Title: Galileon p-forms

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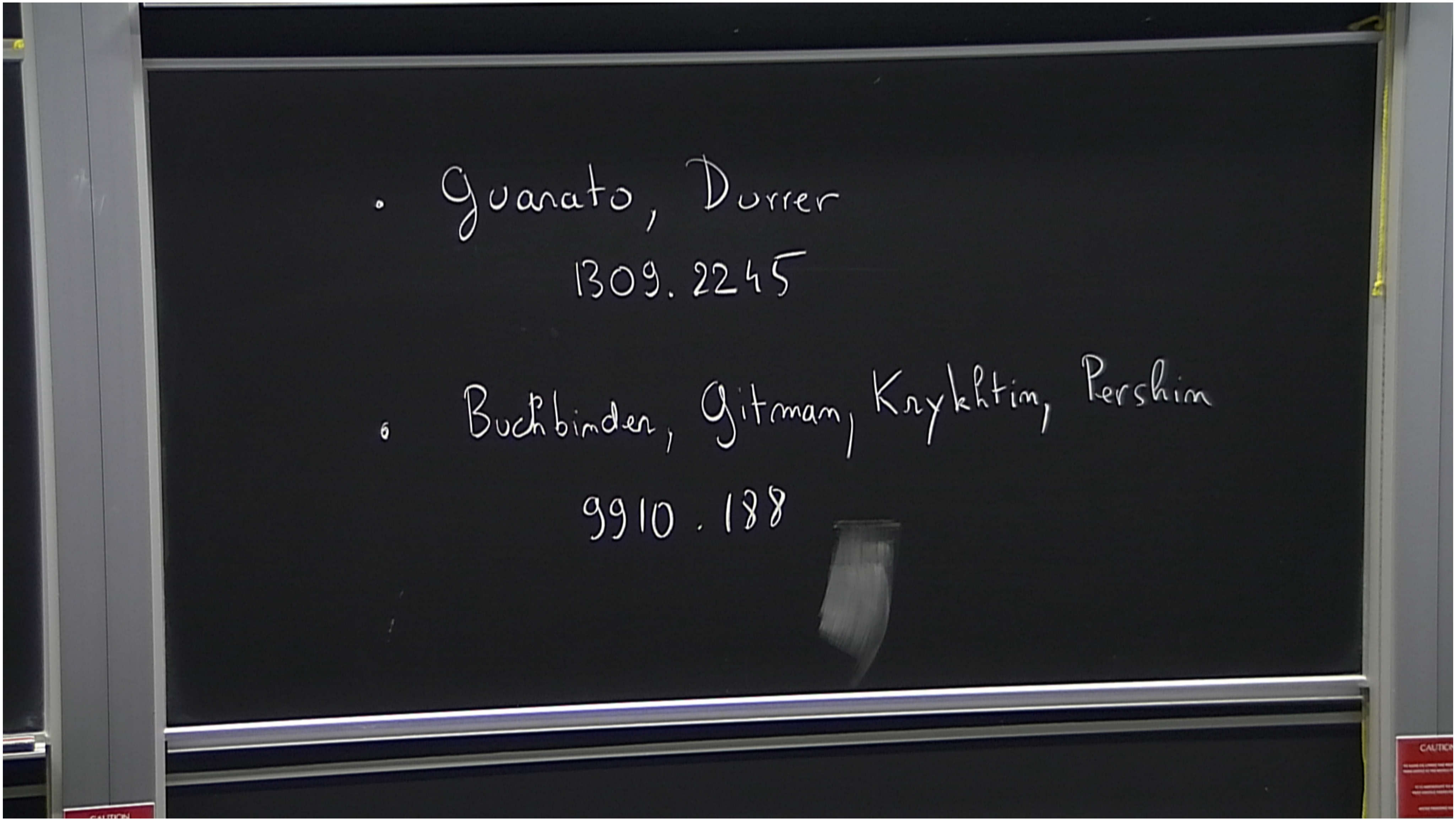
Abstract: I will discuss generalizations and no-go theorems for generalizations to p-forms of Galileon actions



· Guarato, Durrer
1309.2245
· Buchbinder, Gitman, Krykhtin, Pershin
9910.188

"Consistent ma

on arbitrary background

1) d.o.f. counting in F.P. theory

2) Extracting a massive graviton from dRGT

3) d.o.f. counting

DO NOT ERASE

Bernard

C. D.

M. von Strauss

1410.8302 + in prep

+ A. Schmidt-May in prep

(ERC "NIRG" n°307934

FP7)

