Title: Constructing theories from duality: my response to John Wheeler

Date: Oct 17, 2013 02:30 PM

URL: http://pirsa.org/13100072

Abstract: The
late physicist John Wheeler, was renowned for his Socratic method of conducting physics discussions. "Why is general relativity the way it is? What makes it special?" were reportedly questions one should expect in his presence. There are different answers to these questions, each requiring a set of assumptions - which Wheeler would likely question again - and each bringing with it new insights into physics as a whole. This talk will put forward new principles for deriving general relativity. Perhaps more than is the case with other construction principles, the principles introduced are not limited to the derivation of general relativity, requiring only an specification of the theory's phase space in order to be applicable. To be less enigmatic, one defines observable equivalence between physical theories in the Dirac constraint setting, and then the principle merely searches theory space for two equivalent (or dual)

fully constrained

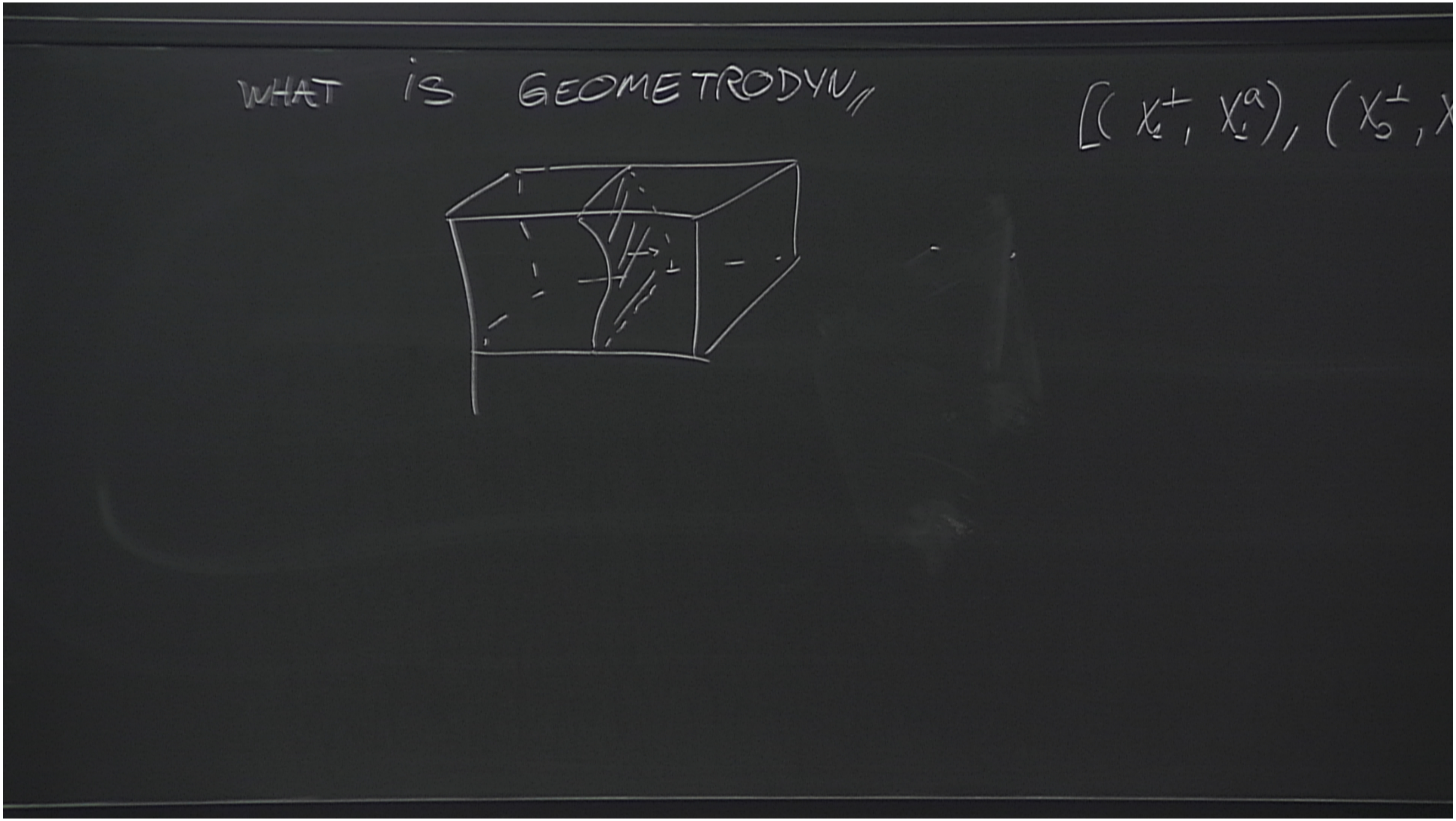
theories.
We find it quite remarkable that such a complex theory as general relativity emerges, when no initial presupposition even on the existence of space-time is made. If there is time (and I will argue there is!) I will discuss another issue that also distinguishes the present set of assumptions: the possibility that they are in a concrete sense ``self-selected", which I like to think would be more satisfactory to Wheeler's line of questioning (or at least give him more to chew on).

