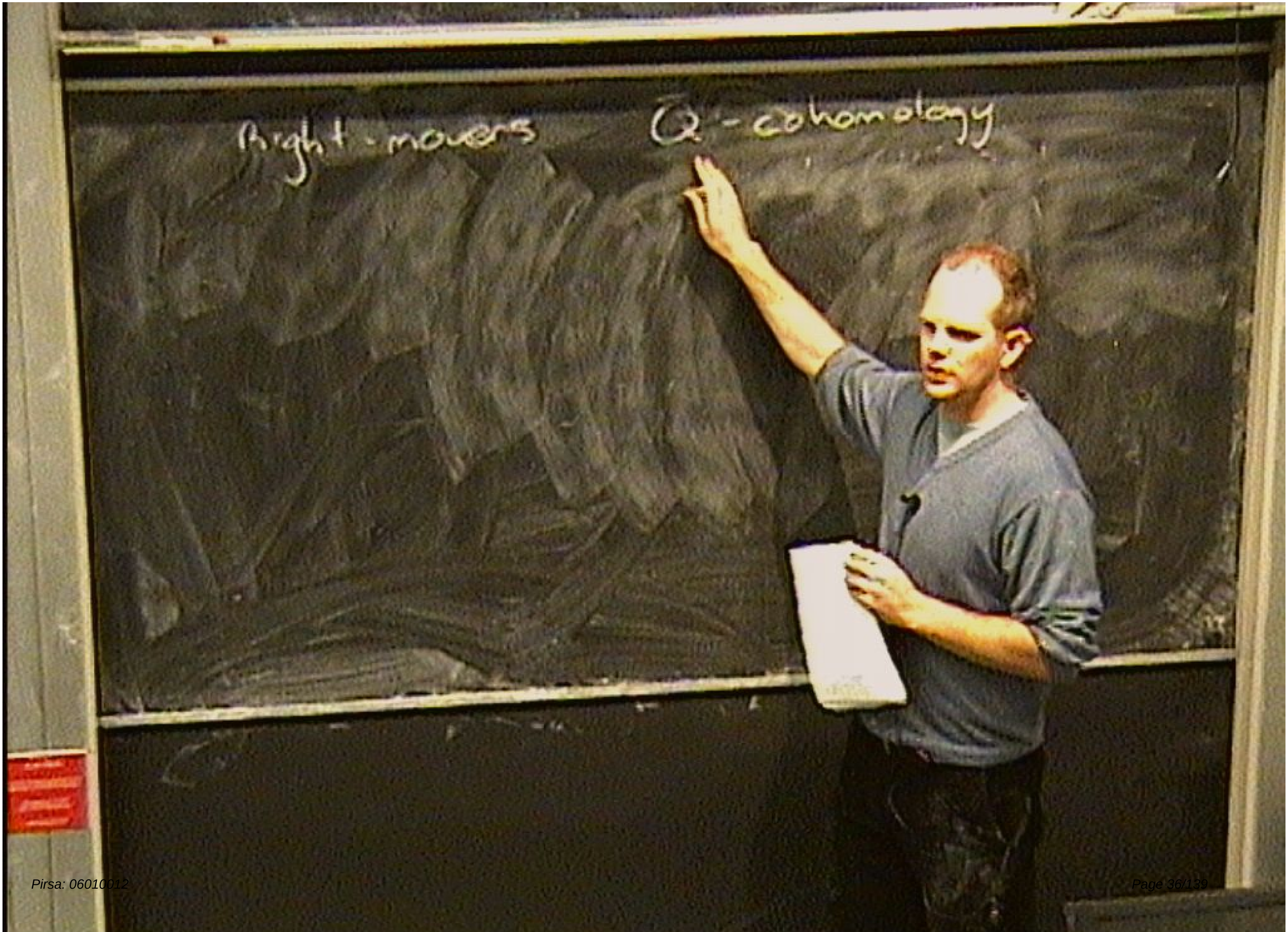
Chiral

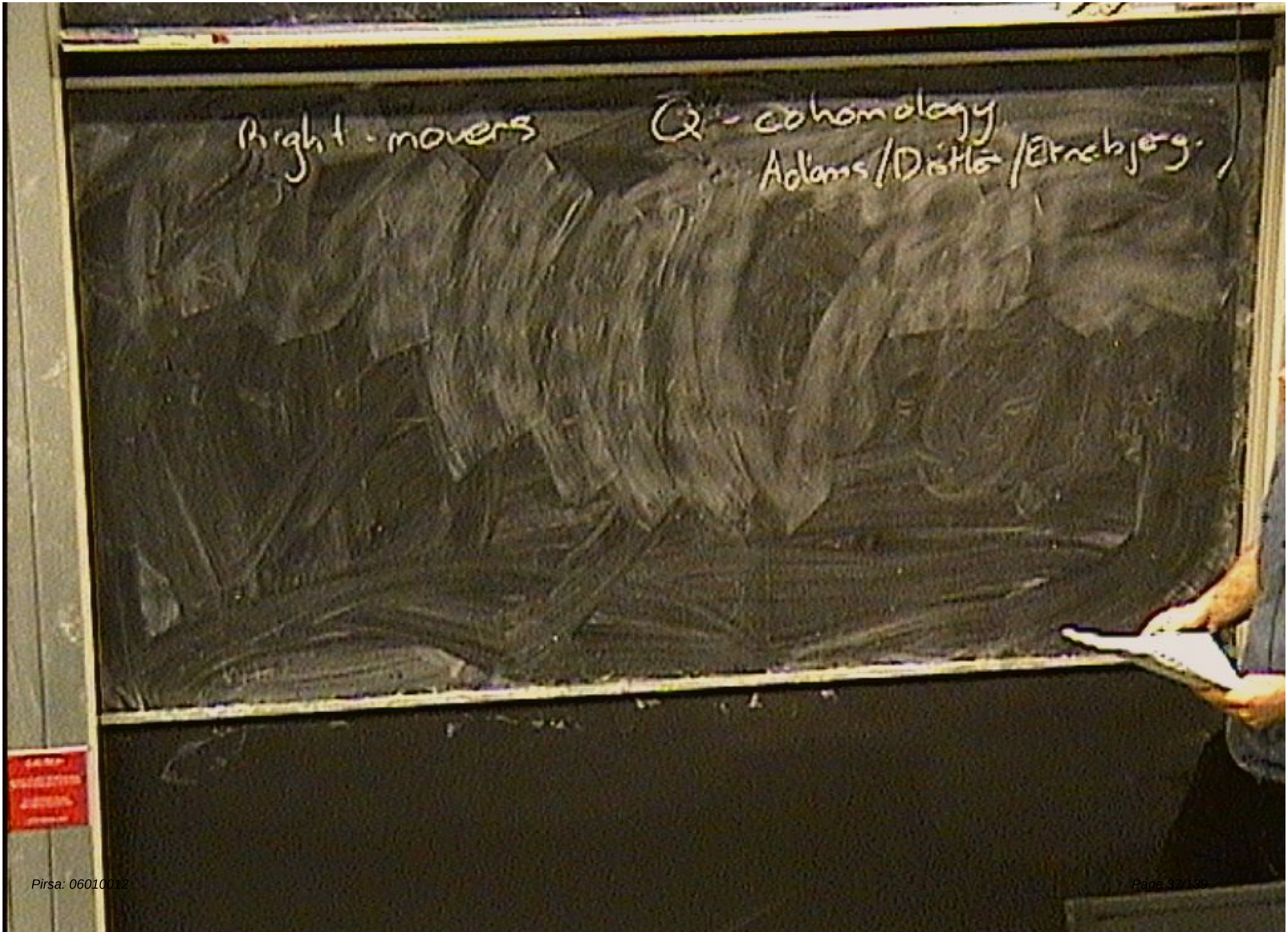
$$G^+_{-1/2}|\psi\rangle = 0$$

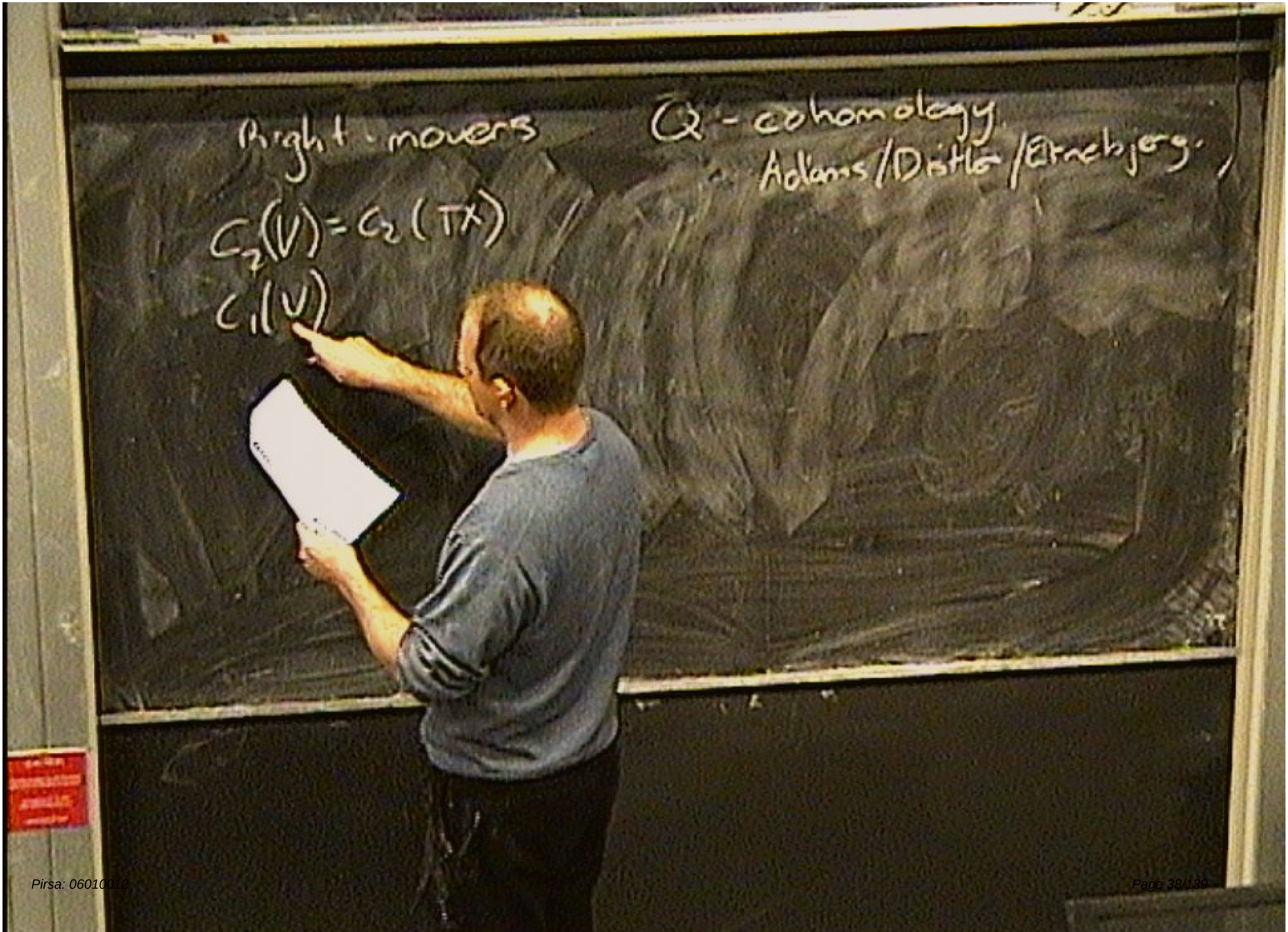
A-χ

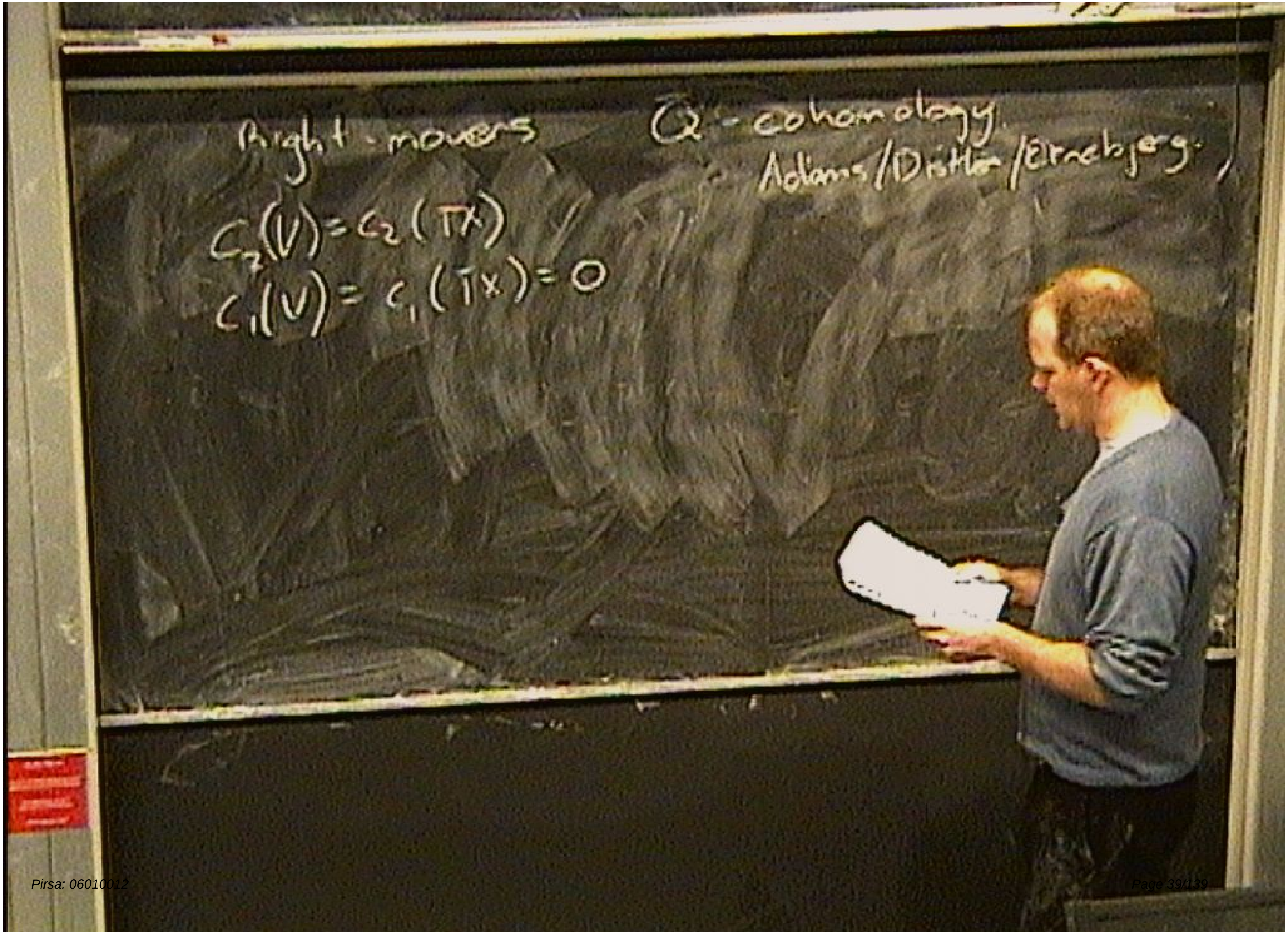
$$G^-_{-1/2}|\psi\rangle = 0$$

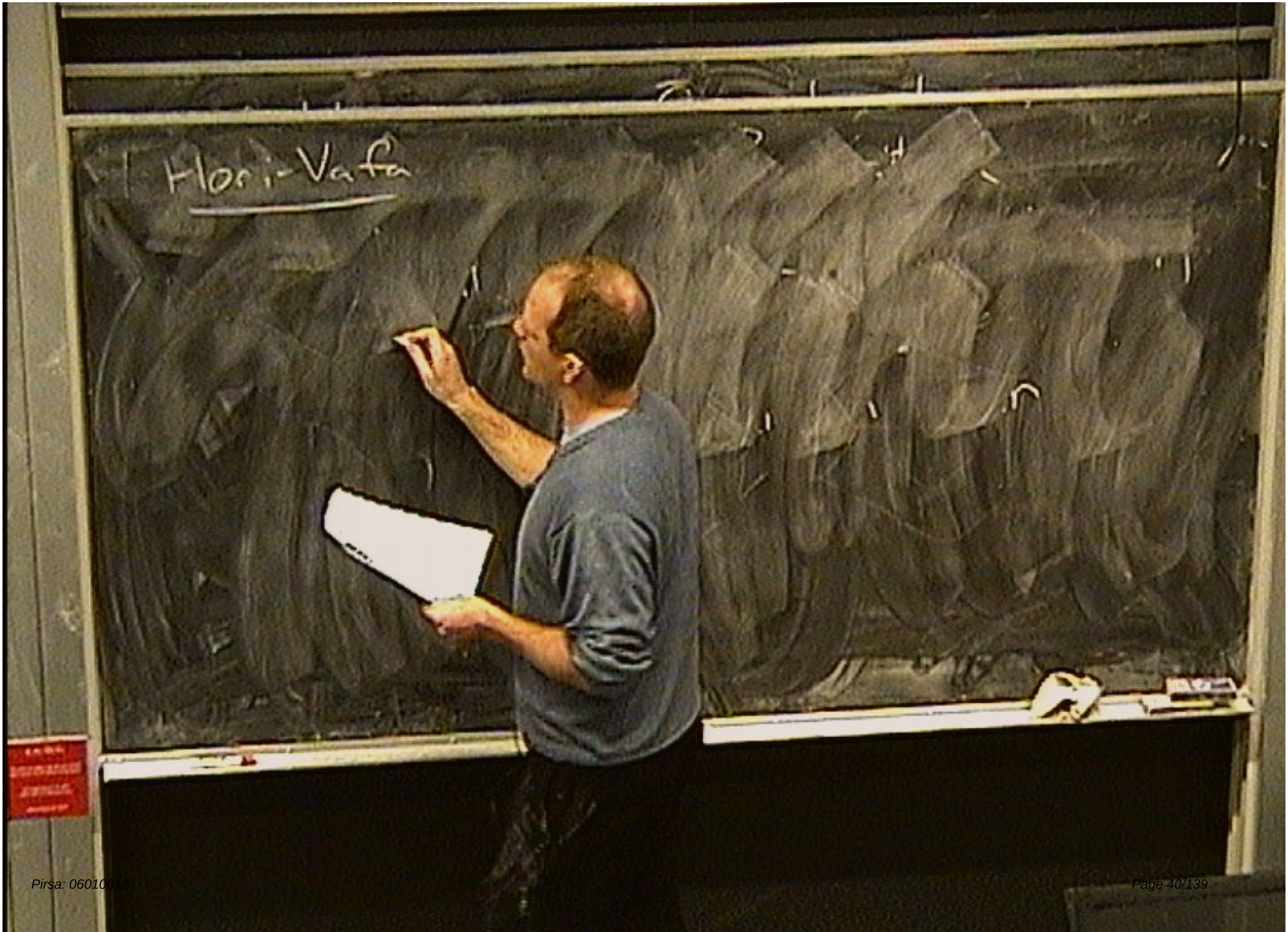
(c,c) (a,a) (a,c) (c,a)

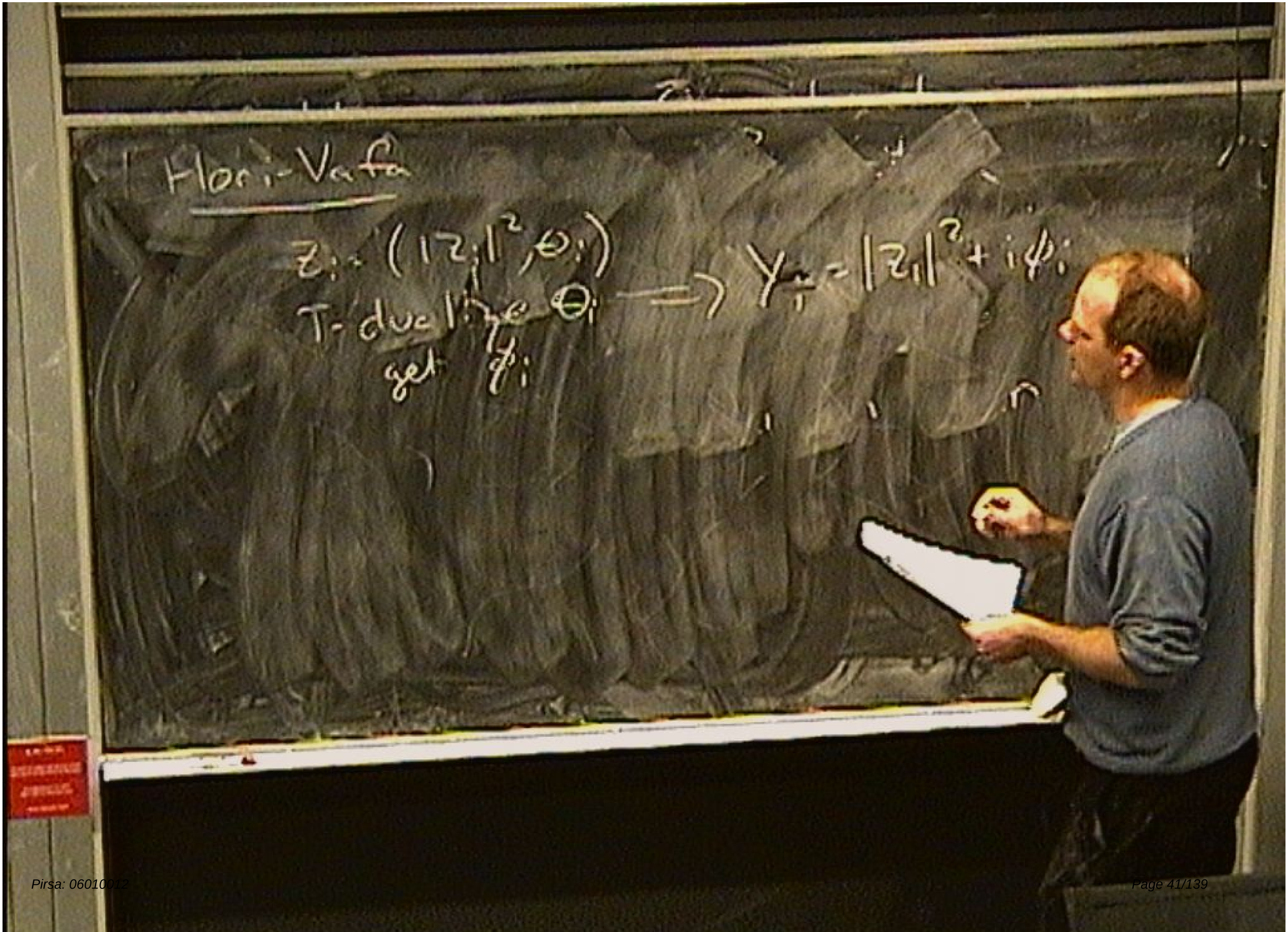

Right-movers
$\bar{Q}$-cohomology

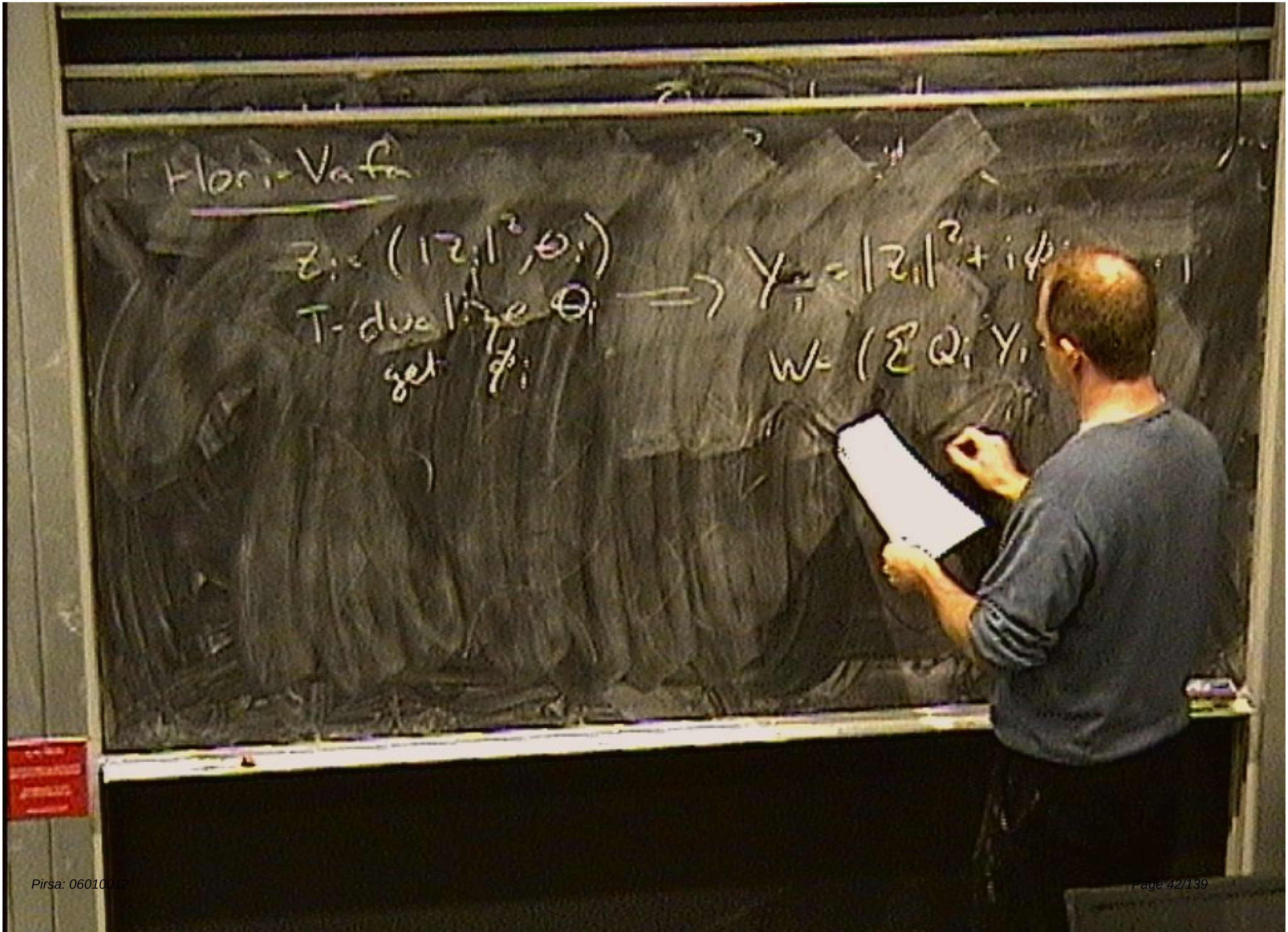

Right - movers
$\bar{Q}$ - cohomology
Adams/Distler/Ernebjerg.


Right-movers
$\bar{Q}$-cohomology
Adams/Distler/Ernebjerg
$c_2(V) = c_2(TX)$
$c_1(V)$


Right - movers
$\bar{Q}$ - cohomology.
Adams/Distler/Ernebjerg.
$c_2(V) = c_2(TX)$
$c_1(V) = c_1(TX) = 0$


Hori-Vafa


Hori-Vafa
z_i = (|z_i|^2, θ_i)
T-dualize θ_i → Y_i = |z_i|^2 + iφ_i
get φ_i


Hori-Vafa
z_i = (|z_i|^2, θ_i)
T-dualize θ_i ⟹ Y_i = |z_i|^2 + iφ_i
get φ_i
W = (Σ Q_i Y_i

Hori-Vafa

$z_i = (|z_i|^2, \theta_i)$ $\Longrightarrow$ $Y_i = |z_i|^2 + i\phi_i$

T-dualize θ_i

get ϕ_i

$W = \left(\sum Q_i Y_i - t\right)\Sigma$

$+ \sum e^{-Y_i}$

Hori-Vafa

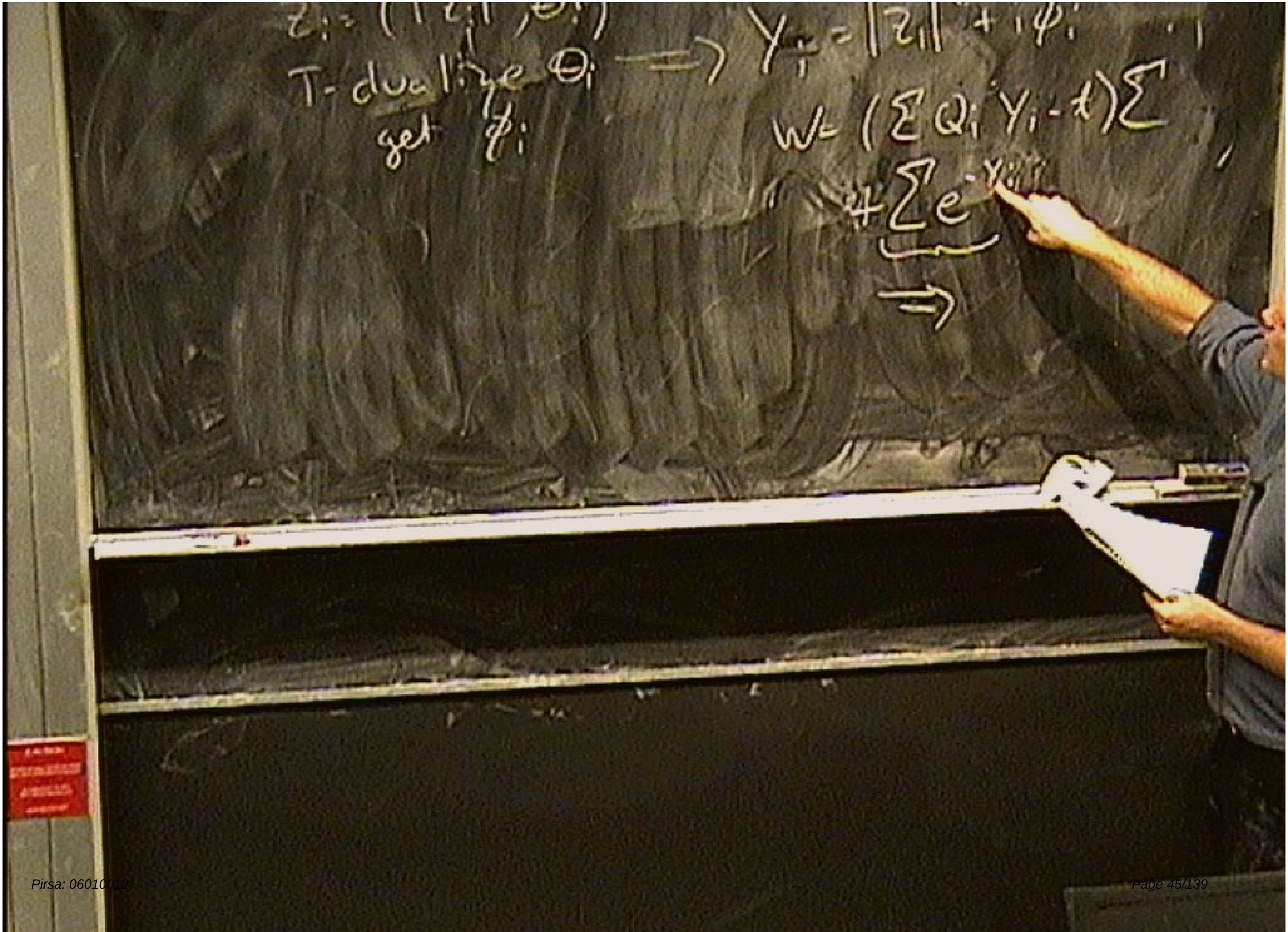
$z_i = (|z_i|^2, \theta_i)$

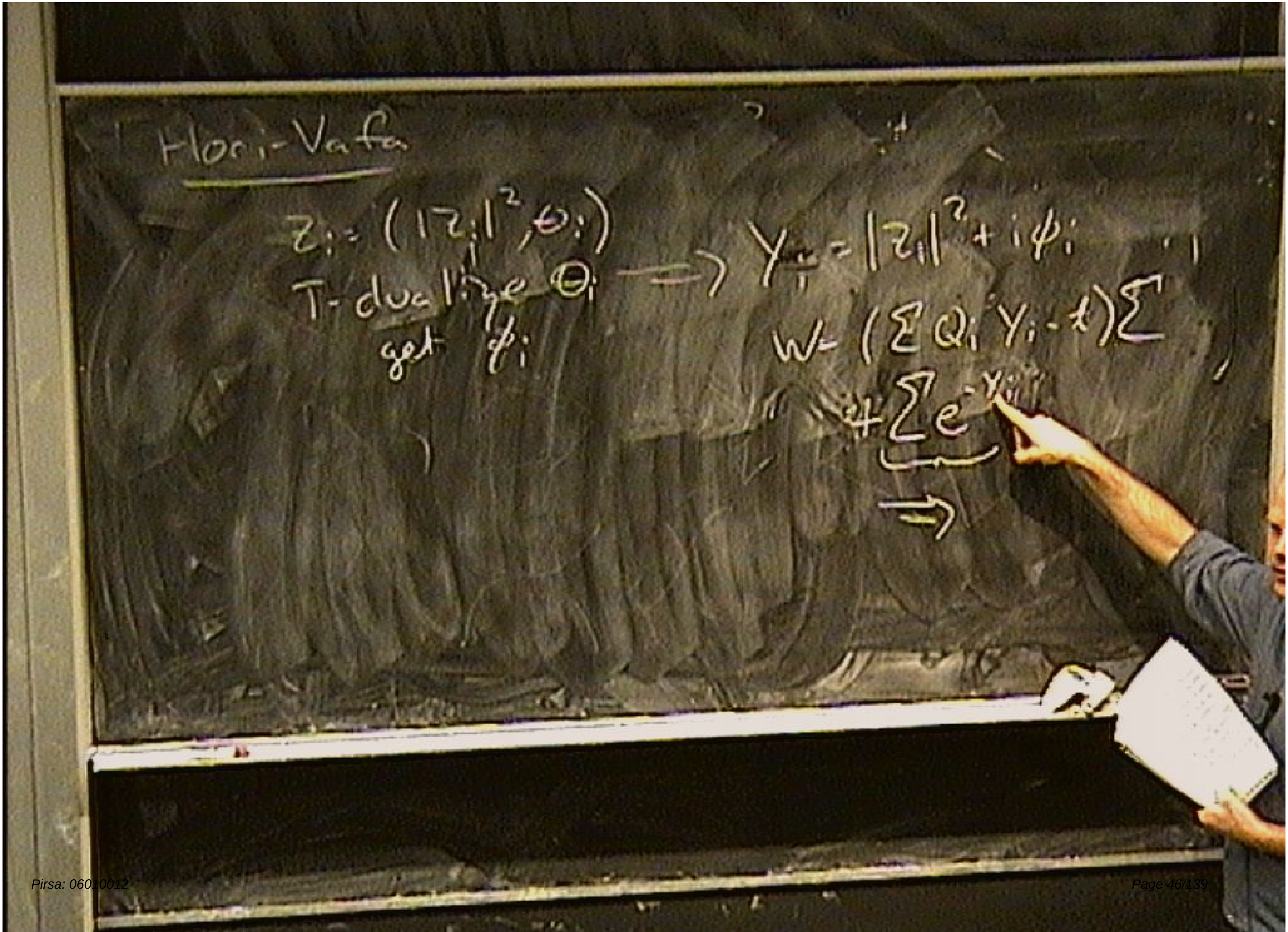
T-dualize $\theta_i \Longrightarrow Y_i = |z_i|^2 + i\phi_i$

get ϕ_i

$W = (\sum Q_i Y_i - t)\Sigma$

$+ \sum e^{-Y_i}$


$z_i = (|z_i|, \theta_i)$
T-dualize θ_i $\Longrightarrow$ $Y_i = |z_i|^2 + i\phi_i$
get ϕ_i
$W = (\sum Q_i Y_i - t)\Sigma$
$+ \sum e^{-Y_i}$
$\Longrightarrow$