- Guarato, Durrer

  1309.2245

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$$h_{\mu\nu}$$

$$h_{\mu\nu} h_{\rho\sigma} \underbrace{T^{\mu\nu\rho\sigma}}_{m^2 g^{\mu\nu} g^{\alpha\beta} + \ldots} (R, g)$$

$$\underbrace{\int d^4x \sqrt{g}}\, R(g)$$

$$\int d^4x \left((\partial h)^2 \ldots \right) + m^2 \left(h_{\mu\nu} h^{\mu\nu} - h^2 \right)$$

$$\Big\downarrow \text{eom}$$

$$K_{\mu\nu\rho\sigma} h^{\rho\sigma} + m^2 \left(h_{\mu\nu} - h \eta_{\mu\nu} \right) = 0$$

- $K_{\mu\nu\rho\sigma} h^{\rho\sigma} + m^2 \left(h_{\mu\nu} - h\,\eta_{\mu\nu} \right) \equiv \delta \bar{E}_{\mu\nu} \overset{\text{on shell}}{=} 0$
- $\partial^\mu K_{\mu\nu\rho\sigma} h^{\rho\sigma} = 0 \Rightarrow m^2 \left(\partial^\mu h_{\mu\nu} - \partial_\nu h \right) = 0$ <u>vector Const.</u>

- $K_{\mu\nu\rho\sigma} h^{\rho\sigma} + m^2 \left(h_{\mu\nu} - h\,\eta_{\mu\nu} \right) \equiv \delta \bar{E}_{\mu\nu} \overset{\text{on shell}}{=} 0$
- $\partial^\mu K_{\mu\nu\rho\sigma} h^{\rho\sigma} = 0 \Rightarrow m^2 \left(\partial^\mu h_{\mu\nu} - \partial_\nu h \right) = 0$ ↯ $\underline{\text{vector Const.}}$
- $\eta^{\mu\nu} K_{\mu\nu\rho\sigma} h^{\rho\sigma} \sim \# \left(\partial^\mu \partial^\nu h_{\mu\nu} - \Box h \right)$

Notation: equal off-shell up to undifferentiated or once differentiated $h_{\mu\nu}$

1)

2)

3)

DO NOT E

$\int d^4x \sqrt{\ }$

$$\bullet\ K_{\mu\nu\rho\sigma} h^{\rho\sigma} + m^2 (h_{\mu\nu} - h\,\eta_{\mu\nu}) \equiv \delta \bar{E}_{\mu\nu} \overset{\text{on shell}}{=} 0$$

$$\bullet\ \partial^\mu K_{\mu\nu\rho\sigma} h^{\rho\sigma} = 0 \Rightarrow m^2 (\partial^\mu h_{\mu\nu} - \partial_\nu h) = 0 \quad \text{4 vector Const.}$$

$$\bullet\ \eta^{\mu\nu} K_{\mu\nu\rho\sigma} h^{\rho\sigma} \sim \# (\partial^\mu \partial^\nu h_{\mu\nu} - \Box h)$$

$\boxed{\text{Notation: equal off-shell up to undifferentiated or once differentiated } h_{\mu\nu}}$

$$\bullet\ 2\partial^\mu \partial^\nu \delta \bar{E}_{\mu\nu} + m^2 \eta^{\mu\nu} \delta \bar{E}_{\mu\nu} \sim 0 \Rightarrow \text{on shell } h = 0 \quad \text{1 Scalar Const}$$

DO NOT ERASE

1)

2)

3)

DO NOT E

$\int d^4x \sqrt{}$

$\int$

DO NOT ERASE

$\Rightarrow$ 1 Scalar Const

dRGT

$$M_p \int d^4x \sqrt{g}\, R(g) + S_{int}[g, f] + \cancel{S_{matter}[g]}$$

$$\propto m^2 M_p^2 \int d^4x \sqrt{-g} \sum_{k=0}^{k=3} \beta_k e_k(S)$$

$$e_0(S) = 1 \qquad e_1(S) = \mathrm{tr}\, S \qquad e_2(S) = \frac{1}{2}\left((\mathrm{tr}\, S)^2 - \mathrm{tr}\, S^2\right)$$