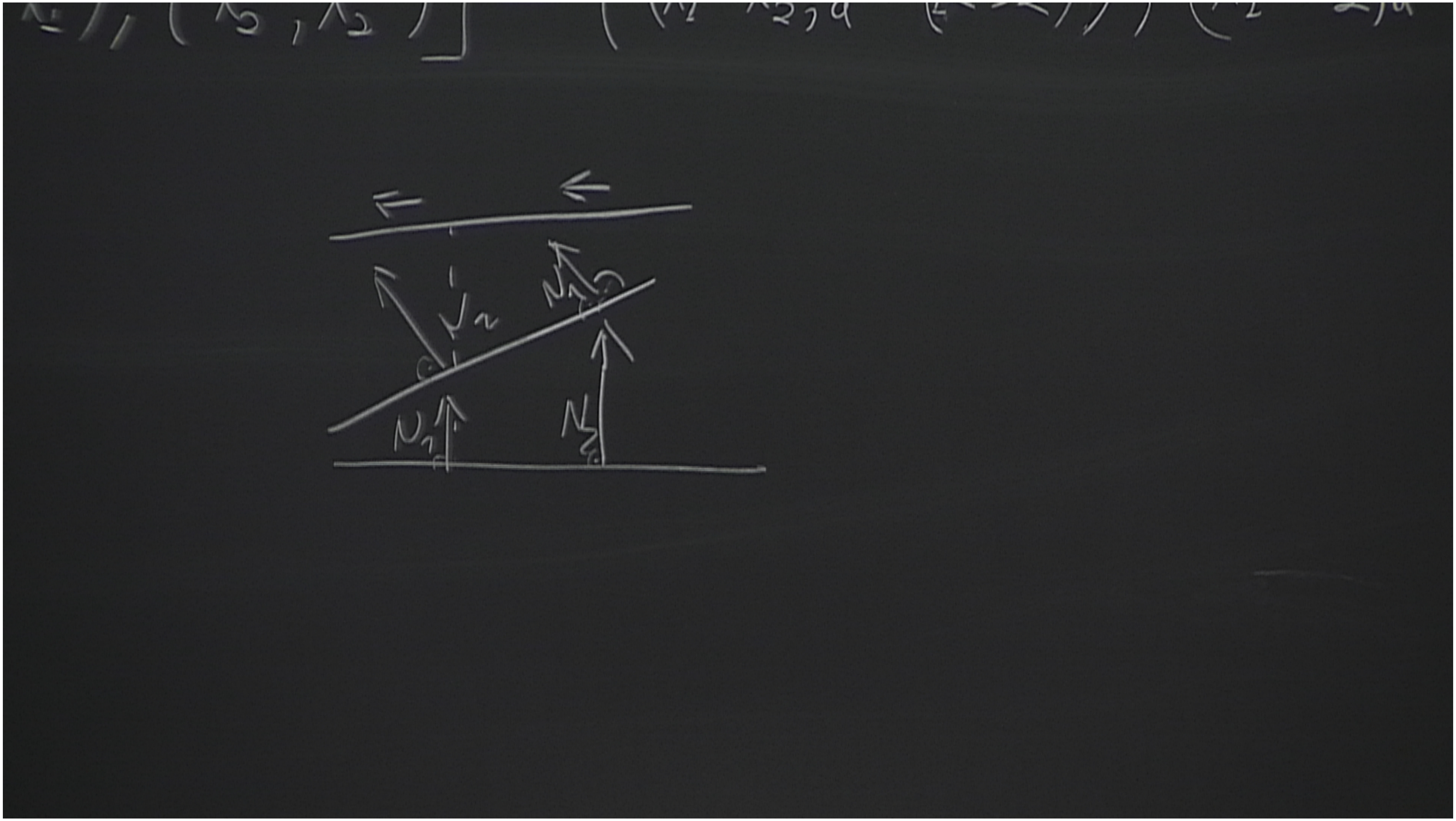
"IF ONE DID NOT KNOW THE EINSTEIN EQS, HOW MIGHT ONE HOPE TO DERIVE IT DIRECTLY FROM FIRST PRINCIPLES?" - JOHN WHEELER