Hori-Vafa
$z_i = (|z_i|^2, \theta_i)$
T-dualize θ_i $\longrightarrow$ $Y_i = |z_i|^2 + i\phi_i$
get ϕ_i
$W = (\sum Q_i Y_i - t)\Sigma$
$+ \sum e^{-Y_i}$
$\Rightarrow$

Hori-Vafa

$z_i = (|z_i|^2, \theta_i)$

T-dualize θ_i $\longrightarrow$ $Y_i = |z_i|^2 + i\phi_i$

get ϕ_i

$W = (\sum Q_i Y_i - t)\Sigma$

$+ \underbrace{\sum e^{-Y_i}}$

$\Rightarrow \sum F_i e^{-Y_i}$

Hori-Vafa

$z_i = (|z_i|^2, \theta_i)$

T-dualize $\theta_i \longrightarrow Y_i = |z_i|^2 + i\phi_i$

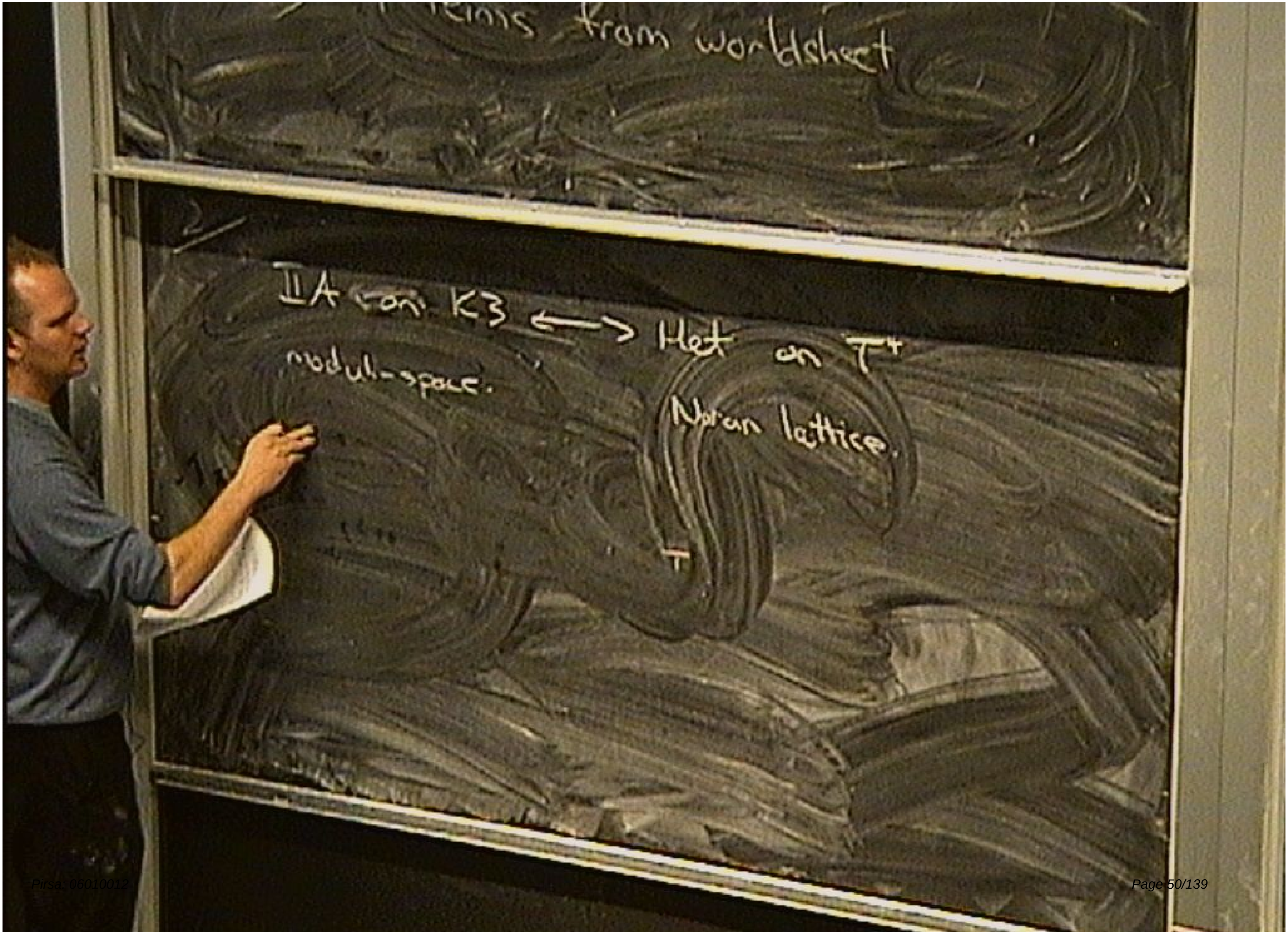
get ϕ_i

$$W = \left(\sum Q_i Y_i - t\right)\Sigma + \sum e^{-Y_i}$$

$$\Longrightarrow \sum_{\beta_j} F_{ij} e^{-Y_i} \quad (0,2)$$

... from worldsheet

IIA on $K3 \longleftrightarrow$ Het on T^4


from worldsheet
IIA on K3 ⟷ Het on T^4
moduli-space.
Narain lattice.

… ems from worldsheet

IIA on $K3 \longleftrightarrow$ Het on T^4

moduli-space

Narain lattice

$\rightarrow$ IIA on $K3 \rightarrow X$

$$\begin{array}{c} K3 \rightarrow X \\ \downarrow \\ P^1 \end{array} \Longleftrightarrow \text{Het on } K3 \times T^2 \text{ w/ } V$$

...ems from worldsheet

IIA on K3 $\longleftrightarrow$ Het on T^4

moduli-space

Narain lattice.

$\to$ IIA on $K3 \to X$

$\downarrow$

$\mathbb{P}^1$

$\Longleftrightarrow$ Het on $K3 \times T^2$ w/ V

FHSV, $h^{1,1} = h^{2,1} = 11$, $\chi = 0$

... from worldsheet

IIA on $K3 \longleftrightarrow$ Het on T^4

moduli-space

Narain lattice.

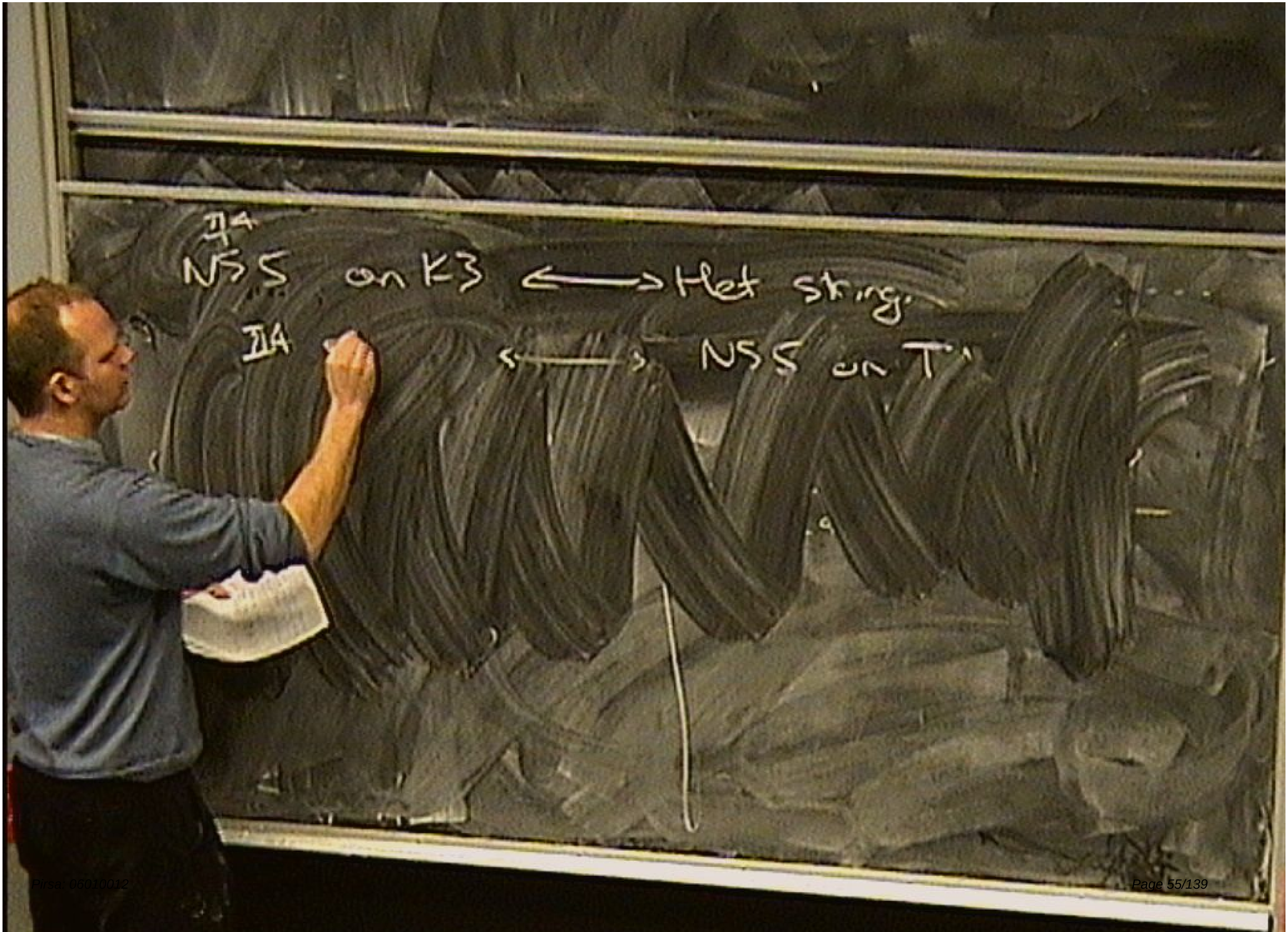
$\rightarrow$ IIA on $K3 \rightarrow X$
$\downarrow$
$\mathbb{P}^1$

$\Longleftrightarrow$ Het on $K3 \times T^2$ w/ V

FHSV, $h^{1,1} = h^{2,1} = 11$ $\chi = 0$

IIA

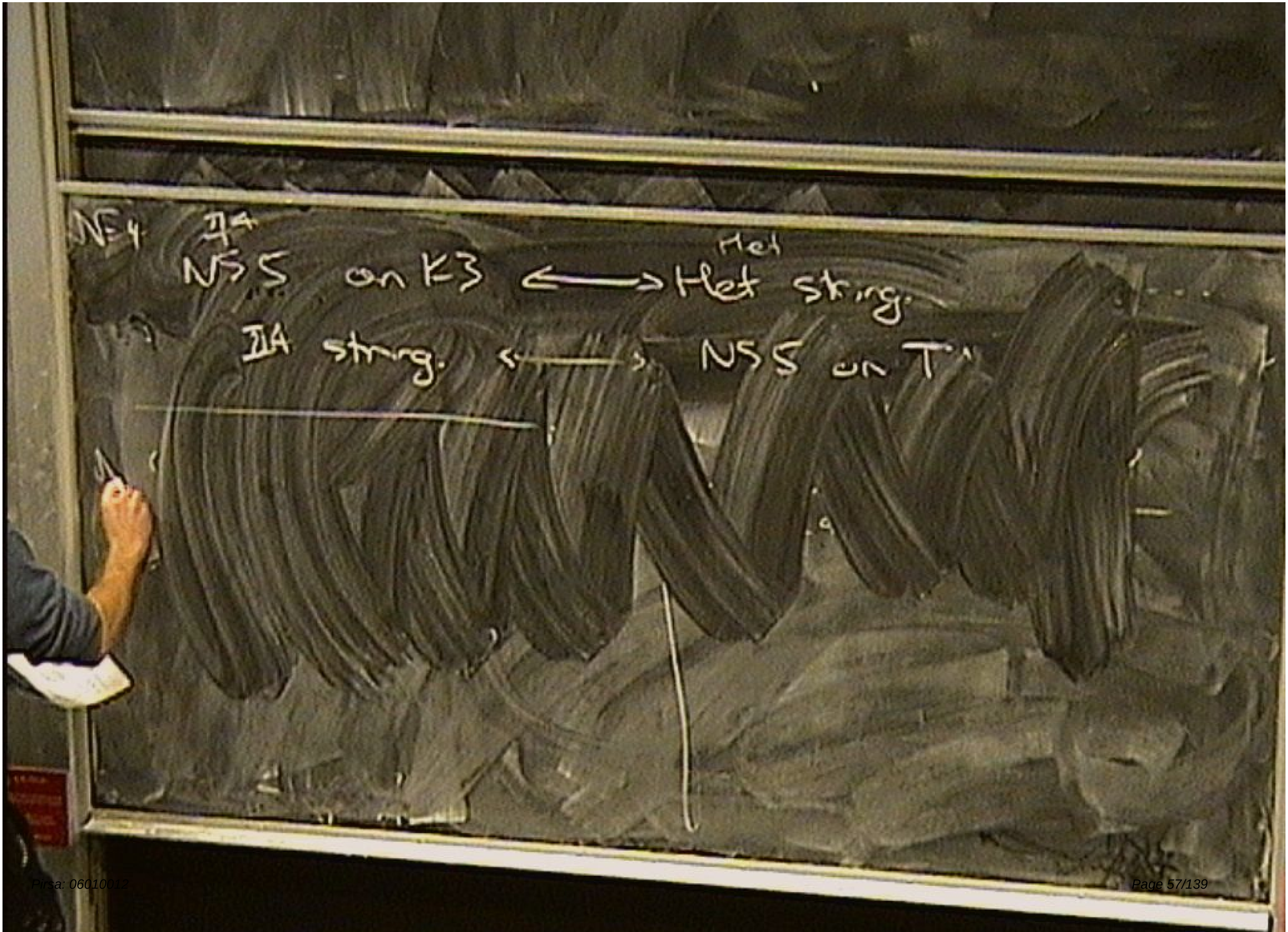
NS5 on K3 $\longleftrightarrow$ Het string.


IIA
NS5 on K3 ⟷ Het string
IIA ⟷ NS5 on T

IIA

NS5 on K3 $\longleftrightarrow$ Het string.

IIA string. $\longleftrightarrow$ NS5 on T^4


N=4
IIA
NS5 on K3 ⟷ Het string.
Het
IIA string. ⟷ NS5 on T⁴

$N=4$ IIA

NS5 on K3 $\longleftrightarrow$ Het string

IIA string $\longleftrightarrow$ NS5 on T^4

$N=2$ NS5 on K3 fiber $\longleftrightarrow$ Het st

IIA string $\longleftrightarrow$ NS5 on K3

...ms from worldsheet

$\mathrm{II}A$ on K3 $\longleftrightarrow$ Het on T^4

moduli-space

Narain lattice

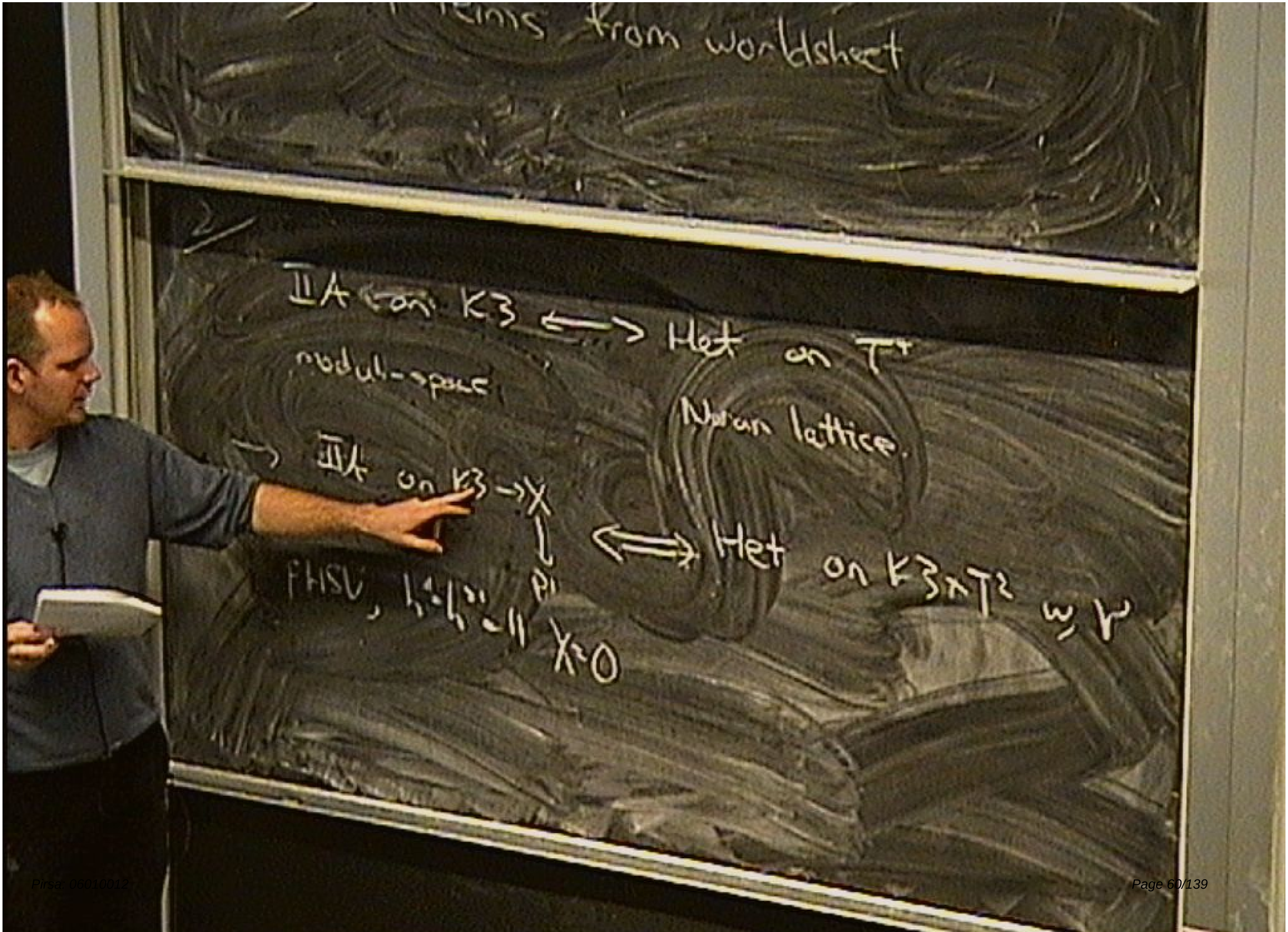
II on $K3 \to X$

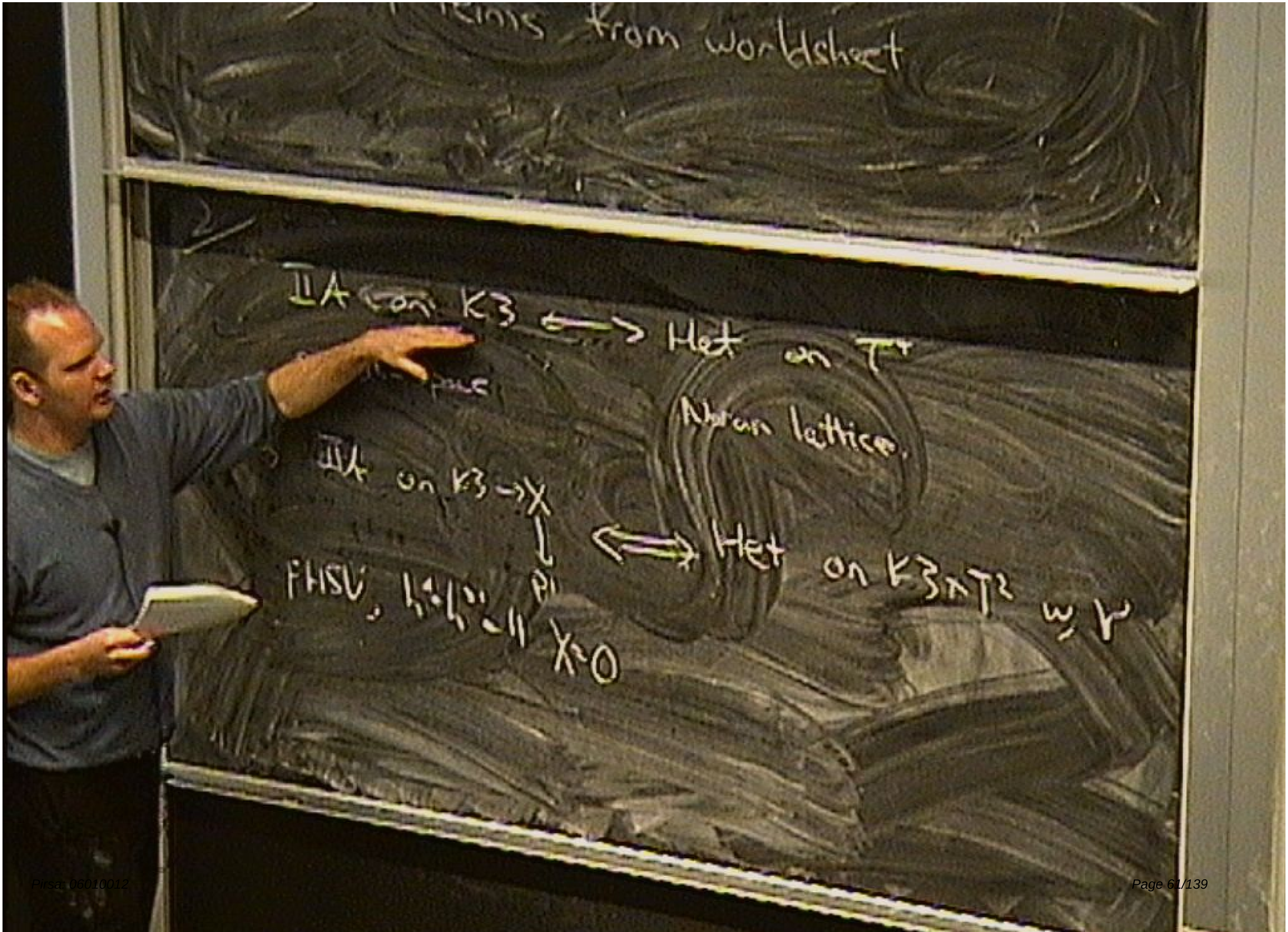
$\downarrow$

$\mathbb{P}^1$

$\Longleftrightarrow$ Het on $K3 \times T^2$ w/ V

FHSV, $h^{1,1} = h^{2,1} = 11$, $\chi = 0$


from worldsheet
IIA on K3 ⟺ Het on T4
moduli-space
Narain lattice
IIA on K3 → X ⟺ Het on K3×T2 w/ V
FHSV, h11=h21=11
X=0


from worldsheet
IIA on K3 ⟷ Het on T⁴
Narain lattice
IIA on K3 → X
Het on K3×T²
FHSV
X=0

$N=4$ IIA

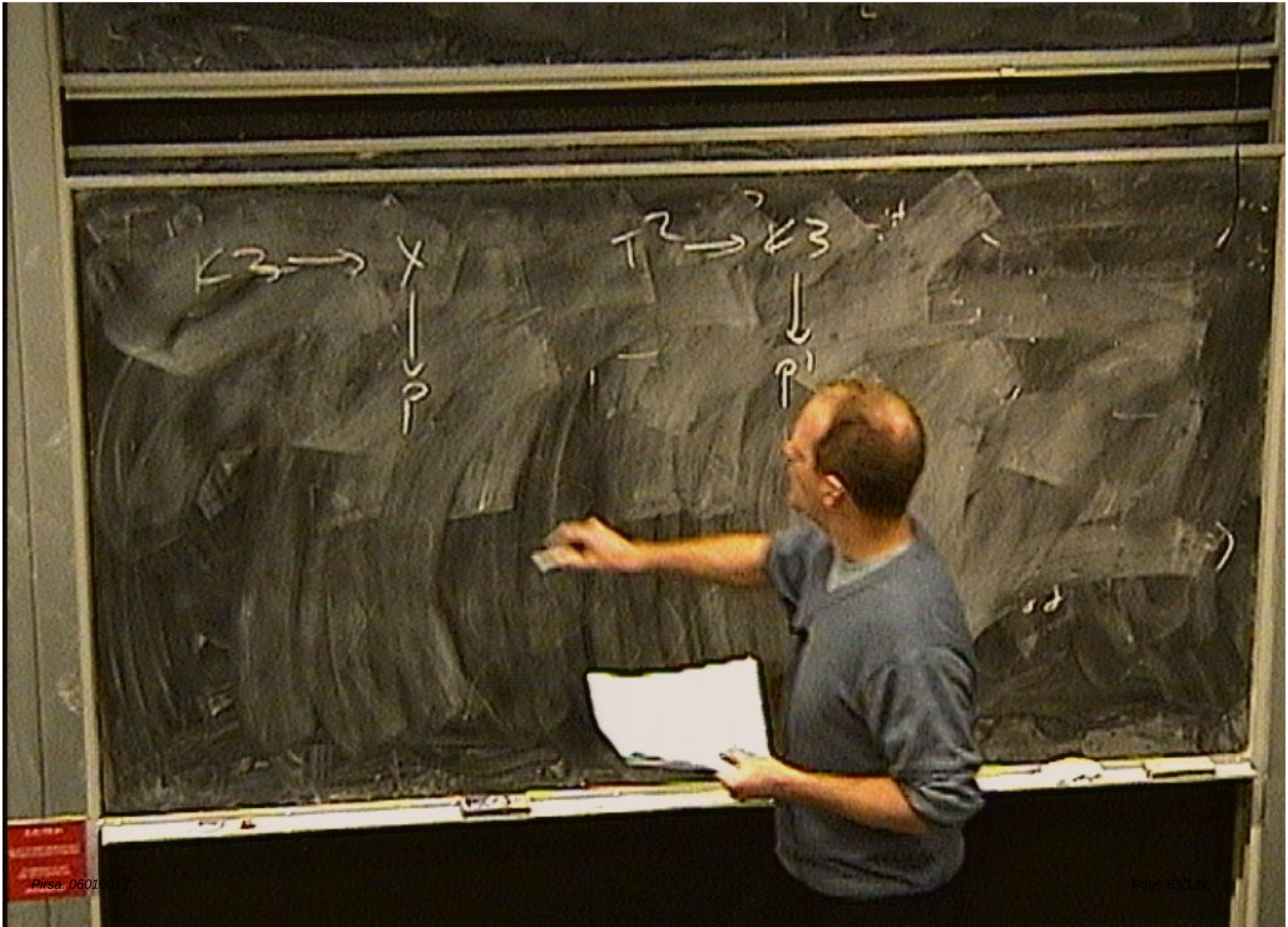
Het

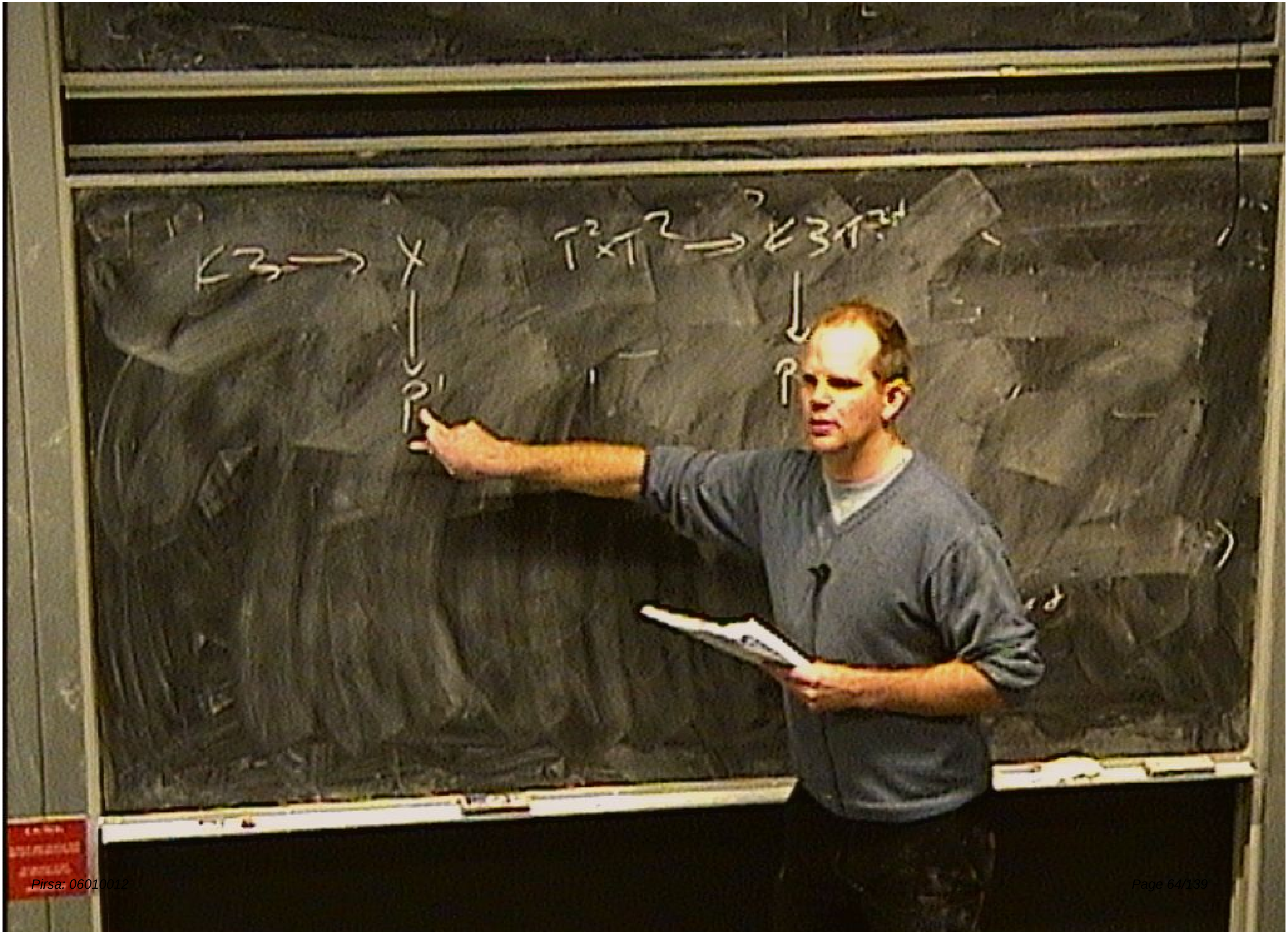
NS5 on K3 $\longleftrightarrow$ Het string.