- $$E_{\mu\nu} = G_{\mu\nu} + \underbrace{m^2 \beta_0 g_{\mu\nu} + m^2 \beta_1 \Big(\big(\underbrace{\mathrm{tr}\, S}_{e_1}\big) g_{\mu\nu} - S_{\mu\nu} \Big)}_{m^2 V_{\mu\nu}}$$

- $$E_{\mu\nu} = G_{\mu\nu} + \underbrace{m^2 \beta_0 g_{\mu\nu} + m^2 \beta_1 \left((\underbrace{\mathrm{tr}\, S}_{e_1})\, g_{\mu\nu} - S_{\mu\nu} \right)}_{m^2 V_{\mu\nu}}$$

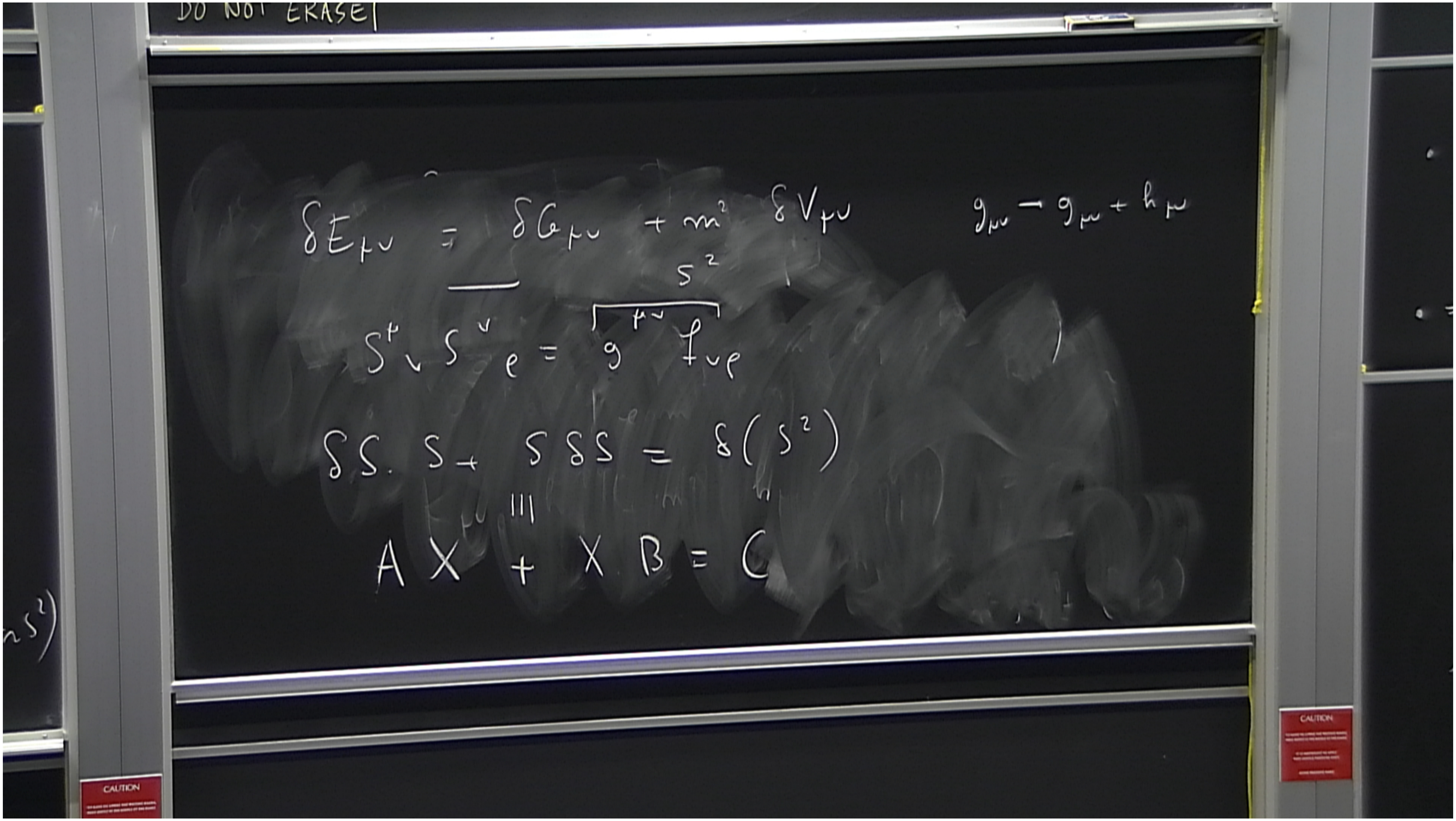
- $$\Rightarrow \quad S^{\mu}{}_{\nu} = \frac{1}{m^2 \beta_1} \left(R^{\mu}{}_{\nu} - \frac{1}{6} R\, \delta^{\mu}{}_{\nu} \right) - \frac{\beta_0}{3\beta_1} \delta^{\mu}{}_{\nu}$$