"A DESIRE TO HAVE GEOMETRODYNAMICS DERIVED FROM PURELY GEOMETRODYNAMICAL PRINC. IS AESTHETIC IN ITS ORIGIN. BUT THERE IS ANOTHER MOTIVATION: THIS LANGUAGE IS MUCH CLOSER TO THAT OF QUANTUM DYNAMICS THAN EINSTEIN'S EVER WAS."

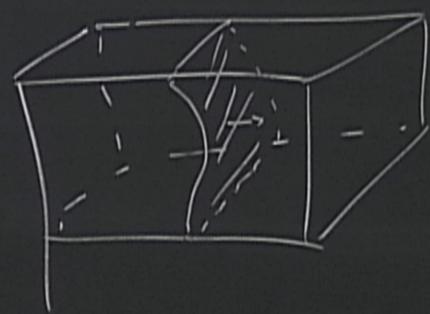
HOJMAN, KUCHAŘ, TEITELBOIM

$$\left[(X_1^\perp, X_1^a), (X_2^\perp, X_2^a)\right] = \left((X_1^a X_{2,a}^\perp - (1 \leftrightarrow 2)), \; (X_1^\perp X_{2,a}^\perp - X_2^\perp X_{1,a}^\perp) g^{ab} + [\vec{X}_1, \vec{X}_2]^a \right)$$


WHAT is GEOMETRODYN//
[(X₁⊥, X₁ᵃ), (X₂⊥, X



WHAT is GEOMETRODYN



$$[(X_1^\perp, X_1^a), (X_2^\perp, X_2^a)] = ((X_1^a X_2^\perp, \ldots$$

$$H = R - (\pi^{ab}\pi_{ab} - \tfrac{1}{2}\pi^2)\tfrac{1}{g} = 0$$

$$H_b = \nabla_a \pi^a{}_b = 0$$

$$\{g_{ab}, NH + N^a H_a\} = \dot{g}_{ab}$$

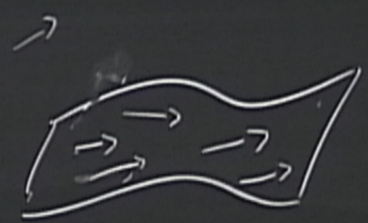
$$\ldots, X_1^a), (X_2^\perp, X_2^a)] = \left((X_1^a X^\perp_{2,a} - (1 \leftrightarrow 2)), \underbrace{(X_1^\perp X^\perp_{2;a} - X_2^\perp X^\perp_{1;a})g^{ab}} + [\vec{X}_1, \vec{X}_2]^a \right)$$