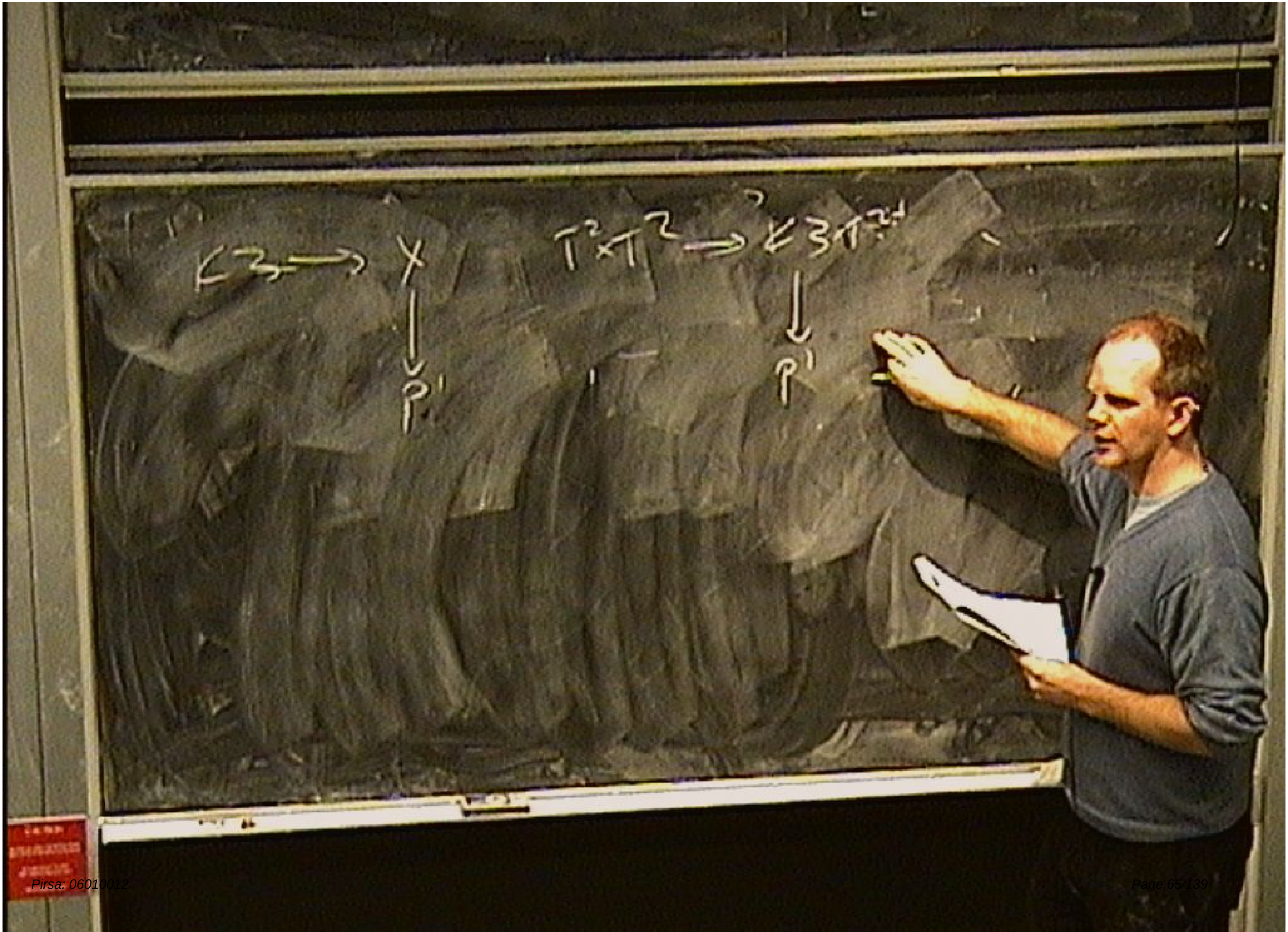
IIA string. $\longleftrightarrow$ NS5 on T^4

NS5 on K3 fiber $\longleftrightarrow$ Het st

IIA string. $\longleftrightarrow$ NS5 on K3


K3 → X
P
T² → K3
P'

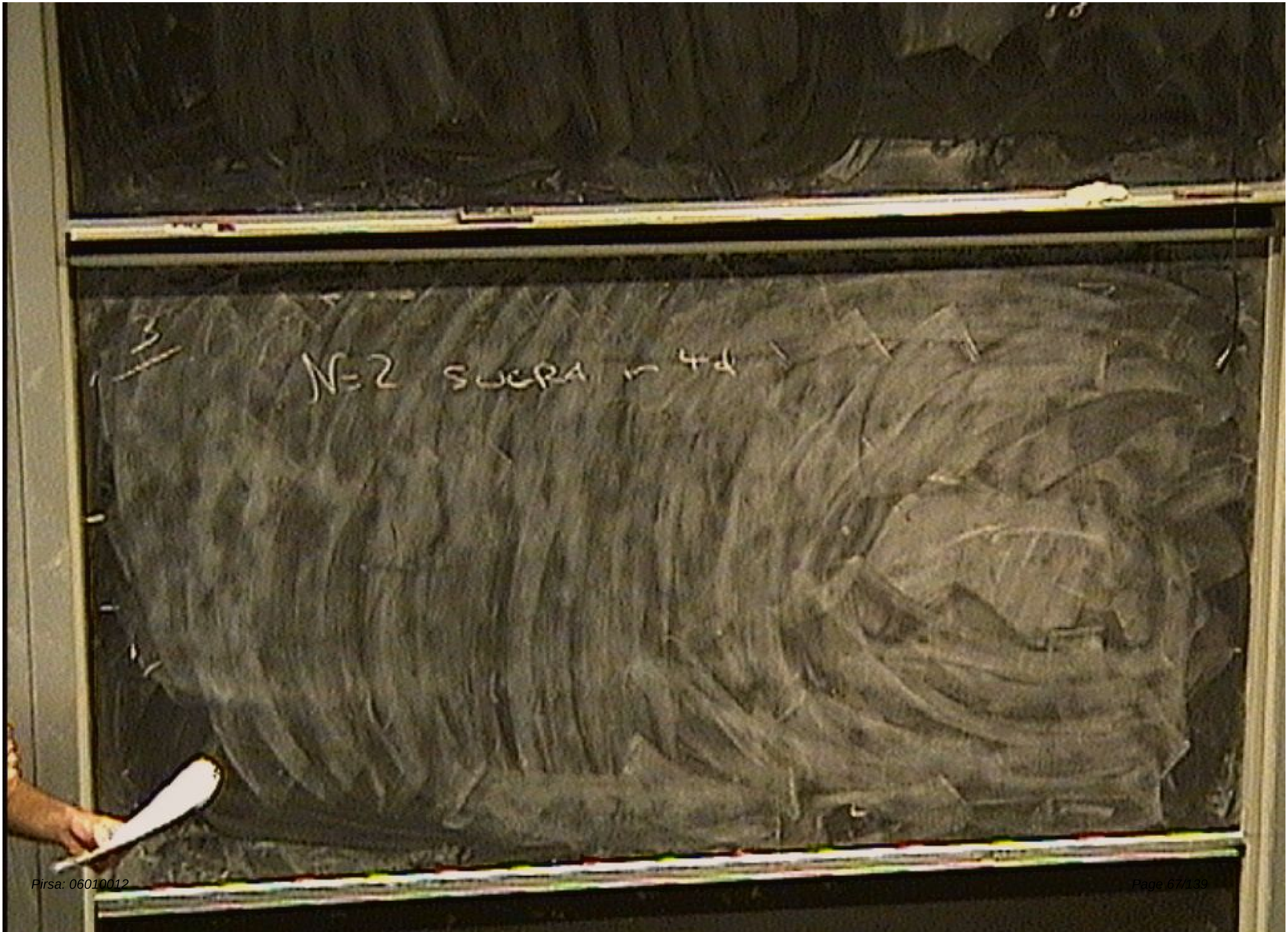

K3 → X
P'
T²×T² → K3
P


$K3 \longrightarrow X$
P^1
$T^2 \times T^2 \longrightarrow K3$
P^1

p'

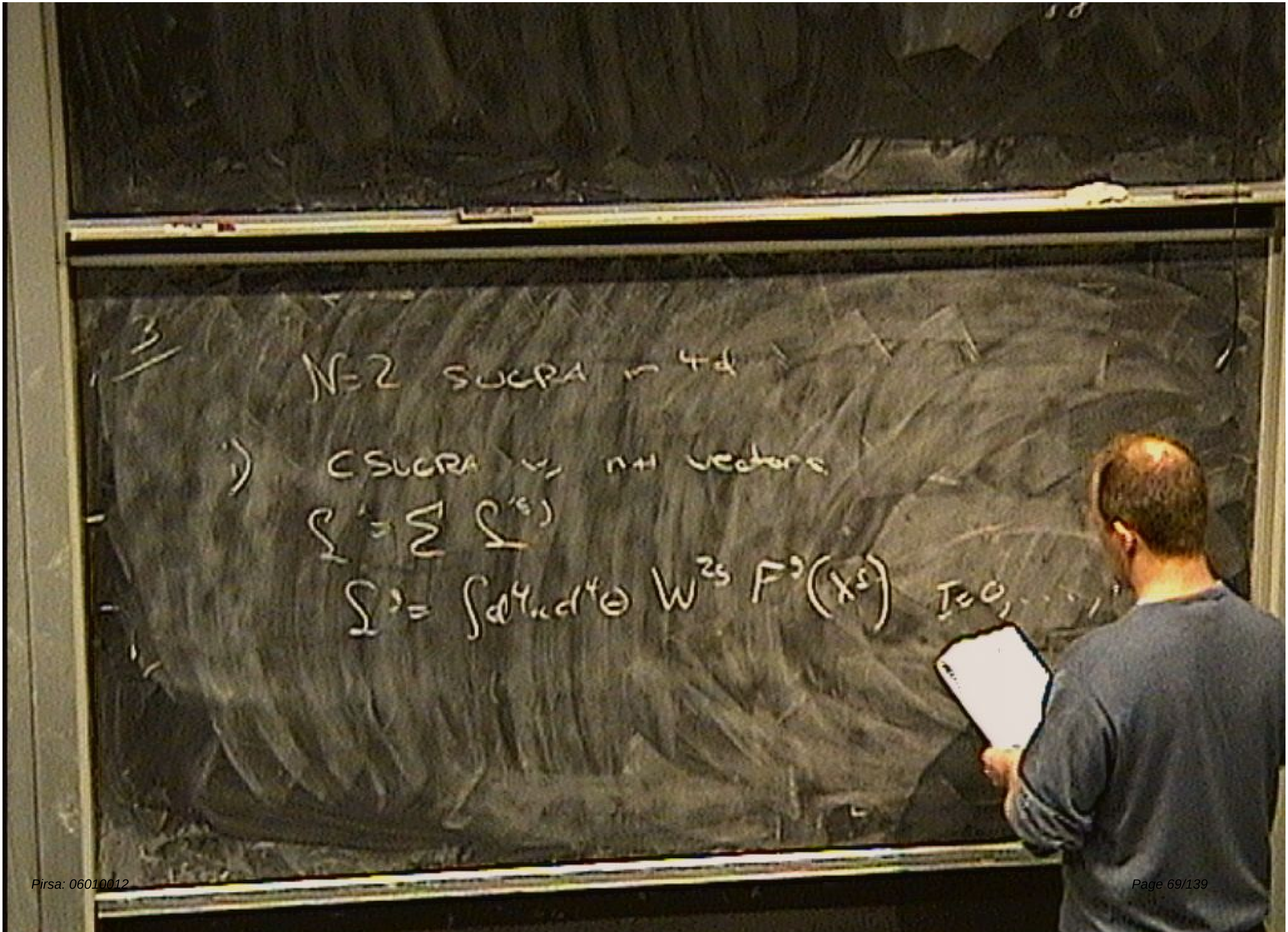
p'

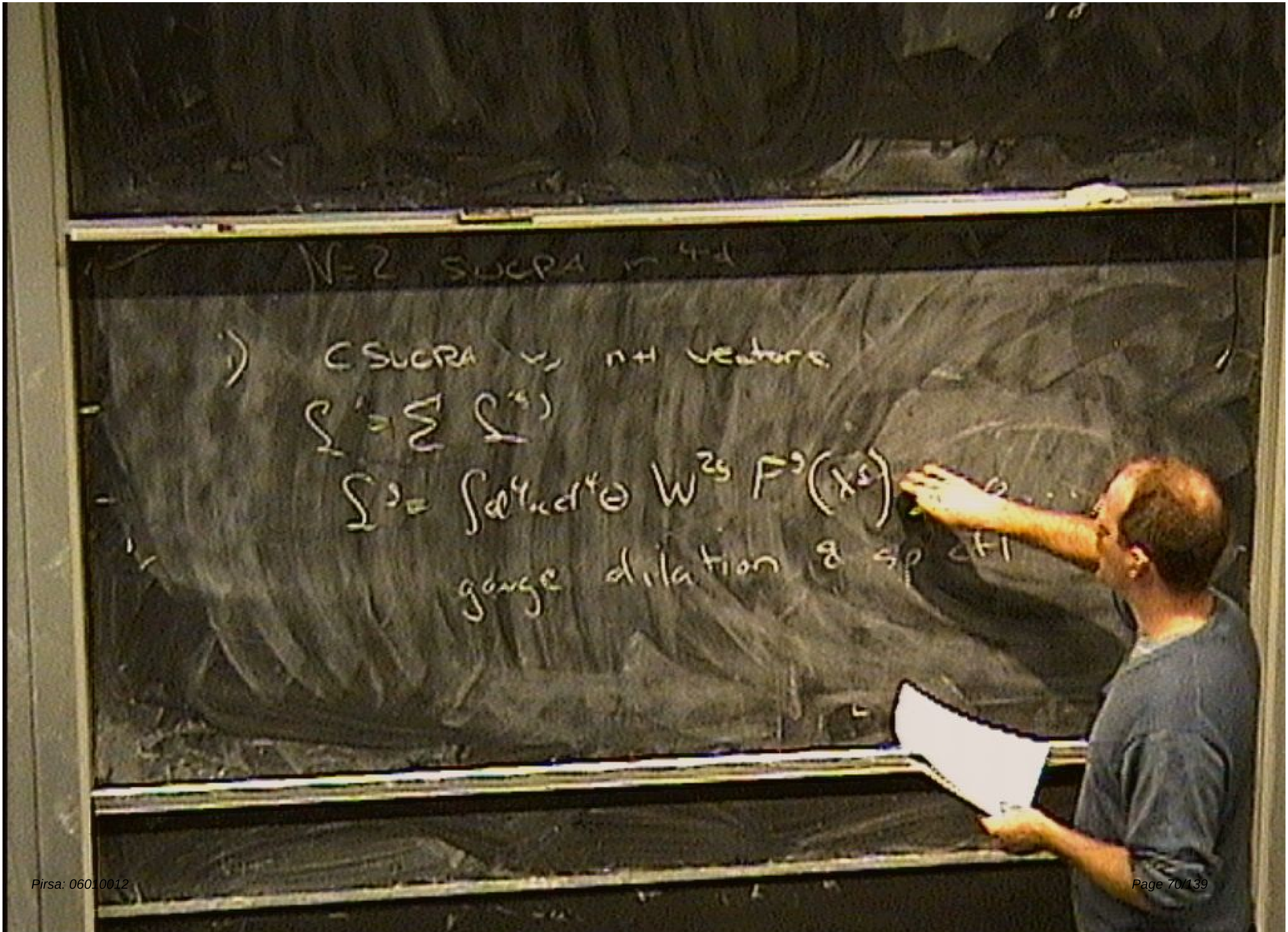
area$(p') \longleftrightarrow$ string cplg


N=2 SUGRA in 4d

3/ $\mathcal{N}=2$ SUGRA in 4d

i) CSUGRA w/ $n+1$ vectors


3
N=2 SUGRA in 4d
1) CSUGRA w/ n+1 vectors
L = Σ L^(s)
L^s = ∫d^4x d^4θ W^2s F^s(X^s) I=0, …


N=2 SUCRA in 4d
1) C SUCRA w/ n+1 vectors
gauge dilation

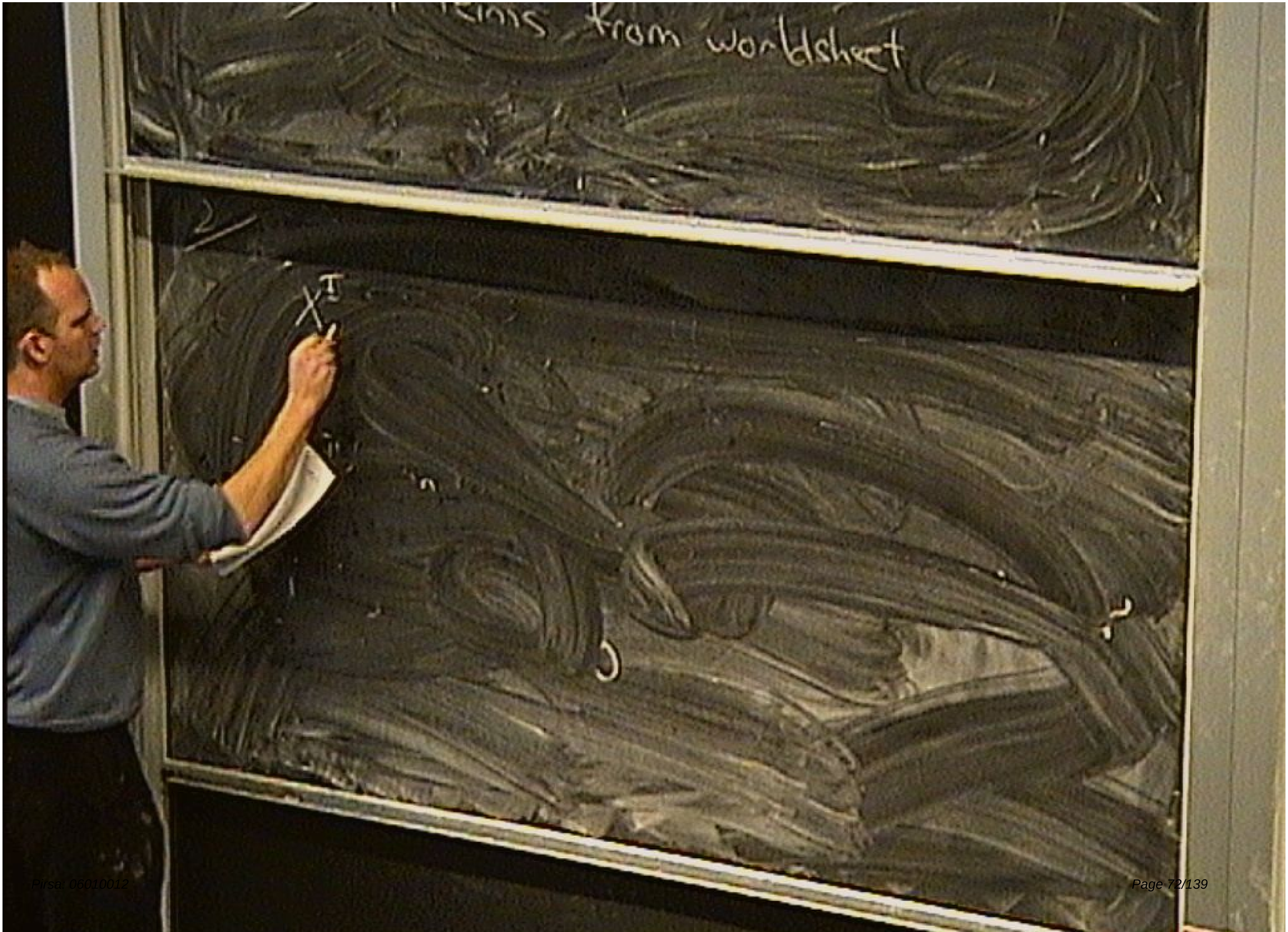
$\mathcal{N}=2$ SUGRA in 4d

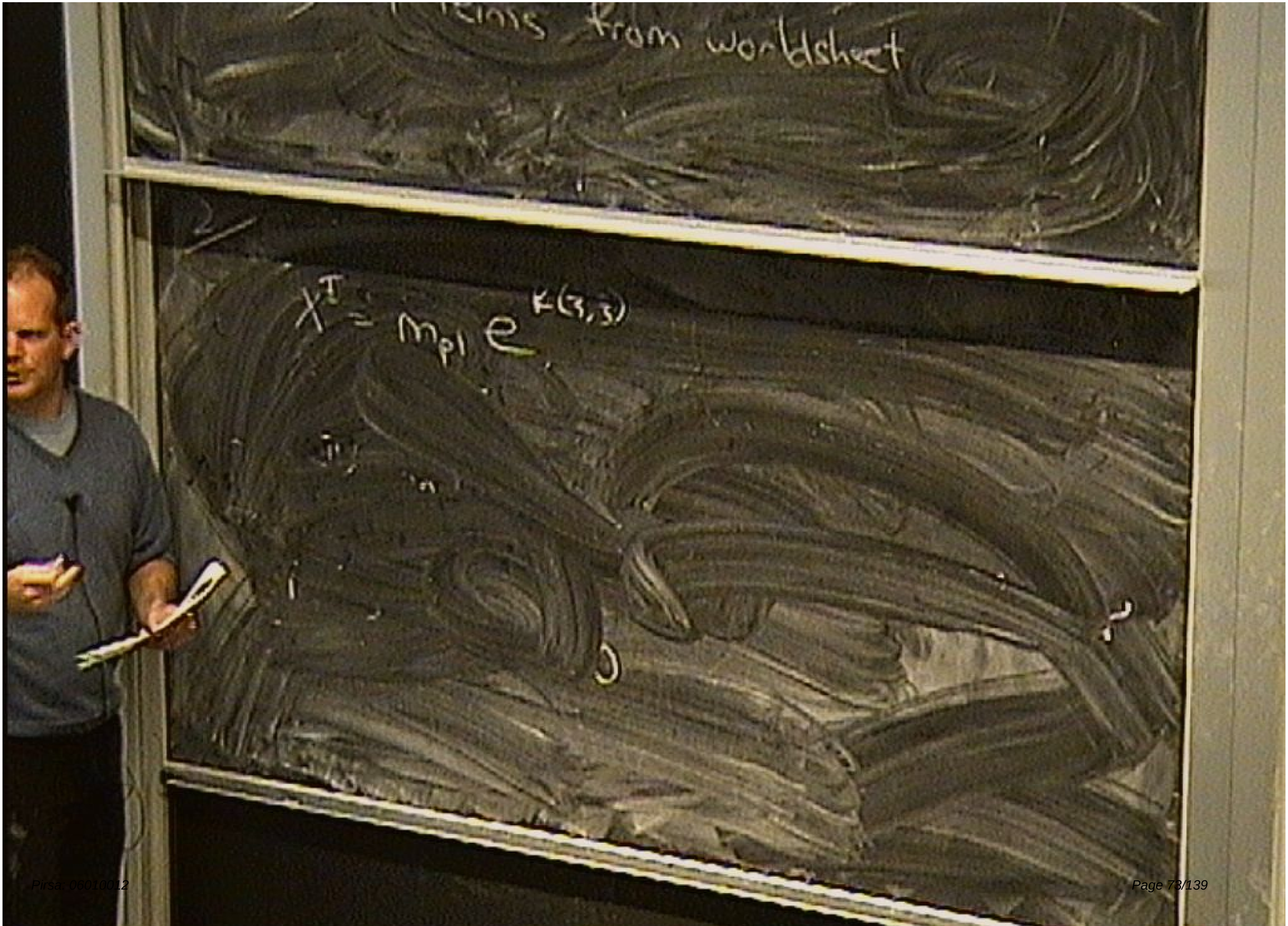
1) CSUGRA w/ n+1 vectors

$$\mathcal{L} = \sum \mathcal{L}^{(s)}$$

$$\mathcal{L}^{s} = \int d^4x\, d^4\theta\, W^{2s} F^{s}(X^I) \quad I = 0, \ldots, n+1$$

gauge dilation & sp cf1


from worldsheet


from worldsheet
$X^I = m_{pl}\, e^{K(z,\bar{z})}$

terms from worldsheet

$$X^I = m_{pl}\, e^{K(z,\bar{z})}, \quad X^I(z)$$

kinks from worldsheet

$$X^I = m_{pl}\, e^{K(z,\bar z)} \, X^I(z)$$

ESUGRA nil vectors no gphoton

PSUGRA in vector + gravphoton.

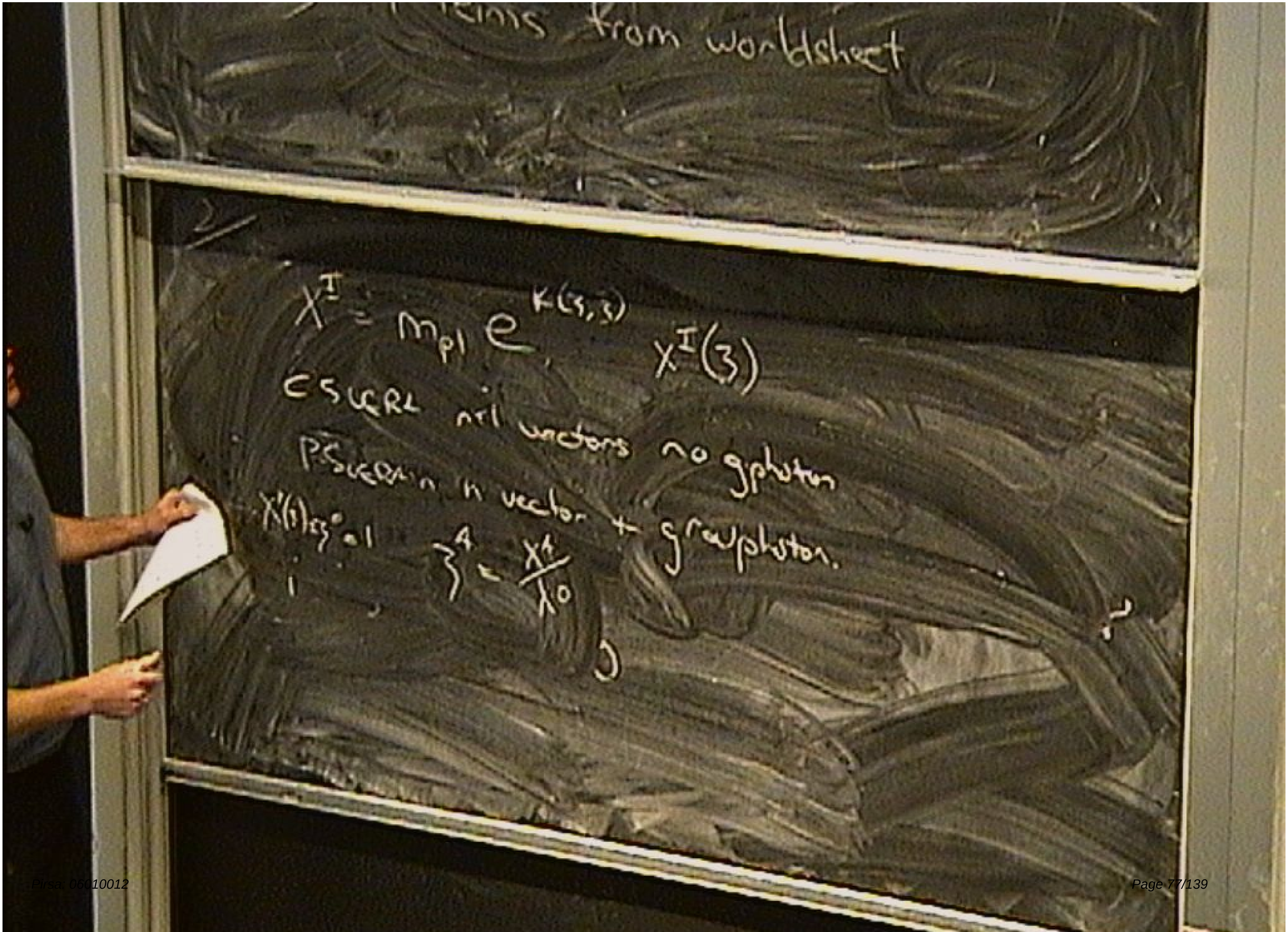
...ermions from worldsheet

$X^I = m_{pl}\, e^{K(\bar{z},z)}\, X^I(z)$

E SUGRA nil vectors no graviphoton

P-SUGRA n vector + graviphoton

$X^I(z) = z^0 = 1$


from worldsheet
X^I = m_pl e^K(z,z̄) x^I(z)
ESUGRA n+1 vectors no graviphoton
PSUGRA n vector + graviphoton
z^A = X^A/X^0

Fg, weight $2g-2$.

F^g ~ weight $2g-2$.

$\mathcal{F}^g \sim \kappa^{2g-2}$

$$\boxed{\kappa \sim m_{pl}^{-1} = m_s^{-1} g_s}$$

F^g ~ weight $2g-2$.