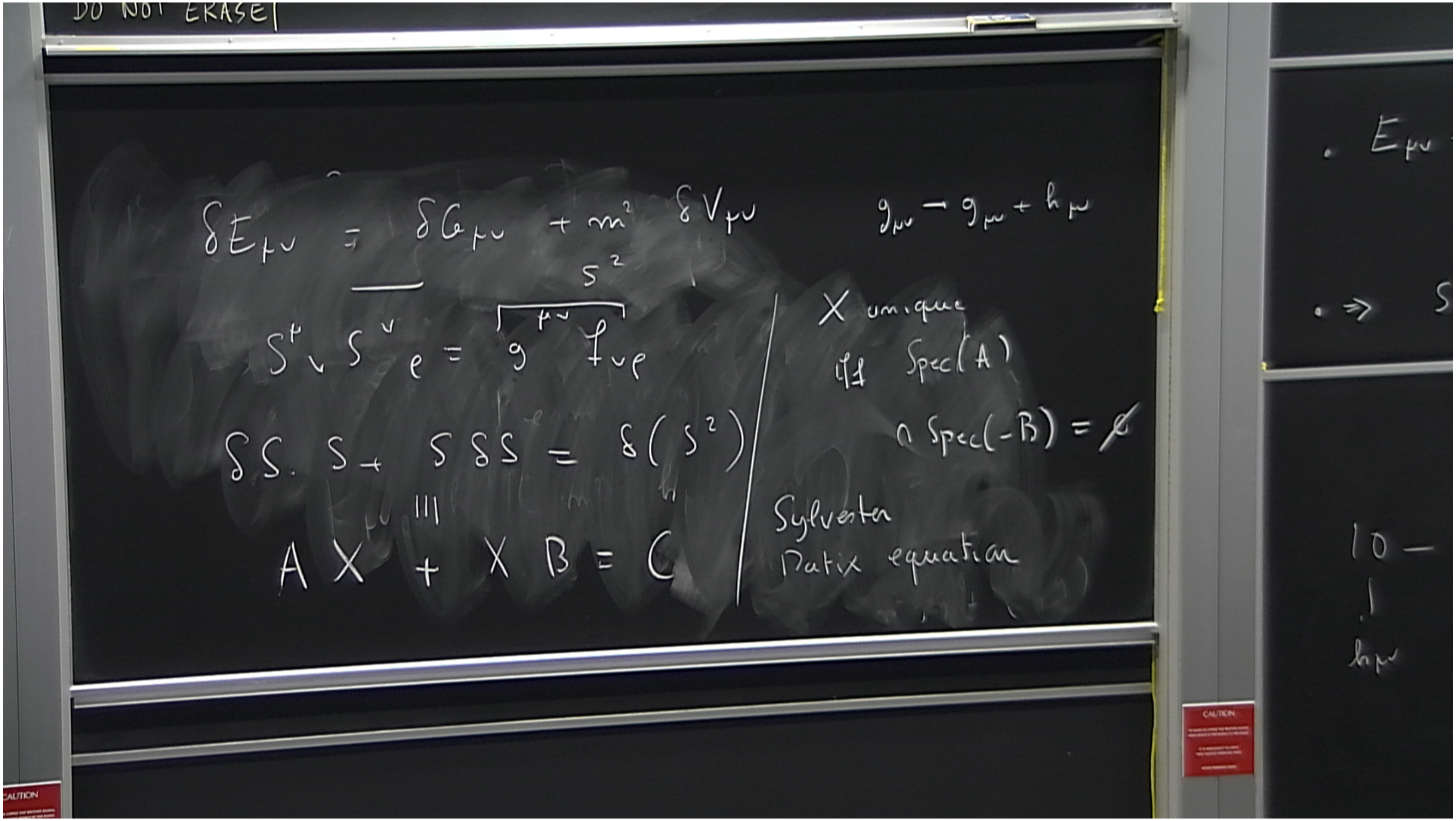
$m^2 m_{\mu\nu}{}^{\rho\sigma} h_{\rho\sigma}$

