Title: Nongeometric Flux Compactifications

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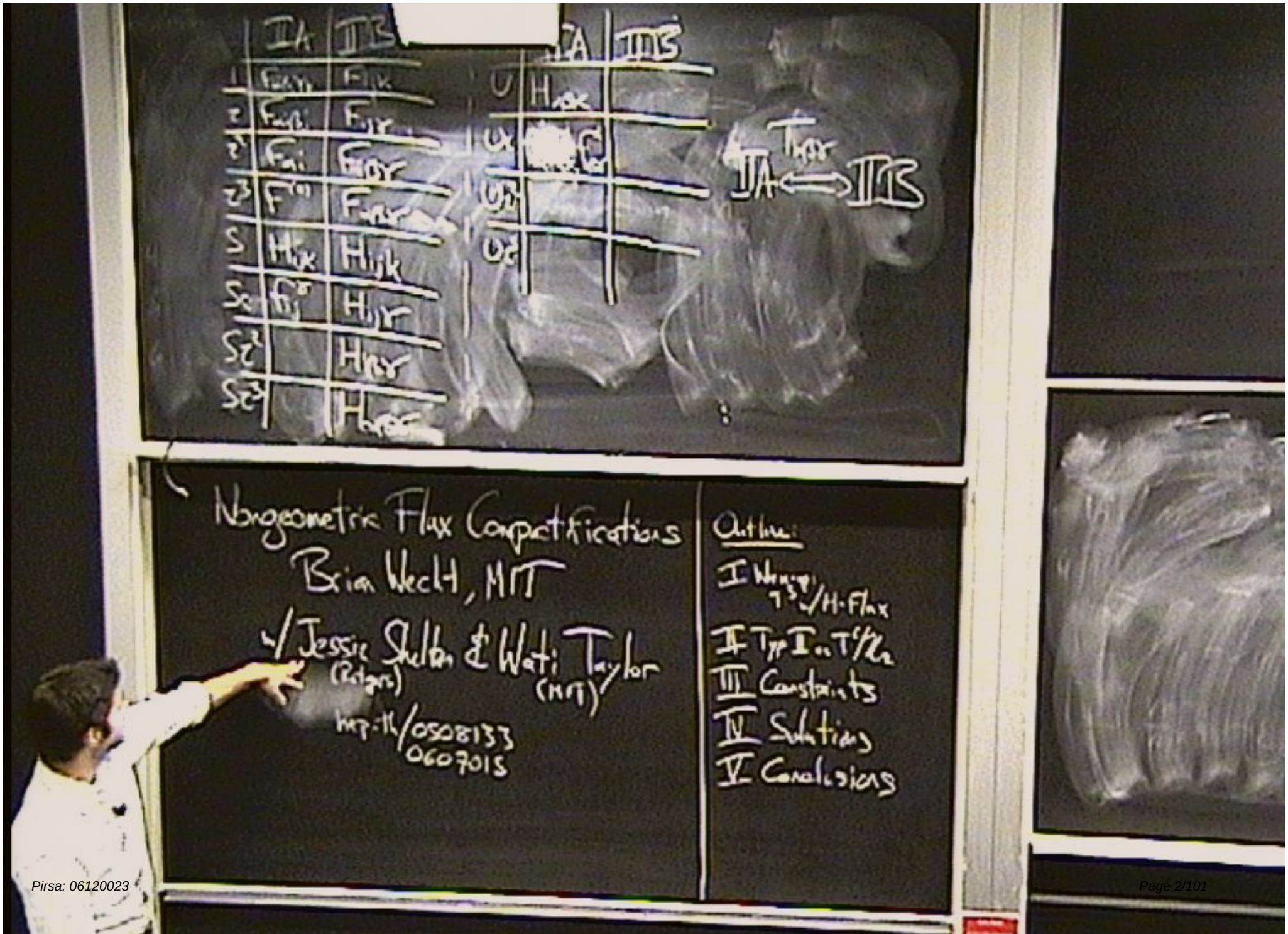
Abstract: TBA


Nongeometric Flux Compactifications
Brian Wecht, MIT
w/ Jessie Shelton & Wati Taylor
(Rutgers)
(MIT)
hep-th/0508133
0607015
Outline:
I
II
III Constraints
IV Solutions
V Conclusions

	IIA	IIB
1	$F_{\alpha\beta\gamma}$	F_{ijk}
z	$F_{\alpha\beta i}$	$F_{ij\gamma}$
z^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
z^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
S	H_{ijk}	H_{ijk}
Sz	f_{ij}^{σ}	$H_{ij\gamma}$
Sz^2		$H_{i\beta\gamma}$
Sz^3		$H_{\alpha\beta\gamma}$

	IIA	IIB
U	$H_{\alpha\beta\gamma}$	
Uz	[illegible]	
Uz^2		
Uz^3		

$$\text{IIA} \xleftrightarrow{T_{\alpha\beta\gamma}} \text{IIB}$$

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Nongeometric Flux Compactifications

Brian Wecht, MIT

w/ Jessie Shelton (Rutgers) & Wati Taylor (MIT)

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Outline:

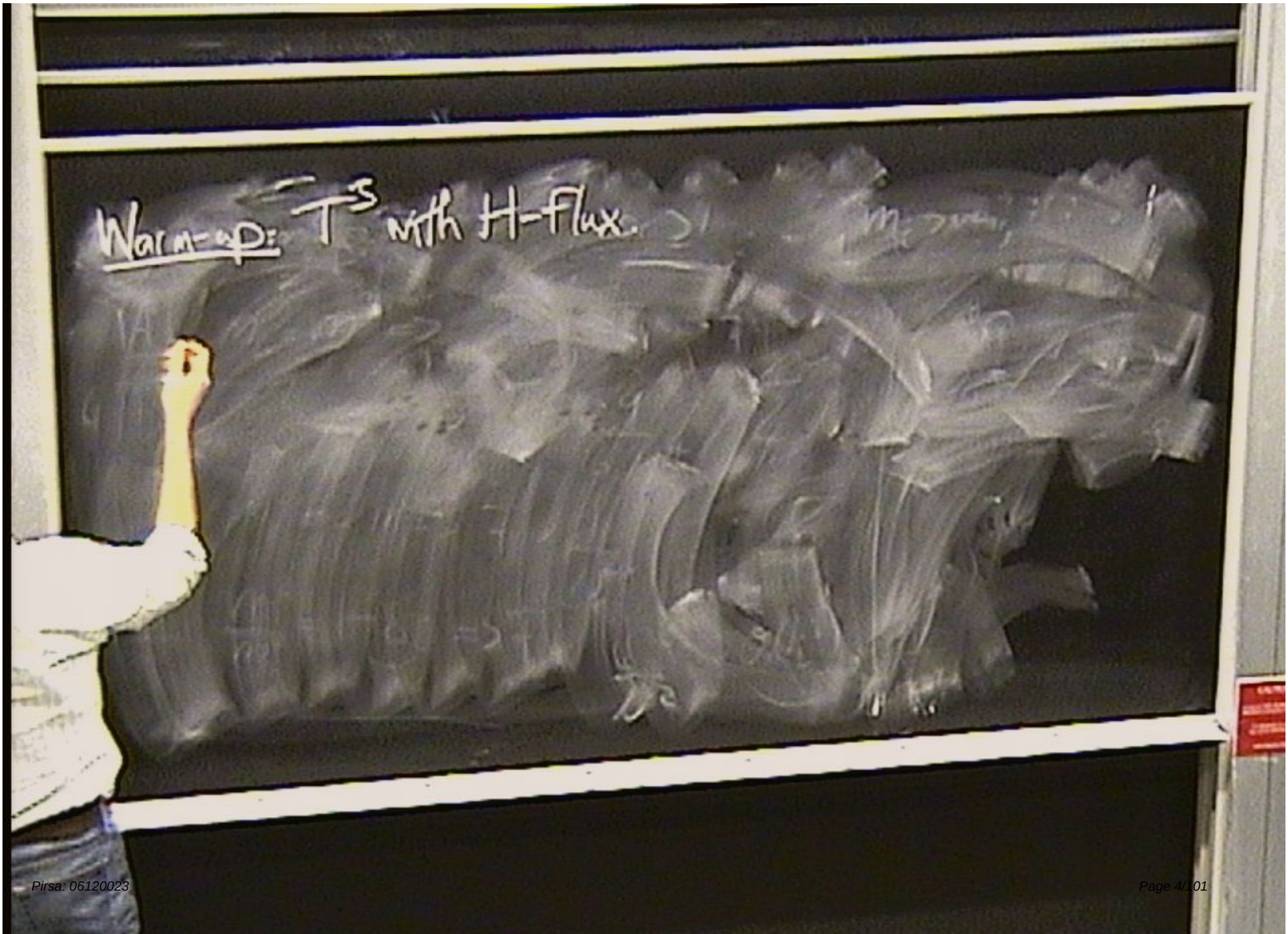
I Wrapped T^3 w/ H-Flux

II Type II on $T^6/\mathbb{Z}_2$

III Constraints

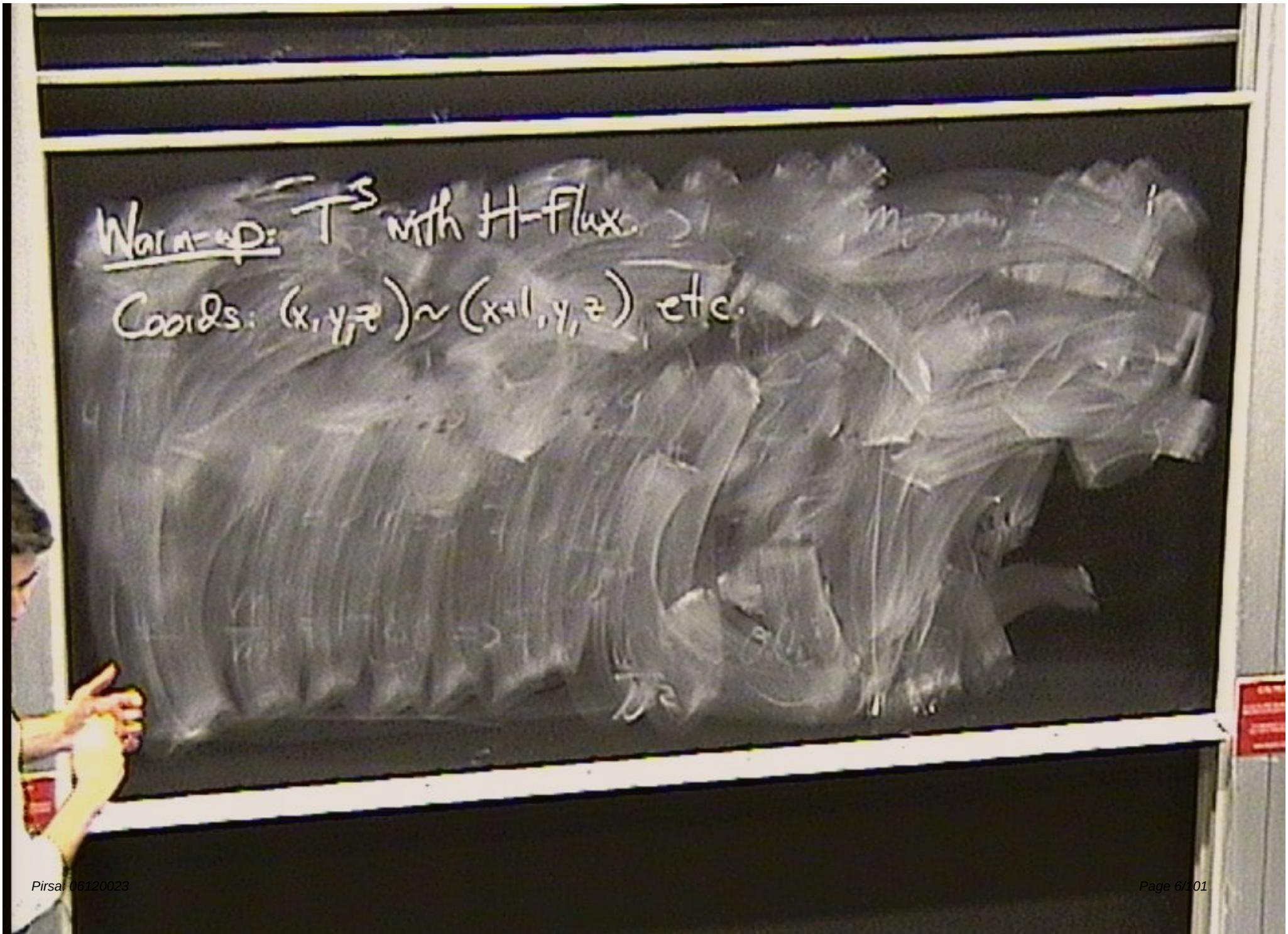
IV Solutions

V Conclusions


Warm-up: T^5 with H-flux.

<u>Warm-up:</u> T^3 with H-Flux.

Coords: (x, y, z)


Warm-up: T^3 with H-flux.
Coords: $(x,y,z) \sim (x+1,y,z)$ etc.

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$$\int_{T^3} H =$$

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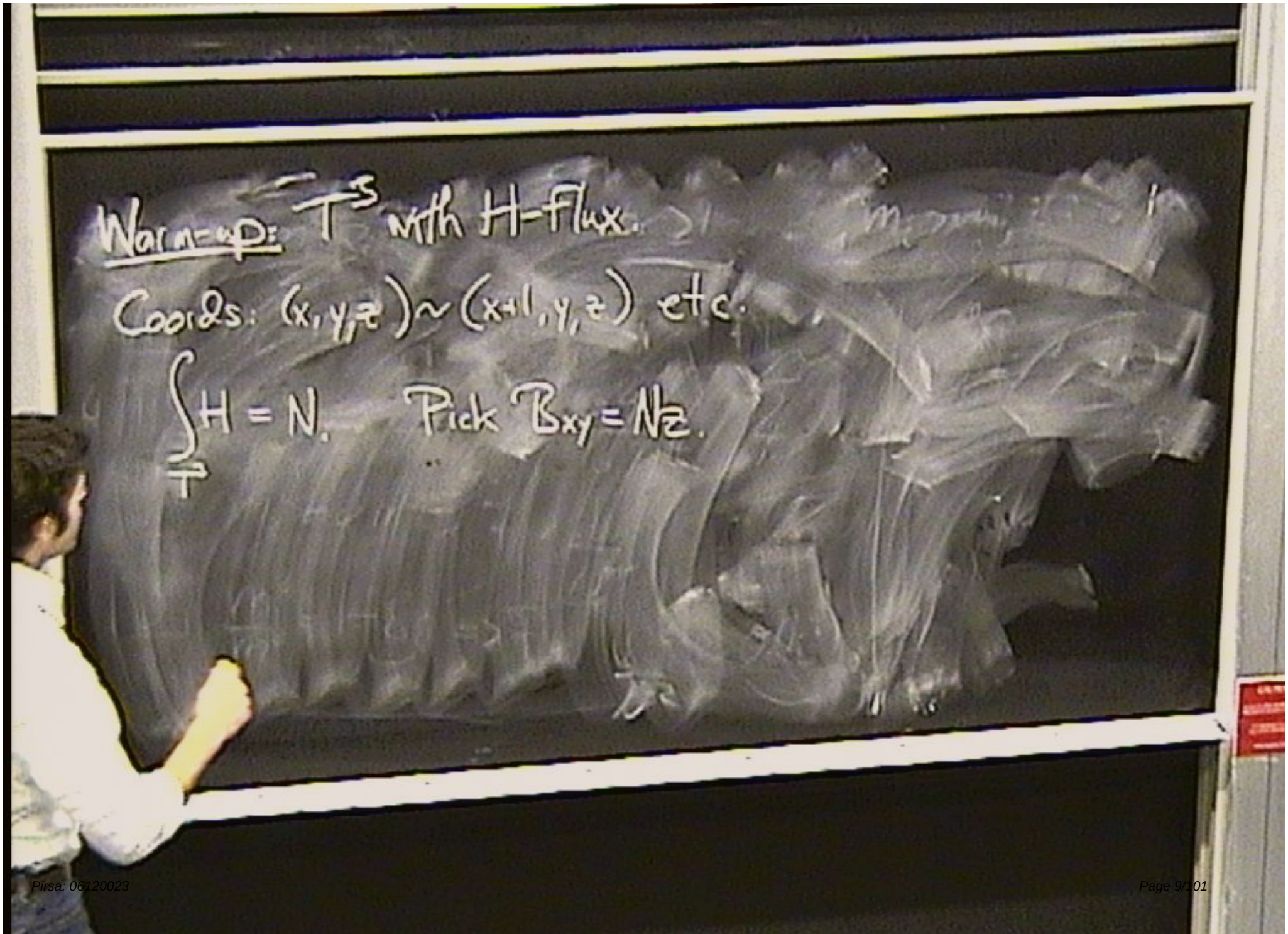
Coords: $(x, y, z) \sim (x+1, y, z)$ etc.

$$\int_{T^3} H = N.$$


Warm-up: T^3 with H-flux.
Coords: $(x,y,z) \sim (x+1,y,z)$ etc.
$\int_T H = N.$ Pick $B_{xy} = Nz.$

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Coords: $(x,y,z) \sim (x+1,y,z)$ etc.

$\int_T H = N$. Pick $B_{xy} = Nz$. (Not a soln to string EOM).

<u>Warm-up:</u> T^3 with H-Flux.

Coords: $(x, y, z) \sim (x+1, y, z)$ etc.

$\int_T H = N$. Pick $B_{xy} = Nz$. (<u>Not</u> a soln to string EOM).

Have isometries in x & y, so can do T_x & T_y.

Warm-up: T^3 with H-flux.

Coords: $(x,y,z) \sim (x+1,y,z)$ etc.

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Have isometries in x & y, so can do T_x & T_y.

Let's

Use "Buscher rules"

Use "Buscher rules" to get new background.

$\int_T H = N$. Pick $B_{xy} = N/2$. (Not a soln to string EOM).

Have isometries in x & y, so can do T_x & T_y.

Let's do T_x.

Use "Buscher rules" to get new background.

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$$ds^2 = (dx + N_z\, dy)^2 + dy^2 + dz^2$$

$$B = 0 \ldots$$

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"twisted torus."