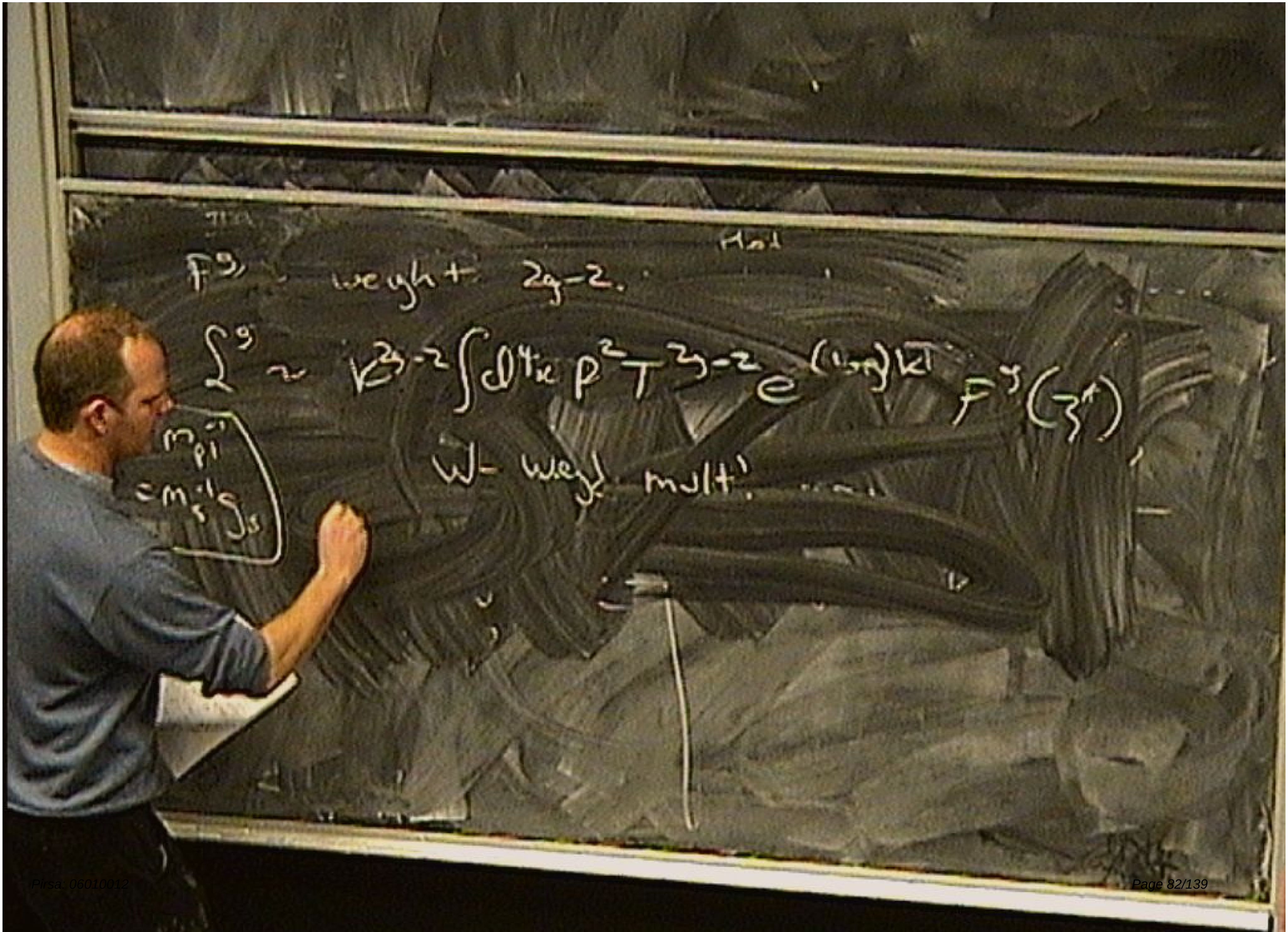
$$\mathcal{L}^g \sim \kappa^{2g-2}\int d^4x\, R^2\, T^{2g-2}\, e^{(1-g)K}\, F^g(z^i)$$

$$\boxed{\kappa \sim m_{pl}^{-1} = m_s^{-1} g_s}$$

Hol

F^g, weight $2g-2$.

$$\mathcal{F}^g \sim \kappa^{2g-2}\int d^4x\, p^2\, T^{2g-2}\, e^{(1-g)K}\, F^g(z^A)$$


F^g ~ weight 2g-2.
Σ^g ~ k^{3g-2} ∫ d^4x ρ^2 T^{3g-2} e^{(1-g)kT} F^g(ζ^A)
m_pl^-1 = m_s^-1 g_s
W- weyl mult'

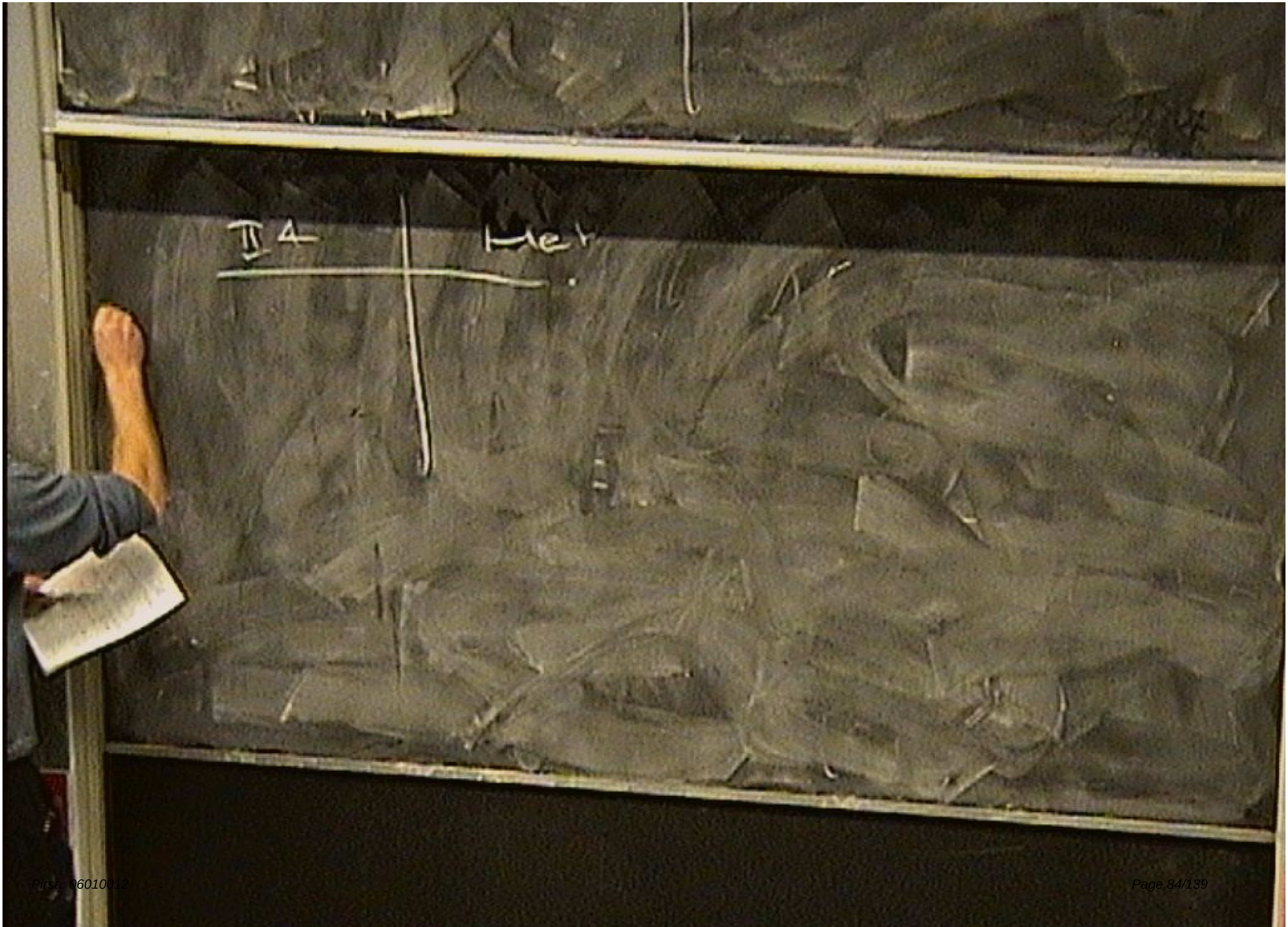
F^g, weight $2g-2$.

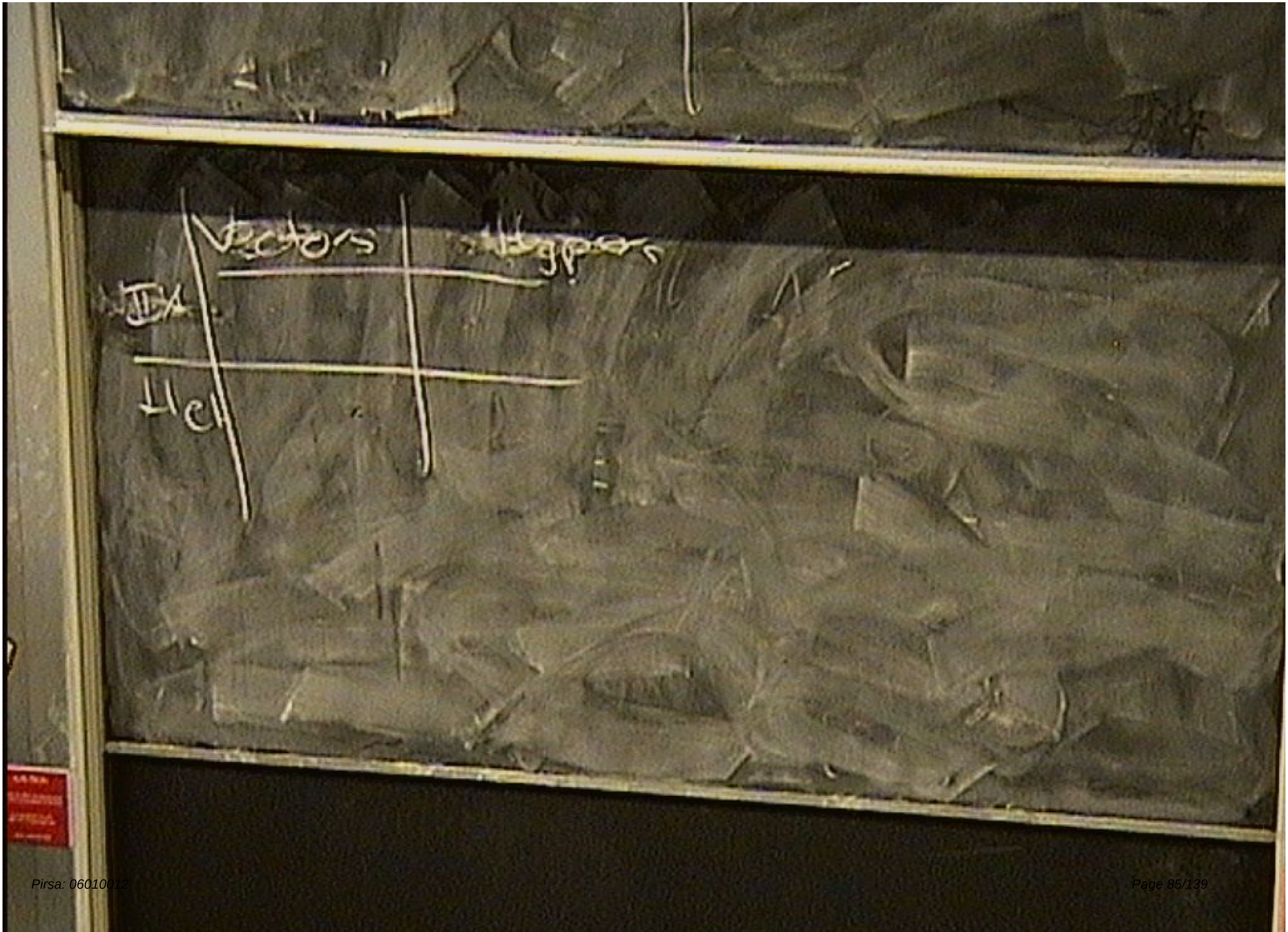
$$F^g \sim \kappa^{2g-2} \int d^4x \, \rho^2 T^{2g-2} e^{(1-g)K} f^g(z^A)$$

$\kappa \sim m_{pl}^{-1}$

W^2 W - weyl mult'.

$$W \sim T^2 + \dots - \theta^2 \bar{\theta}^2 R^2$$


II 4
Het


Vectors

F^g weight $2g-2$.

$$\mathcal{F}^g \sim \lambda^{2g-2} \int d^{4}x \, R^2 T^{2g-2} e^{(\ldots) K} F^g(z^i)$$

$K \sim m_{p\ell}^2$

$= m_{s}^2/g_s^2$

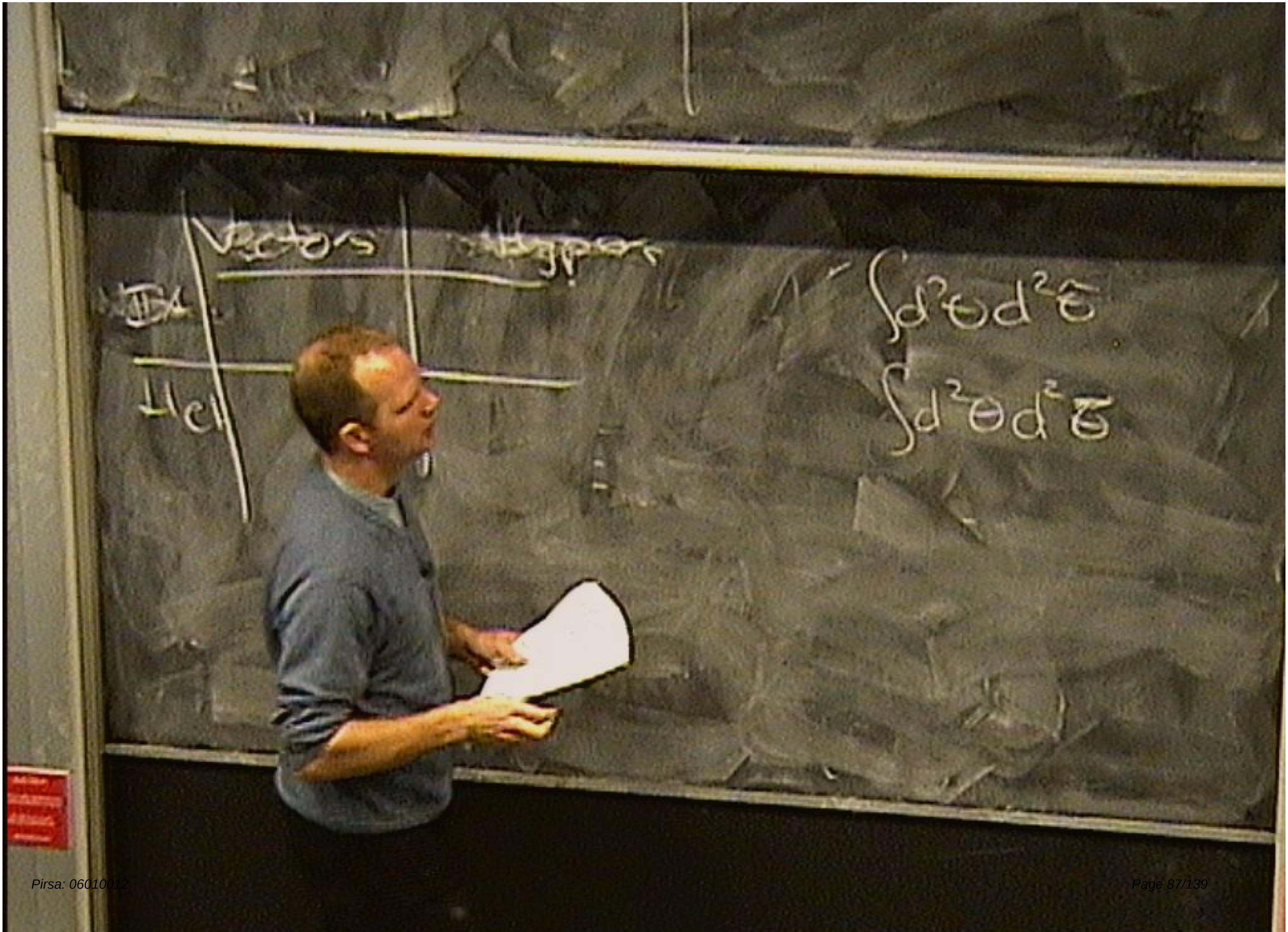
W – weyl multiplet

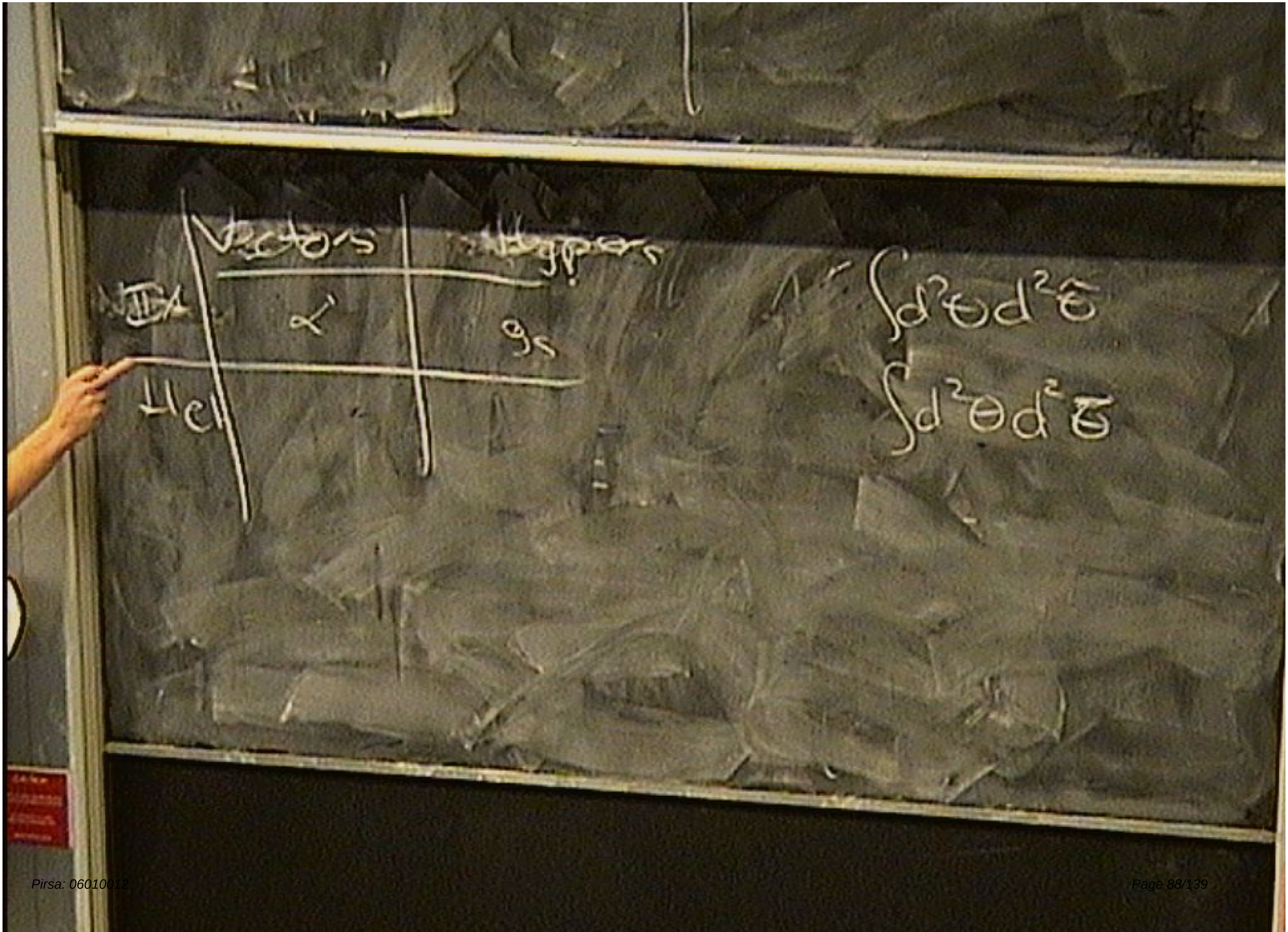
$W^2 \sim T^2 + \ldots \theta^2 R^2$

Vectors | hypers

$II A$

$II B$

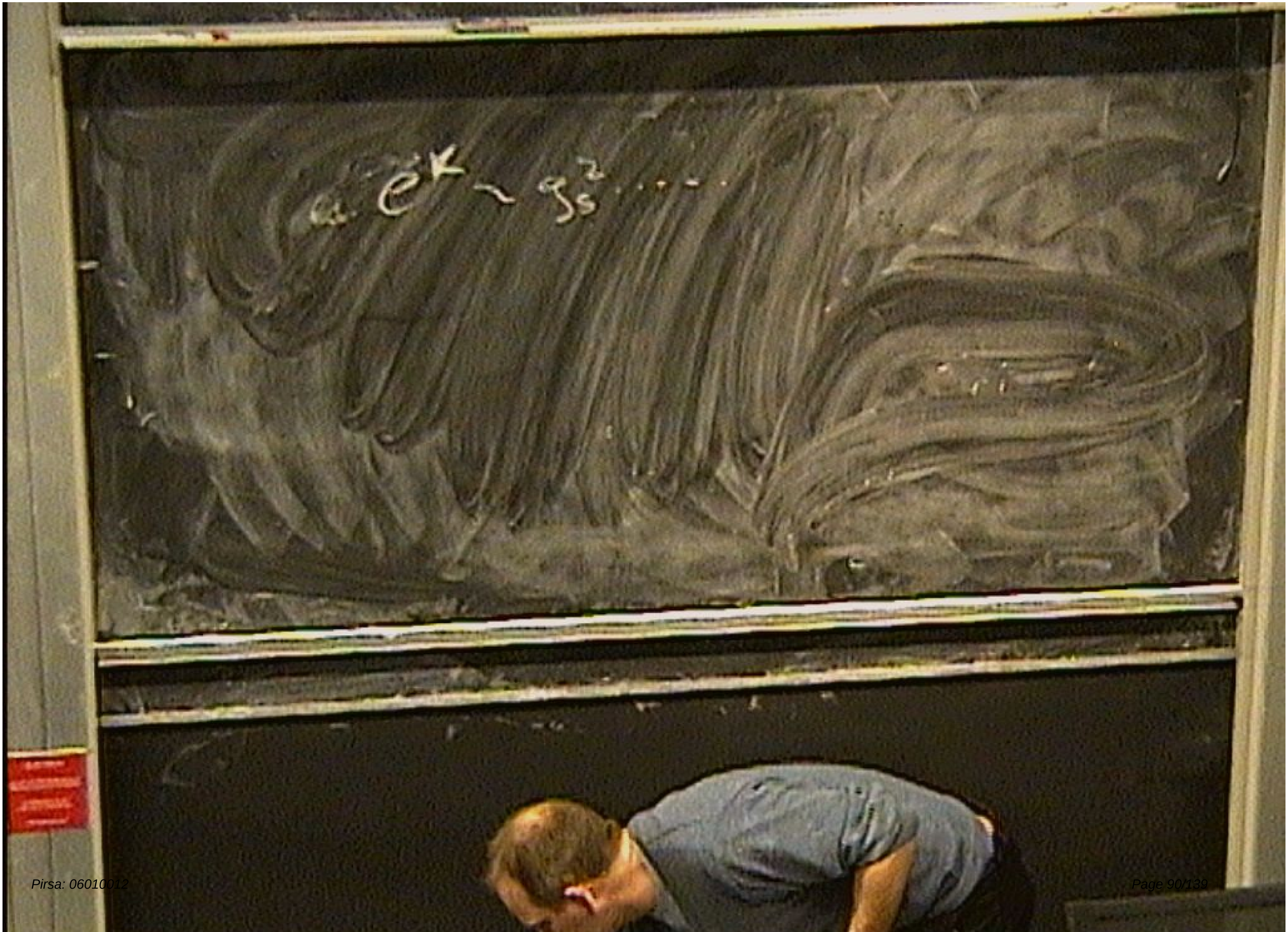

Vectors
$\int d^2\theta d^2\bar{\theta}$
$\int d^2\theta d^2\bar{\theta}$


Vectors
$\int d^2\theta d^2\bar\theta$
$\int d^2\theta d^2\bar\theta$

	Vectors	Higgses
IIA	α'	g_s
Het	g_s	α'

$$\int d^2\theta\, d^2\tilde{\theta}$$

$$\int d^2\theta\, d^2\bar{\theta}$$


e^K ~ g_s^2 . . . .

F^g weight $2g-2$

$$\mathcal{L}^g \sim K^{2g-2} \int d^4x\, R^2 T^{2g-2} e^{(1-g)K^T} F^g(\xi^I)$$

$$\boxed{\begin{aligned} K &\sim m_{pl}^{-1} \\ &= m_s^{-1} g_s \end{aligned}}$$

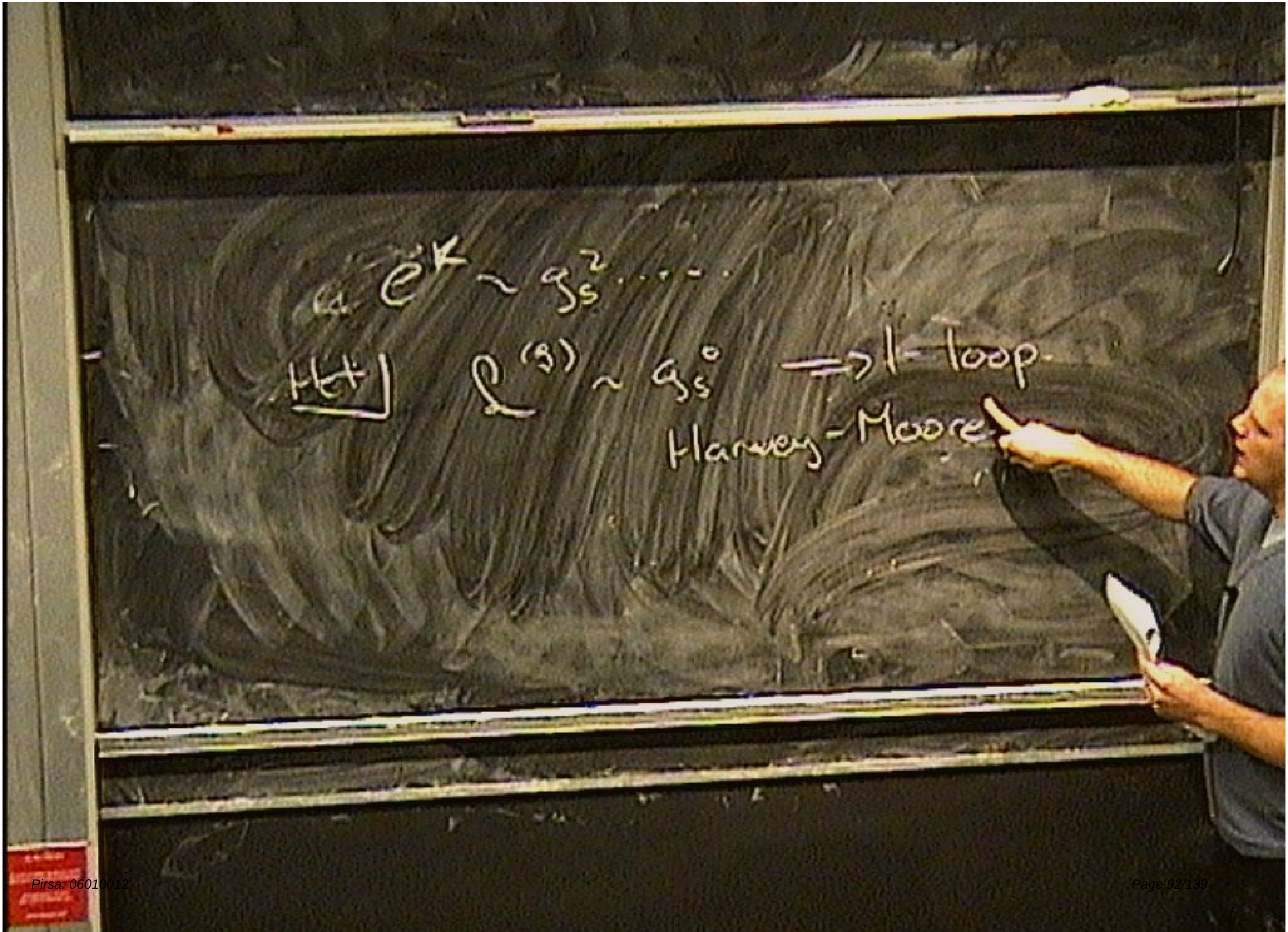
W = weyl mult'

$$W^2 \sim T^2 + \dots \theta^2 \theta^2 R^2$$

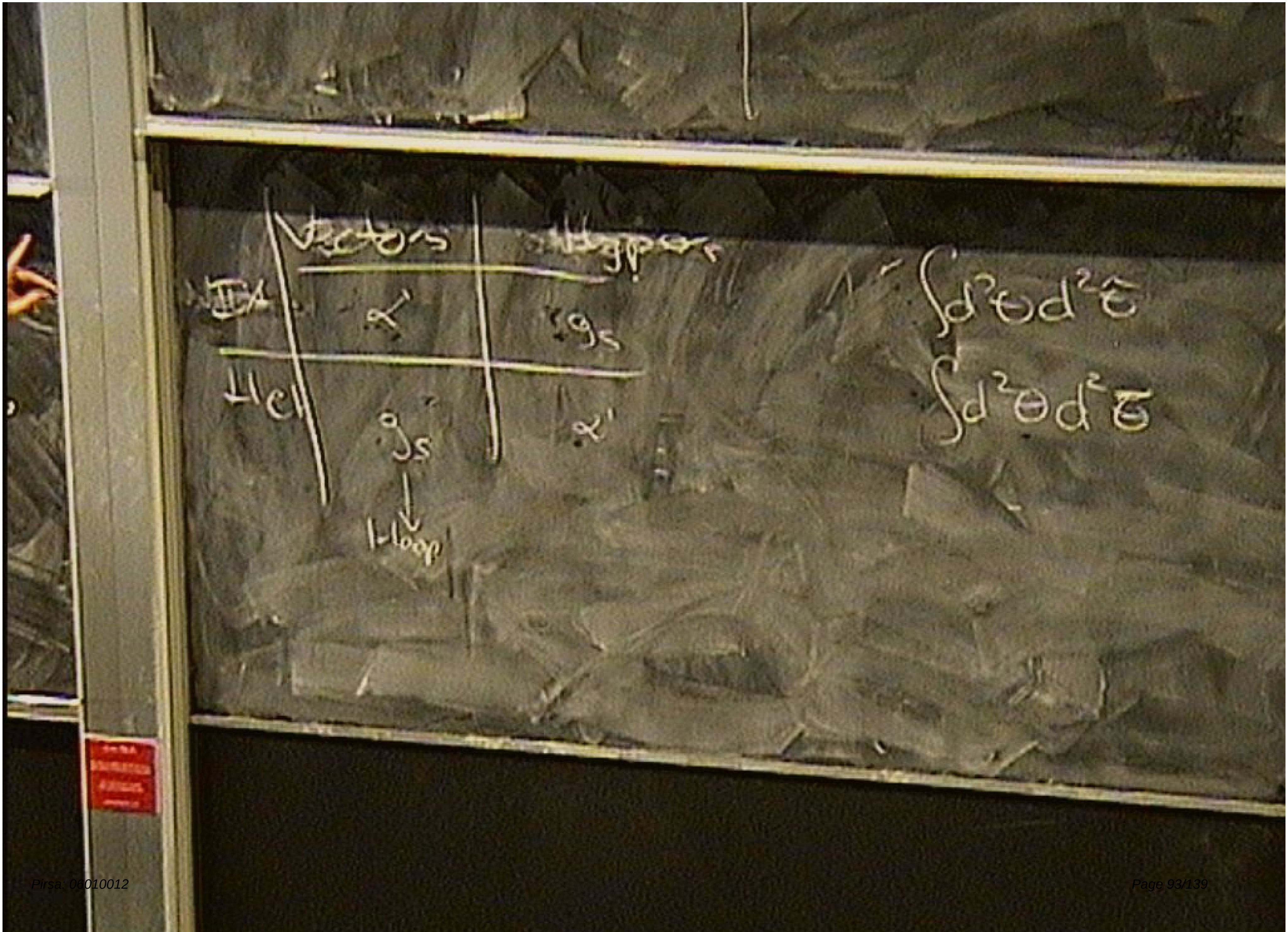
	Vectors	Hypers
IIA	α'	g_s
Het		

$$\sim \int d^2\theta\, d^2\bar{\theta}$$

$$\int d^2\theta\, d^2\bar{\theta}$$



$e^{-K} \sim g_s^2 \ldots$
Het
$f^{(g)} \sim g_s^0 \Rightarrow$ 1-loop
Harvey-Moore



Vectors
Hypers
α'
g_s
g_s
α'
1-loop
∫d²θd²ε
∫d²θd²ε̄

F^g weight $2g-2$.