$10 - 4 \rightarrow 6$

$\downarrow$

$h_{\mu\nu}$


DO NOT ERASE
$\delta E_{\mu\nu} = \delta G_{\mu\nu} + m^2 \delta V_{\mu\nu}$
$g_{\mu\nu} \to g_{\mu\nu} + h_{\mu\nu}$
S^2
$S^\mu{}_\nu S^\nu{}_\rho = g^{\mu\nu} f_{\nu\rho}$
$\delta S . S + S \delta S = \delta(S^2)$
$AX + XB = C$


DO NOT ERASE
δE_μν = δG_μν + m² δV_μν
g_μν → g_μν + h_μν
S²
S^μ_ν S^ν_ρ = g^μν f_νρ
X unique
iff Spec(A)
∩ Spec(−B) = ∅
δS . S + S δS = δ(S²)
Sylvester
Matrix equation
AX + XB = C
E_μν
⇒ S
10
h_μν

DO NOT ERASE

$$\mathcal{M}_{\mu\nu}{}^{\rho\sigma} h_{\rho\sigma} = e_1 h_{\mu\nu} - h^{\lambda}{}_{(\nu} S_{\mu)\lambda} \dots$$

$$- \frac{1}{2}\left[e_4 c_1 \left(\delta^{\rho}_{\nu} \delta^{\sigma}_{\mu} \dots \right) \dots \right] h_{\rho\sigma}$$

$$\vdots$$

$$+ c_3 \, [S^3]_{\mu\nu} [S^3]^{\rho\sigma} h_{\rho\sigma}$$

- $E_{\mu\nu} = G_{\mu\nu} + \underbrace{m^2\beta_0 g_{\mu\nu} + \quad e_1}_{m^2 V_{\mu\nu}}$

- $\Rightarrow \quad S^\mu{}_\nu = \frac{1}{m^2\beta_1}\left(R^\mu{}_\nu - \frac{1}{6} R\,\delta^\mu{}_\nu\right) - \frac{\beta_0}{3\beta_1}\delta^\mu{}_\nu$