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$$(x, y, z) \sim (x \quad , y, z+1)$$

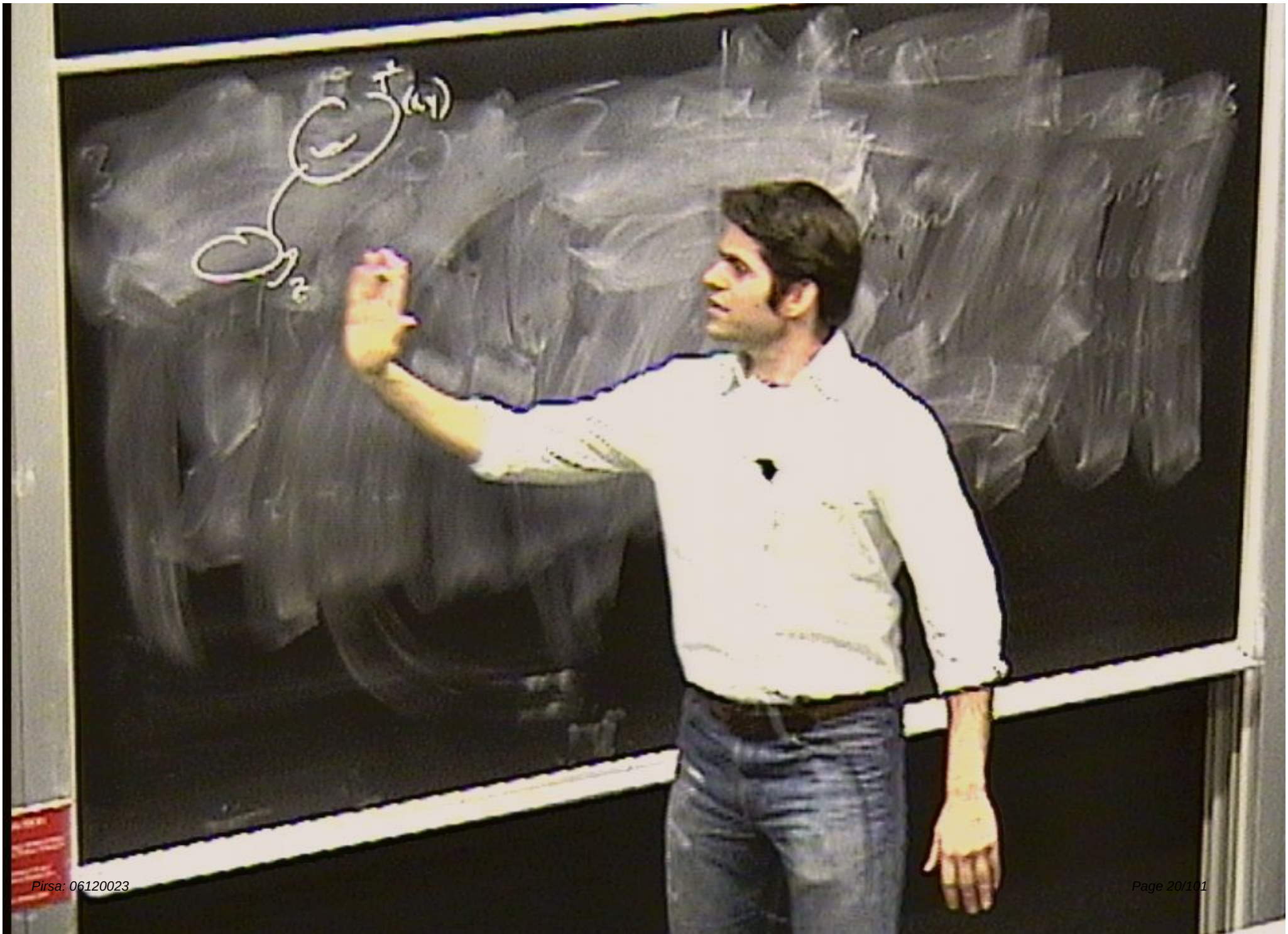
Use "Buscher rules" to get new background.

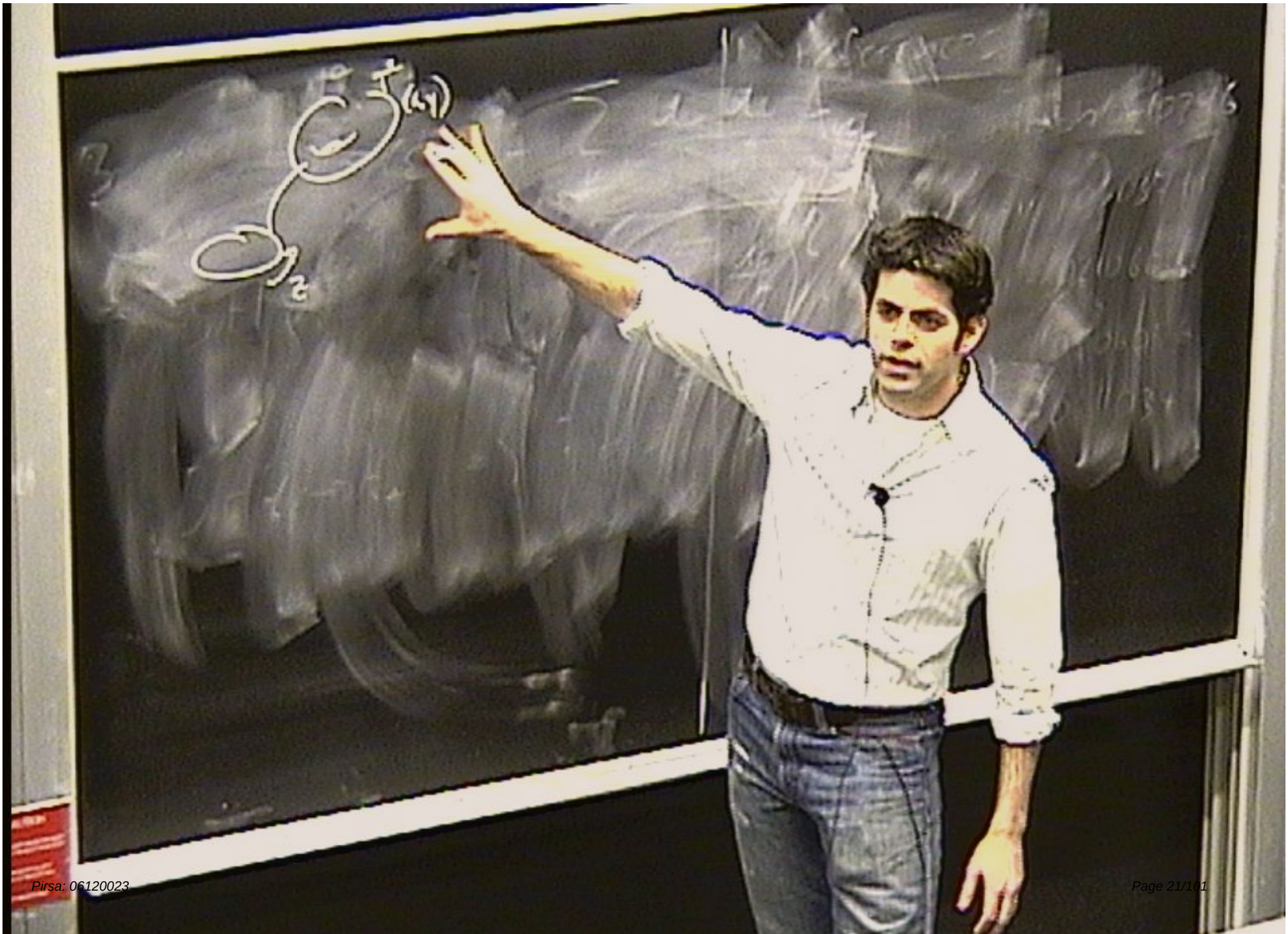
$$ds^2 = (dx + N z\, dy)^2 + dy^2 + dz^2$$

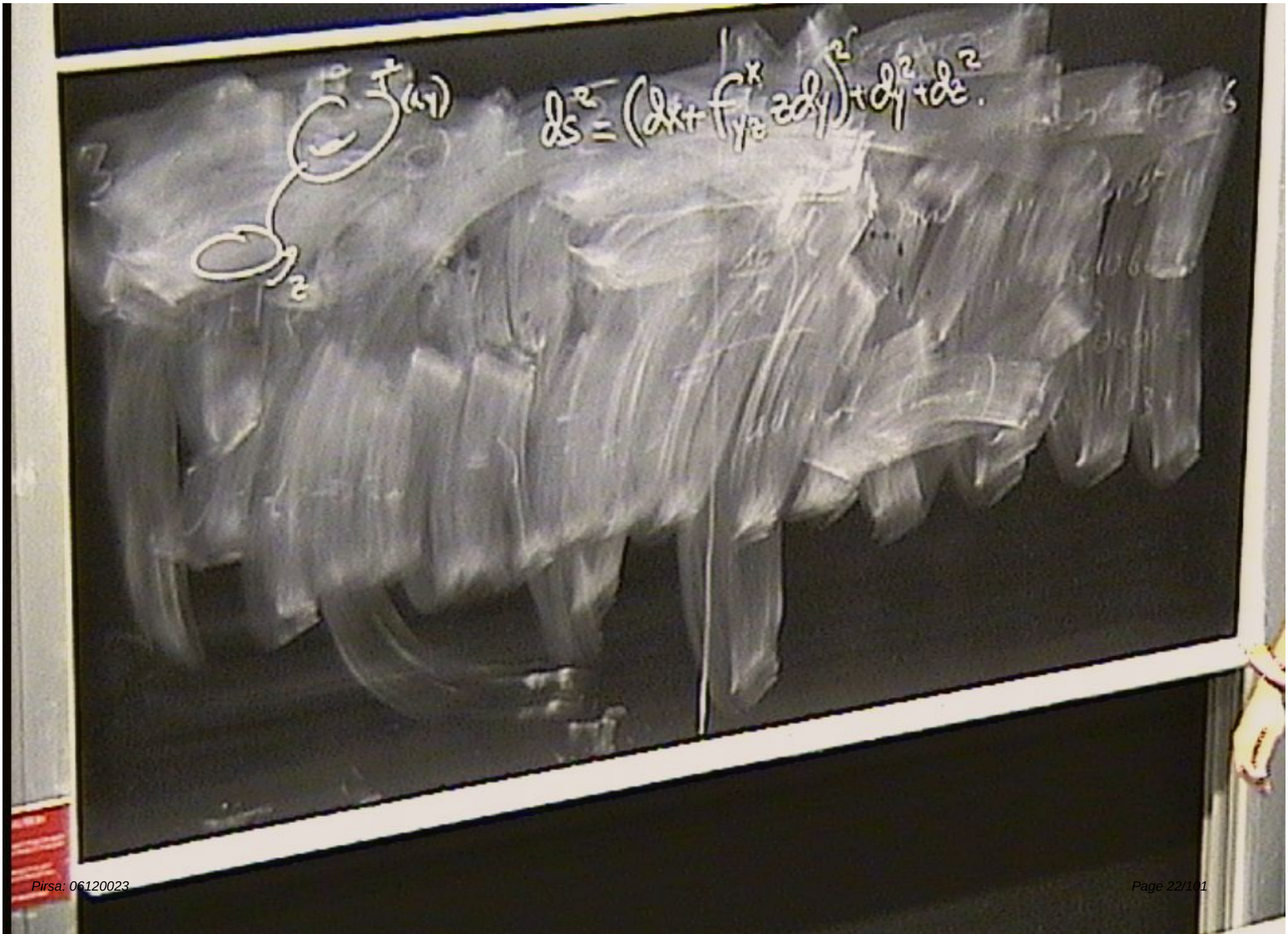
$$B = 0 \ldots$$

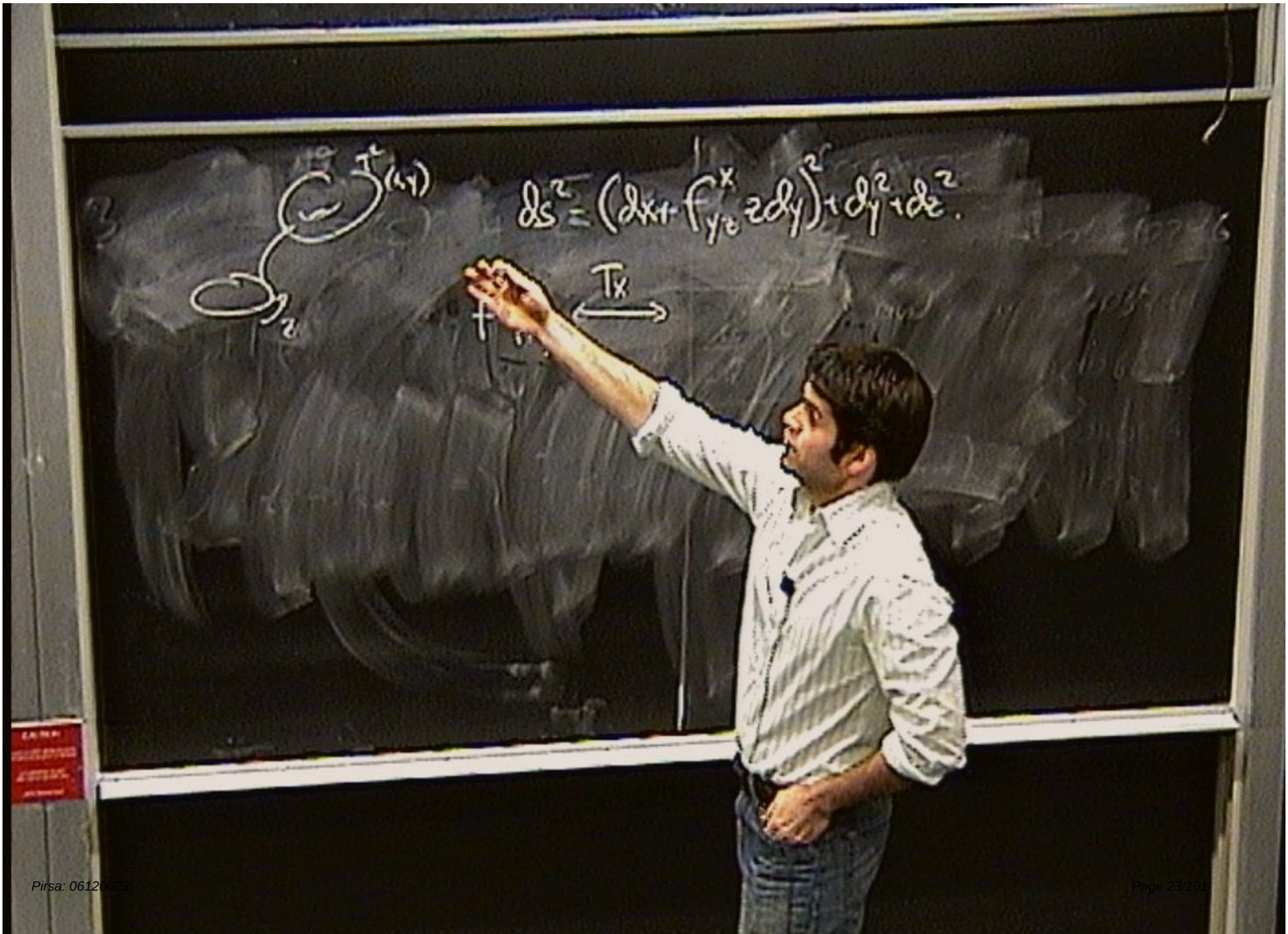
"twisted torus."

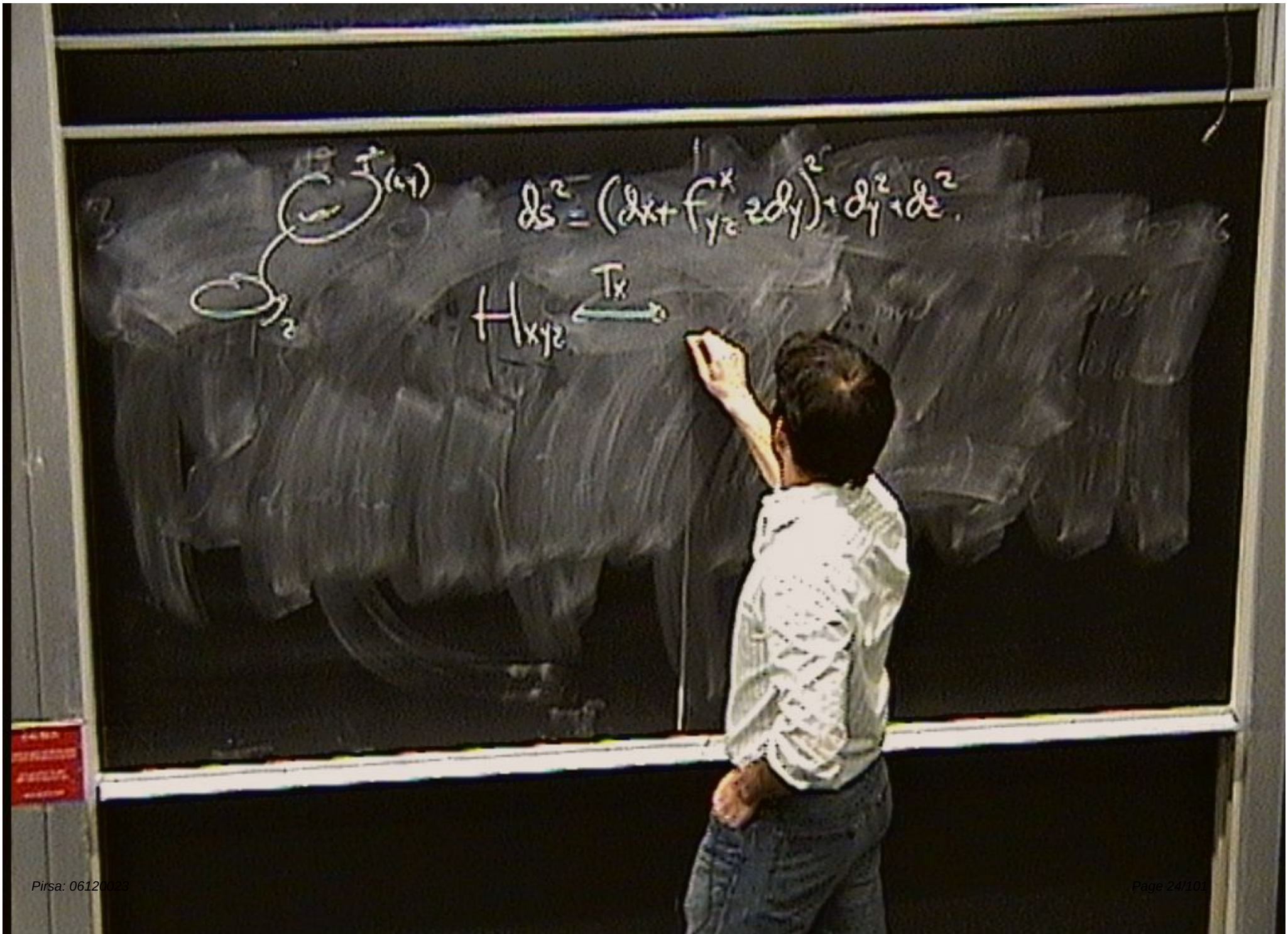
$(x, y, z) \sim (x - Ny, y, z+1)$ keeps metric well-def'd.