$$F^g \sim \kappa^{2g-2} \int d^4x\, R^2\, T^{2g-2}\, e^{(1-g)K}\, F^g(z^i)$$

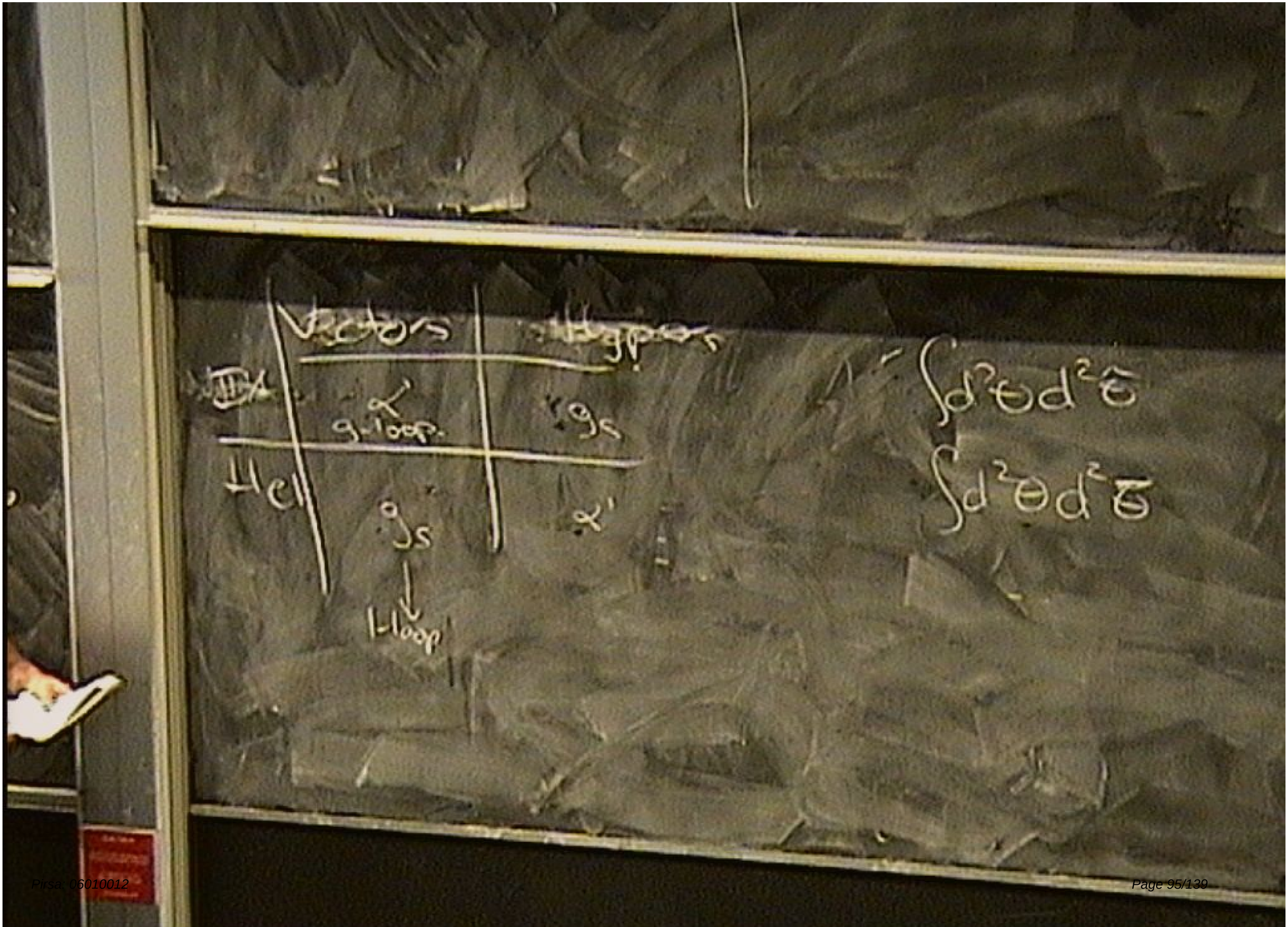
$\kappa \sim m_{pl}^{-1} = m_s^{-1} g_s$

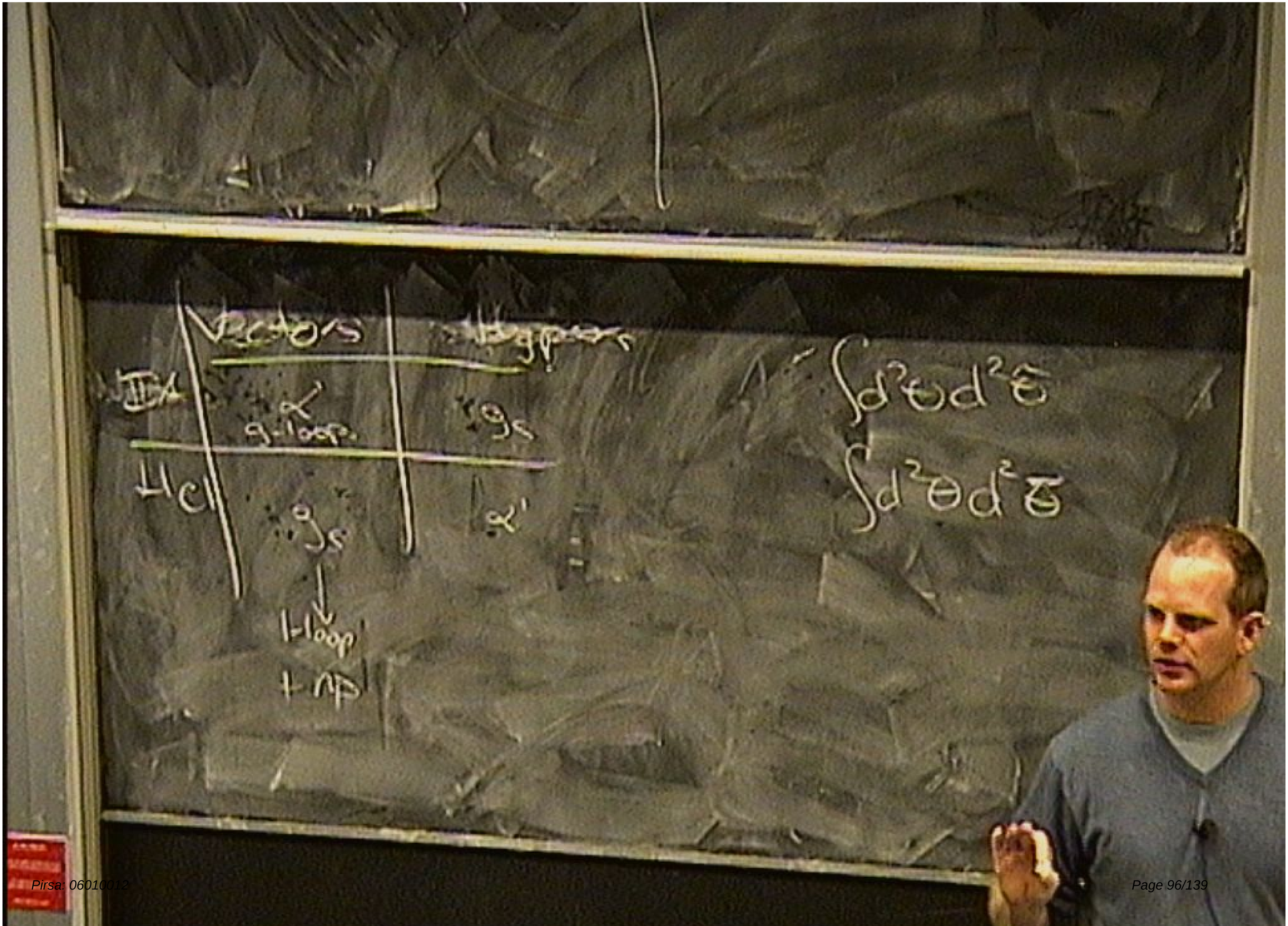
W – Weyl mult.

$$W^2 \sim T^2 + \ldots \theta^2\theta^2 R^2$$

	Vectors	Hypers
	α'	g_s

$\int d^2\theta\, d^2\bar{\theta}$

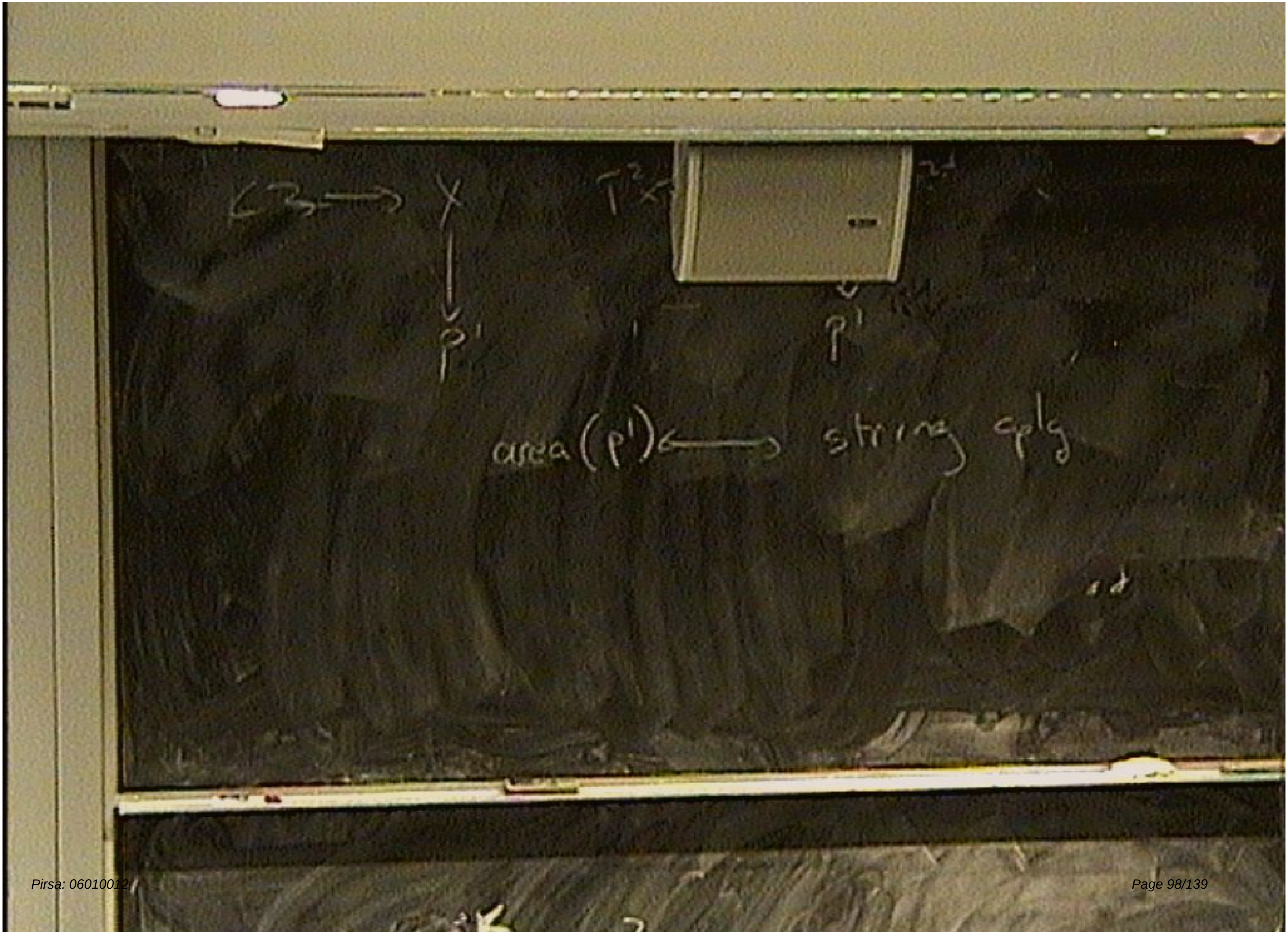

Vectors
Hypers
α'
g-loop
g_s
Het
g_s
α'
1-loop
$\int d^2\theta d^2\bar\theta$
$\int d^2\theta d^2\bar\theta$

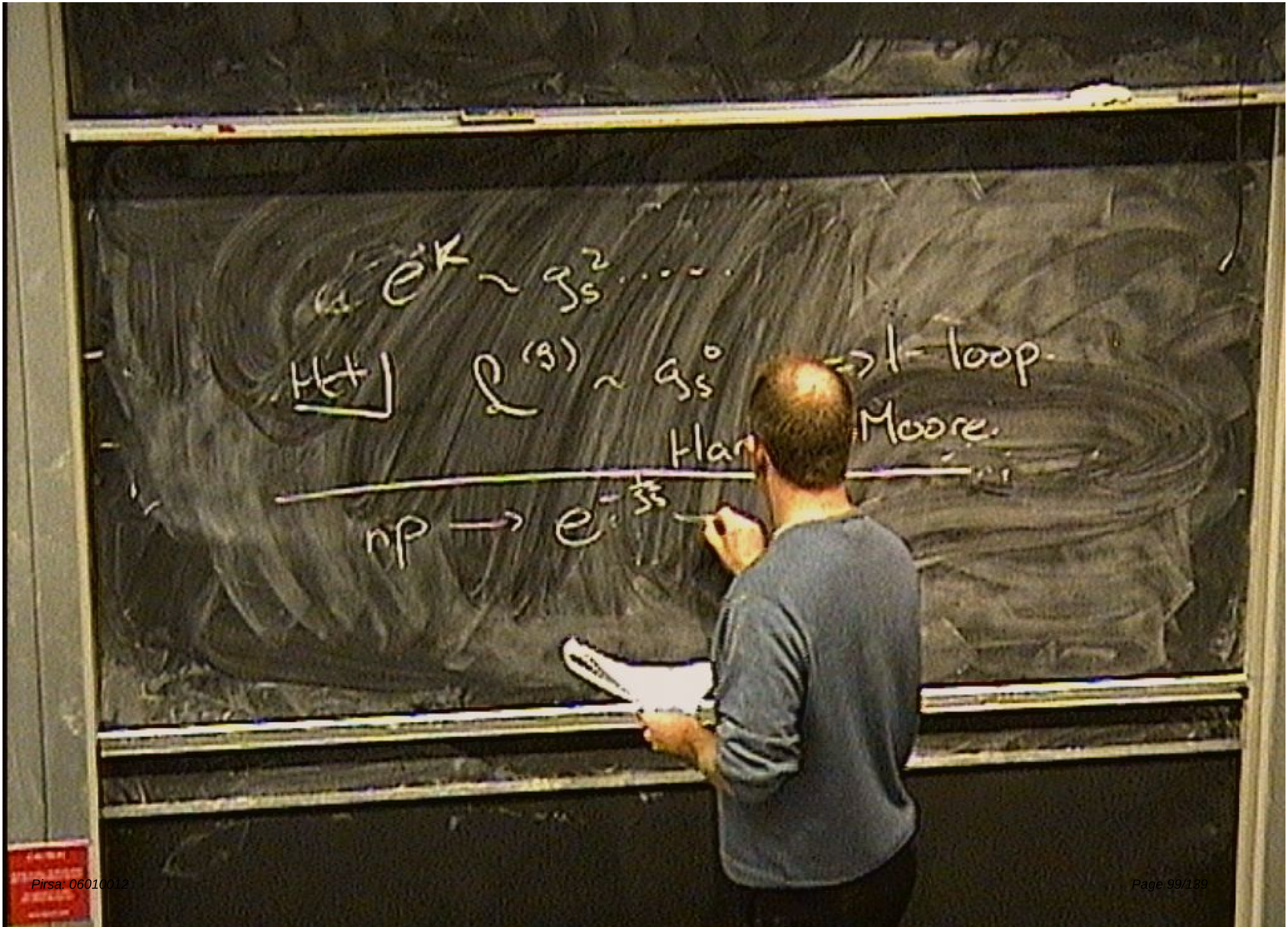

Vectors
IIA
α'
g_s
Het
g_s
α'
1-loop
$\int d^2\theta d^2\bar\theta$
$\int d^2\theta d^2\bar\theta$

	Vectors	Hypers
IIA	α' g-loop.	g_s
Het	g_s $\downarrow$ 1-loop! + np!	α'

$$\int d^2\theta \, d^2\varepsilon$$

$$\int d^2\theta \, d^2\bar{\varepsilon}$$


$\mathbb{C}_3 \to X$
$\mathbb{P}^1$
$\mathbb{P}^1$
$\mathrm{area}(\mathbb{P}^1) \longleftrightarrow$ string cplg



$e^{K} \sim g_s^2 \ldots$
$\ell^{(g)} \sim g_s^0 \Rightarrow$ 1-loop
Moore.
$np \rightarrow e^{-\frac{1}{g_s}}$

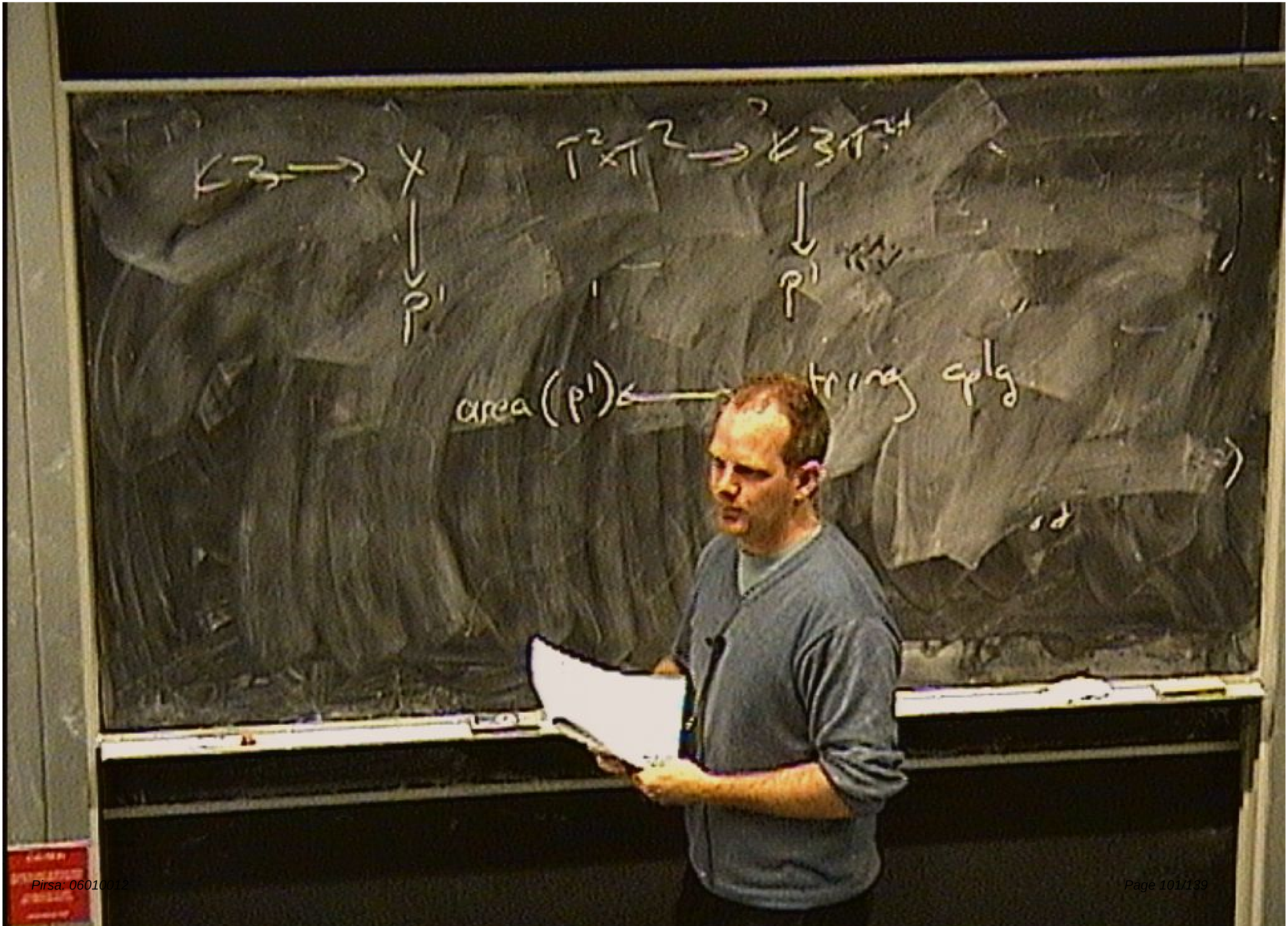
$e^{-K} \sim g_s^2 \cdots$

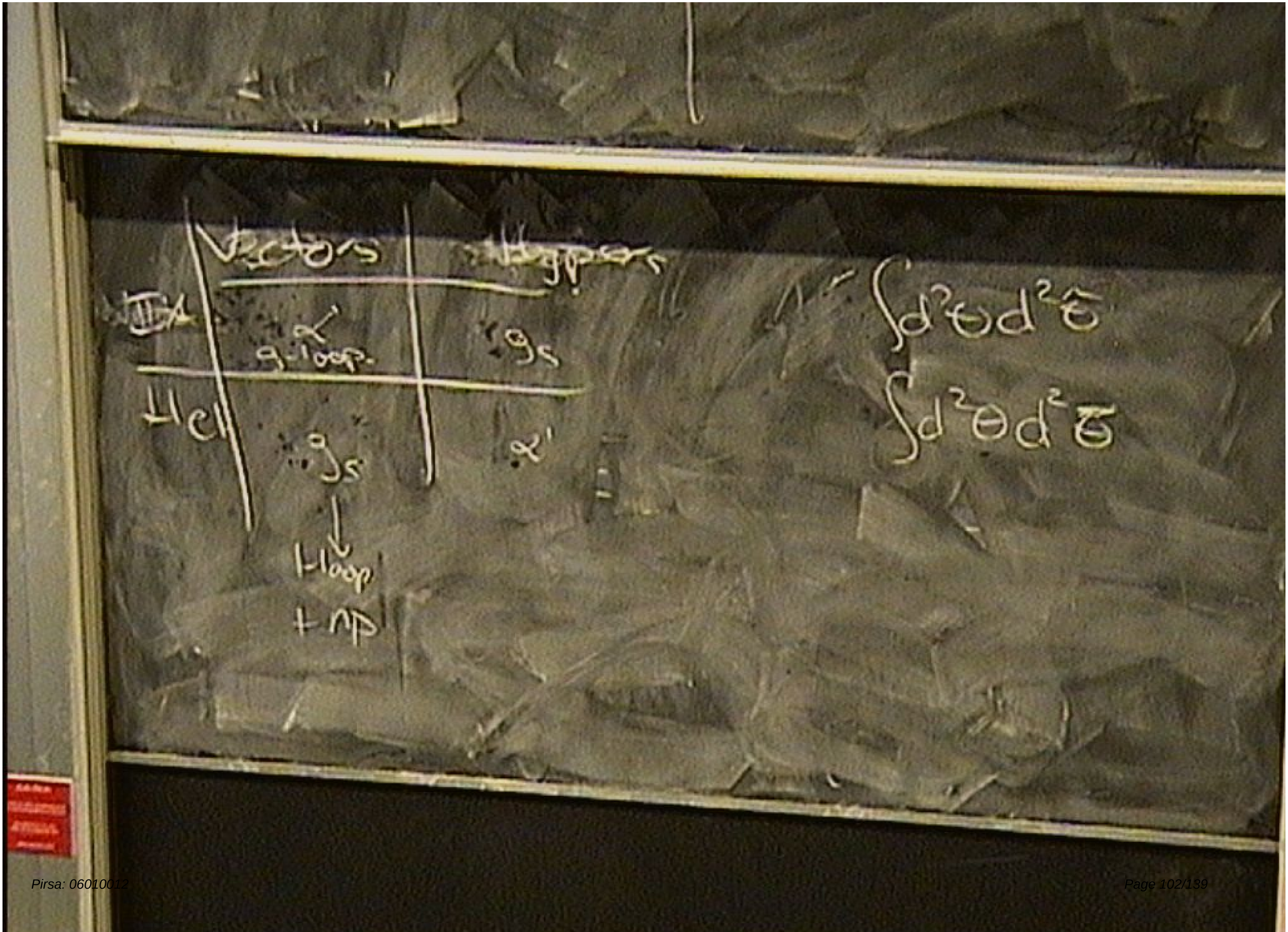
$\boxed{\text{HET}}$ $\mathcal{L}^{(g)} \sim g_s^0 \Longrightarrow$ 1-loop

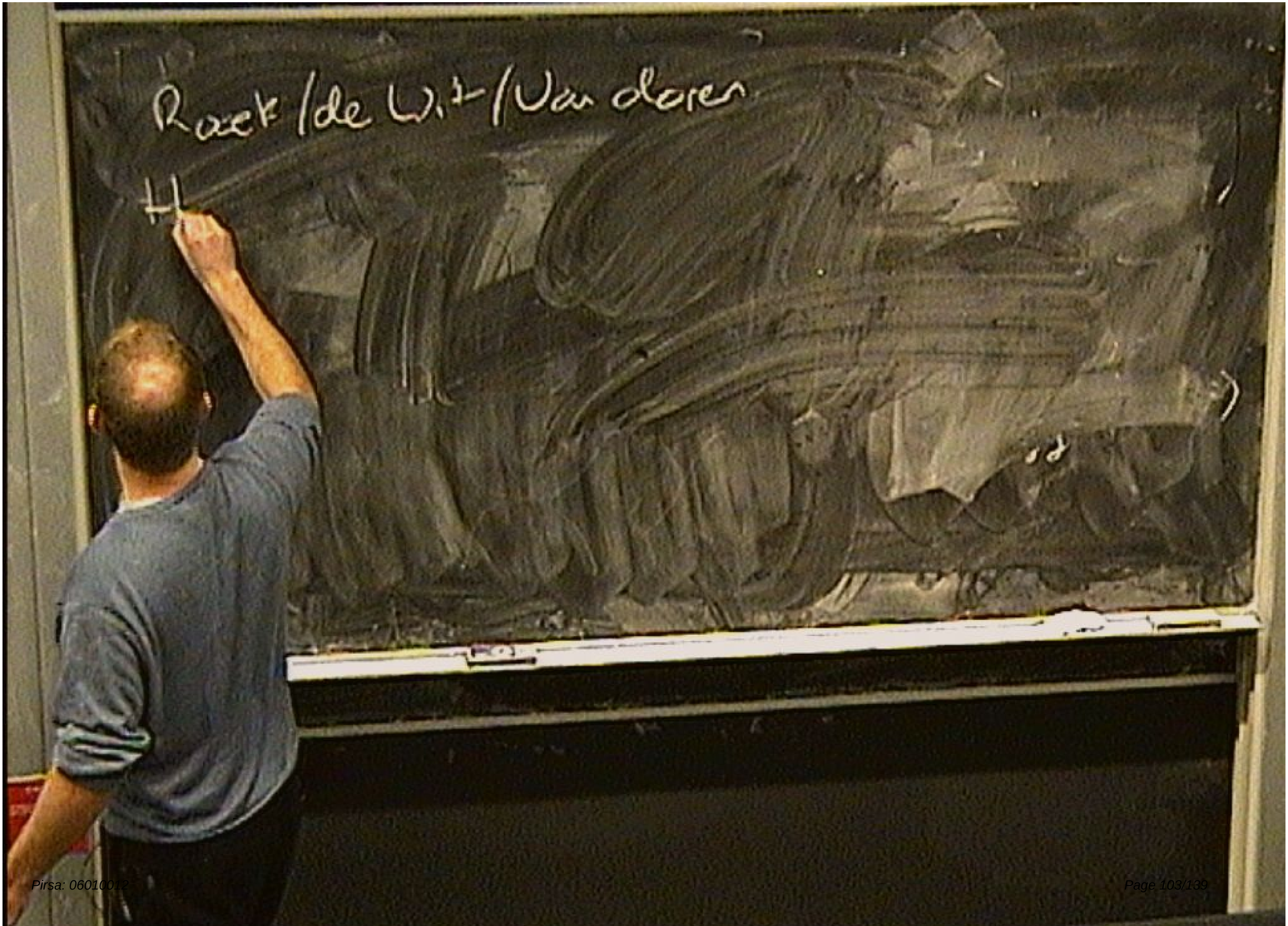
Harvey-Moore

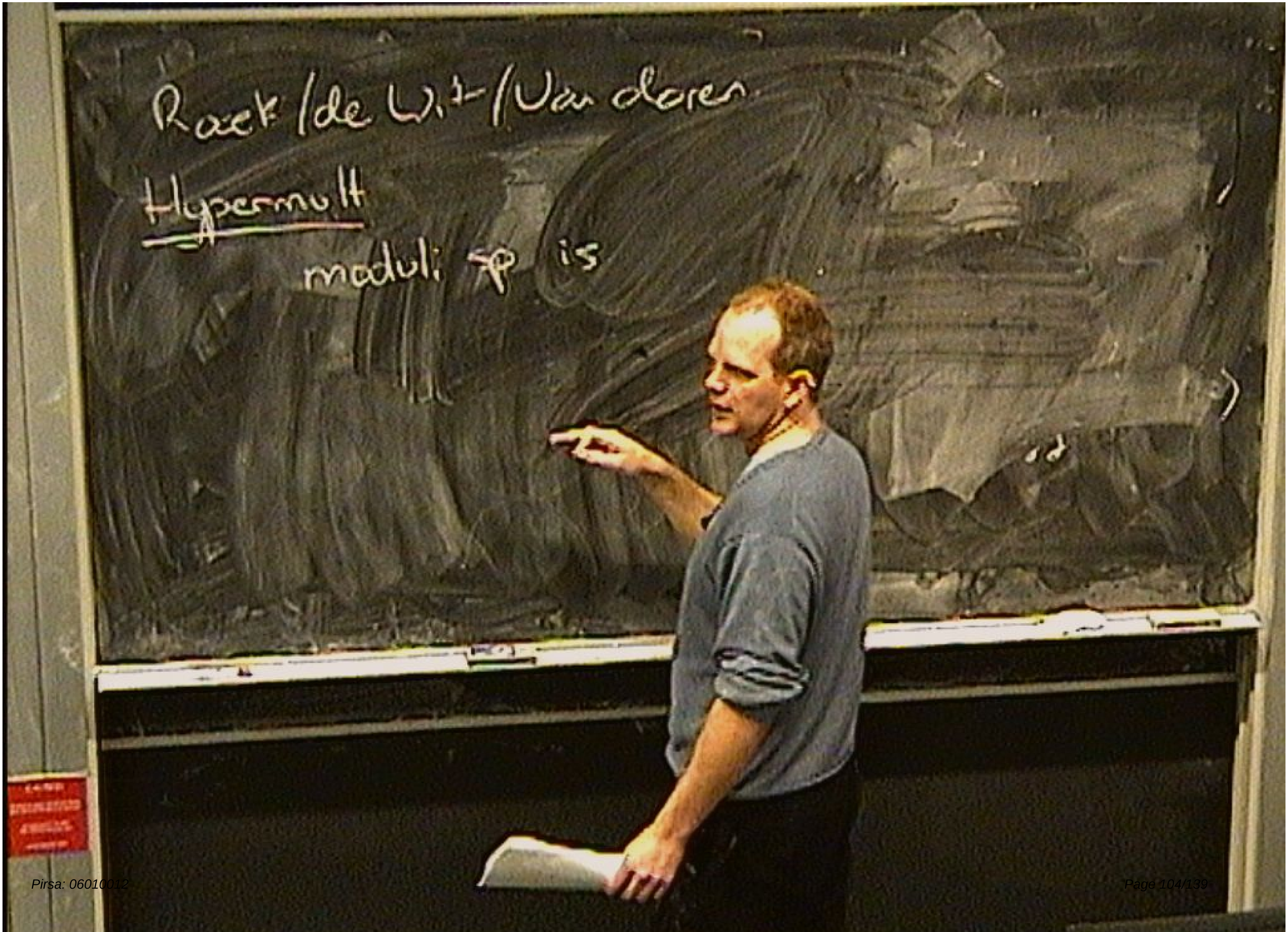
---

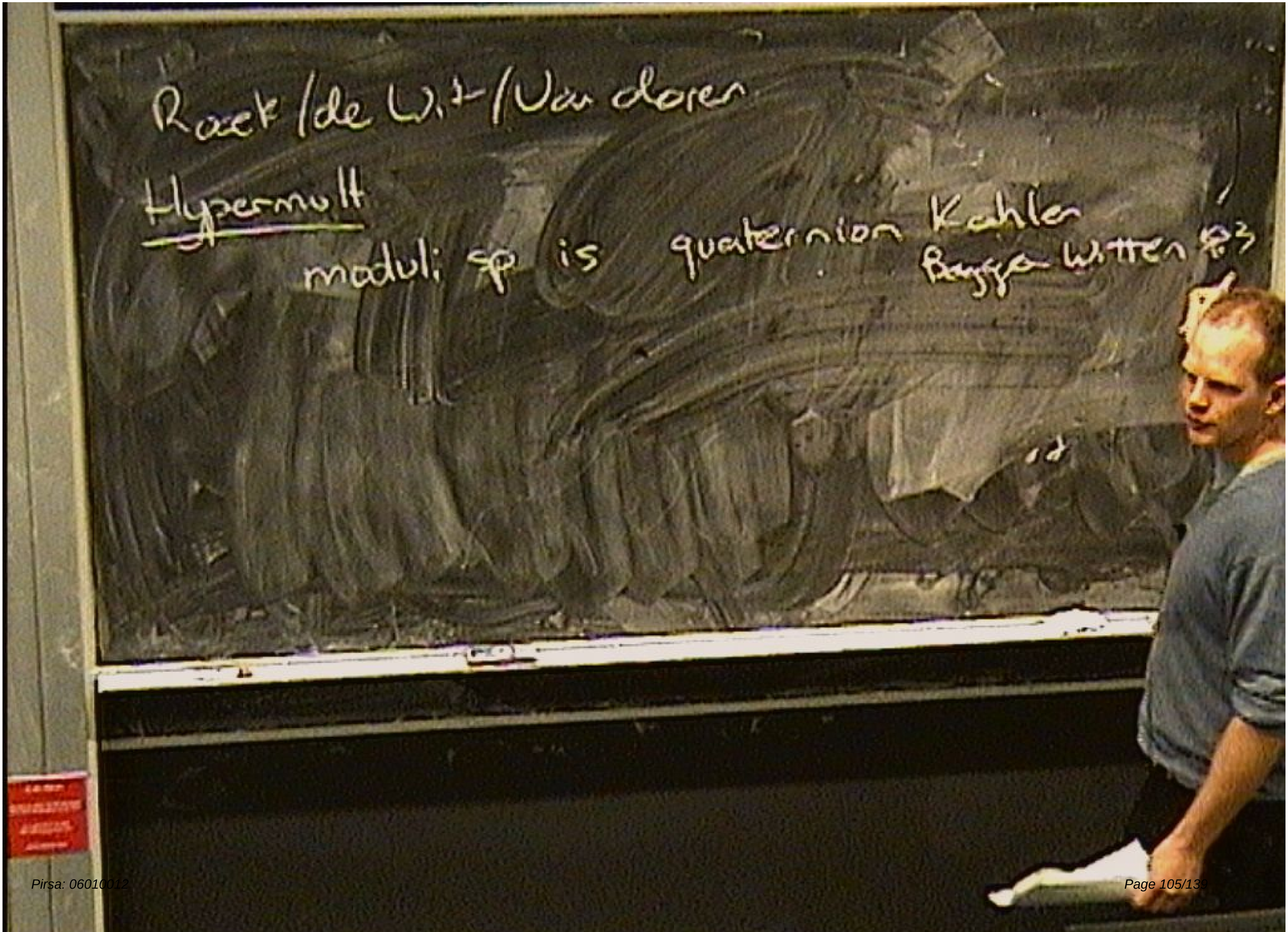
np $\longrightarrow e^{-\frac{1}{g_s}} \longrightarrow$ IIA is ws inst
w/ class in base $\mathbb{P}^1$