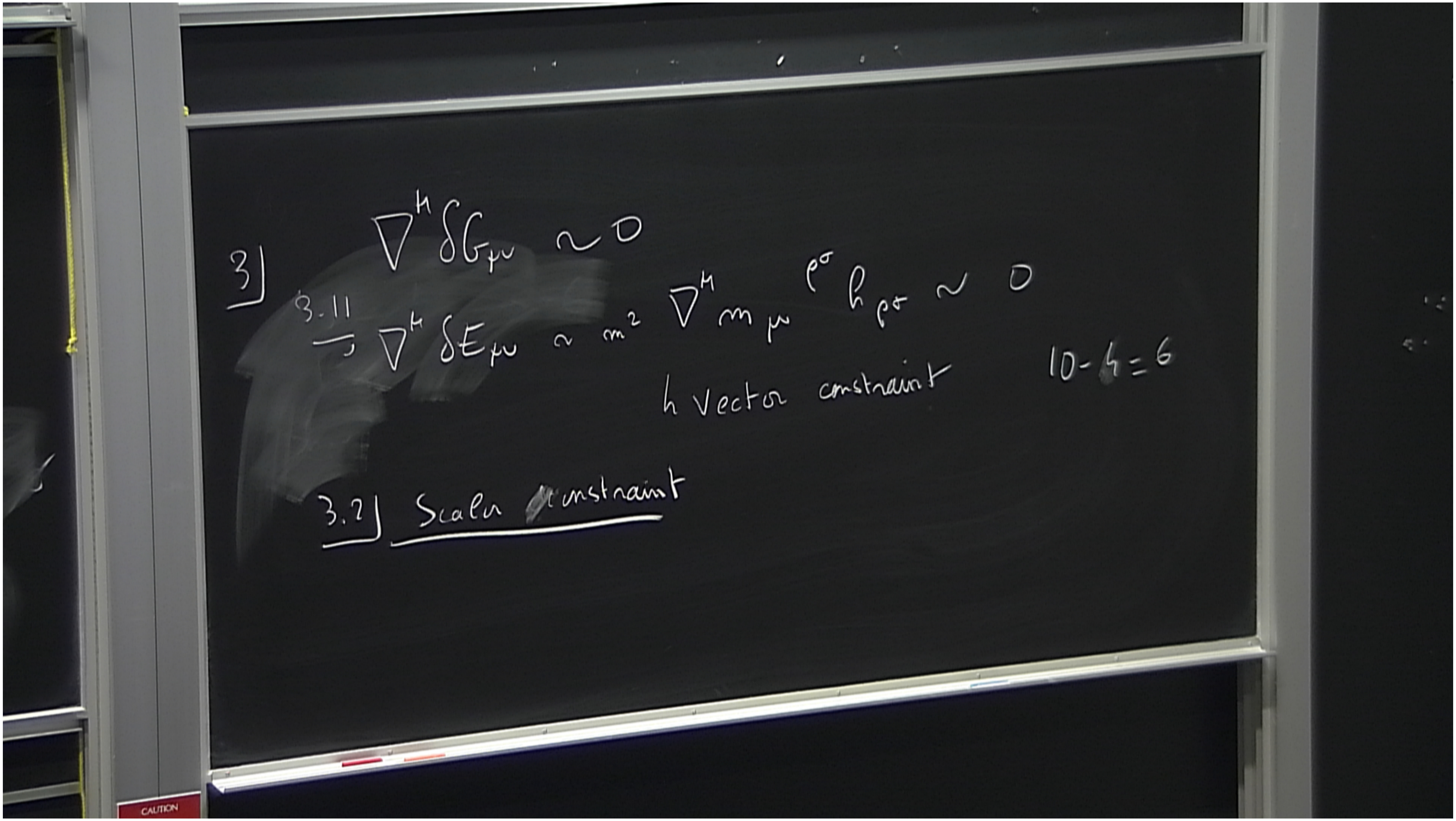
- $\delta E_{\mu\nu} = \delta G_{\mu\nu} + m^2\beta_0 h_{\mu\nu} + m^2\beta_1 \mathcal{M}_{\mu\nu}{}^{\rho\sigma}(S)\, h_{\rho\sigma}$

$m^2 m_{\mu\nu}{}^{\rho\sigma} h_{\rho\sigma}$

- Cayley-Hamilton theorem

$$CH[S] \equiv S^4 - e_1 S^3 + e_2 S^2 - e_3 S + e_4 \mathbb{1} = 0$$

DO NOT ERASE


3)
$\nabla^\mu \delta G_{\mu\nu} \sim 0$
3.11
$\nabla^\mu \delta E_{\mu\nu} \sim m^2 \nabla^\mu m_{\mu}{}^{\rho\sigma} h_{\rho\sigma} \sim 0$
4 vector constraint
10-4=6
3.2) Scalar constraint
CAUTION

$$\left(\nabla_\rho \nabla^\mu \, \delta E_{\mu\nu} \right) g^{\rho\nu} \quad R^{\rho\nu} \,/\, R^\rho{}_\sigma R^{\sigma\nu}$$

$$\begin{cases} \psi^i = [S^i]^\nu{}_\rho \nabla^\rho \nabla^\mu \delta E_{\mu\nu} \\ \phi^i = [S^i]^\nu{}_\rho \, \delta E_\nu{}^\rho \end{cases}$$

DO NOT ERASE!