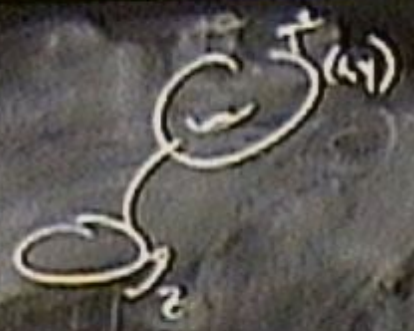





$\gamma(y)$
z
$ds^2 = (dx + f^x_{yz} z\, dy)^2 + dy^2 + dz^2.$

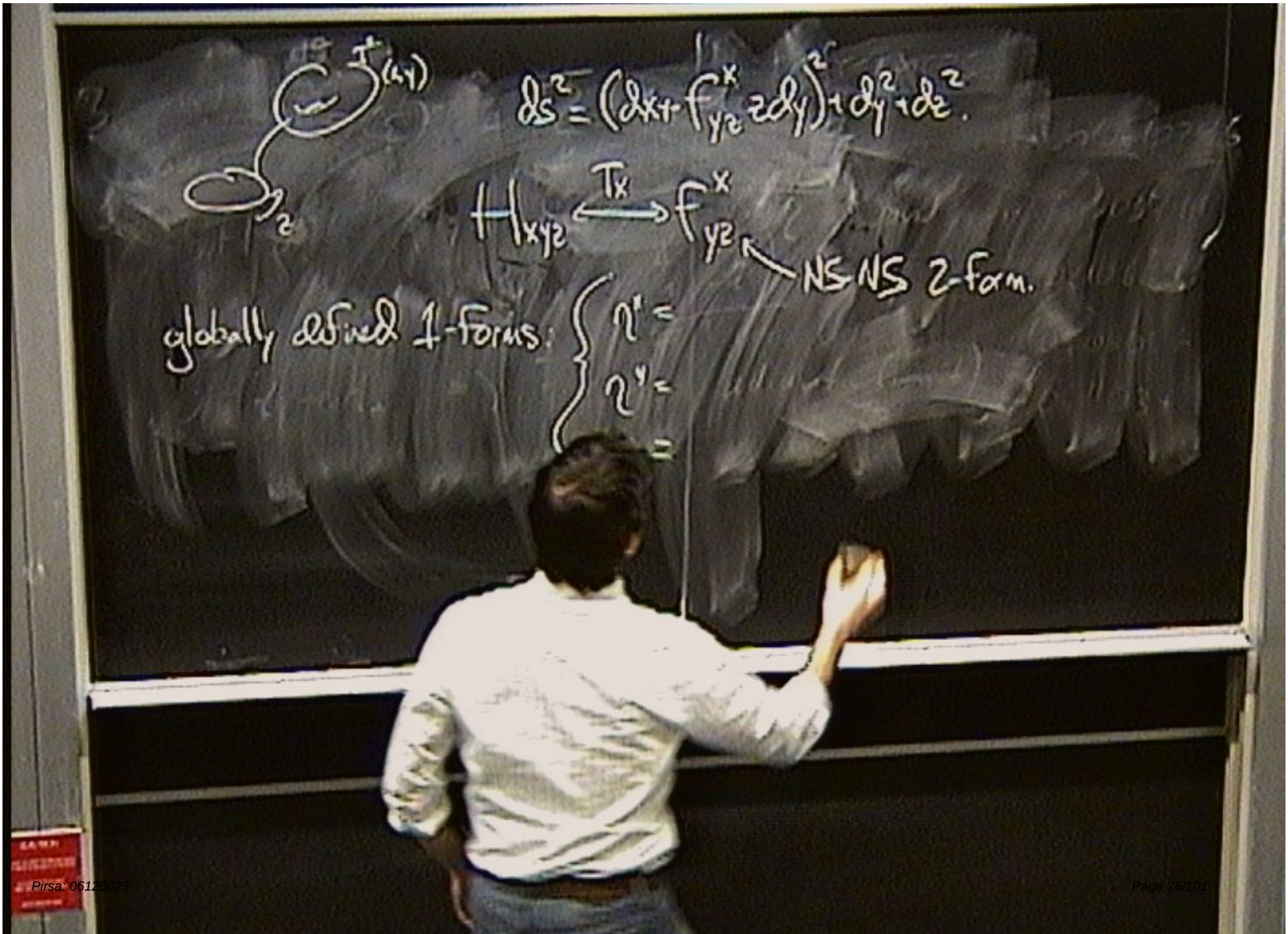

$T^2(x,y)$
$ds^2 = (dx + f^x_{yz} z\,dy)^2 + dy^2 + dz^2.$
T_x

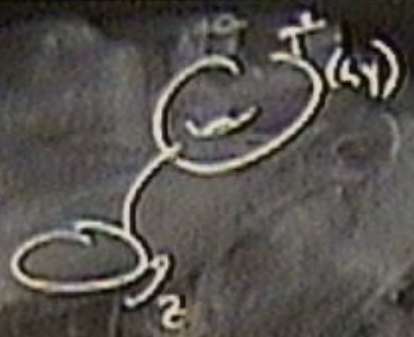

(x,y)
z
$ds^2 = (dx + f^x_{yz} z\,dy)^2 + dy^2 + dz^2$
H_{xyz}
T_x



$$ds^2 = (dx + f^x_{yz}\, z\, dy)^2 + dy^2 + dz^2.$$

$$H_{xyz} \xleftrightarrow{T_x} f^x_{yz}.$$


$T^2(x,y)$
z
$ds^2 = (dx + f^x_{yz}\, z\, dy)^2 + dy^2 + dz^2.$
$H_{xyz} \xleftrightarrow{T_x} f^x_{yz}$
NS-NS 2-form.
globally defined 1-forms: $\eta^1 =$
$\eta^2 =$
$=$

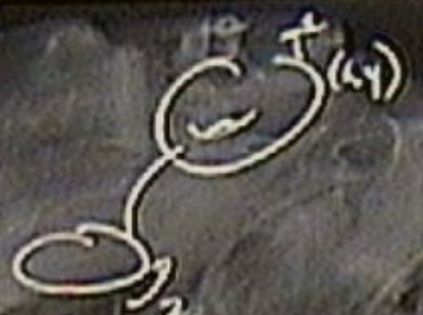


$$ds^2 = (dx + f^x_{yz}\, z\, dy)^2 + dy^2 + dz^2.$$

$$H_{xyz} \xleftrightarrow{T_x} f^x_{yz}.$$

globally defined 1-forms:
$$\begin{cases} \eta^x = dx - Nz\, dy \\ \eta^y = dy \\ \eta^z = dz. \end{cases}$$

$$d\eta^x = N\eta^y \wedge \eta^z = f^x_{yz}$$



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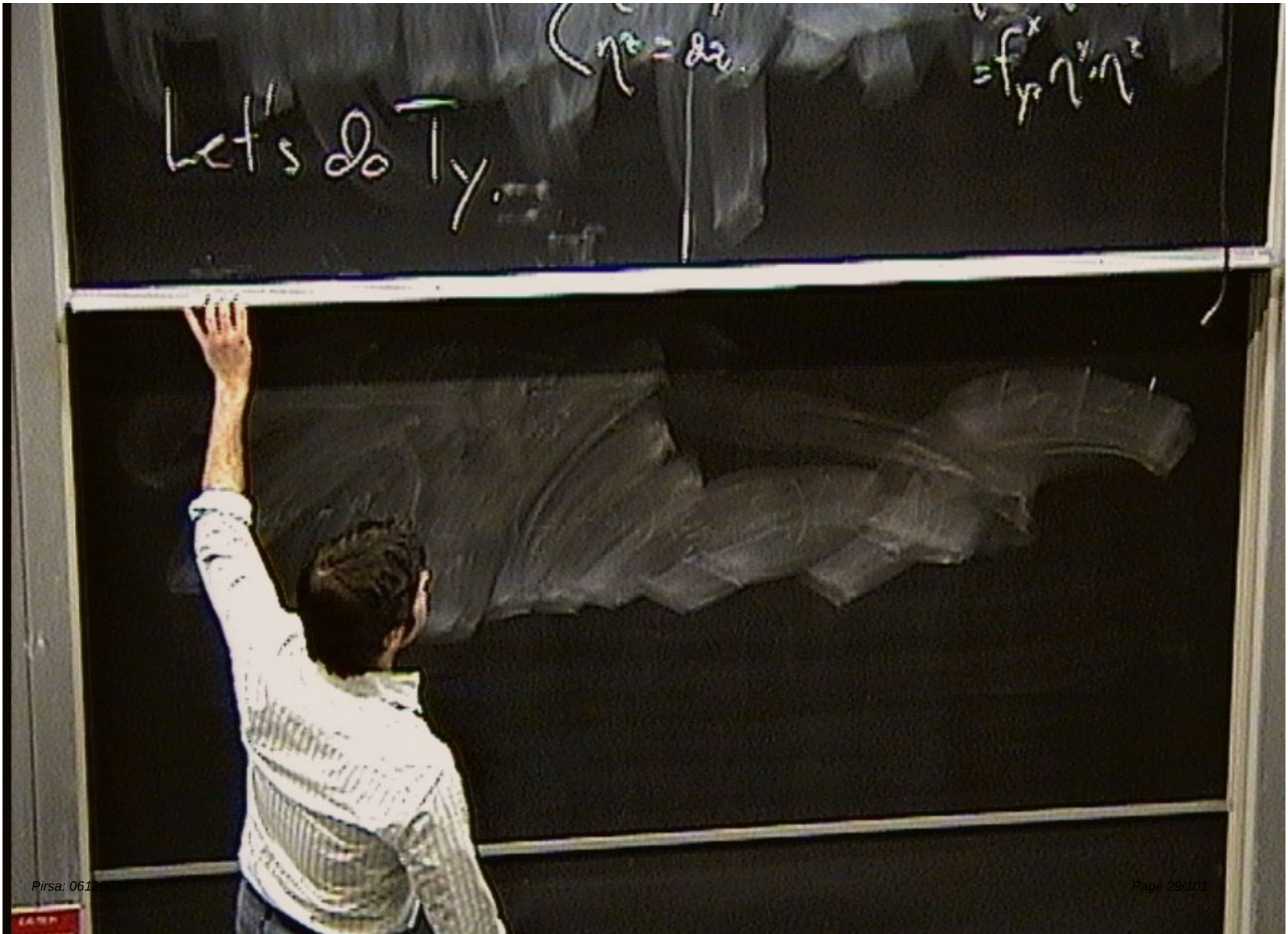
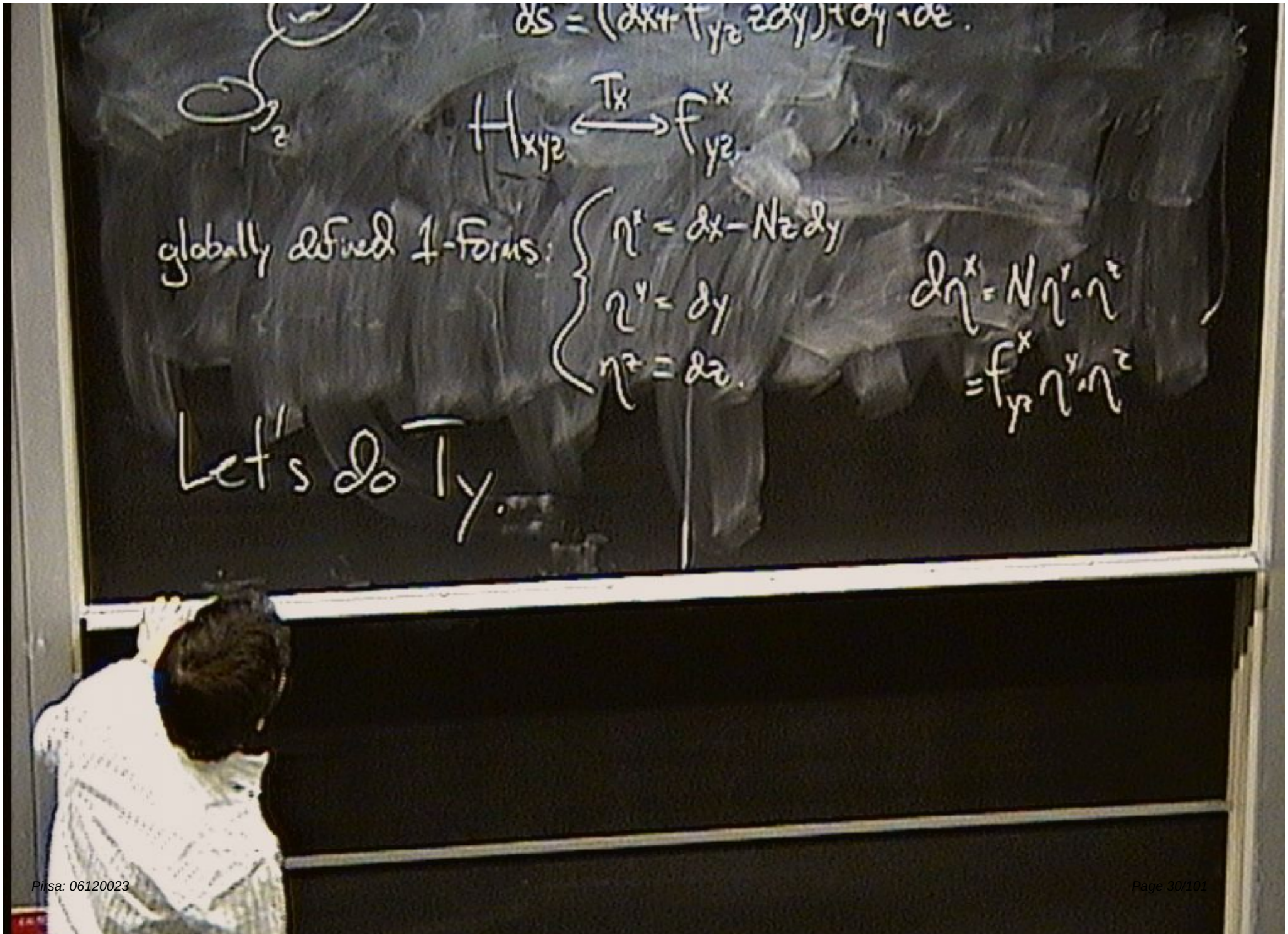

Let's do Ty.


$ds = (dx + f_{yz}\, z\, dy) + dy + dz.$
z
$H_{xyz} \xleftrightarrow{T_x} f^x_{yz}$
globally defined 1-forms:
$\eta^x = dx - Nz\, dy$
$\eta^y = dy$
$\eta^z = dz.$
$d\eta^x = N \eta^y \wedge \eta^z$
$= f^x_{yz} \eta^y \wedge \eta^z$
Let's do T_y.

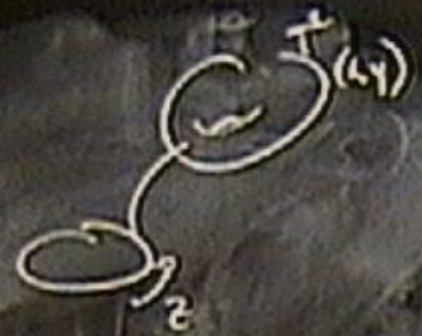
$$ds^2 = (dx + F^x_{yz}\, z\, dy)^2 + dy^2 + dz^2$$

$$H_{xyz} \xleftrightarrow{T_x} F^x_{yz}$$

globally defined 1-forms:
$$\begin{cases} \eta^x = dx - Nz\,dy \\ \eta^y = dy \\ \eta^z = dz \end{cases}$$

$$d\eta^x = N\eta^y \wedge \eta^z = F^x_{yz}\,\eta^y \wedge \eta^z$$

Let's do T_y.



$$ds^2 = (dx + f^x_{yz}\, z\, dy)^2 + dy^2 + dz^2.$$

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Let's do T_y.

As $z \to z+1$, $\tau \to \tau$

$$\begin{cases} \eta^y = dy \\ \eta^z = dz. \end{cases}$$

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Let's do T_y.

As $z \to z+1$, $z \to z+N$.

$$T_y: \quad ds^2 = \frac{1}{1+N^2z^2}\left(dx^2+dy^2\right) + dz^2.$$

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$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2z^2}\left(dx^2+dy^2\right) + dz^2. \\ B_{xy} = \dfrac{Nz}{1+N^2z^2}. \end{cases}$$

Have isometries in x & y, so can do T_x & T_y (FOM).

Let's do T_x.

Use "Buscher rules" to get new background.

$$\left.\begin{aligned} ds^2 &= (dx - N z\, dy)^2 + dy^2 + dz^2 \\ B &= 0 \\ (x, y, z) &\sim (x - Ny, y, z+1) \end{aligned}\right] \text{"twisted torus."}$$

keeps metric well-def'd.

Let's do T_y. As $z \to z+1$, $z \to z+N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 . \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} . \end{cases}$$

<u>What is this?</u>

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$\rho = B + iV$

<u>What is this?</u>

Let's do T_y. As $z \to z+1$, $\tau \to \tau + N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 . \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} . \end{cases}$$

$\rho = B + iV$

$= \dfrac{1}{1+N^2 z^2}\left(Nz + i\right)$

What is this?

$\dfrac{1}{\rho} =$

Let's do T_y. As $z \to z+1$, $z \to z+N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 . \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} . \end{cases}$$

What is this?

$$\rho = B + iV = \frac{1}{1+N^2 z^2}\left(Nz + i\right)$$

$$\frac{1}{\rho} = Nz - i$$

$$\boxed{\text{As } z \to z+1, \ \frac{1}{\rho} \to \frac{1}{\rho} + N.}$$

Let's do T_y. As $z \to z+1$, $z \to z+N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} \end{cases}$$

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Nongeometric!

Let's do T_y. As $z \to z+1$, $z \to z+N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 . \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} . \end{cases}$$

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Nongeometric!

BtG mix.

Let's do T_y. As $z \to z+1$, $\tau \to \tau + N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} \end{cases}$$

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$$\boxed{\text{As } z \to z+1, \ \frac{1}{\rho} \to \frac{1}{\rho} + N.}$$

Nongeometric!