K3 → X
P¹
T² × T² → K3
P¹
area(P¹) ⟷ string cplg


Vectors
α'
g-loop.
g_s
g_s
α'
1-loop
+np
$\int d^2\theta d^2\tilde{\theta}$
$\int d^2\theta d^2\bar{\theta}$


Rocek /de Wit /Van doren
H


Roček / de Wit / Van doren
Hypermult
moduli sp is


Rocek /de Wit /Van doren
Hypermult
moduli sp is quaternion Kahler
Bagger Witten '83

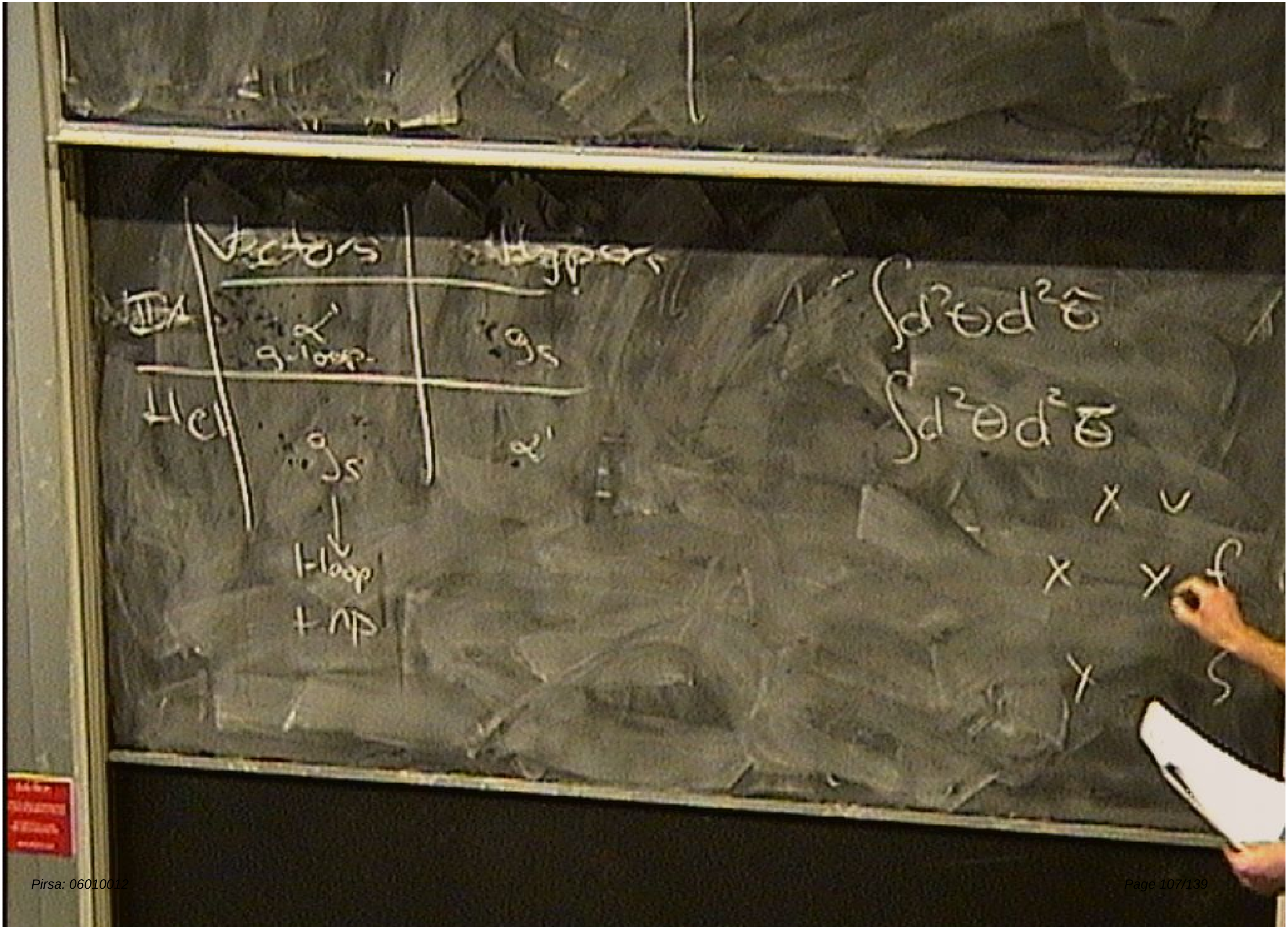
Rocek / de Wit / Van doren

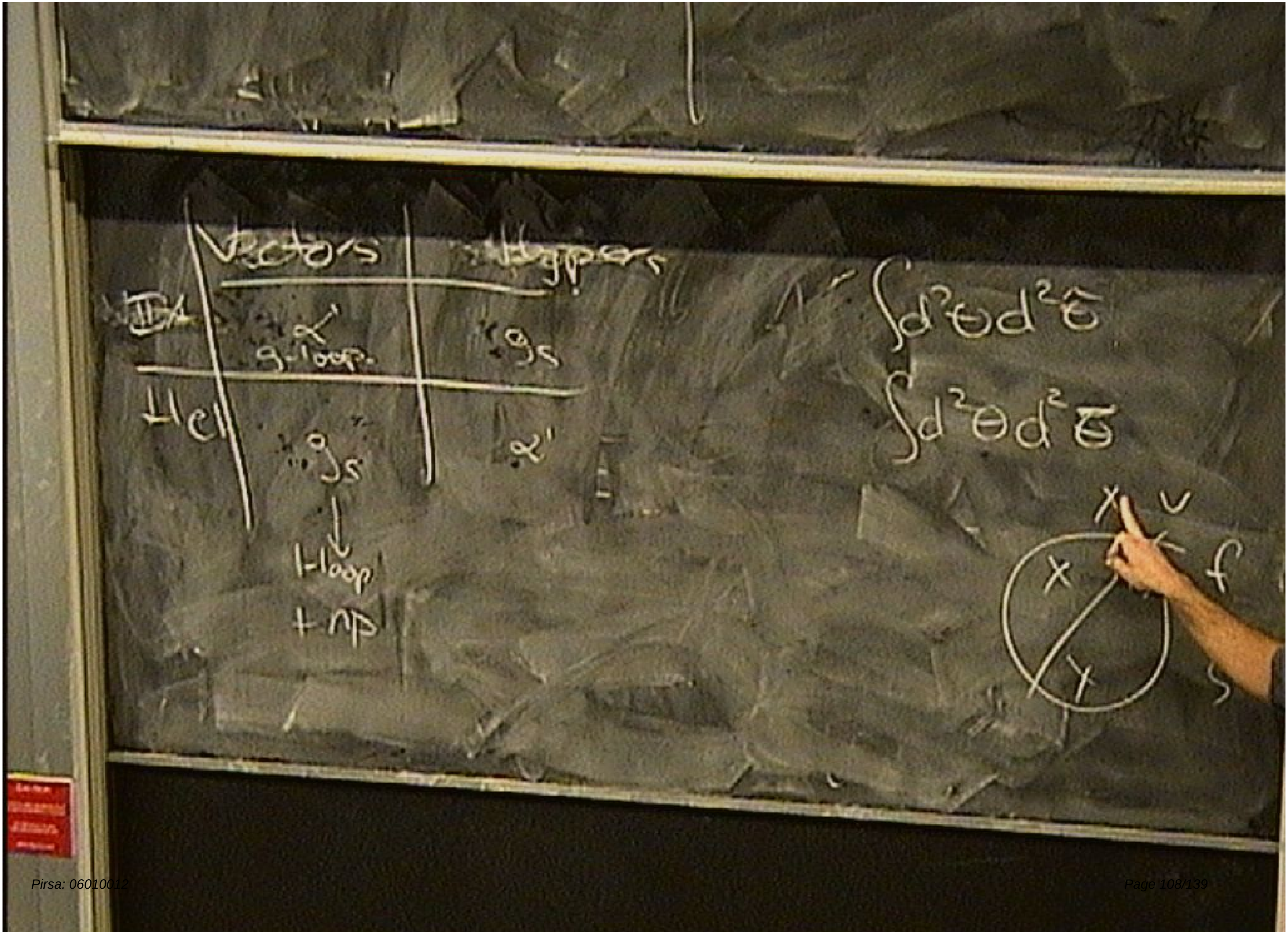
<u>Hypermult</u>

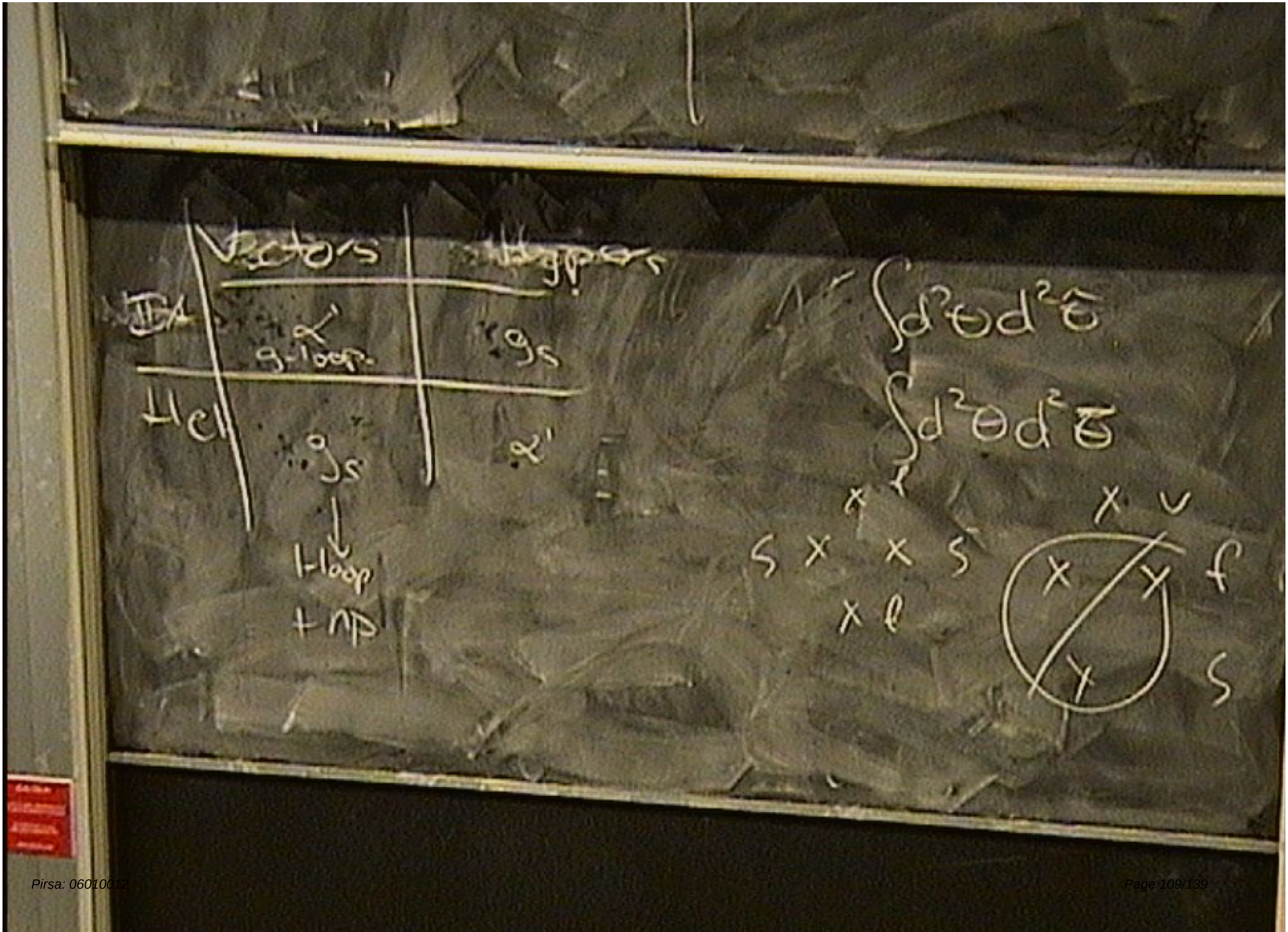
moduli sp is quaternion Kahler

Bagger-Witten '83

$Sp(n) \cdot Sp(1)$


Vectors
Het
1-loop
+ NP
∫d²θd²θ̄
X
Y


Vectors
g-loop
Het
1-loop
+ np


Vectors
Hypers
IIA
α'
g-loop
g_s
Het
g_s
α'
1-loop
+ np
∫d²θd²θ̃
∫d²θd²θ̄
x
x v
s x x s
x f
x l
y
s

	Vectors	Hypers
IIA	α' g-loop.	g_s (g-loop) Nwein
Het	g_s → 1-loop + np	α'

$$\int d^2\theta\, d^2\tilde{\theta}$$

$$\int d^2\theta\, d^2\bar{\theta}$$

x f

s x x s

x l

x v

x x f

y s

F^g - weight $2g-2$.

$$\mathcal{L}^g \sim K^{2g-2} \int d^4x\, R^2 T^{2g-2} e^{(1-g)K} F^g(z^i)$$

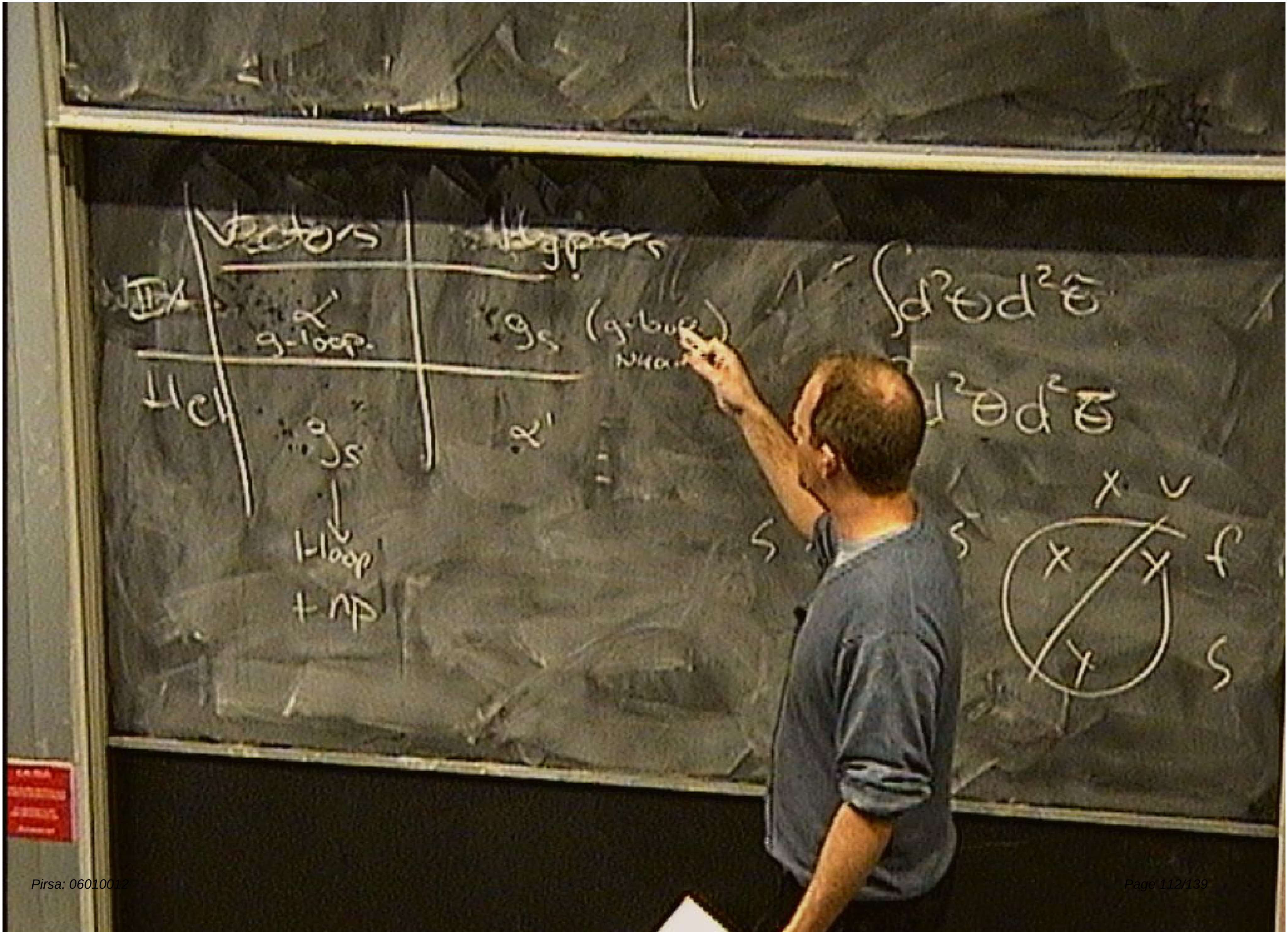
$\boxed{K \sim m_{pl}^{-1} = m_s^{-1} g_s}$

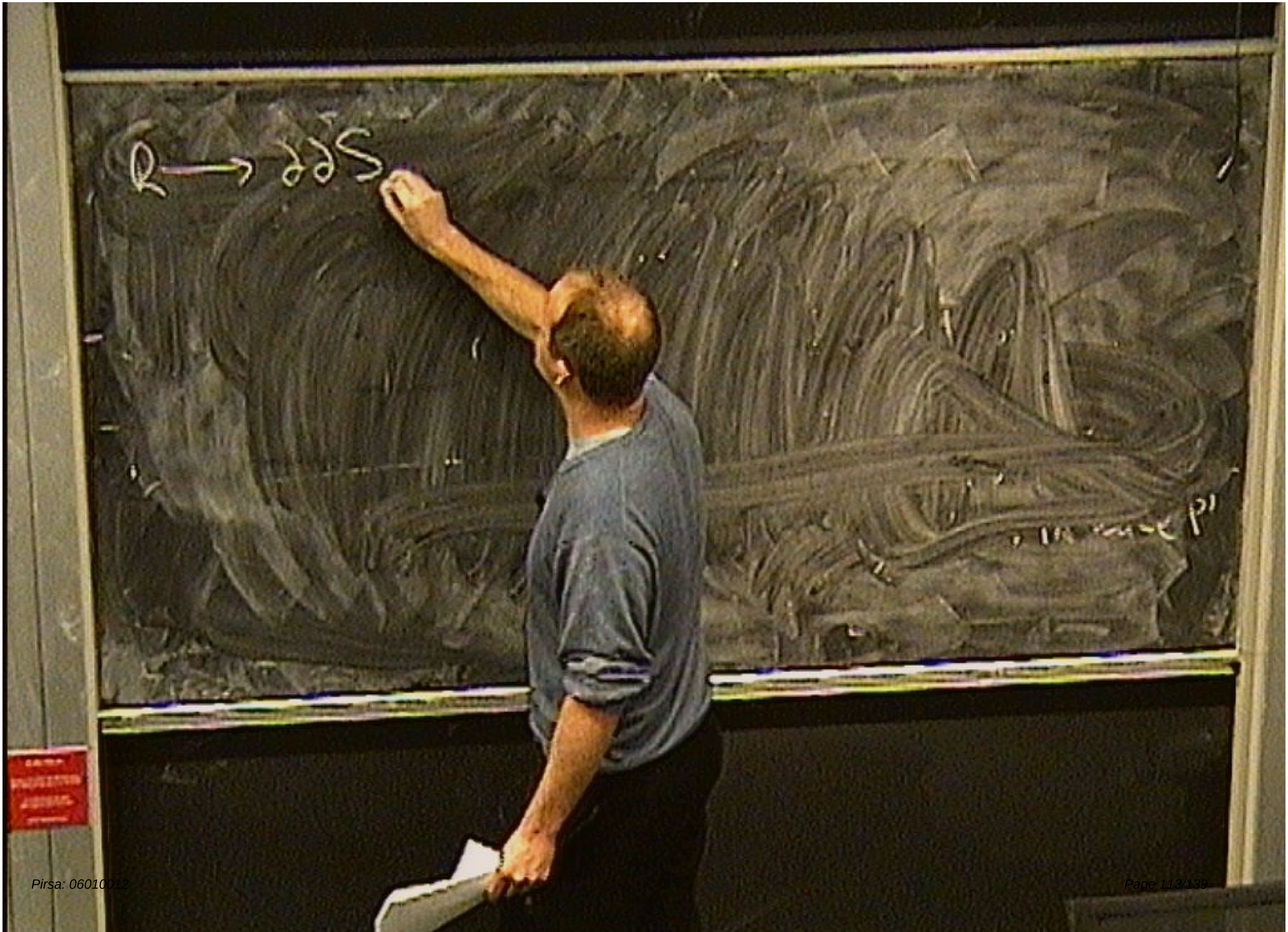
W - weyl mult.

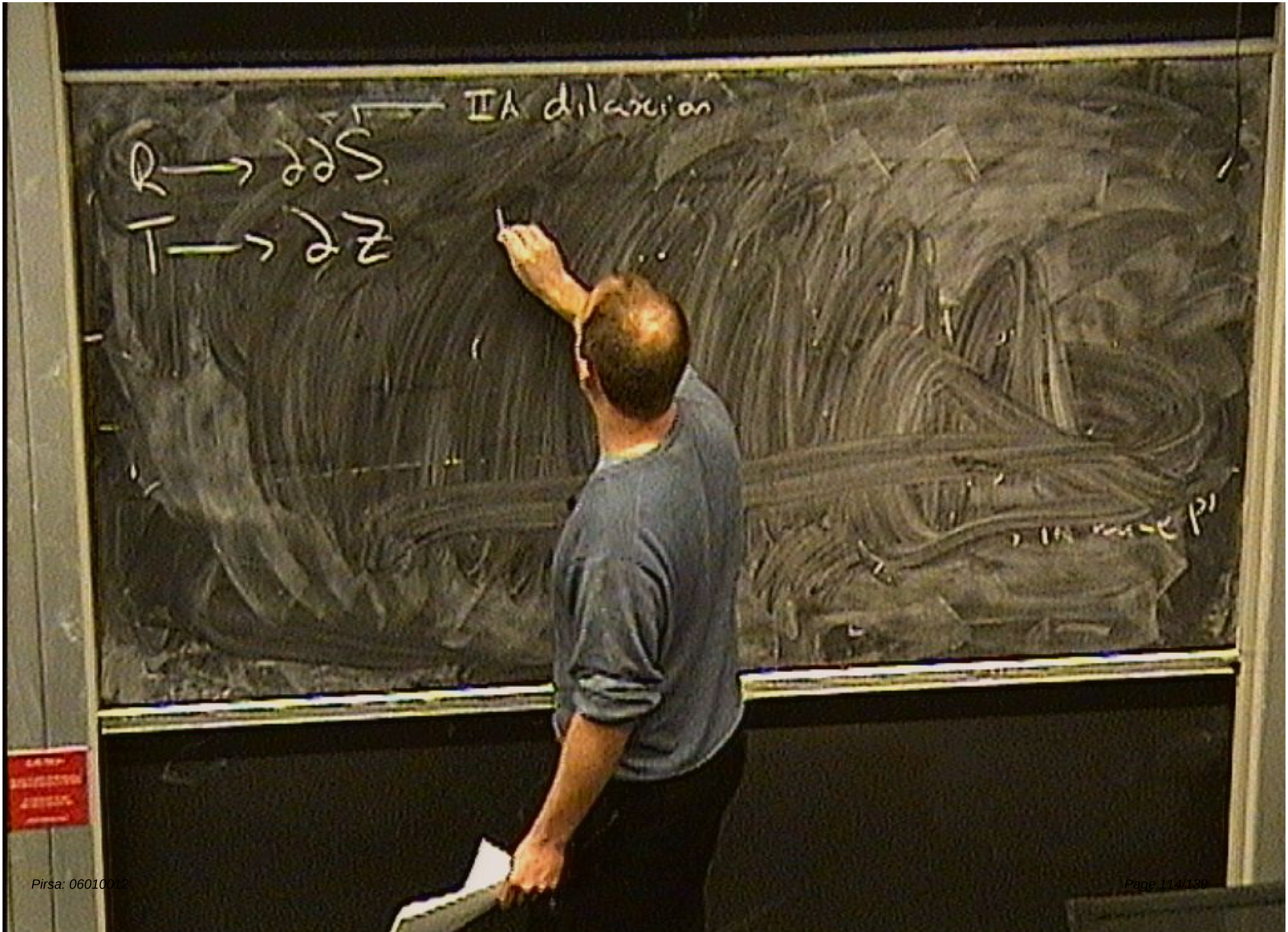
$$W^2 \sim T^2 + \ldots - \theta^2 \partial^2 R^2$$

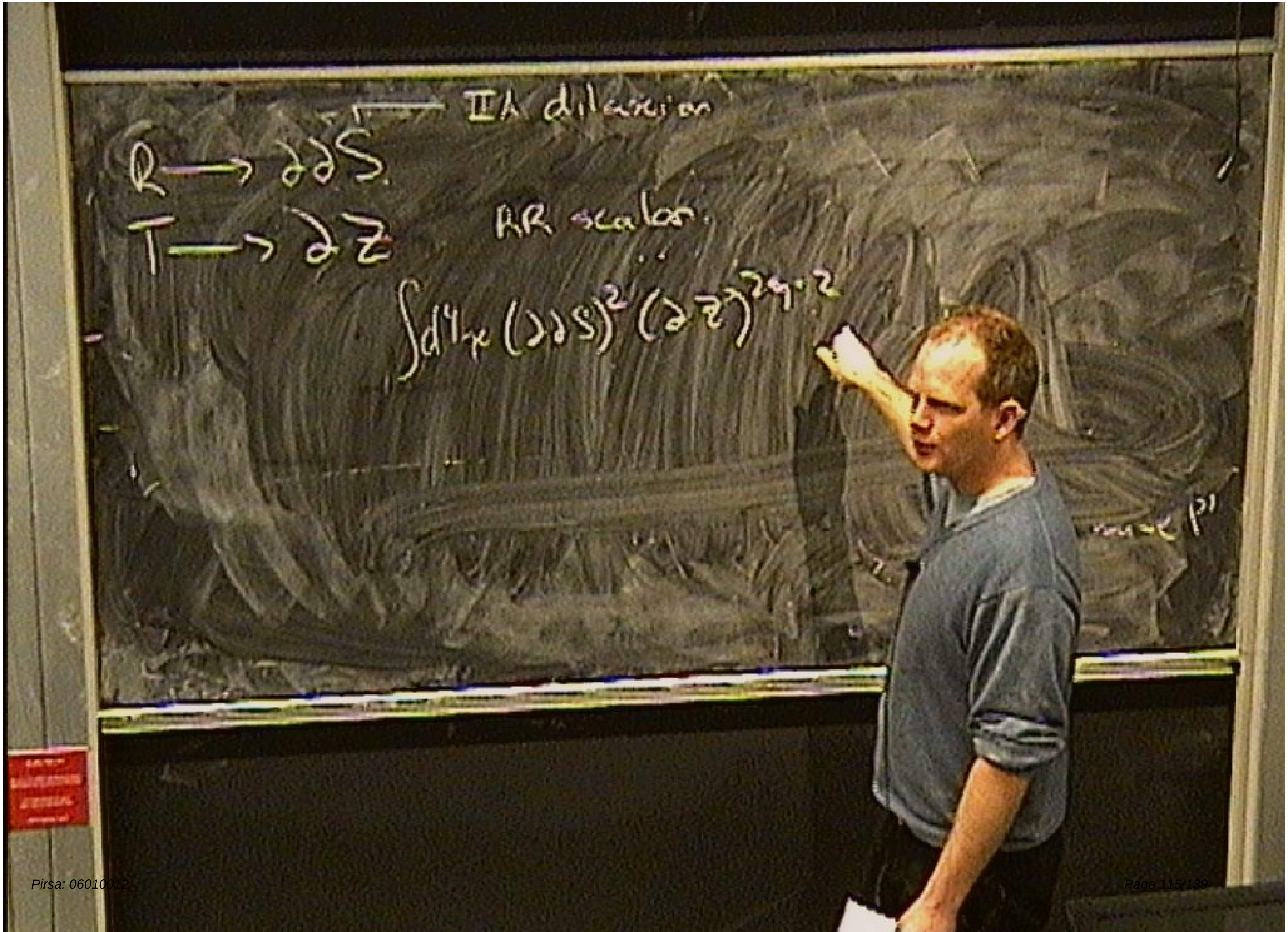
Vectors	Hypers
IIA α' g-loops	g_s (g-loop)