$$\sum_{i=0}^{3} u_i \psi^i + v_i \phi^i \sim 0$$

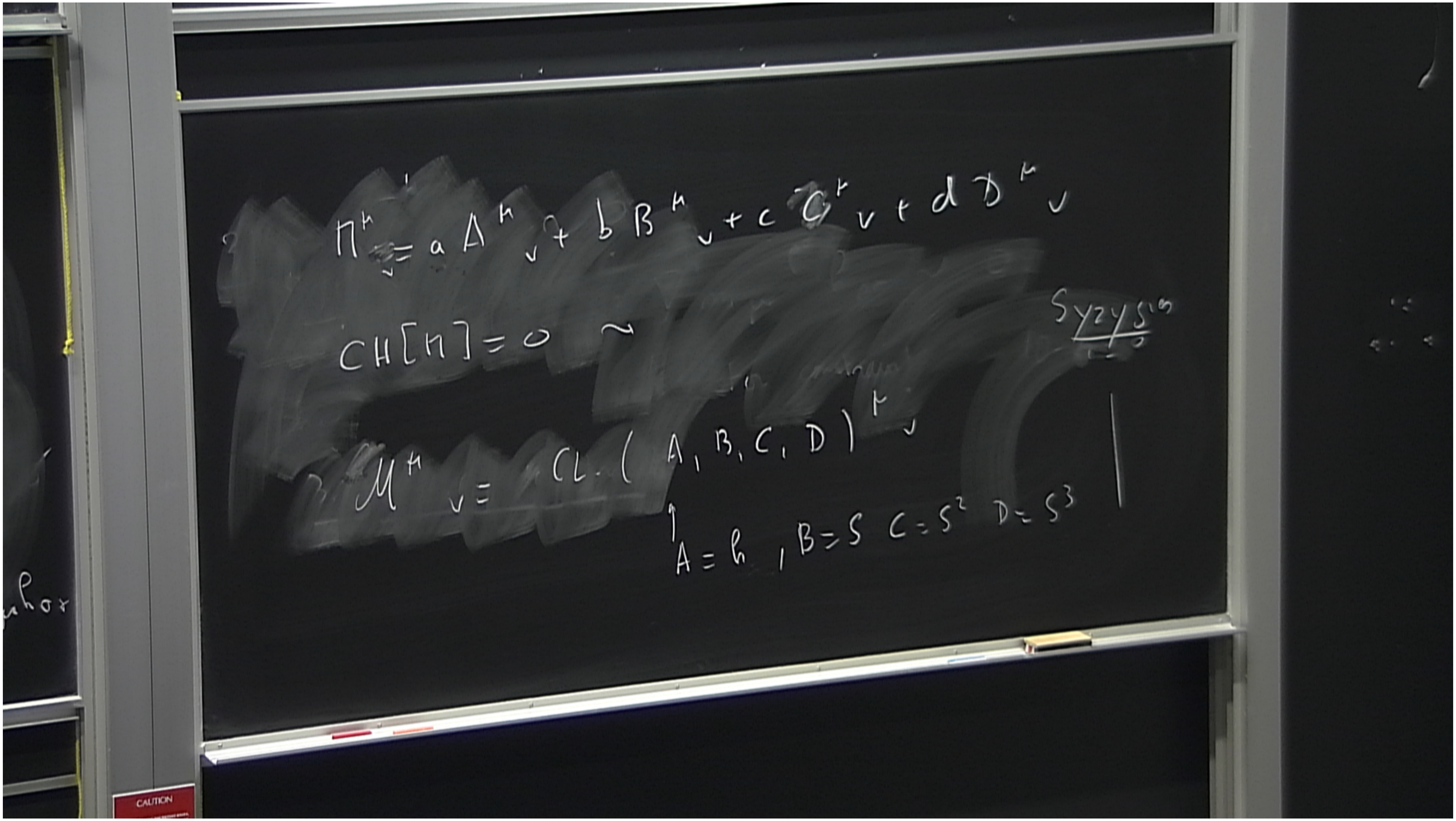
CL 26 scalars χ_i

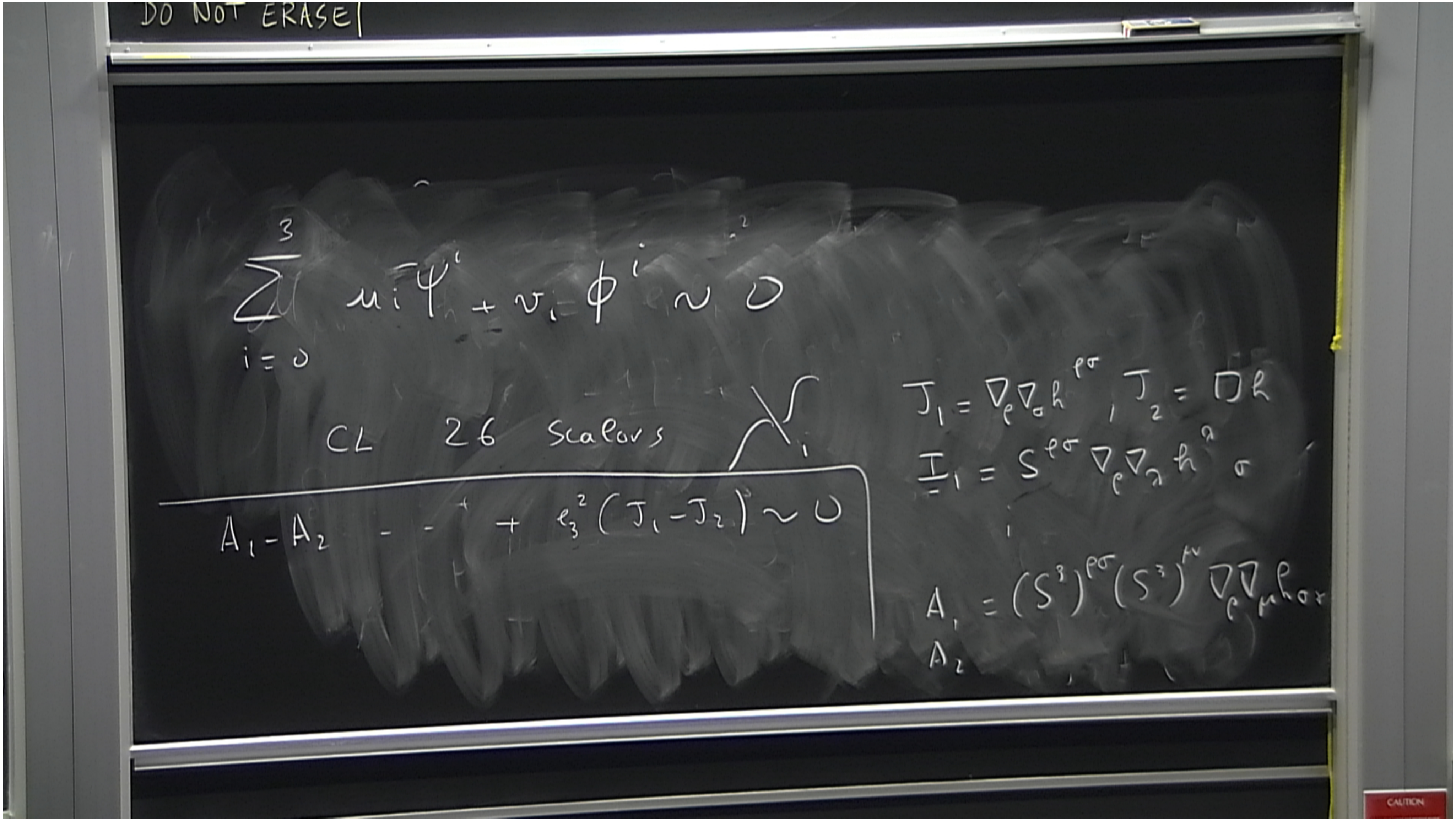
$J_1 = \nabla_\rho \nabla_\sigma h^{\rho\sigma}$, $J_2 = \Box h$

$I_1 = S^{\rho\sigma} \nabla_\rho \nabla_\lambda h^{\lambda}{}_{\sigma}$

$A_1 = (S^3)^{\rho\sigma} (S^3)^{\mu\nu} \nabla_\rho \nabla_\mu h_{\sigma\nu}$

A_2


$\Pi^\mu{}_\nu = a A^\mu{}_\nu + b B^\mu{}_\nu + c C^\mu{}_\nu + d D^\mu{}_\nu$
$CH[\Pi] = 0 \sim$
Syzygies
$M^\mu{}_\nu = CL.(A, B, C, D)^\mu{}_\nu$
$A = h, B = S \quad C = S^2 \quad D = S^3$


DO NOT ERASE
$\sum_{i=0}^{3} u_i \varphi^i + v_i \phi^i \sim 0$
CL 26 scalars X_i
$A_1 - A_2 - - + e_3^2 (J_1 - J_2) \sim 0$
$J_1 = \nabla_\rho \nabla_\sigma h^{\rho\sigma}, J_2 = \Box h$
$I_1 = S^{\rho\sigma} \nabla_\rho \nabla_\lambda h^\lambda{}_\sigma$
$A_1 = (S^3)^{\rho\sigma} (S^3)^{\mu\nu} \nabla_\rho \nabla_\mu h_{\sigma\nu}$
A_2
CAUTION

$$-m^2 \left(\frac{\beta_1 e_4}{2} \phi_0 - e_3 \psi_0 + e_2 \psi_1 - e_1 \psi_2 + \psi_3 \approx 0 \right)$$

5^{th} constraint

h