BtG mix.

$$H_{yyz} \xleftrightarrow{T_x} f^{x}_{yz} \xleftrightarrow{T_y} Q^{xy}_{z}$$

Let's do T_y. As $z \to z+1$, $\tau \to \tau + N$.

$$T_y : \begin{cases} ds^2 = \dfrac{1}{1+N^2 z^2}\left(dx^2 + dy^2\right) + dz^2 . \\ B_{xy} = \dfrac{Nz}{1+N^2 z^2} . \end{cases}$$

What is this?

$$\rho = B + iV = \frac{1}{1+N^2 z^2}\left(Nz + i\right)$$

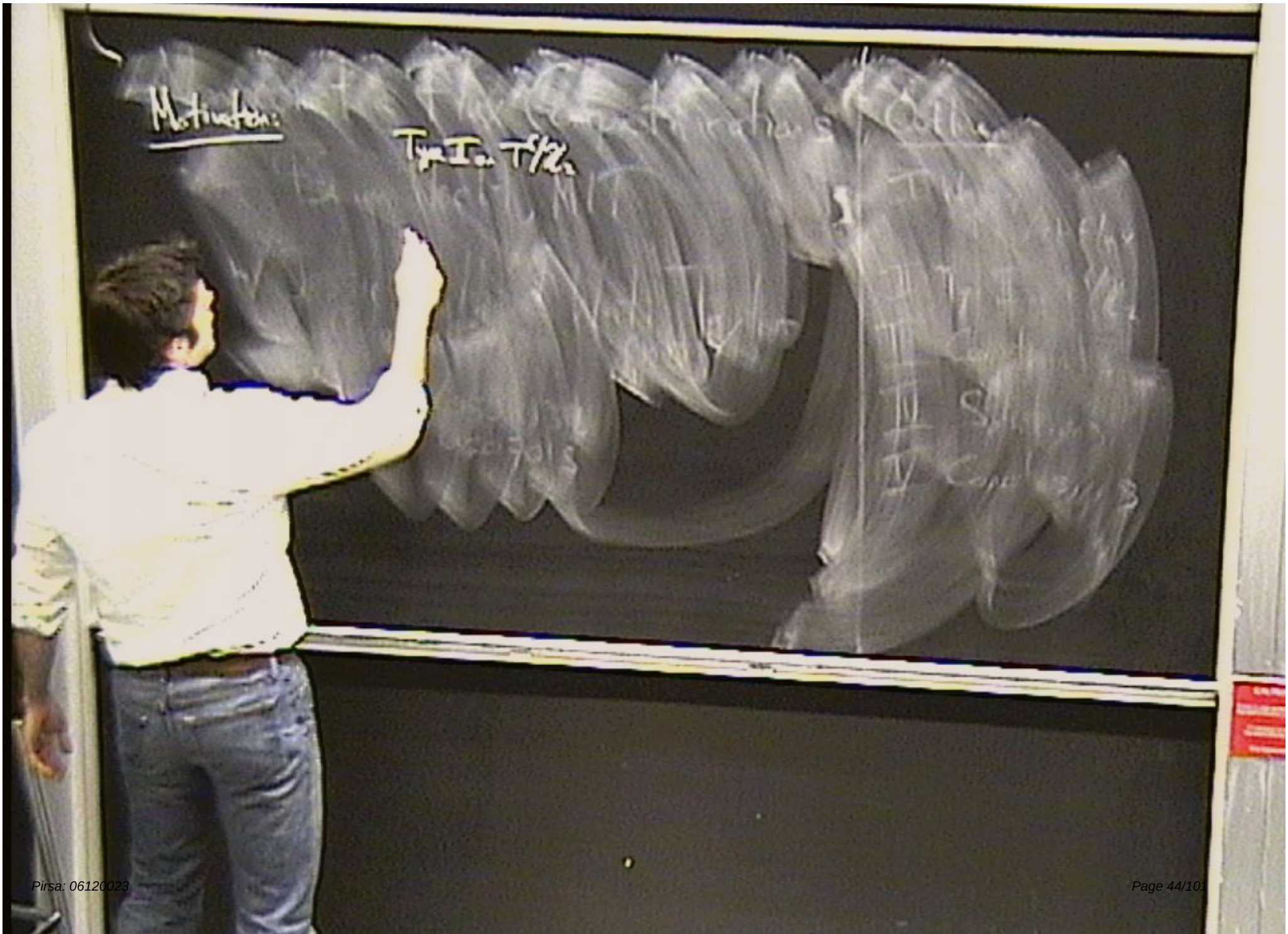
$$\frac{1}{\rho} = Nz - i$$

$$\boxed{\text{As } z \to z+1, \ \frac{1}{\rho} \to \frac{1}{\rho} + N.}$$

Nongeometric!

B & G mix.

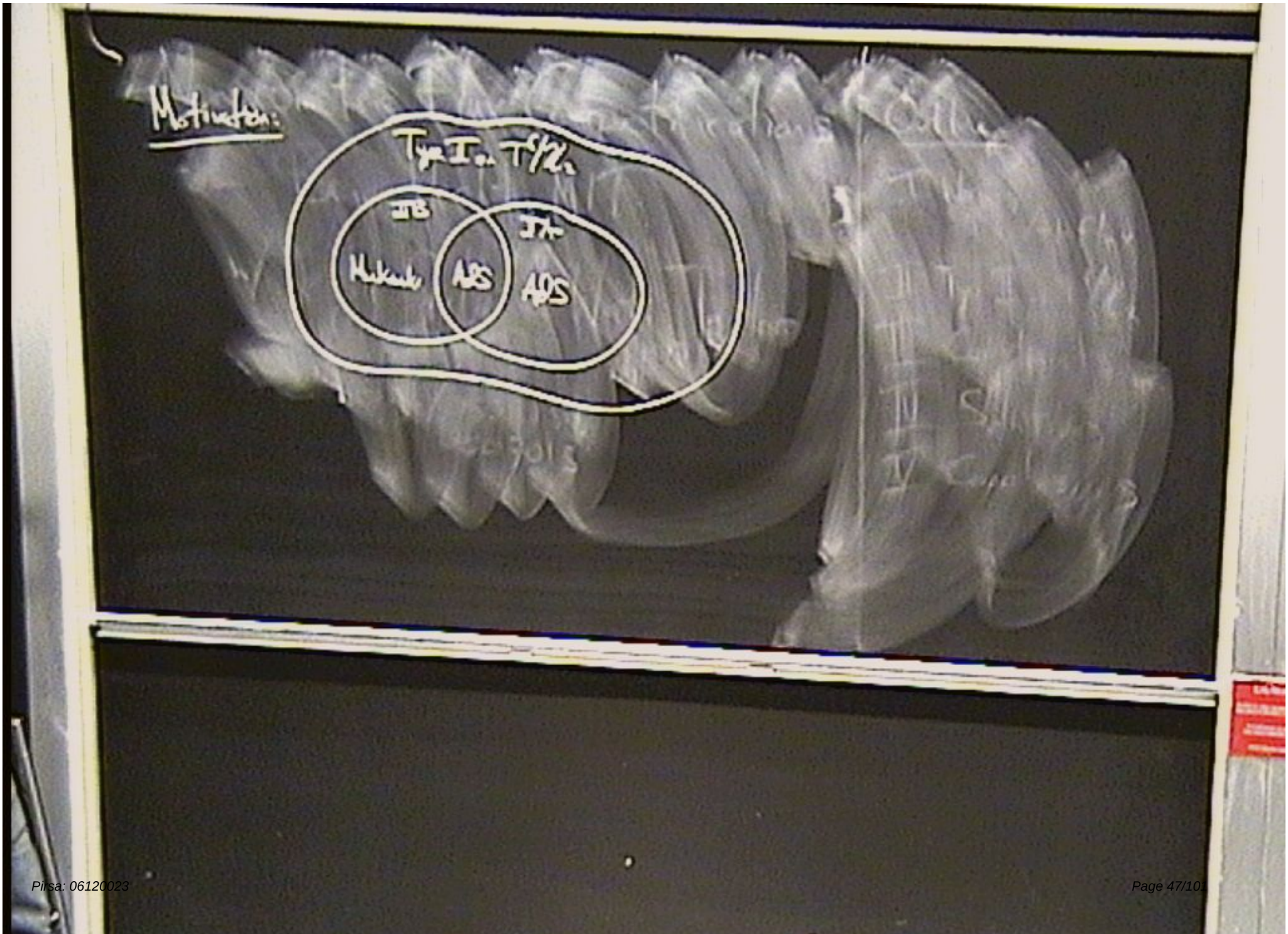
$$H_{yyz} \xleftrightarrow{T_x} f^{x}_{yz} \xleftrightarrow{T_y} Q^{xy}_{z} \xleftrightarrow{T_z} X$$

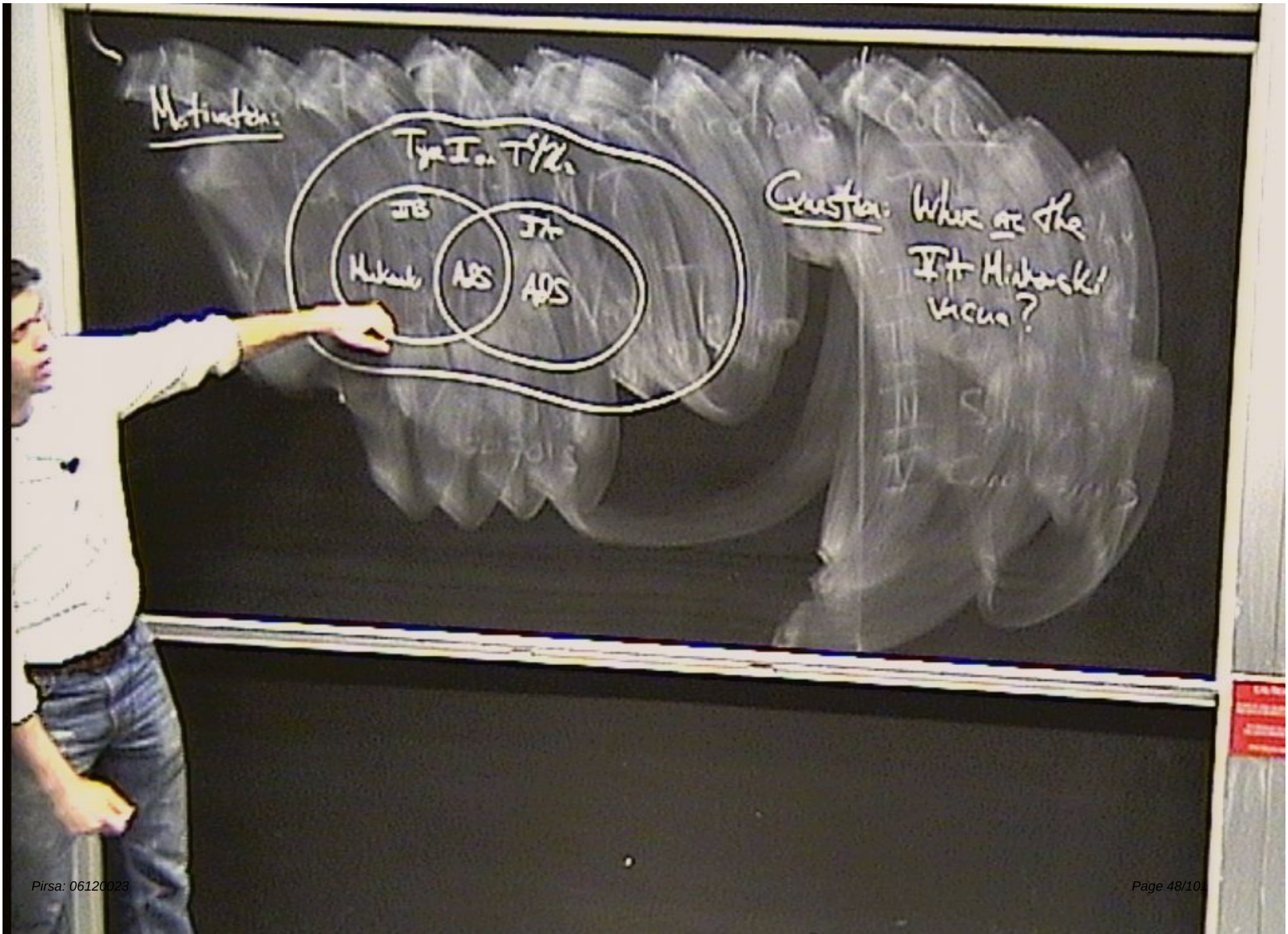

Motivation:
Type I: T^{5/2}

Motivation:

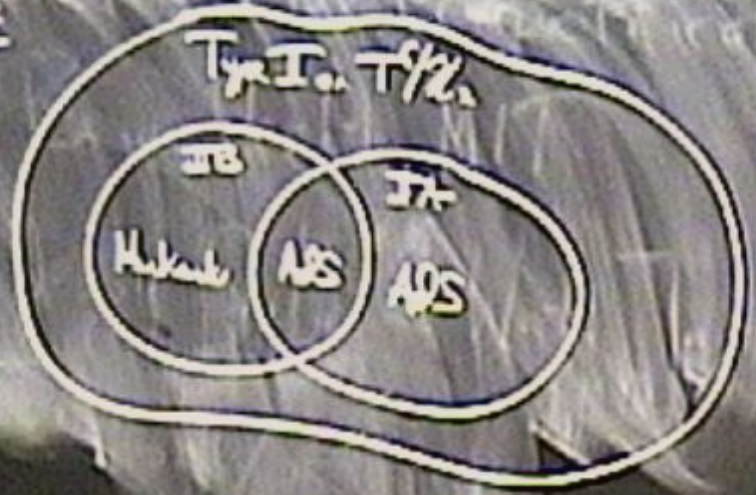
Type I: T/2

Motivation:

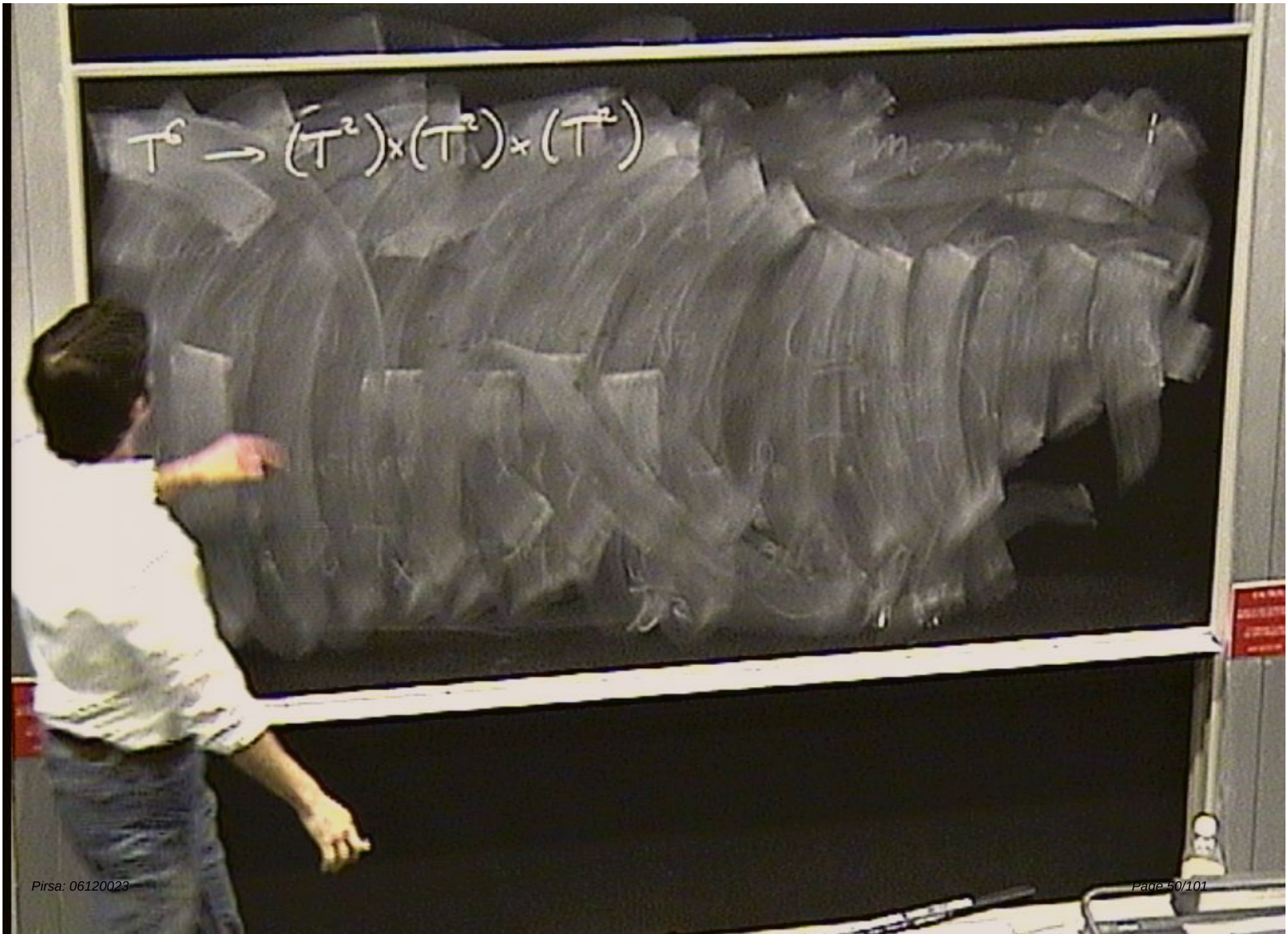

Motivation:
Type I, T^{5/2}
JTB
JT
Hubeny
AdS
AdS

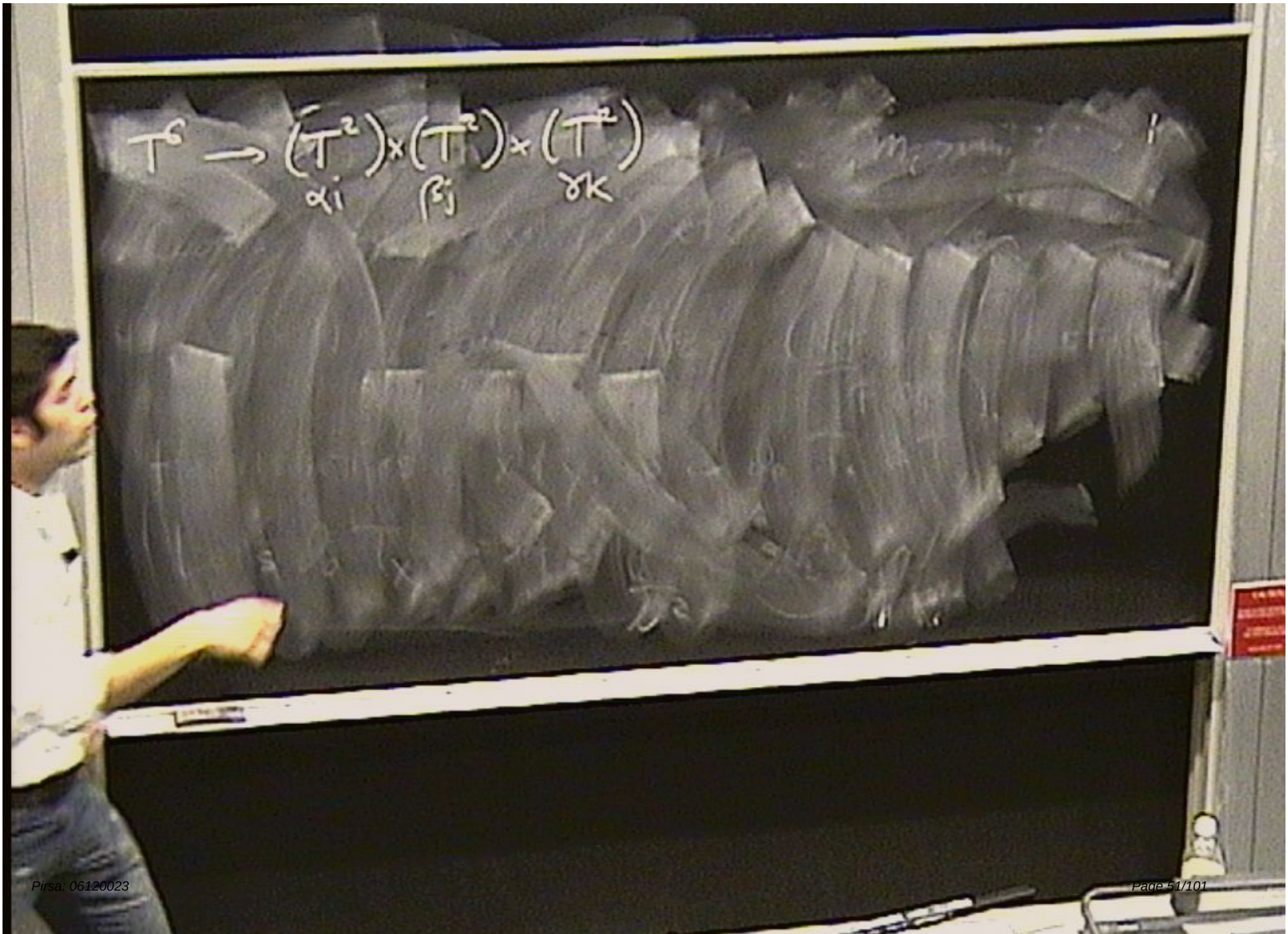

Motivation:
Type IIB T^6/Z_2
JIB
JIA
Hubsch
AdS
AdS
Question: What are the
IIA Hubsch!
vacua?