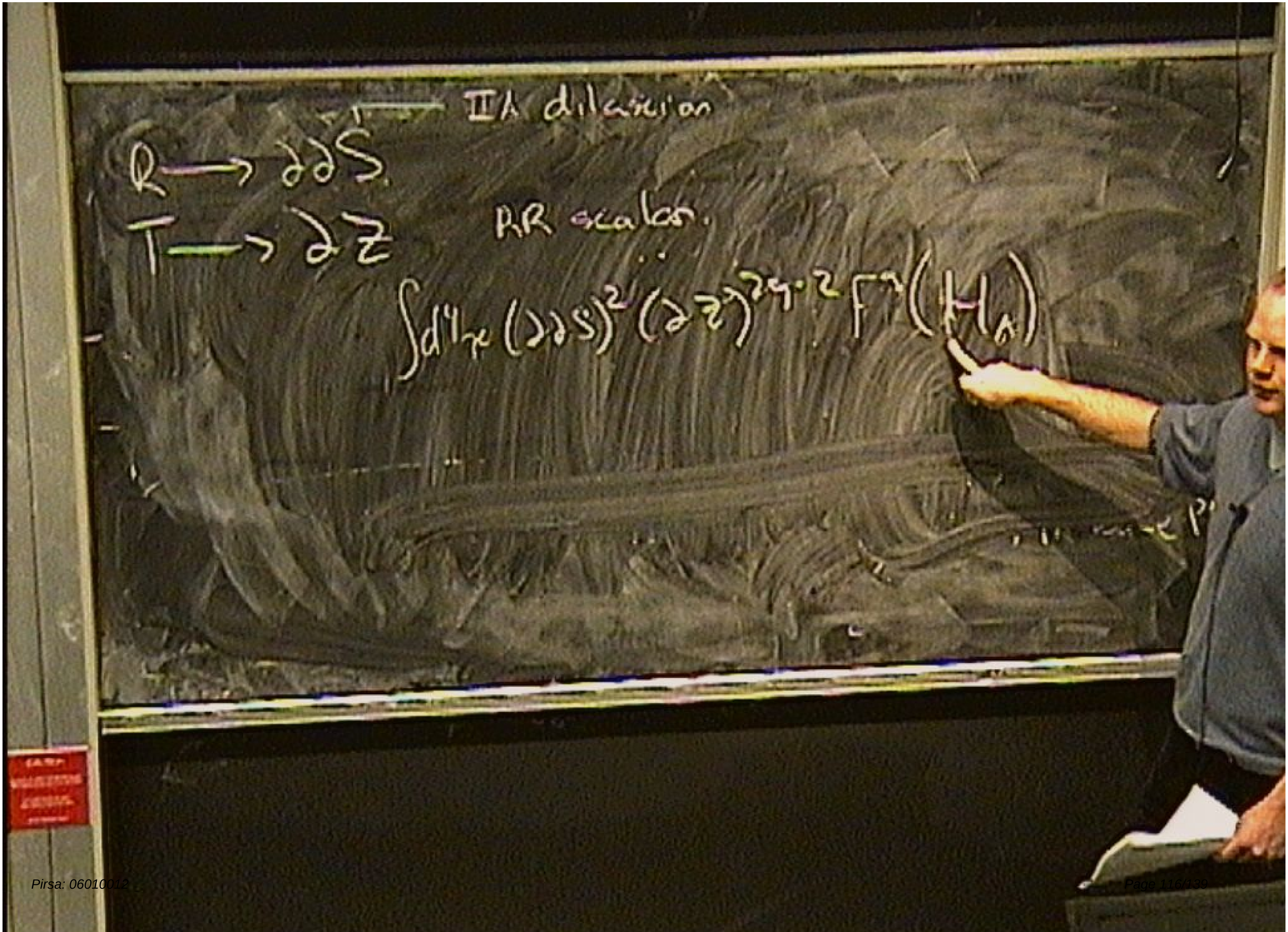
$$\int d^2\theta\, d^2\bar{\theta}$$

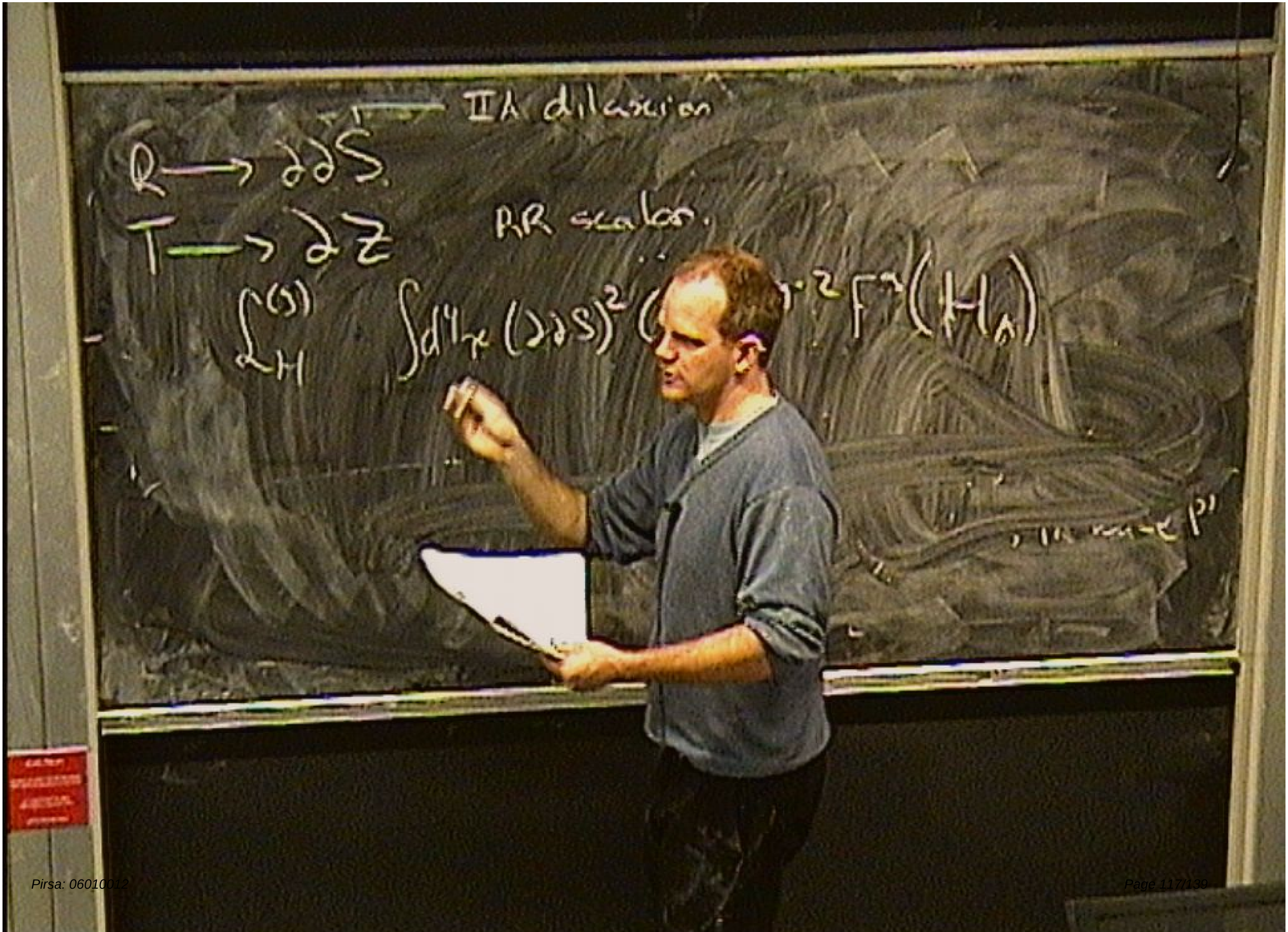

Vectors
Hypers
IIA
α'
g-loop
g_s
Hc
g_s
1-loop
+ np
α'
∫d²θd²θ̄
X
Y
S
f




IIA dilaton
R → ∂∂S
T → ∂Z


IIA dilaton
R → ∂∂S
T → ∂Z
RR scalar
∫d⁴x (∂∂S)² (∂Z)^{2g-2}


IIA dilaton
R → ∂∂S
T → ∂Z
RR scalar


IIA dilation
R → ∂∂S
T → ∂Z
RR scalar.

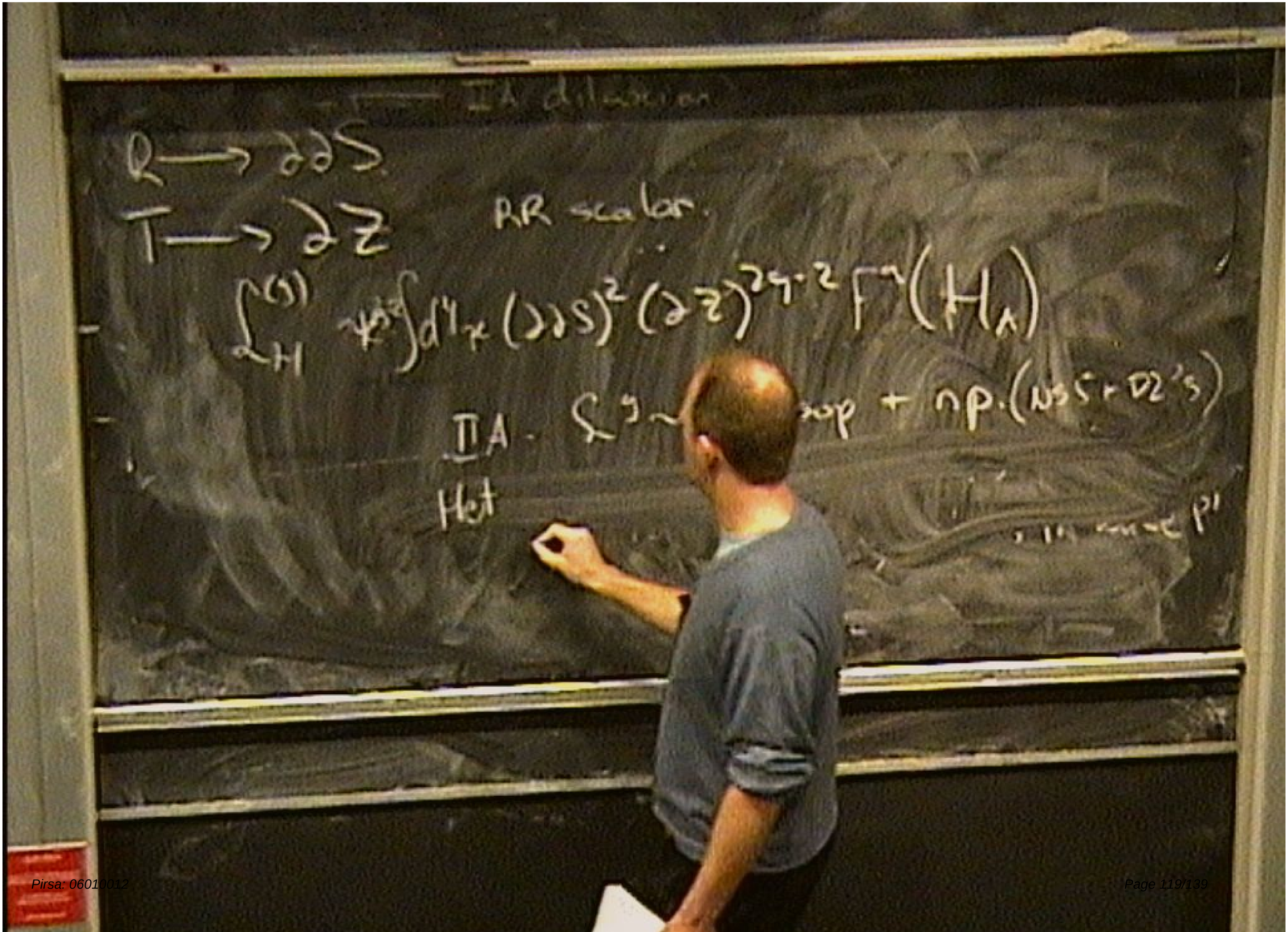
IIA dilaxion

$R \to \partial\partial S$

$T \to \partial Z$ RR scalar.

$$\mathcal{L}_H^{(g)} \sim \int d^4x \, (\partial\partial S)^2 (\partial Z)^{2g-2} F^g(H_A)$$

IIA: $\mathcal{L}^g \sim$ g-loop + n.p. (NS5 + D2's)


IIA dilaton
R → ∂∂S
T → ∂Z
RR scalar
Het

IIA dilatation

$$R \longrightarrow \partial\partial S$$

$$T \longrightarrow \partial Z \qquad \text{RR scalar.}$$

$$\mathcal{L}^{(g)}_{H} \sim \int d^4x\, (\partial\partial S)^2 (\partial Z)^{2g-2} F^g(H_A)$$

IIA : $f_g \sim$ g-loop + n.p.(NS5 + D2's)

Het : $f_g \sim$ g loop

— IIA dilatation

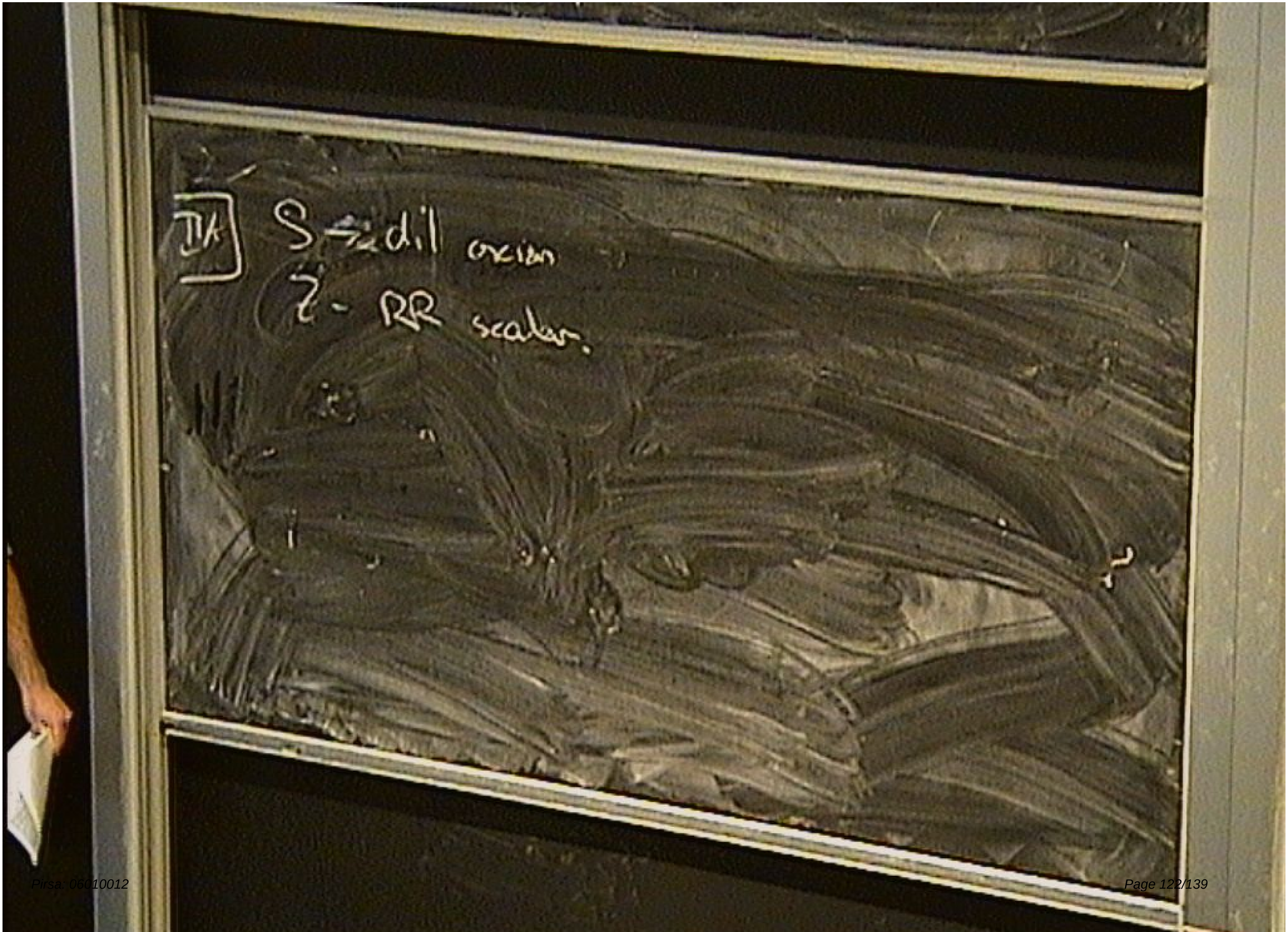
$R \longrightarrow \partial\partial S$.

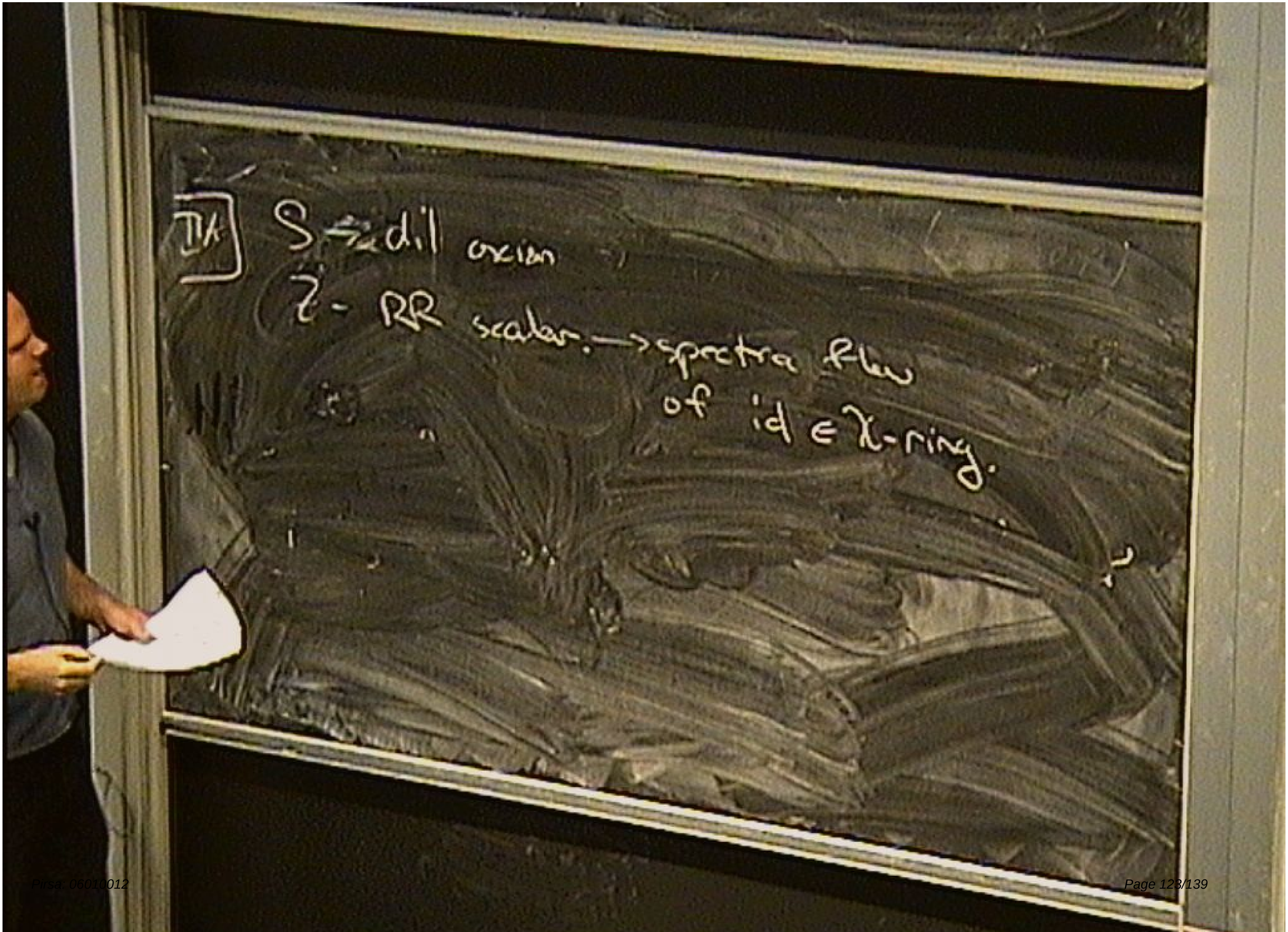
$T \longrightarrow \partial Z$ RR scalar.

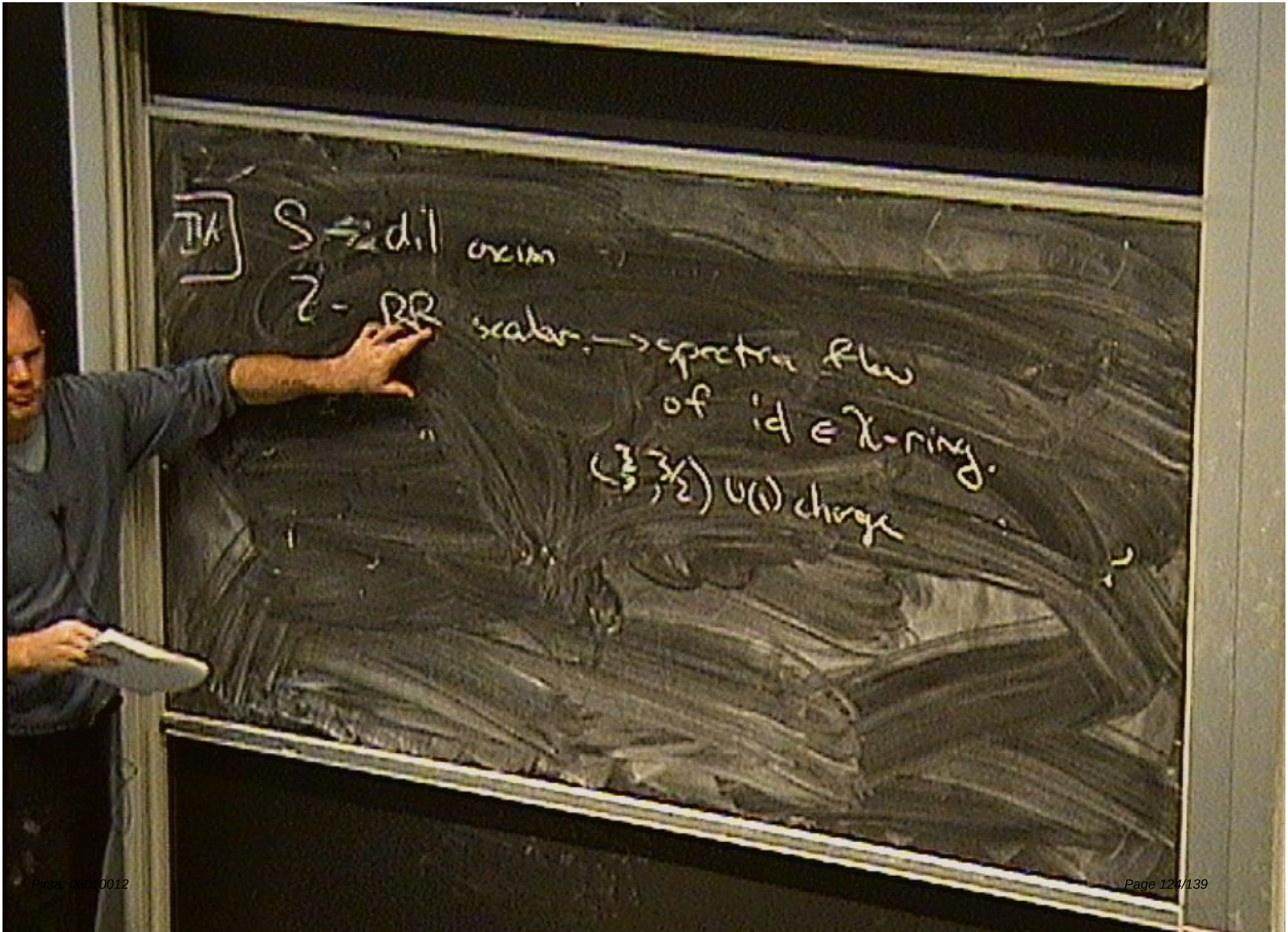
$$\mathcal{L}_H^{(g)} \quad \int d^4x \, (\partial\partial S)^2 (\partial Z)^{2g-2} F^g(H_A)$$

IIA : $\mathcal{L}^g \sim$ g-loop + n.p.(NS5 + D2's)

Het : $\mathcal{L}^g \sim$ g loop


IIA
S - dil axion
τ - RR scalar.


IIA
S - dil axion
τ - RR scalar. → spectra flow
of id ∈ χ-ring.

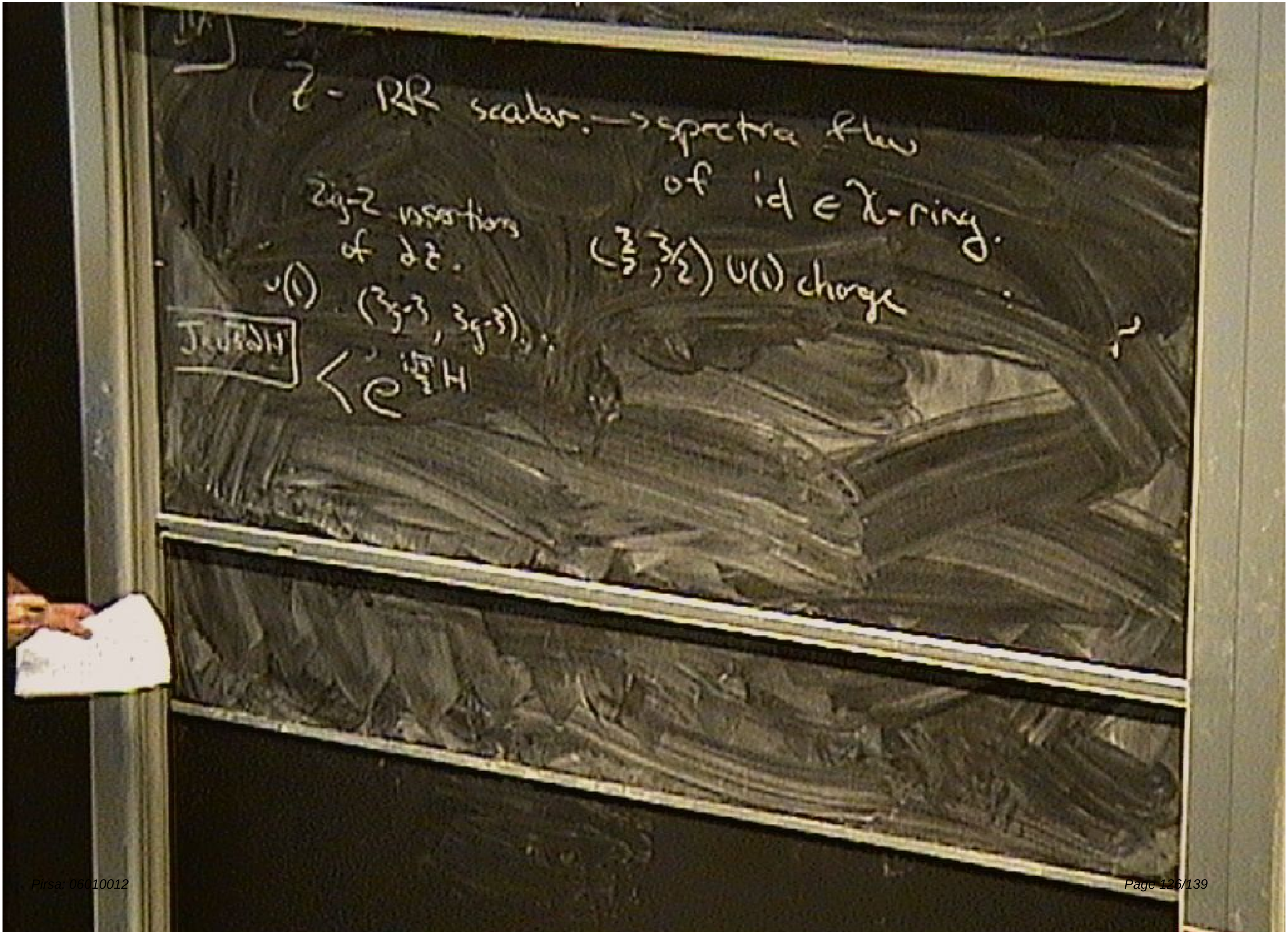

S ⇄ dil axion
τ - RR scalar → spectral flow
of id ∈ χ-ring.
U(1) charge

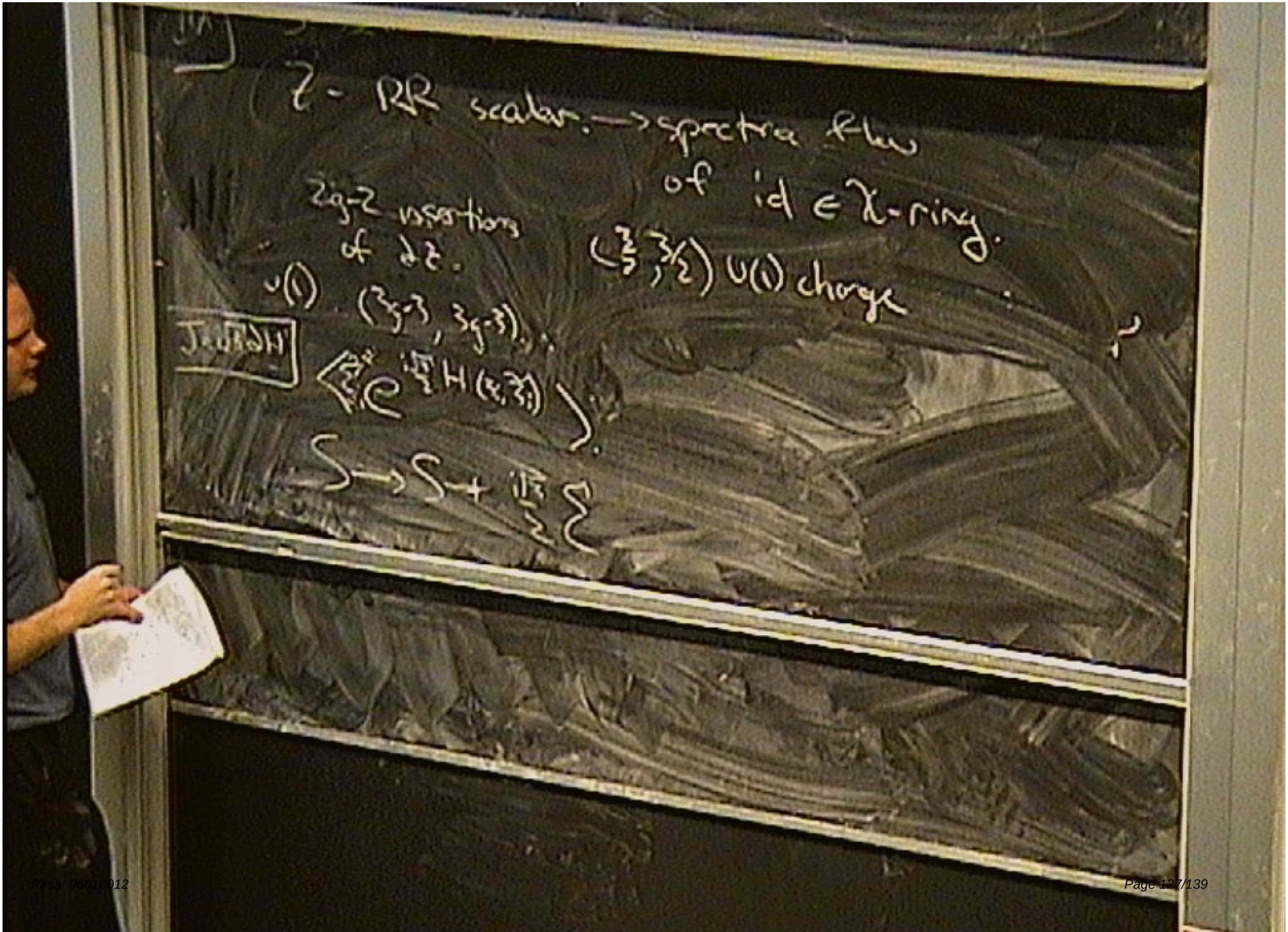
τ - RR scalar $\longrightarrow$ spectral flow
of id $\in \chi$-ring.

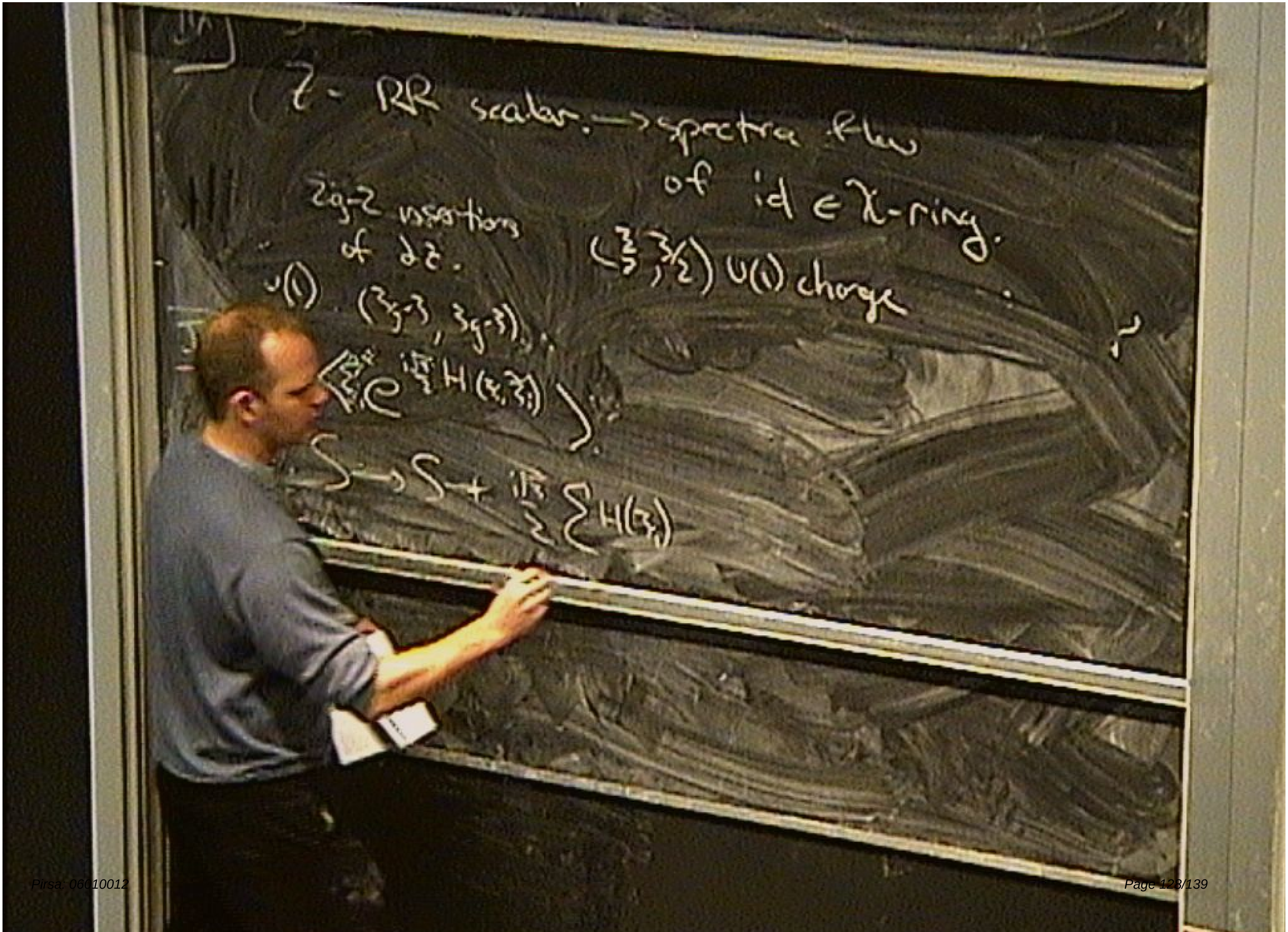
$2g-2$ insertions
of $\partial\tau$.