$$\ldots (\pi^{ab}\pi_{ab} - \tfrac{1}{2}\pi^2)\tfrac{1}{g} = 0 \qquad \{H(N_1), H(N_2)\} = H_a(\qquad)$$

$$\ldots = 0$$

$$\ldots + N^a H_a\} = \dot{g}_{ab}$$

$\chi_\alpha = 0 \qquad X_{\chi_\alpha}(f) = \{\chi_\alpha , f\}$



g_{ab} , π^{ab}

$\{\cdot , \cdot\}$

$\pi^{a}{}_{b;a} = 0$

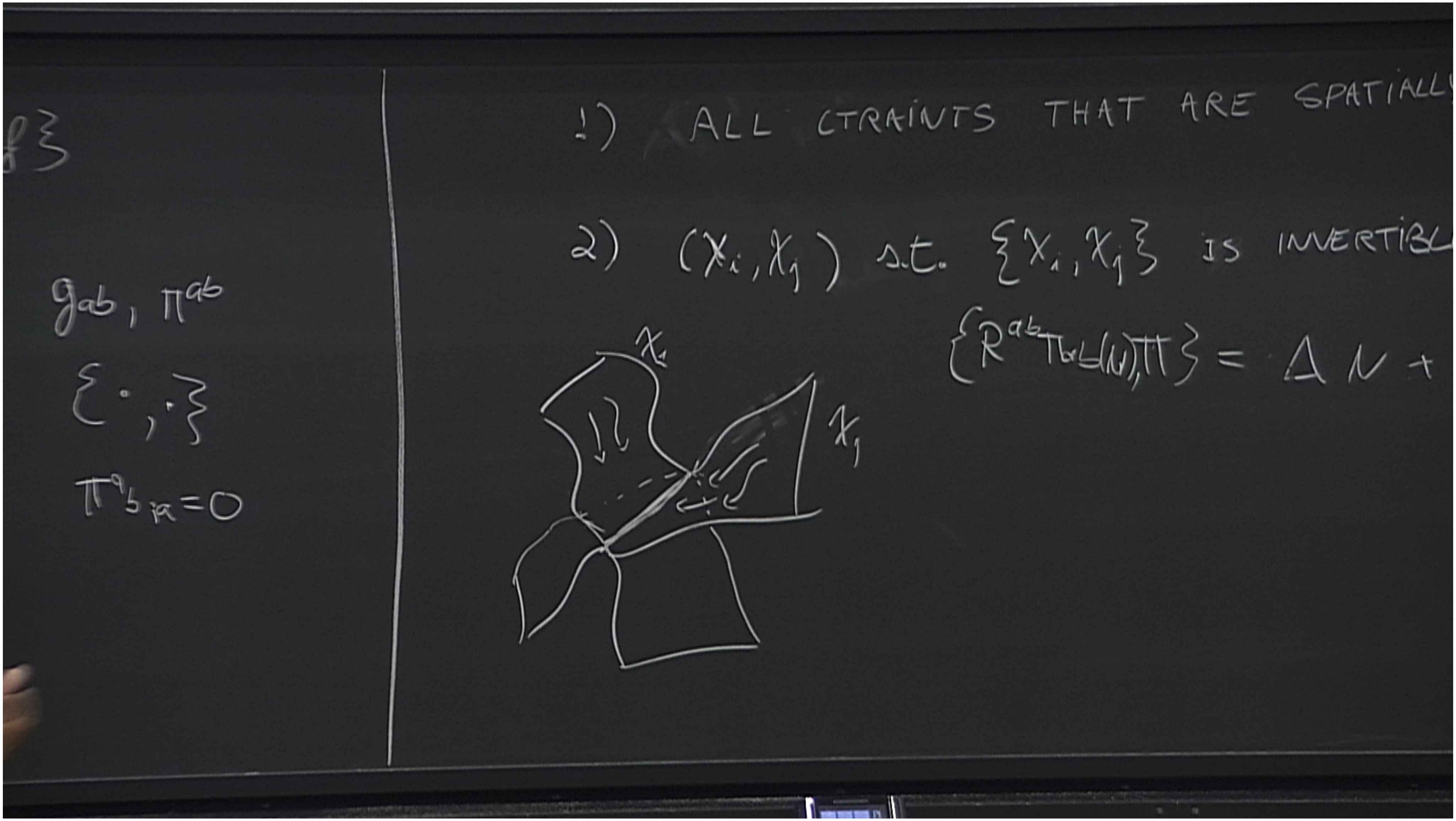
1) ALL CTRAINTS THAT ARE SPATIALLY COV. AND