Motivation:



Question: Where are the IIA Minkowski vacua?


$T^6 \to (T^2)\times(T^2)\times(T^2)$


$T^6 \to (T^2)_{\alpha_i} \times (T^2)_{\beta_j} \times (T^2)_{\gamma_k}$

$$T^6 \longrightarrow \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_K}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

$$T^6 \longrightarrow \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

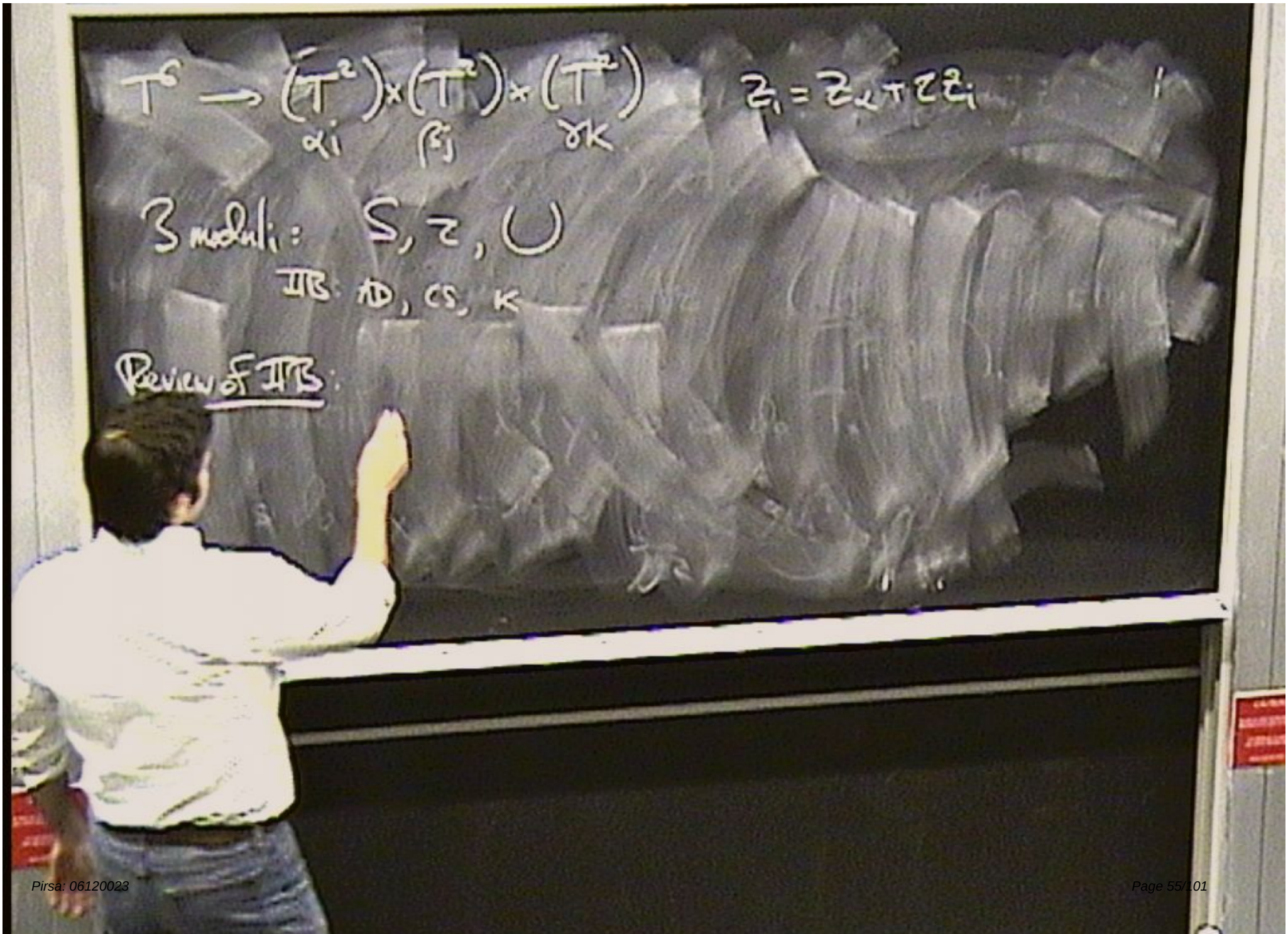
3 moduli: S, τ, U

$$T^6 \to \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)}$$

$$z_1 = z_\alpha + \tau z_\beta$$

3 moduli: S, τ, U

IIB: λD, CS, K


$T^6 \to (T^2)_{\alpha_i} \times (T^2)_{\beta_j} \times (T^2)_{\gamma_k}$
$z_1 = z_2 + \tau z_1$
3 moduli: S, τ, U
IIB: AD, CS, K
Review of IIB:

$$T^6 \longrightarrow \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_\alpha + \tau z_i$$

3 moduli: S, τ, U

IIB: Λ_D, CS, K

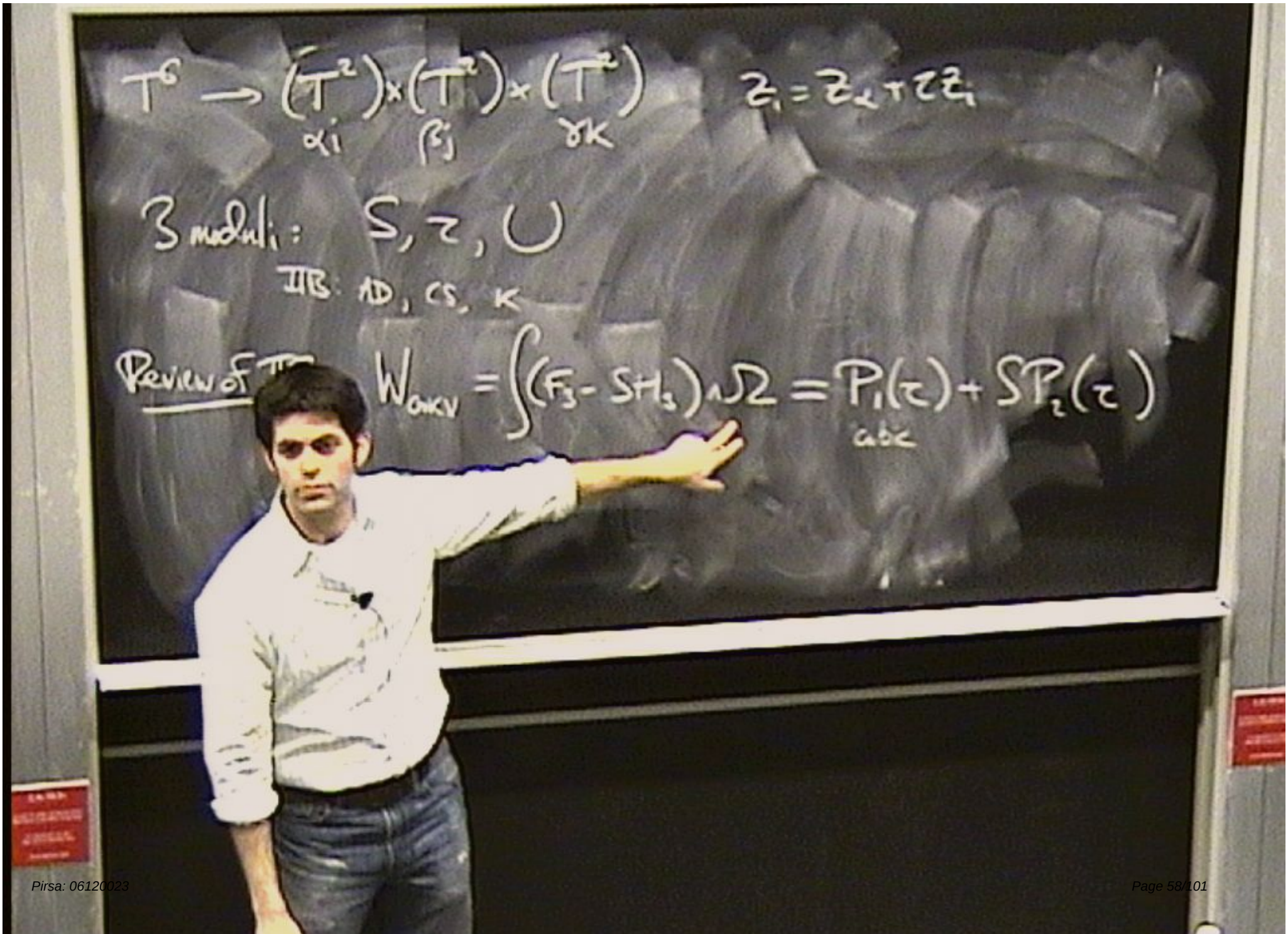
<u>Review of IIB</u>: $W_{GKV} =$

$$T^6 \to \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_\alpha + \tau z_i$$

3 moduli: S, τ, U

IIB: AD, CS, K

<u>Review of IIB</u>: $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega$


$T^6 \to (T^2_{\alpha_i}) \times (T^2_{\beta_j}) \times (T^2_{\gamma_k})$
$z_1 = z_2 + \tau z_1$
3 moduli: S, τ, U
IIB: AD, CS, K
Review of
$W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = P_1(\tau) + S P_2(\tau)$
abc

$$T^6 \longrightarrow (T^2_{\alpha_i}) \times (T^2_{\beta_j}) \times (T^2_{\gamma_k}) \qquad z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB: λD, CS, K

<u>Review of IIB</u>: $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = P_1(\tau) + S P_2(\tau)$

abc

$$T^6 \to \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)}$$

$$z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB ΛD, CS, K

$$K = -3\ln(-i(U-\bar{U})) - 3\ln(-i(\tau-\bar{\tau})) - \ln(-i(S-\bar{S}))$$

<u>Review of IIB</u>. $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{cubic}}{P_2(\tau)}$

$$T^6 \longrightarrow \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB: AD, CS, K

$$K = -3\ln(-i(U-\bar{U})) - 3\ln(-i(\tau-\bar{\tau})) - \ln(-i(S-\bar{S}))$$

$$V = e^K\left(\sum_{i,j} K^{i\bar{j}} D_i W \overline{D_j W} - 3|W|^2\right)$$

<u>Review of IIB</u>: $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{cubic}}{P_2(\tau)}$

<u>Review IIA</u>:

$$T^6 \to \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB: AD, CS, K

$$K = -3\ln(-i(U-\bar{U})) - 3\ln(-i(\tau-\bar{\tau})) - \ln(-i(S-\bar{S}))$$

$$V = e^K\left(\sum_{i,j} K^{i\bar{j}} D_i W \overline{D_j W} - 3|W|^2\right)$$

<u>Review of IIB</u>: $W_{orev} = \int (F_3 - S H_3) \wedge \Omega = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{cubic}}{P_2(\tau)}$

<u>Review IIA</u>: $W = P_1(\tau) + S P_2(\tau) + U P_3(\tau)$

$$T^6 \to \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB: AD, CS, K

$$K = -3\ln(-i(\tau-\bar\tau)) - 3\ln(-i(U-\bar U)) - \ln(-i(S-\bar S))$$

$$V = e^K\left(\sum_{i,j} K^{i\bar j} D_i W \overline{D_j W} - 3|W|^2\right)$$

<u>Review of IIB</u>: $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{cubic}}{P_2(\tau)}$

<u>Review IIA</u>: $W = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{linear}}{P_2(\tau)} + U \underset{\text{linear}}{P_3(\tau)}$

$$T^6 \longrightarrow \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB: ΛD, CS, K

$$K = -3\ln(-i(U-\bar{U})) - 3\ln(-i(\tau-\bar{\tau})) - \ln(-i(S-\bar{S}))$$

$$V = e^{K}\left(\sum_{ij} K^{i\bar{j}} D_i W \overline{D_j W} - 3|W|^2\right)$$

<u>Review of IIB</u>: $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{cubic}}{P_2(\tau)}$

<u>Review IIA</u>: $W = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{linear}}{P_2(\tau)} + U \underset{\text{linear}}{P_3(\tau)}$ <u>mirror!</u>

$$T^6 \to \underset{\alpha_i}{(T^2)} \times \underset{\beta_j}{(T^2)} \times \underset{\gamma_k}{(T^2)} \qquad z_1 = z_2 + \tau z_1$$

3 moduli: S, τ, U

IIB: AD, CS, K

$$K = -3\ln(-i(\rho-\bar\rho)) - 3\ln(-i(\tau-\bar\tau)) - \ln(-i(S-\bar S))$$

$$V = e^K\left(\sum_{i,j} K^{i\bar j} D_i W \overline{D_j W} - 3|W|^2\right)$$

<u>Review of IIB</u>: $W_{GKV} = \int (F_3 - S H_3) \wedge \Omega = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{cubic}}{P_2(\tau)}$

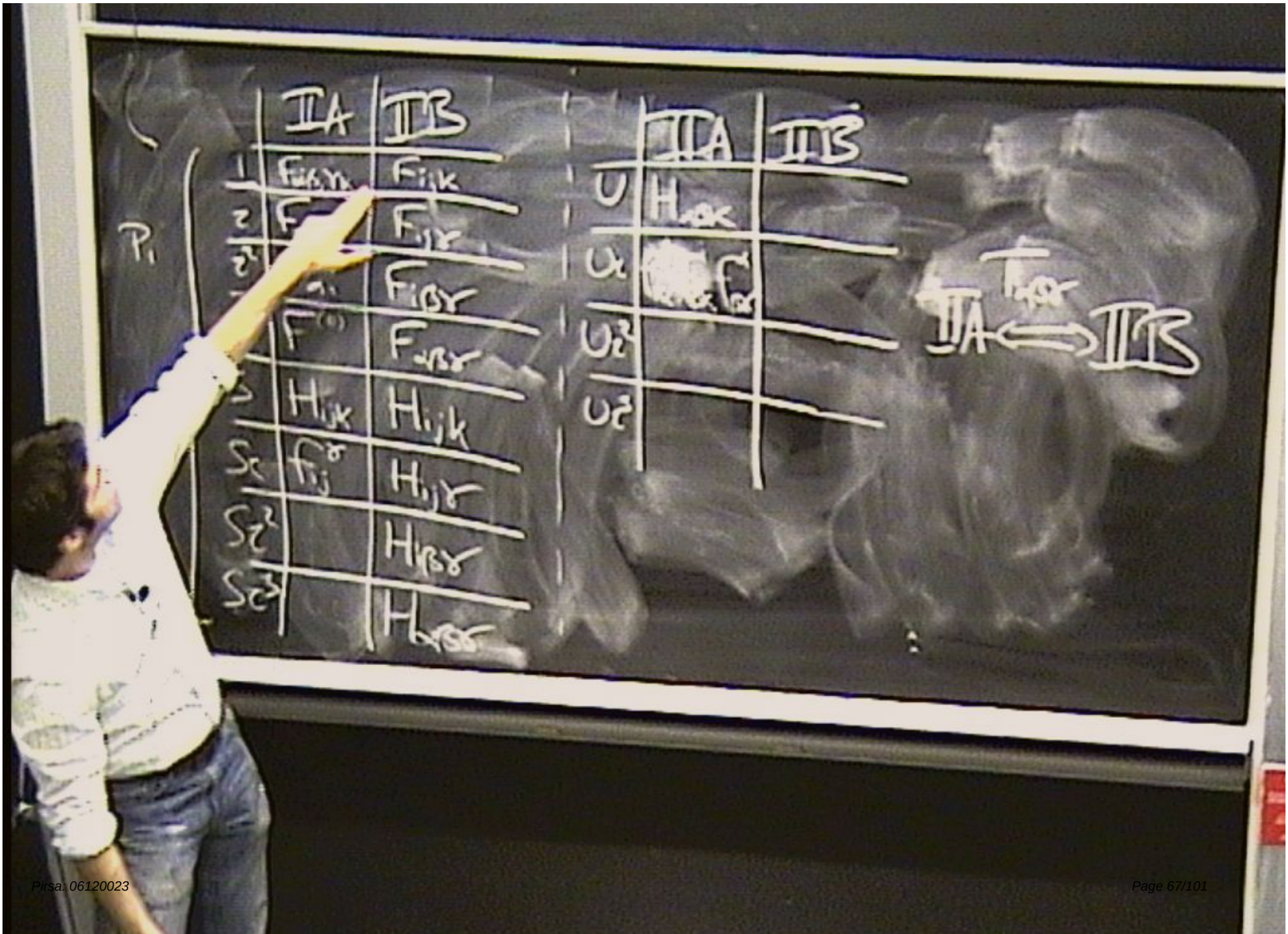
<u>Review IIA</u>: $W = \underset{\text{cubic}}{P_1(\tau)} + S \underset{\text{linear}}{P_2(\tau)} + U \underset{\text{linear}}{P_3(\tau)}$ ← cubic <u>mistakes!</u>