$(\tfrac{3}{2}, \tfrac{3}{2})$ $U(1)$ charge

$U(1)$: $(3g-3, 3g-3)$.


τ - RR scalar → spectral flow
of id ∈ χ-ring.
2g-2 insertions
of ∂τ.
U(1) (3g-3, 3g-3).
(3/2, 3/2) U(1) charge


τ - RR scalar. → spectral flow
of id ∈ χ-ring.
2g-2 insertions
of ∂τ.
(3/2, 3/2) U(1) charge
U(1) (3g-3, 3g-3).
J = i∂H
S → S +


RR scalar. → spectral flow
of id ∈ χ-ring.
2g-2 insertions
of ∂z.
U(1) (3g-3, 3g-3)
(3/2, 3/2) U(1) charge

τ - RR scalar. $\rightarrow$ spectral flow of id $\in \chi$-ring.

$2g-2$ insertions of $\partial\tau$.

$U(1)$ $(3g-3, 3g-3)$.

$(\frac{3}{2}, \frac{3}{2})$ $U(1)$ charge

$\boxed{J = i\sqrt{3}\,\partial H}$

$\left\langle \prod^{2g-2} e^{i\frac{\sqrt{3}}{2} H(z,\bar{z})} \right\rangle$

$$S \to S + \frac{i\sqrt{3}}{2} \int H(R) = S + \frac{i\sqrt{3}}{2} \int RH$$

γ - RR scalar. → spectral flow of 'id' $\in$ χ-ring.

2g-2 insertions of ∂z.

$(\frac{3}{2}, \frac{3}{2})$ U(1) charge

U(1) $(3g-3, 3g-3)$.

$\boxed{J = i\partial H}$

$$\left\langle \prod_{i}^{2g-2} e^{\frac{i\sqrt{3}}{2} H(z_i, \bar{z}_i)} \right\rangle \qquad R = -\sum_{i=1}^{2g-2} \delta(z - z_i)$$

$$S \to S + \frac{i\sqrt{3}}{2} \sum H(z_i) = S + \frac{i\sqrt{3}}{2} \int R H$$

ζ - RR scalar $\rightarrow$ spectral flow of id $\in \chi$-ring.

$2g-2$ insertions of $\partial\zeta$.

$(\tfrac{3}{2}, \tfrac{3}{2})$ U(1) charge

U(1) $(3g-3,\ 3g-3)$.

$$\boxed{J = \sqrt{3}\,\partial H} \qquad \Big\langle \prod_i^{2g-2} e^{\frac{\sqrt{3}}{2} H(z_i, \bar{z}_i)} \Big\rangle \qquad R = -\sum_{i=1}^{2g-2} \delta(z - z_i)$$

$$S \rightarrow S + \frac{\sqrt{3}}{2} \sum H(z_i) = S + \frac{\sqrt{3}}{2} \int R H\, d^2 z$$

$$T \rightarrow T + \tfrac{1}{2}\,\partial J$$

$\tilde{\phi}$ - RR scalar $\rightarrow$ spectral flow of id $\in \chi$-ring.

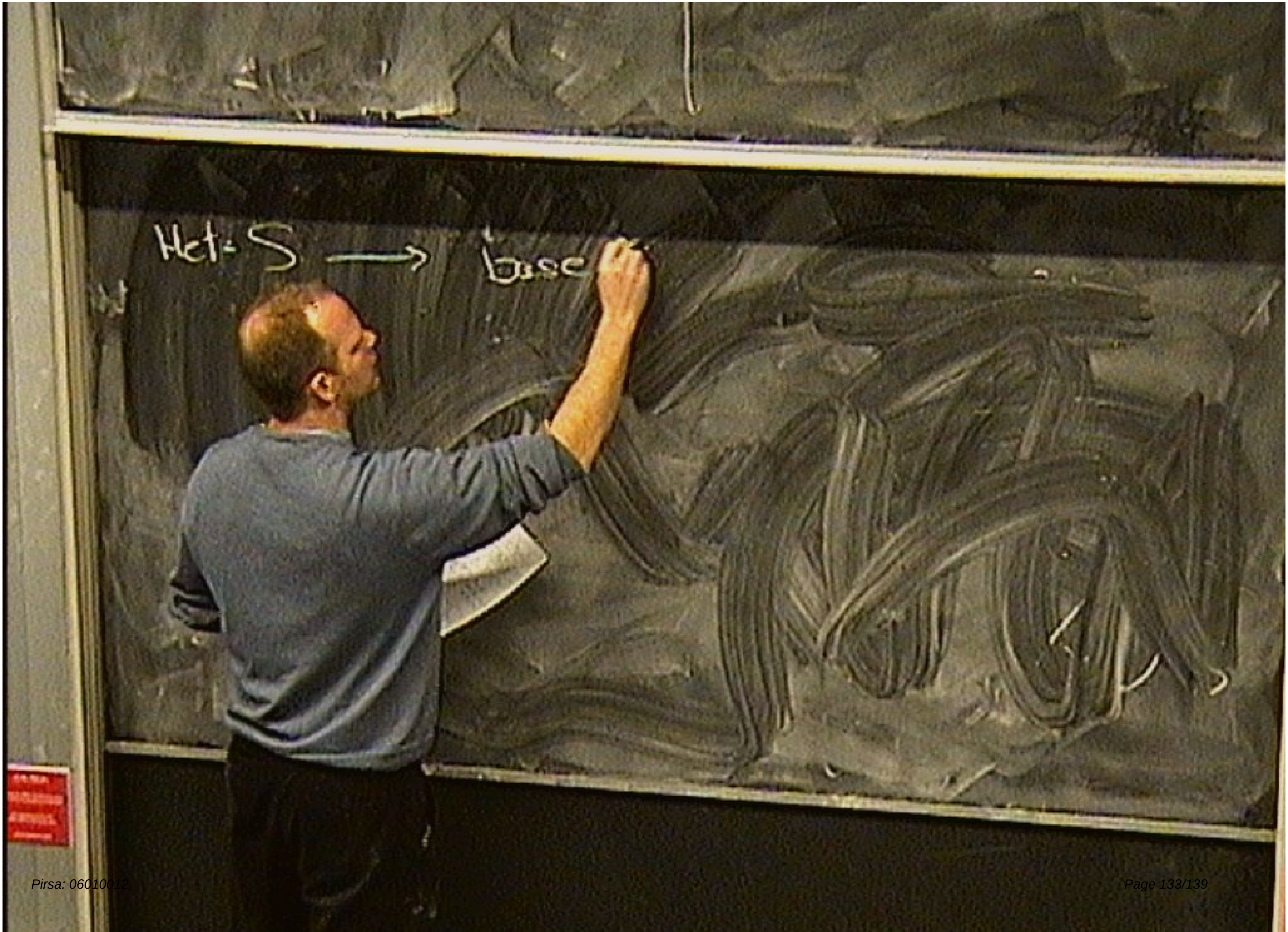
$2g-2$ insertions of $\partial\tilde{\phi}$.

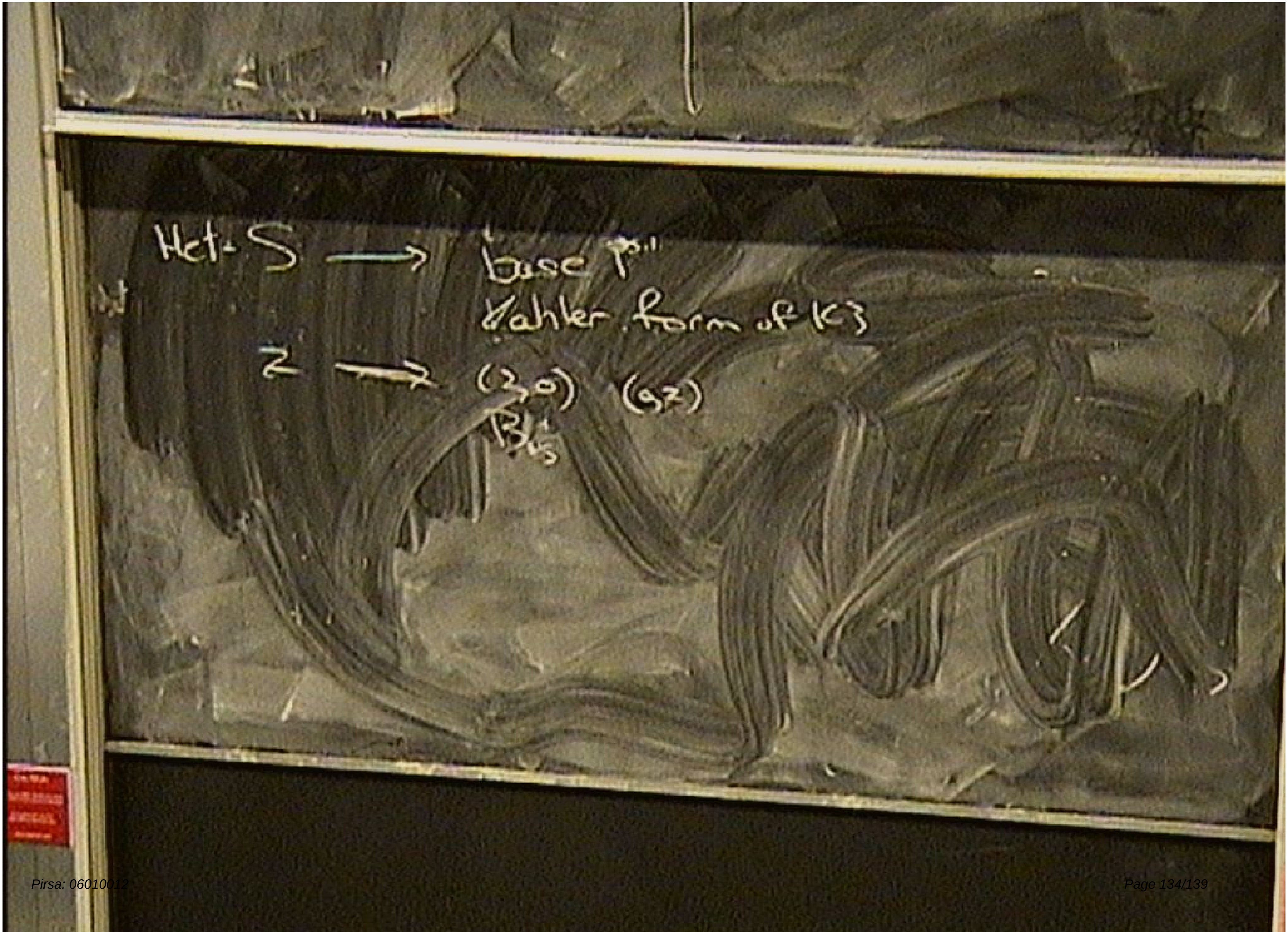
$U(1)$ $(3g-3, 3g-3)$ $\quad (\tfrac{3}{2}, \tfrac{3}{2})$ $U(1)$ charge

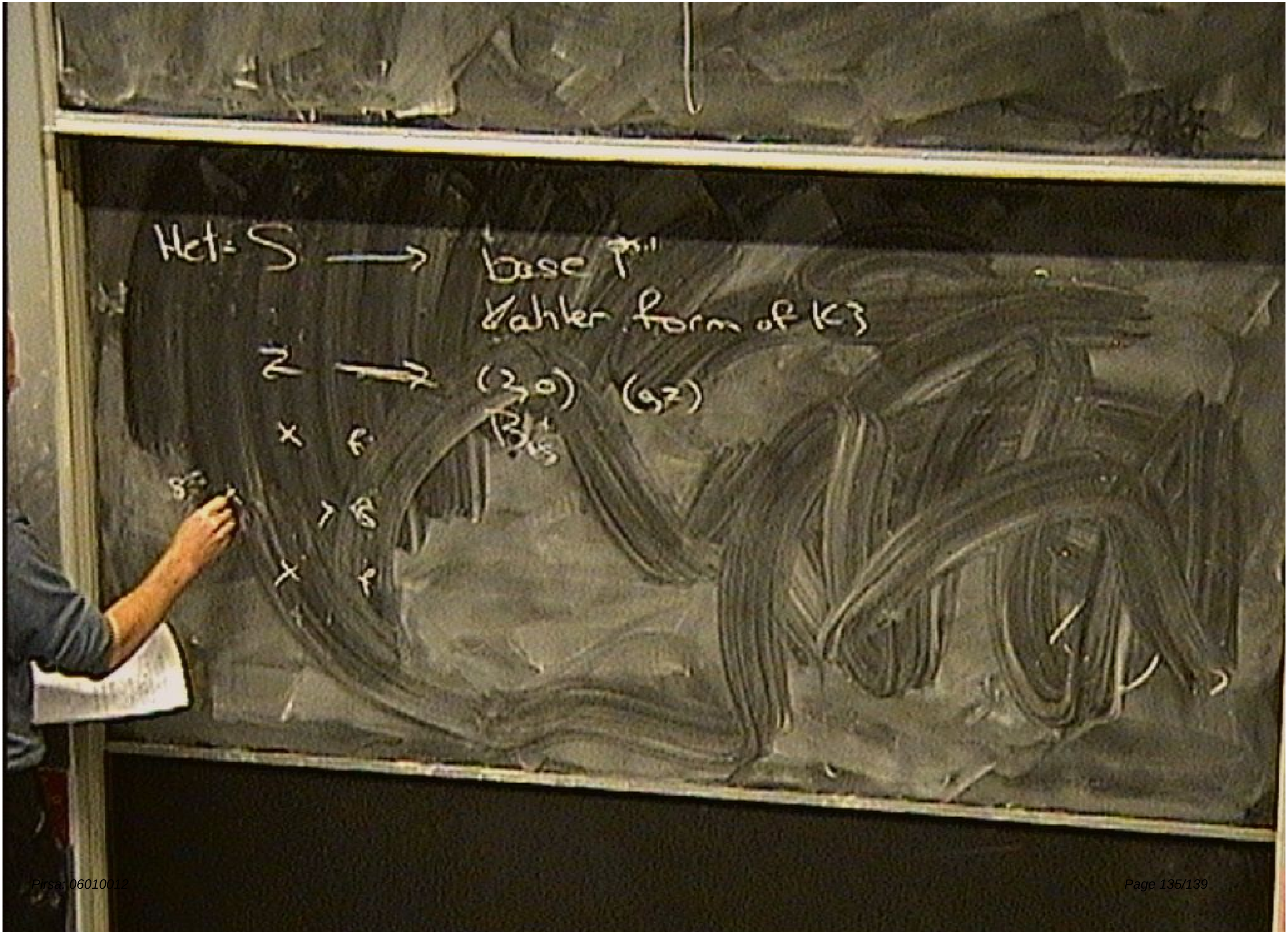
$\boxed{J = i\sqrt{3}\,\partial H}$

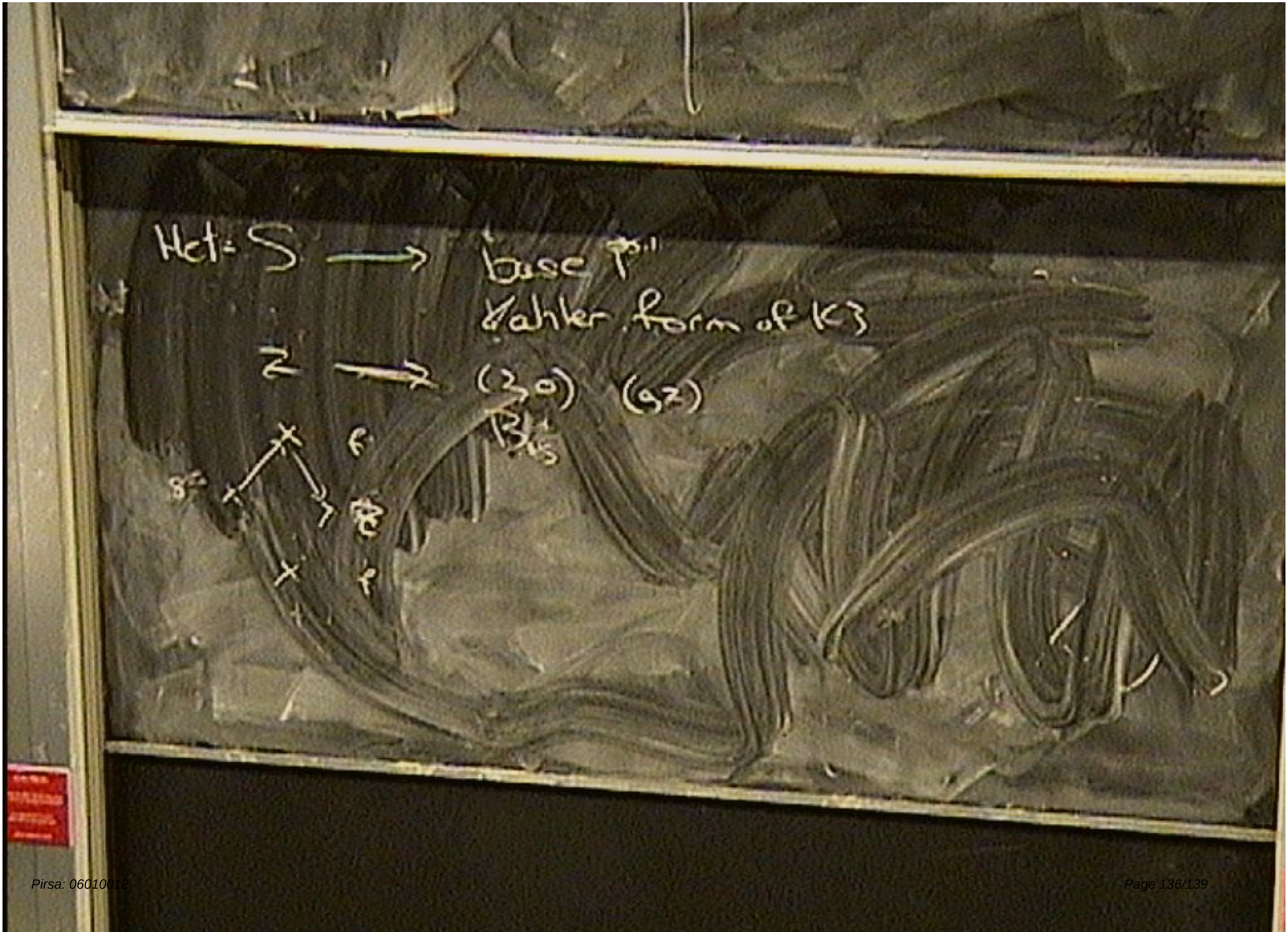
$$\left\langle \prod_{i}^{2g-2} e^{\frac{i\sqrt{3}}{2} H(z_i, \bar z_i)} \right\rangle \qquad R = -\sum_{i=1}^{2g-2} \delta(z - z_i)$$

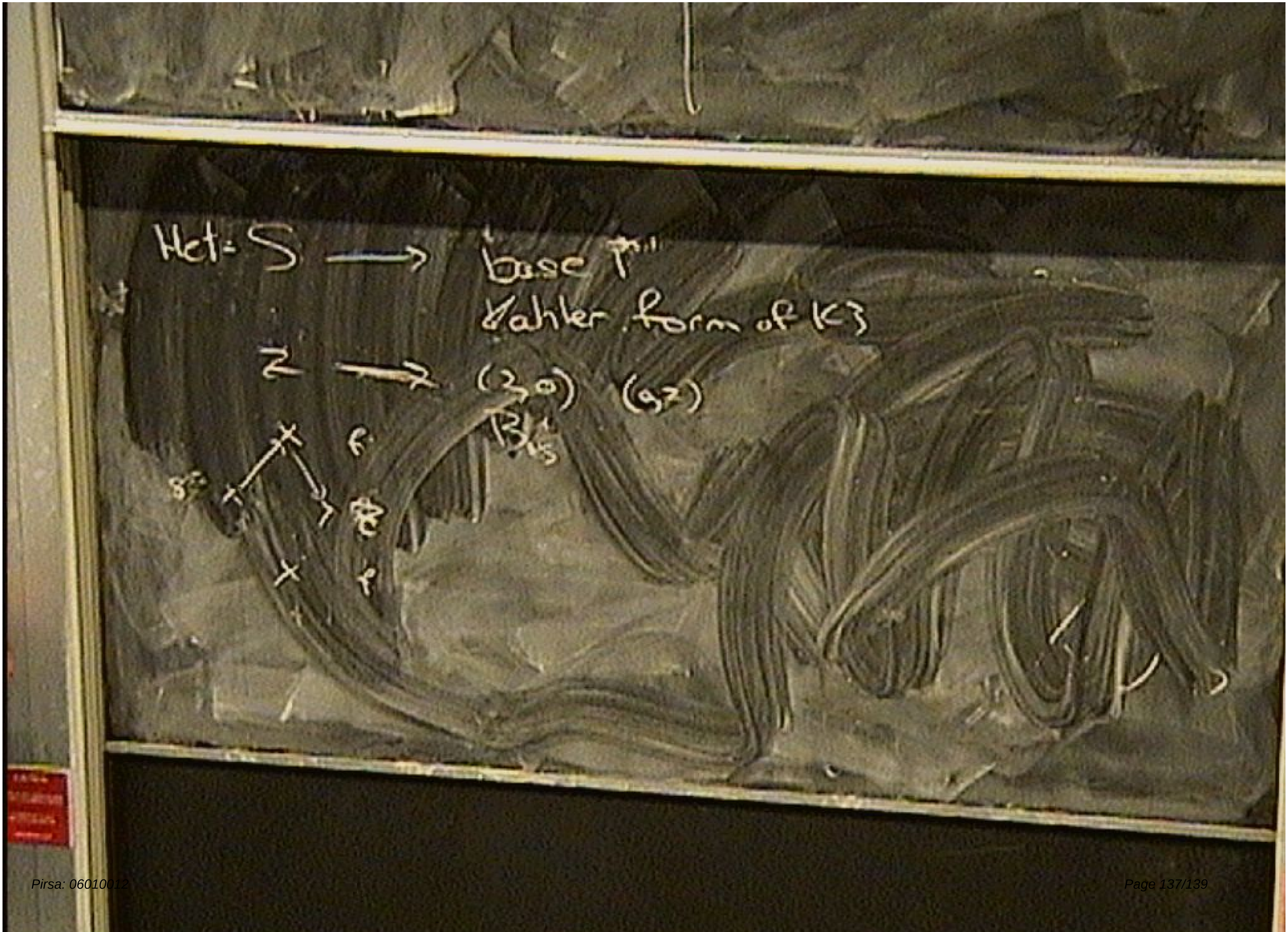
$$S \rightarrow S + \frac{i\sqrt{3}}{2} \sum H(z_i) = S + \frac{i\sqrt{3}}{2} \int R H d^2 z \longrightarrow T \rightarrow T + \frac{1}{2}\partial J$$

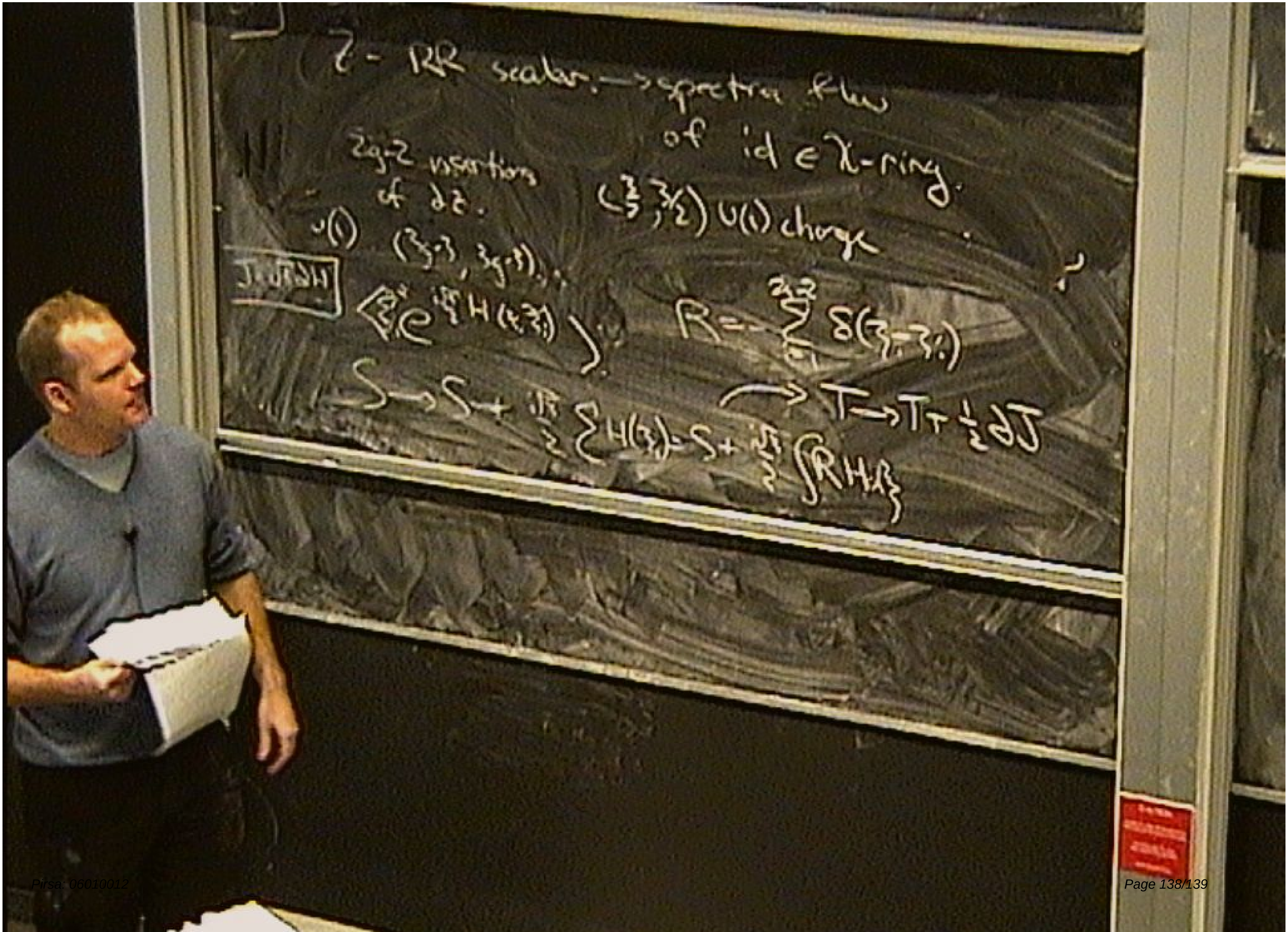

Act: S ⟶ base

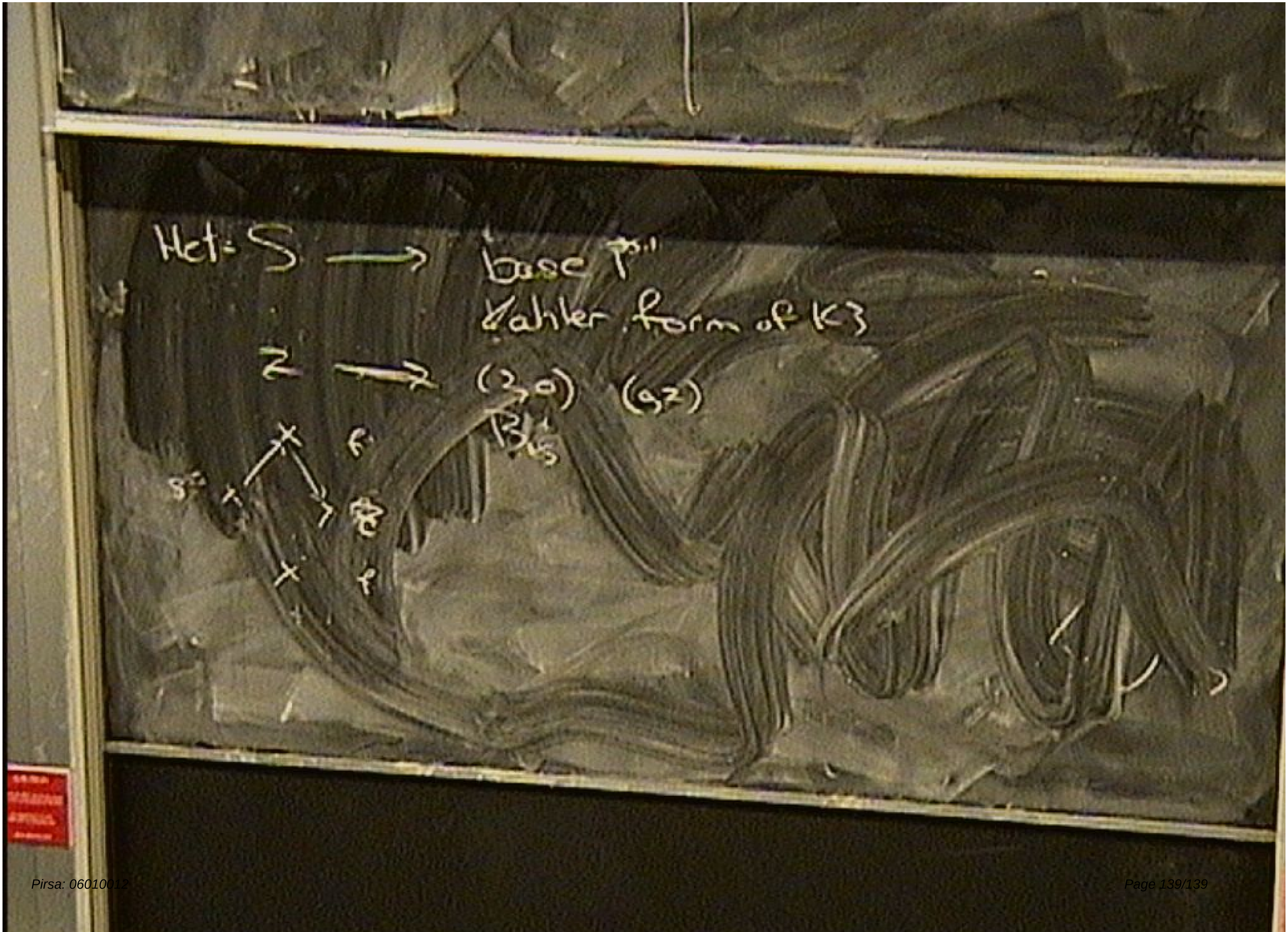

Het-S → base p"
Kahler form of K3
Z → (2,0) (0,2)


base
Kahler form of K3


Het - S
base P'
Kahler form of K3
Z


Het-S → base
Kahler form of K3
Z → (3,0)


RR scalar → spectral flow
of id ∈ χ-ring
2g-2 insertions
of ∂z
U(1) charge


Het: S → base P¹
Kahler form of K3
Z → (2,0) (0,2)