2) (χ_i, χ_j) s.t. $\{\chi_i, \chi_j\}$ IS INVERTIBLE.

1) ALL CTRAINTS THAT ARE SPATIALLY COV. AND 1^{st} CLASS

2) (χ_i, χ_j) s.t. $\{\chi_i, \chi_j\}$ IS INVERTIBLE.

$$\{R^{ab} \mathrm{Tr}_{ab}(N), \pi\} = \Delta N + \dots$$



gab , π^ab
{ · , · }
π^a_b|a = 0
1) ALL CTRAINTS THAT ARE SPATIALL
2) (χi , χj) s.t. {χi , χj} IS INVERTIBL
χi
χj

THAT ARE SPATIALLY COV. AND 1^{st} CLASS

$\{\chi_i, \chi_j\}$ IS INVERTIBLE.

$\{R^{ab}\pi_{ab}(N), \pi\} = \Delta N + \dots$

THM $\quad \alpha \nabla^2 R + \beta R^{ab} R_{ab} + \gamma_n R^n + \dfrac{\left(a\pi^{ab}\pi_{ab} + b\pi^2\right)}{g} + \dfrac{c\pi}{\sqrt{g}} + d = 0$

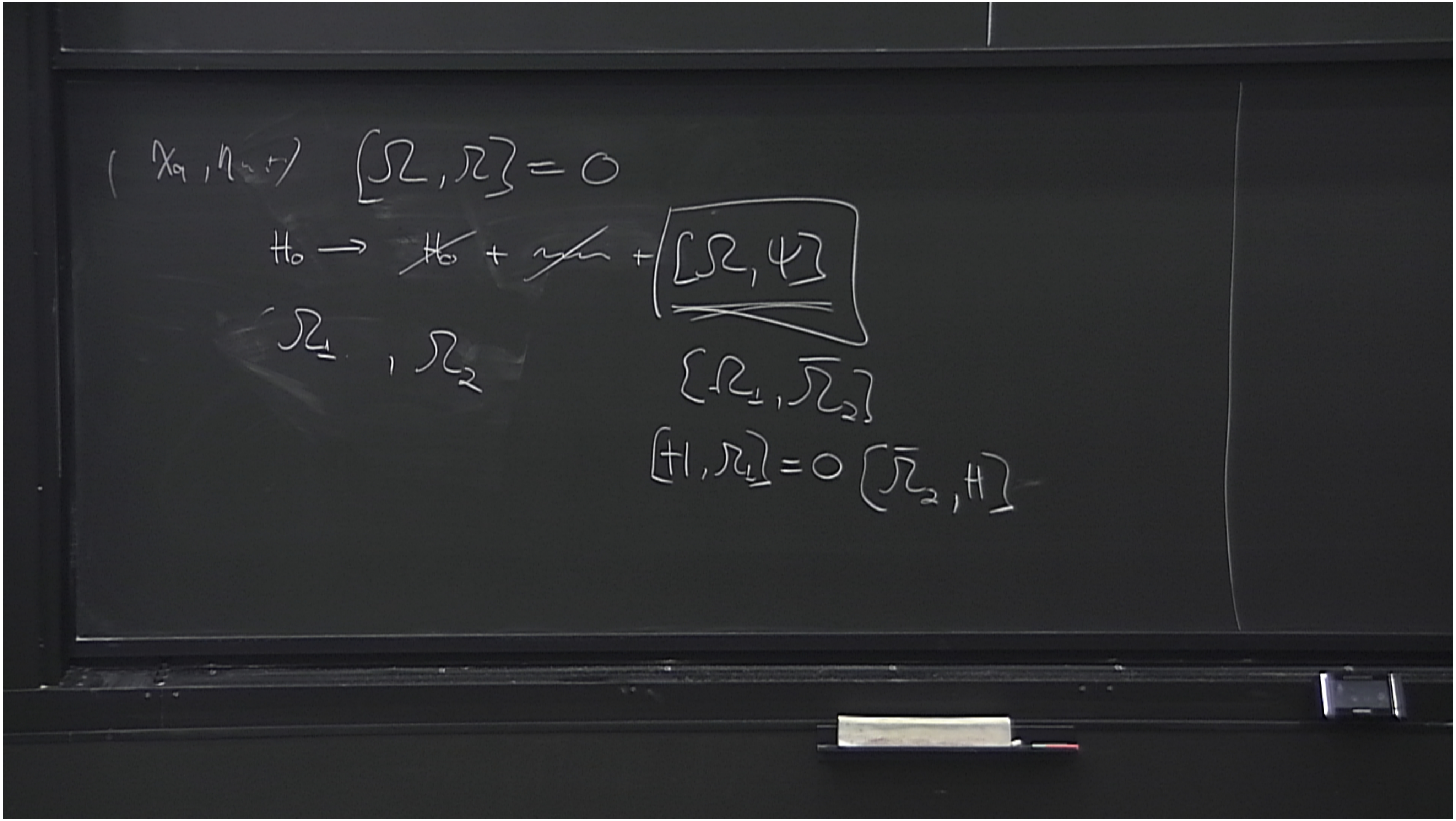
THAT ARE SPATIALLY COV. AND 1^{st} CLASS

$\{\chi_i, \chi_j\}$ IS INVERTIBLE.