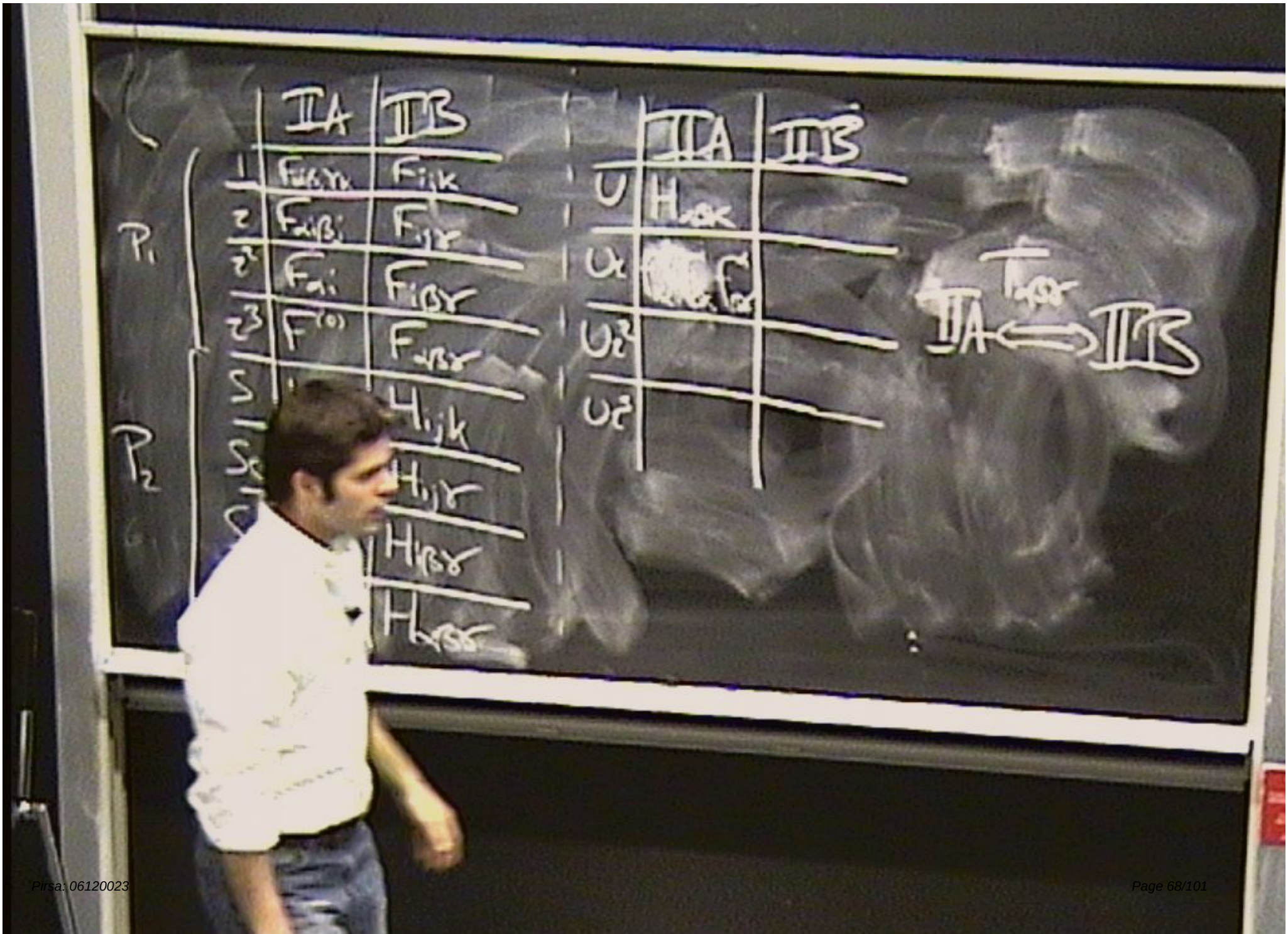
	IIA	IIB
1	$F_{\alpha\beta\gamma k}$	F_{ijk}
τ	$F_{\alpha\beta i}$	$F_{ij\gamma}$
τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
S	H_{ijk}	H_{ijk}
$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
$S\tau^2$		$H_{i\beta\gamma}$
$S\tau^3$		$H_{\alpha\beta\gamma}$

	IIA	IIB
U	$H_{\alpha\beta k}$	
$U\tau$	[illegible] $f_{\alpha\beta}$	
$U\tau^2$		
$U\tau^3$		

$\overline{T}_{\alpha\beta\gamma}$

IIA $\Longleftrightarrow$ IIB


IIA
IIB
IIA
IIB
IIA ⟺ IIB

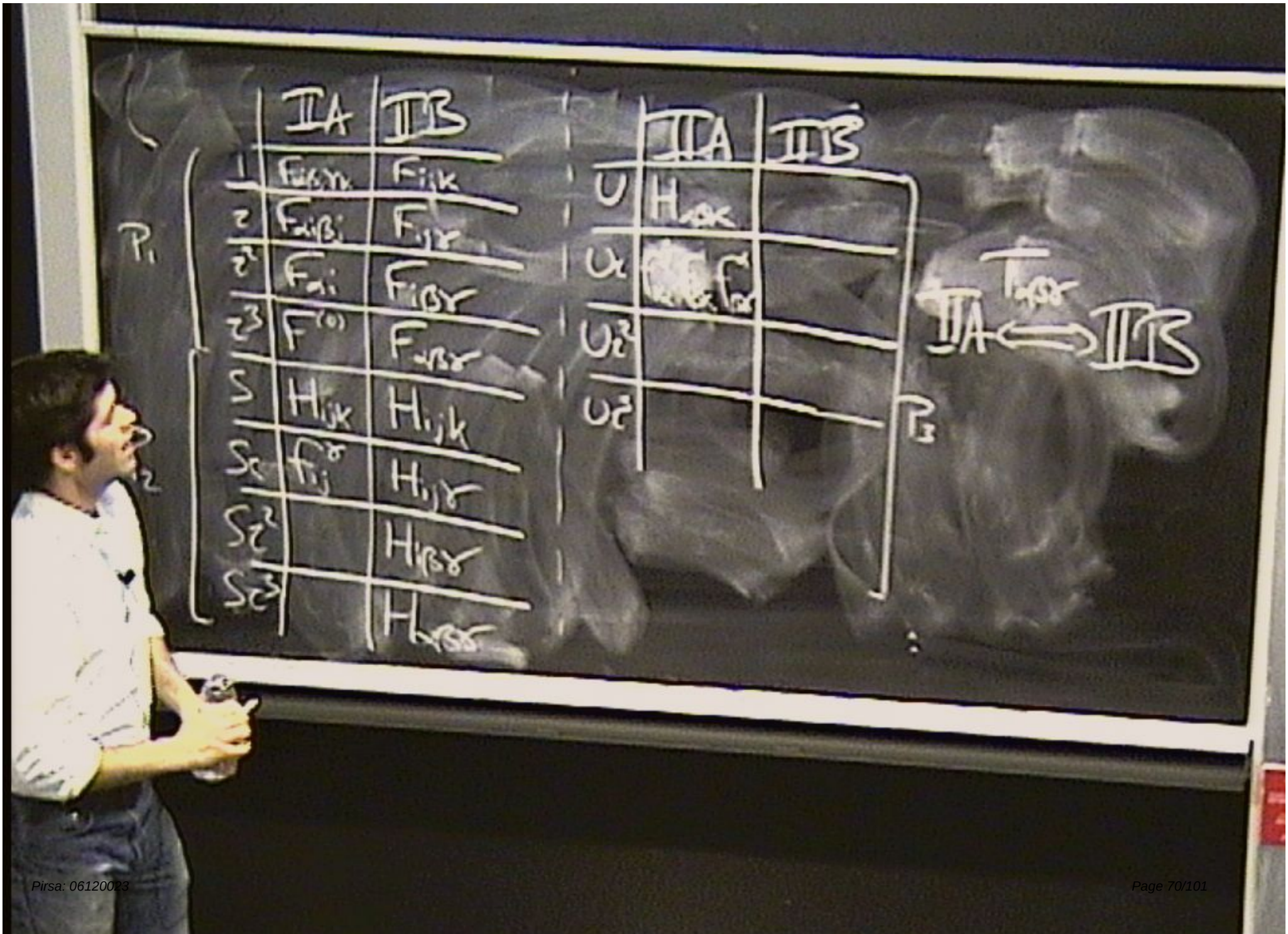

IIA
IIB
IIA
IIB
IIA ⟺ IIB

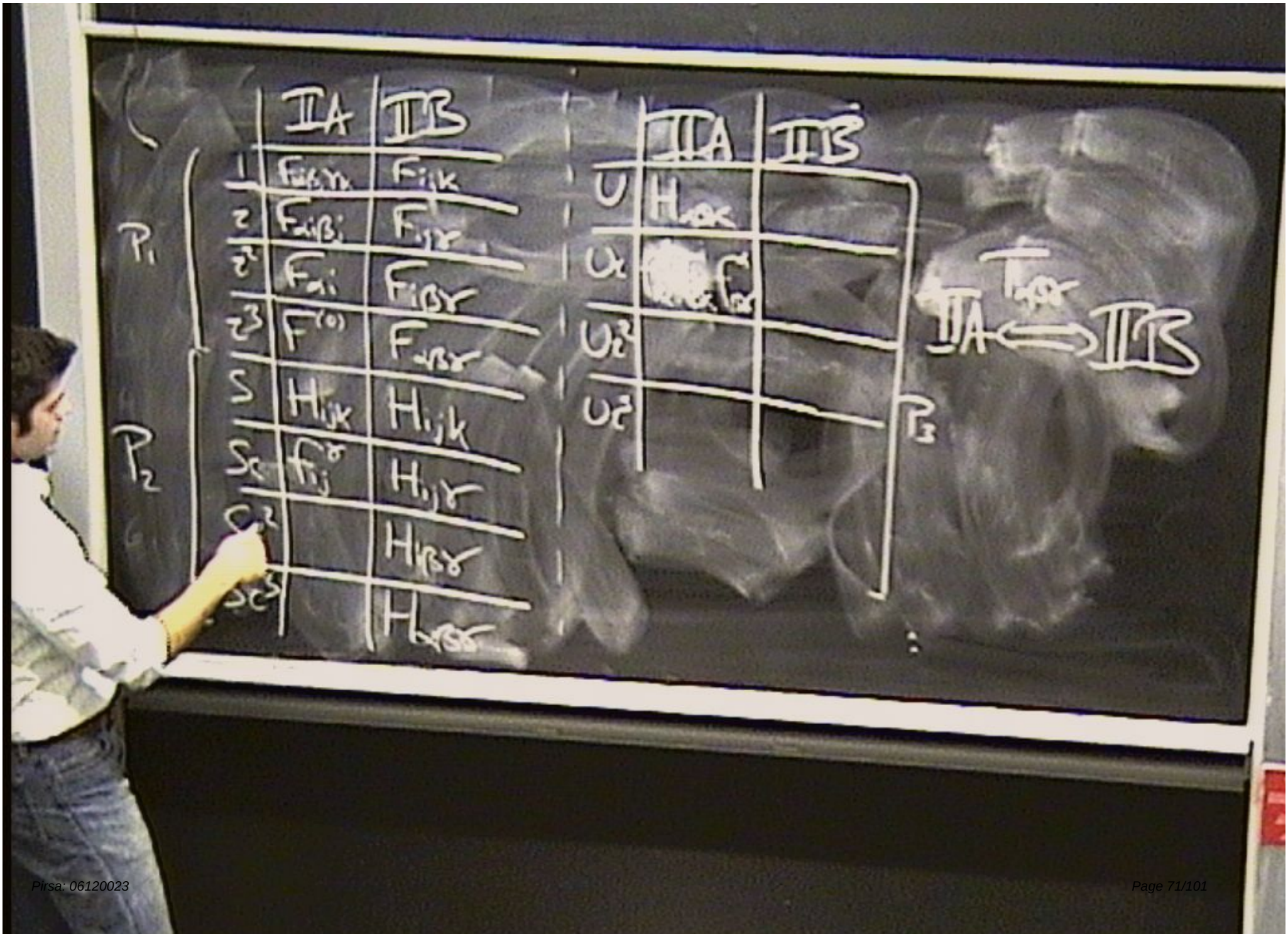
		IIA	IIB
P_1	1	$F_{\alpha\beta\gamma\delta}$	F_{ijk}
	2	$F_{\alpha\beta i}$	$F_{ij\gamma}$
	τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
	τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
P_2	S	H_{ijk}	H_{ijk}
	$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
	$S\tau^2$		$H_{i\beta\gamma}$
	$S\tau^3$		$H_{\alpha\beta\gamma}$

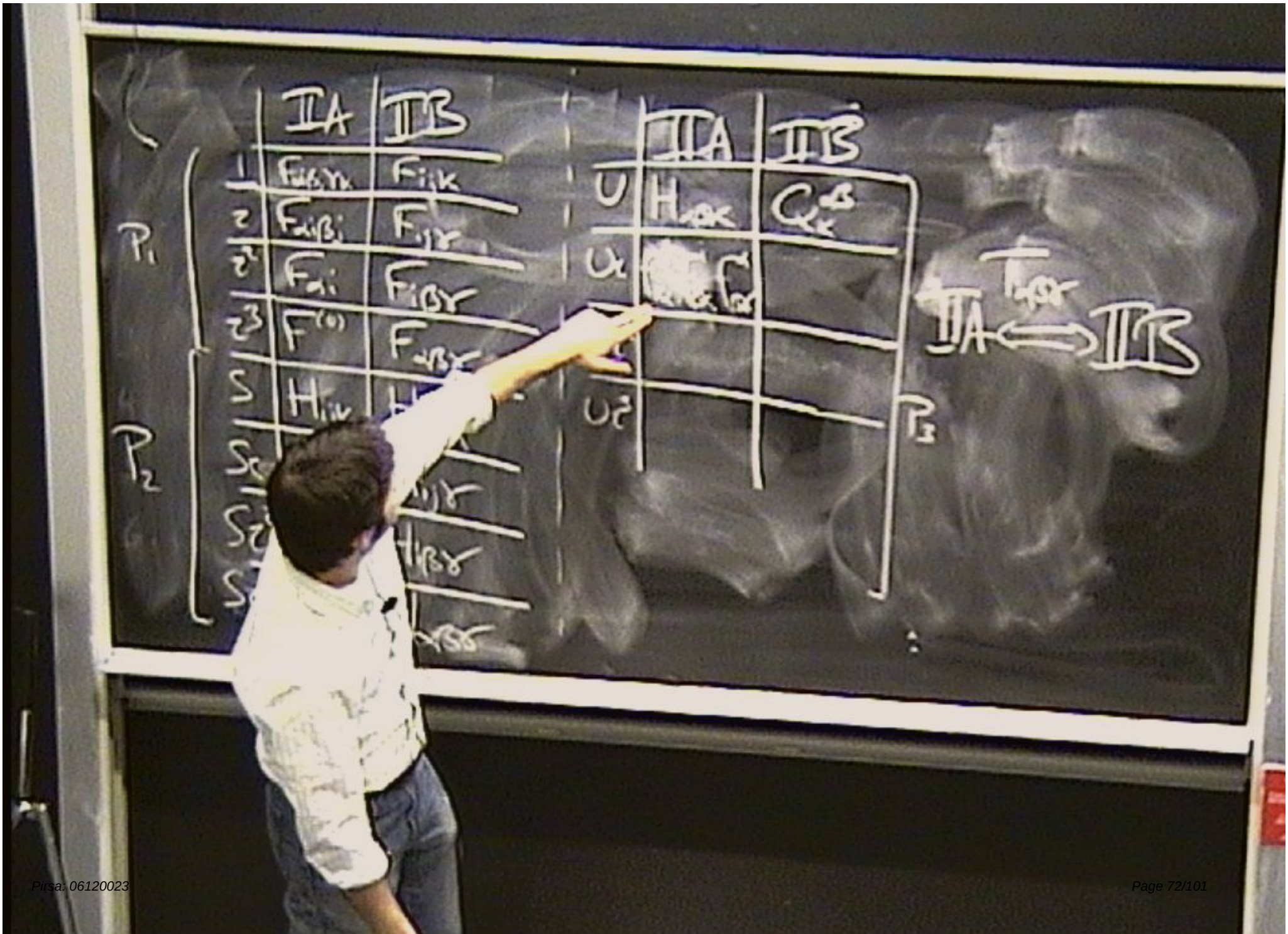
	IIA	IIB
U	$H_{\alpha\beta\gamma}$	
$U\tau$	[illegible] $f_{\alpha\beta}$	
$U\tau^2$		
$U\tau^3$		

$T_{\alpha\beta\gamma}$

IIA $\Longleftrightarrow$ IIB


IIA
IIB
IIA
IIB
IIA ⟺ IIB


IIA
IIB
IIA
IIB
IIA ⟺ IIB


IIA
IIB
IIA
IIB
IIA ⟺ IIB

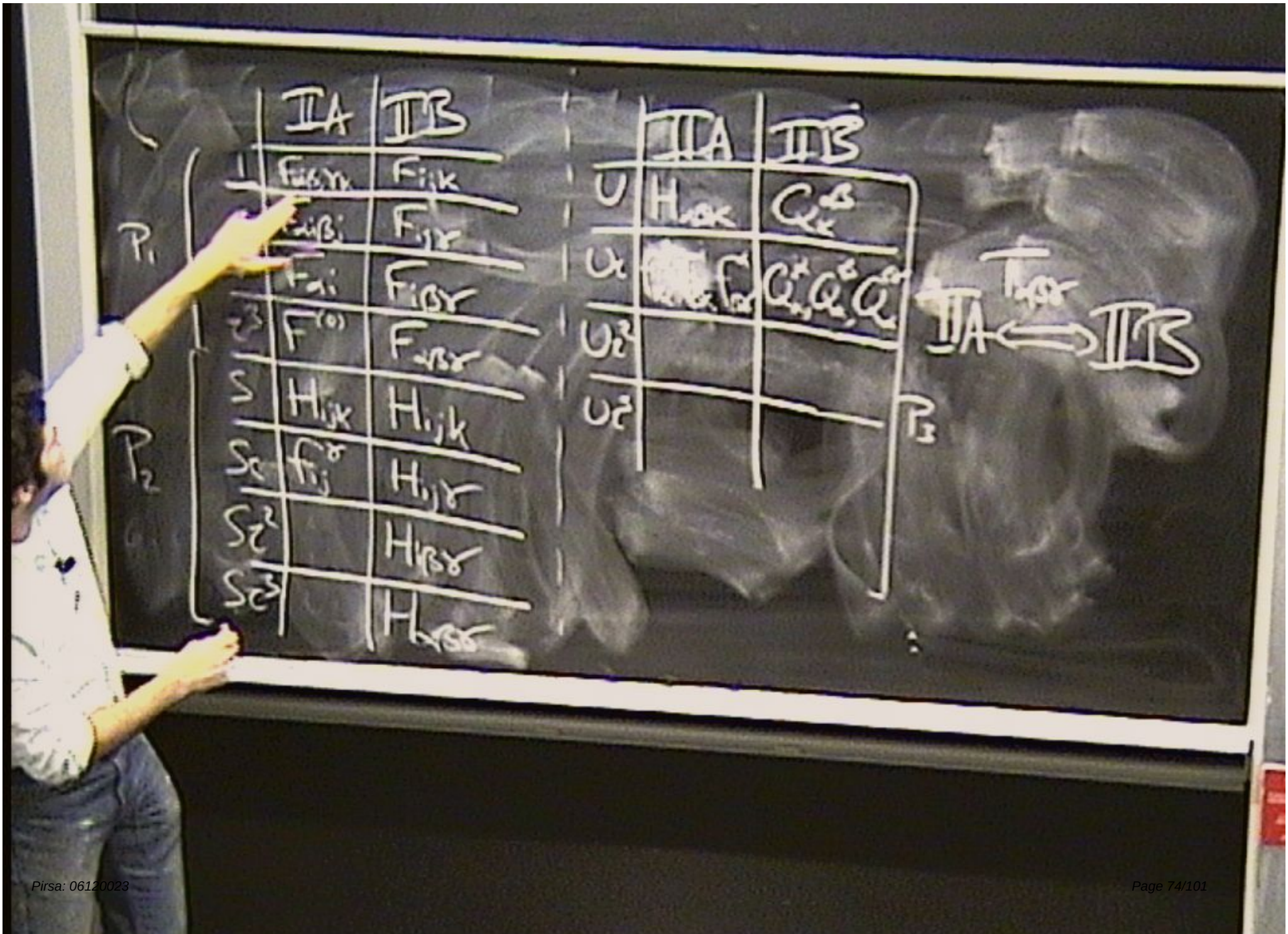
		IIA	IIB
P_1	1	$F_{\alpha\beta\gamma ijk}$	F_{ijk}
	τ	$F_{\alpha i\beta j}$	$F_{ij\gamma}$
	τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
	τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
P_2	S	H_{ijk}	H_{ijk}
	$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
	$S\tau^2$		$H_{i\beta\gamma}$
	$S\tau^3$		$H_{\alpha\beta\gamma}$

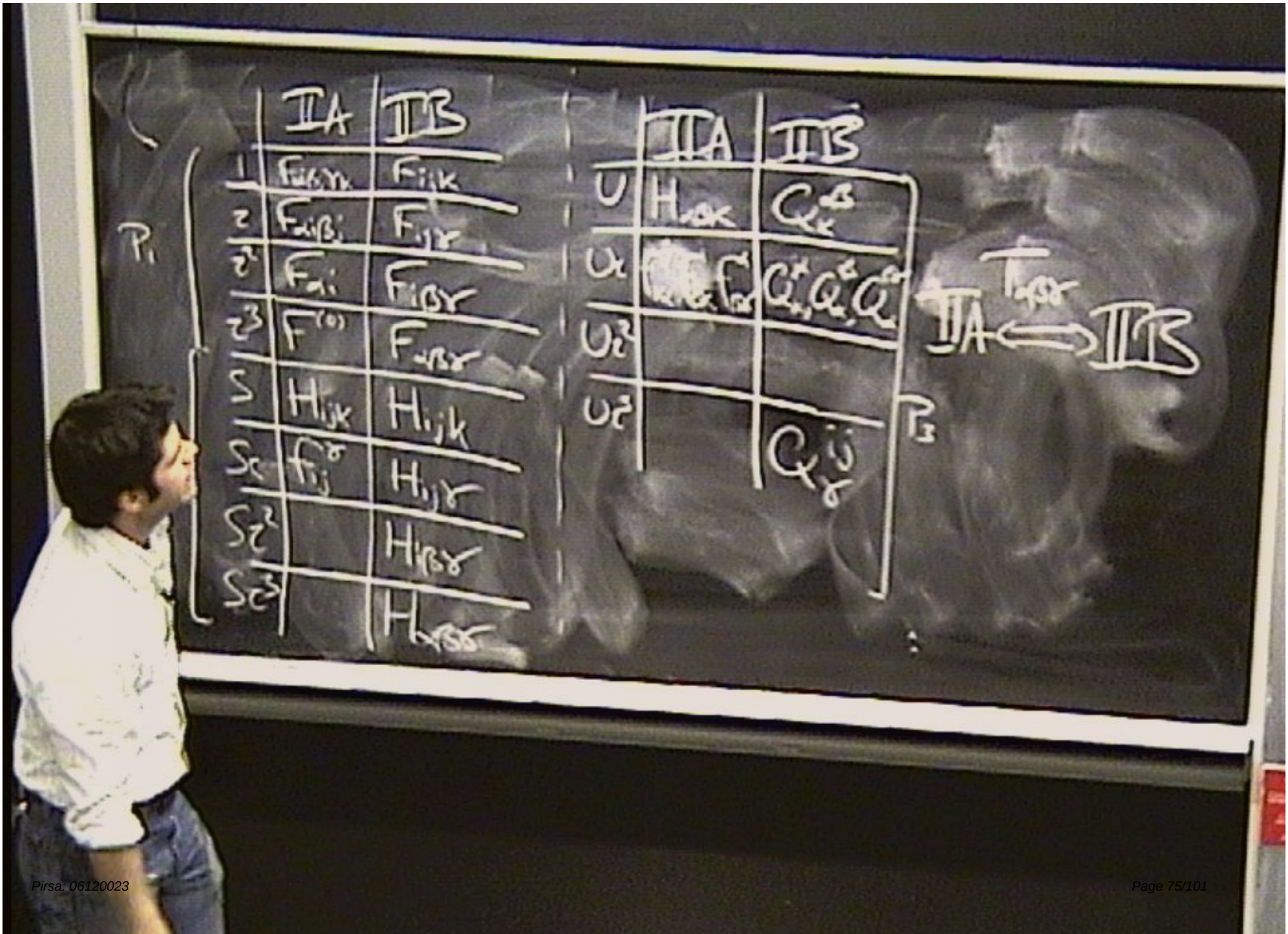
	IIA	IIB
U	$H_{\alpha\beta k}$	$Q_k^{\alpha\beta}$
$U\tau$	$f_{\alpha\beta}^{\gamma}$	$Q_\alpha^{\gamma}, Q_\beta^{\alpha}, Q_\gamma^{\alpha\beta}$
$U\tau^2$		
$U\tau^3$		

P_3

$\overline{T}_{\alpha\beta\gamma}$

IIA $\Longleftrightarrow$ IIB


IIA
IIB
IIA
IIB
IIA ⟺ IIB


IIA
IIB
IIA
IIB
IIA ⟺ IIB

		IIA	IIB
P_1	1	$F_{\alpha\beta\gamma}$, F_{ijk}	F_{ijk}
	2	$F_{\alpha i\beta j}$	$F_{ij\gamma}$
	τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
	τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
P_2	S	H_{ijk}	H_{ijk}
	$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
	$S\tau^2$		$H_{i\beta\gamma}$
	$S\tau^3$		$H_{\alpha\beta\gamma}$

	IIA	IIB	
U	$H_{\alpha\beta\gamma}$	Q_{α}^{β}	
$U\tau$	$f_{\alpha\beta}$	$Q_{\alpha}^{\beta}, Q_{\alpha}^{\beta}, Q_{\alpha}^{\beta}$	P_3
$U\tau^2$		$Q_{\gamma}^{\beta i}, \ldots$	
$U\tau^3$		Q_{γ}^{ij}	

$\overline{T}_{\alpha\beta\gamma}$

IIA $\Longleftrightarrow$ IIB

		IIA	IIB
P_1	1	$F_{\alpha\beta\gamma k}$	F_{ijk}
	2	$F_{\alpha i\beta j}$	$F_{ij\gamma}$
	τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
	τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
P_2	S	H_{ijk}	H_{ijk}
	$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
	$S\tau^2$	$Q_i^{\beta\gamma}$	$H_{i\beta\gamma}$
	$S\tau^3$		$H_{\alpha\beta\gamma}$

	IIA	IIB
U	$H_{\alpha\beta k}$	$Q_k^{\alpha\beta}$
$U\tau$	$f_{\alpha\beta}$	$Q_{\alpha i}^{\beta}, Q_{\alpha i}^{\alpha}, Q_{\alpha}^{\alpha\beta}$
$U\tau^2$	$Q_{\alpha}^{\beta i} \cdots$	$Q_{\gamma i}^{\alpha i} \cdots$
$U\tau^3$		Q_{γ}^{ij}

P_3

$\Gamma_{\alpha\beta\gamma}$

IIA $\Longleftrightarrow$ IIB

		IIA	IIB
P_1	1	$F_{\alpha\beta\gamma}$	F_{ijk}
	τ	$F_{\alpha\beta i}$	$F_{ij\gamma}$
	τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
	τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
P_2	S	H_{ijk}	H_{ijk}
	$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
	$S\tau^2$	$Q_i^{\beta\gamma}$	$H_{i\beta\gamma}$
	$S\tau^3$	$R^{\alpha\beta\gamma}$	$H_{\alpha\beta\gamma}$

	IIA	IIB
U	$H_{\alpha\beta\gamma}$	Q_α^{β}
$U\tau$	$F_{\alpha\beta}$	$Q_{\alpha_1}^{\beta_1}, Q_{\alpha_2}^{\beta_2}, Q_{\alpha_3}^{\beta_3}$
$U\tau^2$	$Q_{\alpha_1}^{\beta_1} \cdots$	$Q_{\gamma_1}^{\beta_1} \cdots$
$U\tau^3$	$R^{ij\gamma}$	Q_γ^{ij}

P_3

$\overline{T}_{\alpha\beta\gamma}$

IIA $\longleftrightarrow$ IIB

$$T_y: \begin{cases} ds^2 = \dfrac{1}{1+N^2z^2}\left(dx^2+dy^2\right) + dz^2 \\ B_{xy} = \dfrac{Nz}{1+N^2z^2} \end{cases}$$

What is this?

$$\rho = B + iV = \frac{1}{1+N^2z^2}\left(Nz + i\right)$$

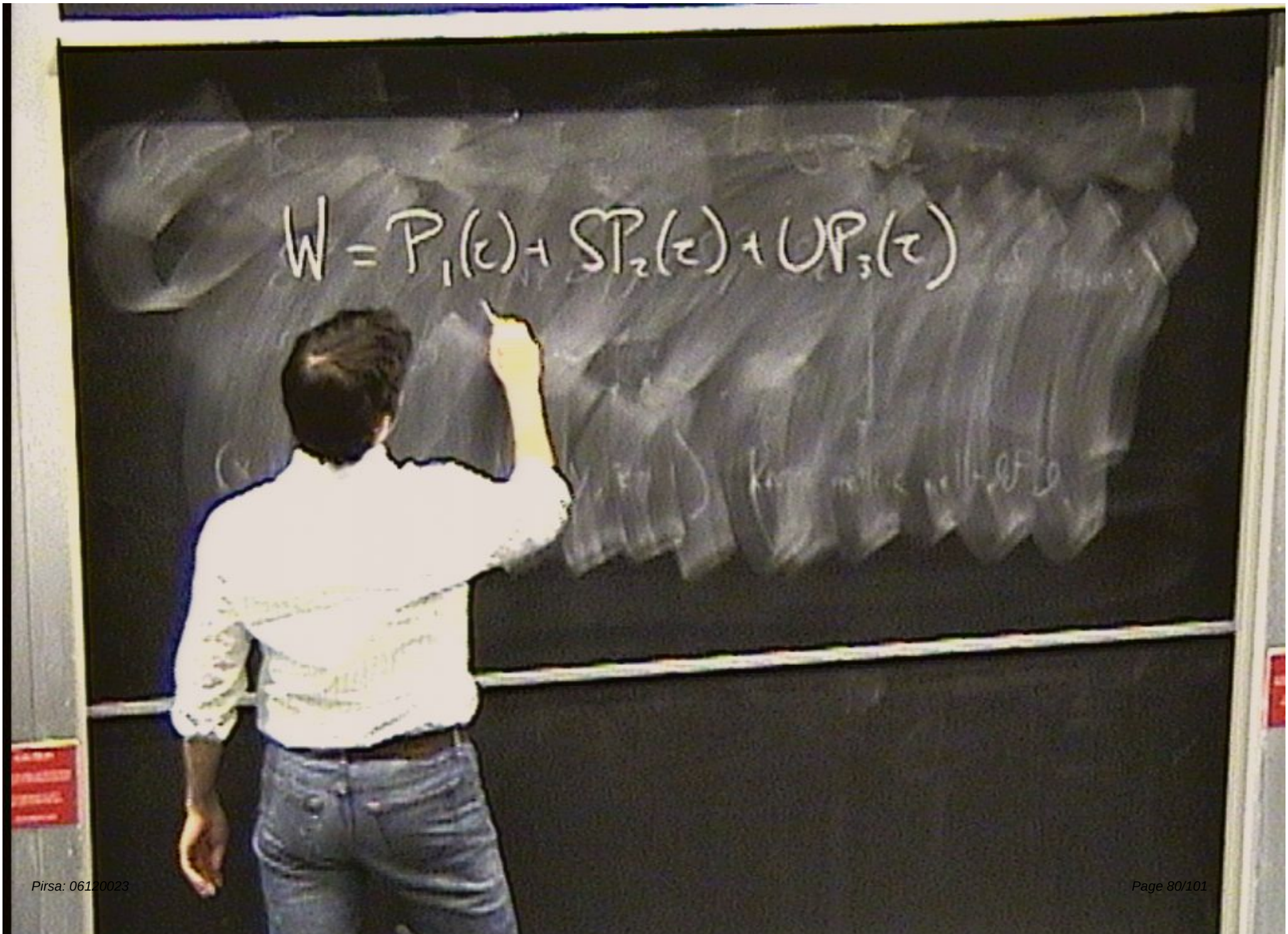
$$\frac{1}{\rho} = Nz - i$$

$$\boxed{\text{As } z \to z+1, \quad \frac{1}{\rho} \to \frac{1}{\rho} + N.}$$

Nongeometric!

B & G mix.

$$H_{xyz} \xleftrightarrow{T_x} F^x_{yz} \xleftrightarrow{T_y} Q^{xy}_z \xleftrightarrow{T_z} R^{xyz}$$


W = P1(τ) + SP2(τ) + UP3(τ)

$$W = P_1(\tau) + S P_2(\tau) + U P_3(\tau)$$

cubic

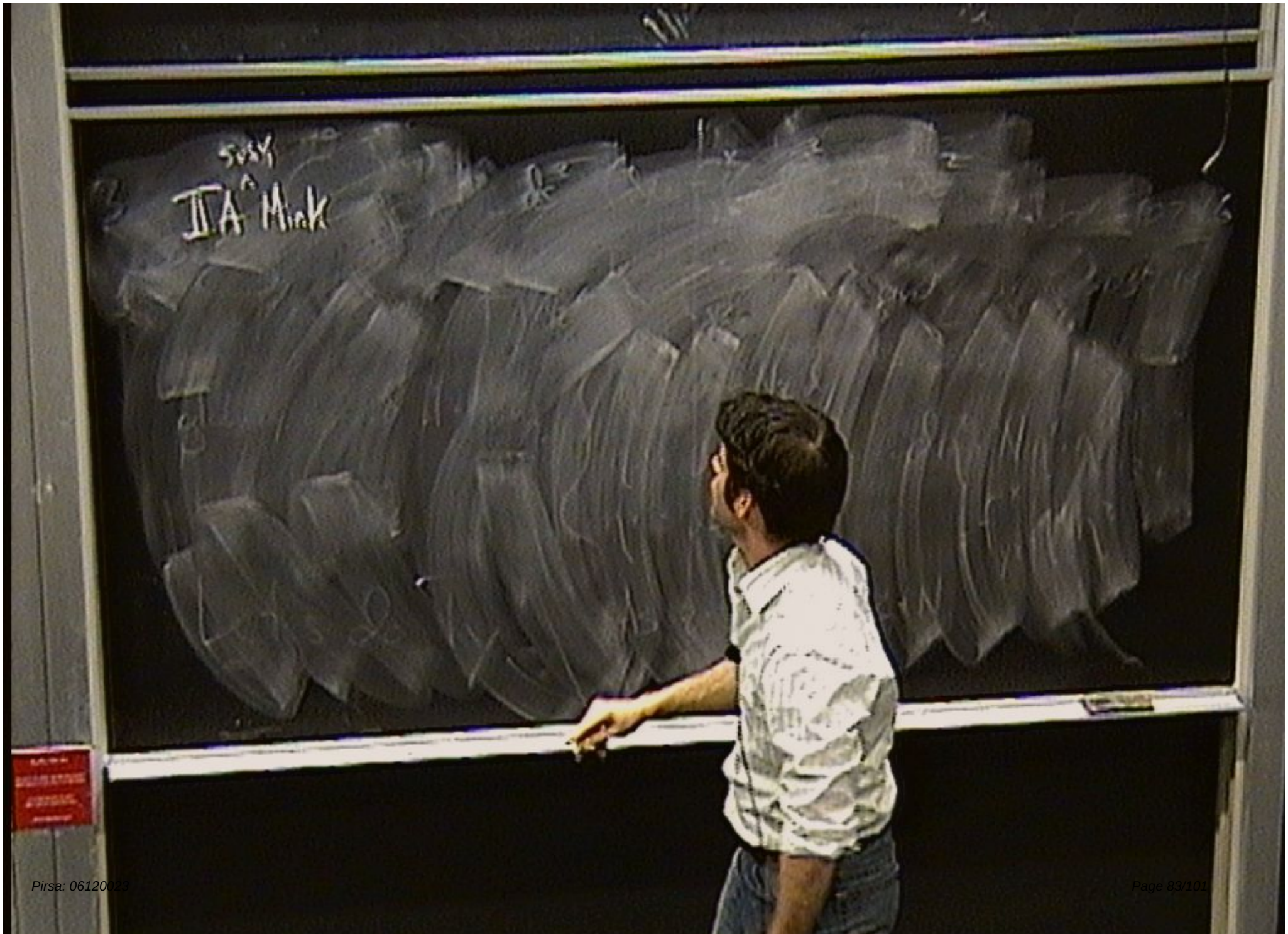
		IIA	IIB
P_1	1	$F_{\alpha\beta\gamma k}$	F_{ijk}
	τ	$F_{\alpha i\beta i}$	$F_{ij\gamma}$
	τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
	τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
P_2	S	H_{ijk}	H_{ijk}
	$S\tau$	f_{ij}^{σ}	$H_{ij\gamma}$
	$S\tau^2$	$Q_i^{\beta\gamma}$	$H_{i\beta\gamma}$
	$S\tau^3$	$R^{\alpha\beta\gamma}$	$H_{\alpha\beta\gamma}$

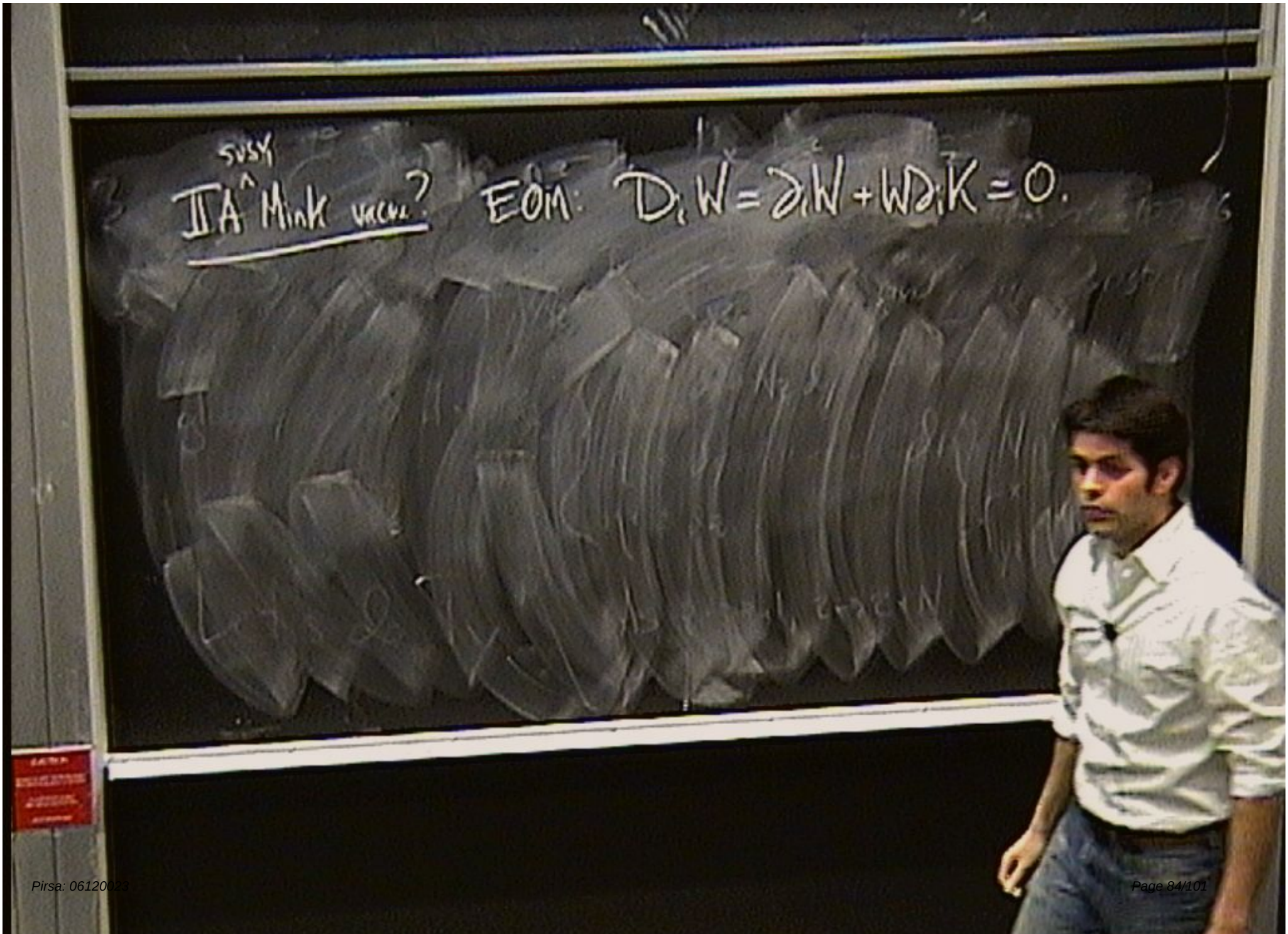
	IIA	IIB
U	$H_{\alpha\beta k}$	$Q_k^{\alpha\beta}$
$U\tau$	$f_{\beta\gamma}^{\alpha}$	$Q_k^{\alpha}, Q_k^{\beta}, Q_k^{\gamma}$
$U\tau^2$	$Q_{\beta}^{\alpha\gamma}, \ldots$	$Q_{\gamma}^{\beta i}, \ldots$
$U\tau^3$	$R^{ij\gamma}$	Q_{γ}^{ij}