$\{\ldots R^{ab}\pi_{ab}(N), \pi\} = \Delta N + \sim$

THM $\alpha \nabla^2 R + \beta R^{ab} R_{ab} + \gamma_n R^n + \frac{(a\pi^{ab}\pi_{ab} + b\pi^2)}{g} + \frac{c\pi}{\sqrt{g}} + d = 0$

$$\exists! \ (\chi_i, \chi_j) \ \Big| \ \begin{cases} R - \frac{1}{g}\left(\pi^{ab}\pi_{ab} - \frac{1}{2}\pi^2\right) + c = 0 \\ \pi + d\sqrt{g} = 0 \end{cases}$$



[Ω, Ω] = 0
H₀ → + [Ω, Ψ]
Ω₁ , Ω₂
{Ω₁, Ω̄₂}
[H, Ω₁] = 0 [Ω̄₂, H]

3D SCALE INV. $\Pi = 0$

$$\{\Pi(\rho), g_{ab}\} = \rho\, g_{ab}$$

$$\pi^{ab} g_{ab}$$

$$\{\Pi, \pi^{ab}\} = -\rho\, \pi^{ab}$$

$$(\underbrace{g_{ab}}, \underbrace{\pi^{ab}})$$

$$\Big(\big(\underbrace{\tfrac{\sqrt{g}}{\sqrt{g_0}}}_{\Phi_0}, \hat{g}_{ab}\big)\big(\underbrace{\pi^{ab} - \tfrac{1}{3}\pi}_{\sigma^{ab}}\big), \pi = \Big) \sim \sqrt{g}$$