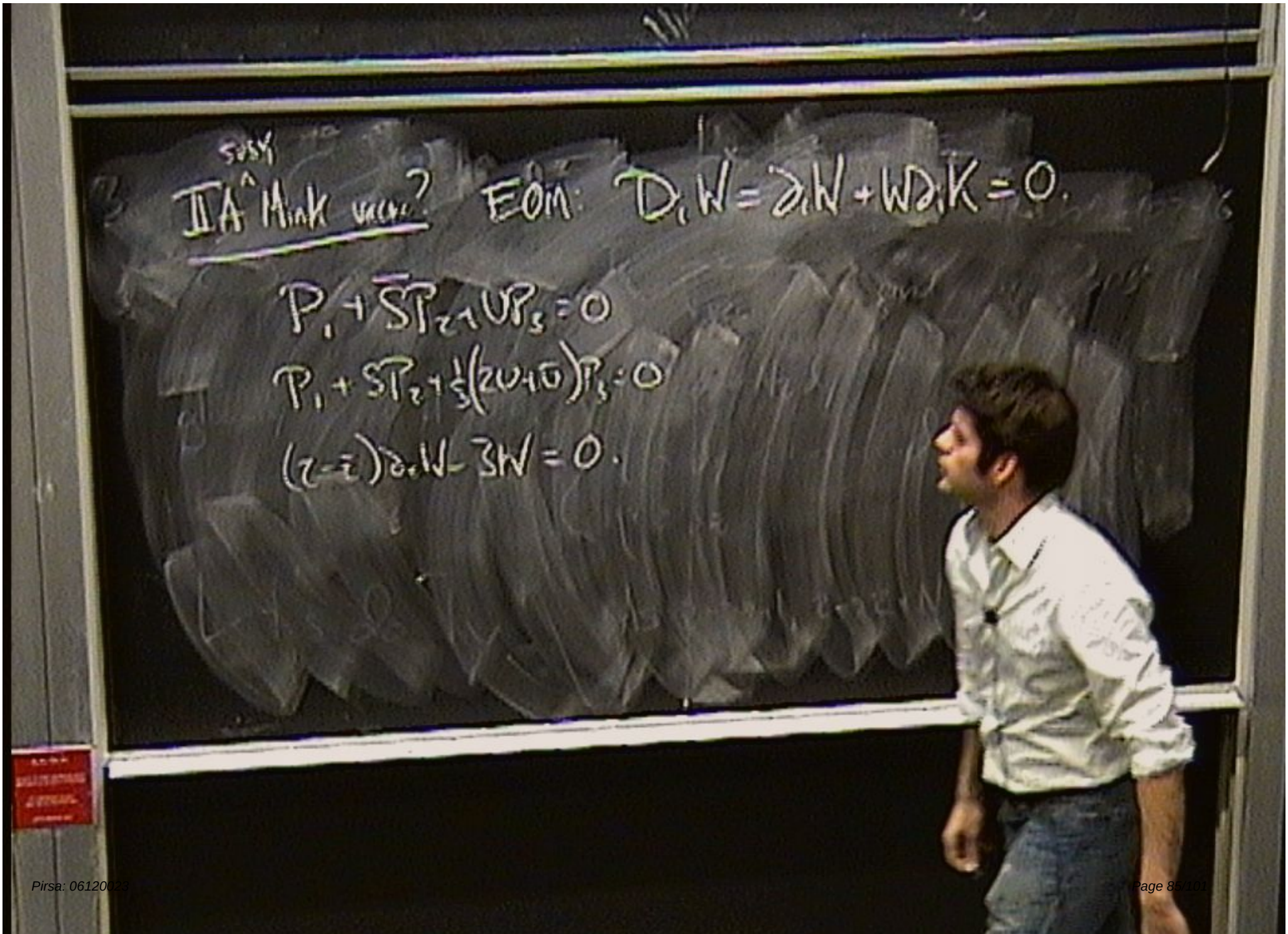
P_3

$T_{\alpha\beta\gamma}$

IIA $\Longleftrightarrow$ IIB


SUSY
IIA Mink


SUSY
IIA Mink vacua?
EOM: $D_i W = \partial_i W + W \partial_i K = 0.$


SUSY
IIA Mink vacua?
EOM: $D_i W = \partial_i W + W \partial_i K = 0.$
$P_1 + \bar{S} P_2 + U P_3 = 0$
$P_1 + S P_2 + \frac{1}{S}(2U + \bar{U}) P_3 = 0$
$(\tau - \bar{\tau}) \partial_\tau W - 3W = 0.$

IIA SUSY Mink vacua? EOM: $D_i W = \partial_i W + W \partial_i K = 0.$

$$\begin{cases} P_1 + \bar{S} P_2 + U P_3 = 0 \Rightarrow W + (\bar{S} - S) P_2 = 0 \\ P_1 + S P_2 + \frac{1}{3}(2U + \bar{U}) P_3 = 0 \\ (\tau - \bar{\tau}) \partial_\tau W - 3W = 0. \end{cases}$$

IIA SUSY Mink vacua? EOM: $D_i W = \partial_i W + W \partial_i K = 0.$

$$\begin{cases} P_1 + \bar{S} P_2 + U P_3 = 0 \Rightarrow \cancel{W}^{\,0} + (\bar{S} - S) P_2 = 0 \\ P_1 + S P_2 + \frac{1}{3}(2U + \bar{U}) P_3 = 0 \\ (\tau - \bar{\tau}) \partial_\tau W - 3 W = 0. \end{cases}$$

IIA SUSY Mink vacua? EOM: $D_i W = \partial_i W + W \partial_i K = 0.$

$$\begin{cases} P_1 + \bar{S} P_2 + U P_3 = 0 \\ P_1 + S P_2 + \frac{1}{3}(2U + \bar{U}) P_3 = 0 \\ (\tau - \bar{\tau}) \partial_\tau W - 3W = 0. \end{cases}$$

$\Rightarrow \cancel{W}^{\,0} + (\bar{S} - S) P_2 = 0$

$(\mathrm{Im}\, S) P_2 = 0.$

IIA SUSY Mink vacua? EOM: $D_i W = \partial_i W + W \partial_i K = 0.$

$$\begin{cases} P_1 + \bar{S} P_2 + U P_3 = 0 \\ P_1 + S P_2 + \frac{1}{2}(2U + \bar{U}) P_3 = 0 \\ (\tau - \bar{\tau}) \partial_\tau W - 3 K W = 0. \end{cases}$$

$$\Rightarrow \quad \cancel{W}^{\,0} + (\bar{S} - S) P_2 = 0$$

$$(\mathrm{Im}\, S) P_2 = 0.$$

IIA SUSY Mink vacua? EOM: $D_i W = \partial_i W + W \partial_i K = 0.$

$$\begin{cases} P_1 + \bar{S} P_2 + U P_3 = 0 \\ P_1 + S P_2 + \frac{1}{3}(2U + \bar{U}) P_3 = 0 \\ (\tau - \bar{\tau}) \partial_\tau W - 3W = 0. \end{cases}$$

$\Rightarrow \cancel{W}^{\,0} + (\bar{S} - S) P_2 = 0$

$(\mathrm{Im}\, S) P_2 = 0.$

$\downarrow$

$a + b\tau = 0$

SUSY

IIA Mink vacua? EOM: $D_i W = \partial_i W + W \partial_i K = 0.$

$$\begin{cases} P_1 + \bar{S} P_2 + U P_3 = 0 \\ P_1 + S P_2 + \frac{1}{3}(2U + \bar{U}) P_3 = 0 \\ (\tau - \bar{\tau}) \partial_\tau W - 3W = 0. \end{cases}$$

$\Rightarrow \cancel{W}^{\,0} + (\bar{S} - S) P_2 = 0$

$(\mathrm{Im}\, S) P_2 = 0.$

$\downarrow$

$a + b\tau = 0$

$\tau = -a/b.$ ⊗

	IIA	IIB
1	$F_{\alpha\beta\gamma k}$	F_{ijk}
τ	$F_{\alpha\beta i}$	$F_{ij\gamma}$
τ^2	$F_{\alpha i}$	$F_{i\beta\gamma}$
τ^3	$F^{(0)}$	$F_{\alpha\beta\gamma}$
S	H_{ijk}	H_{ijk}
$S\tau$	f_{ij}^{γ}	$H_{ij\gamma}$
$S\tau^2$	$Q_i^{\beta\gamma}$	$H_{i\beta\gamma}$
$S\tau^3$	$R^{\alpha\beta\gamma}$	$H_{\alpha\beta\gamma}$

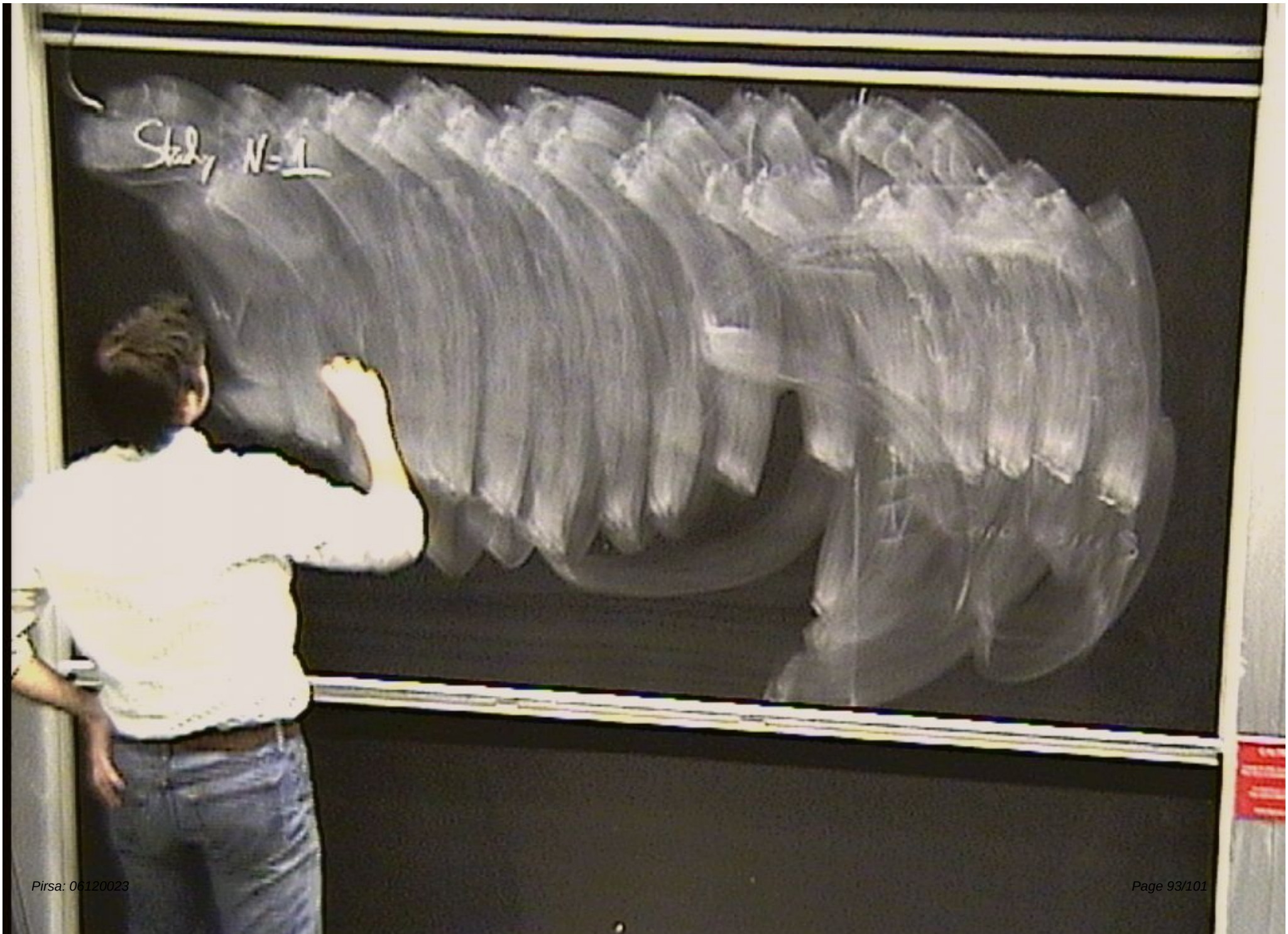
P_1

P_2

	IIA	IIB
U	$H_{\alpha\beta k}$	$Q_k^{\alpha\beta}$
$U\tau$	$f_{\alpha\beta}^{\gamma}$	$Q_k^{ij}, Q_k^{\beta}, Q_{\alpha}^{\beta\gamma}$
$U\tau^2$	$Q_{\beta}^{\alpha\gamma}, \ldots$	$Q_{\gamma}^{\beta i}, \ldots$
$U\tau^3$	$R^{ij\gamma}$	Q_{γ}^{ij}

P_3

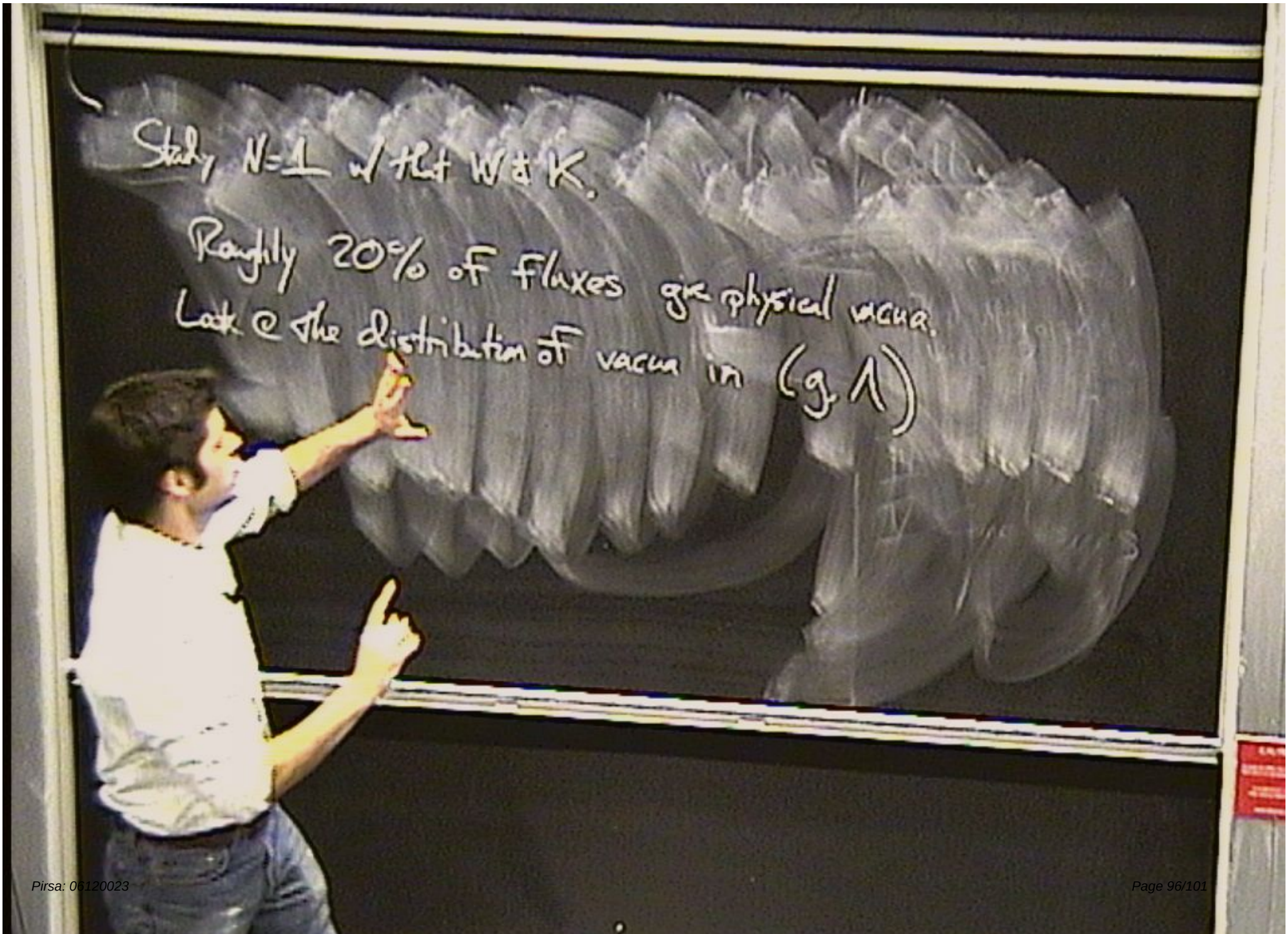
$$\text{IIA} \xleftrightarrow{T_{\alpha\beta\gamma}} \text{IIB}$$


Stably N=1

Study N=1 w/ that W & K.

Study N=1 w/ that W & K.

Roughly 20% of fluxes give physical vacua.


Study N=1 w/ that W & K.
Roughly 20% of fluxes are physical vacua.
Look @ the distribution of vacua in (g, Λ)

Stably N=1 w/ that W & K.

Roughly 20% of fluxes give physical vacua.

Look @ the distribution of vacua in (g, Λ) space

$\Rightarrow$ Looks like there are an ∞ # of vacua in

<u>any</u> finite region of (g, Λ) space.

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