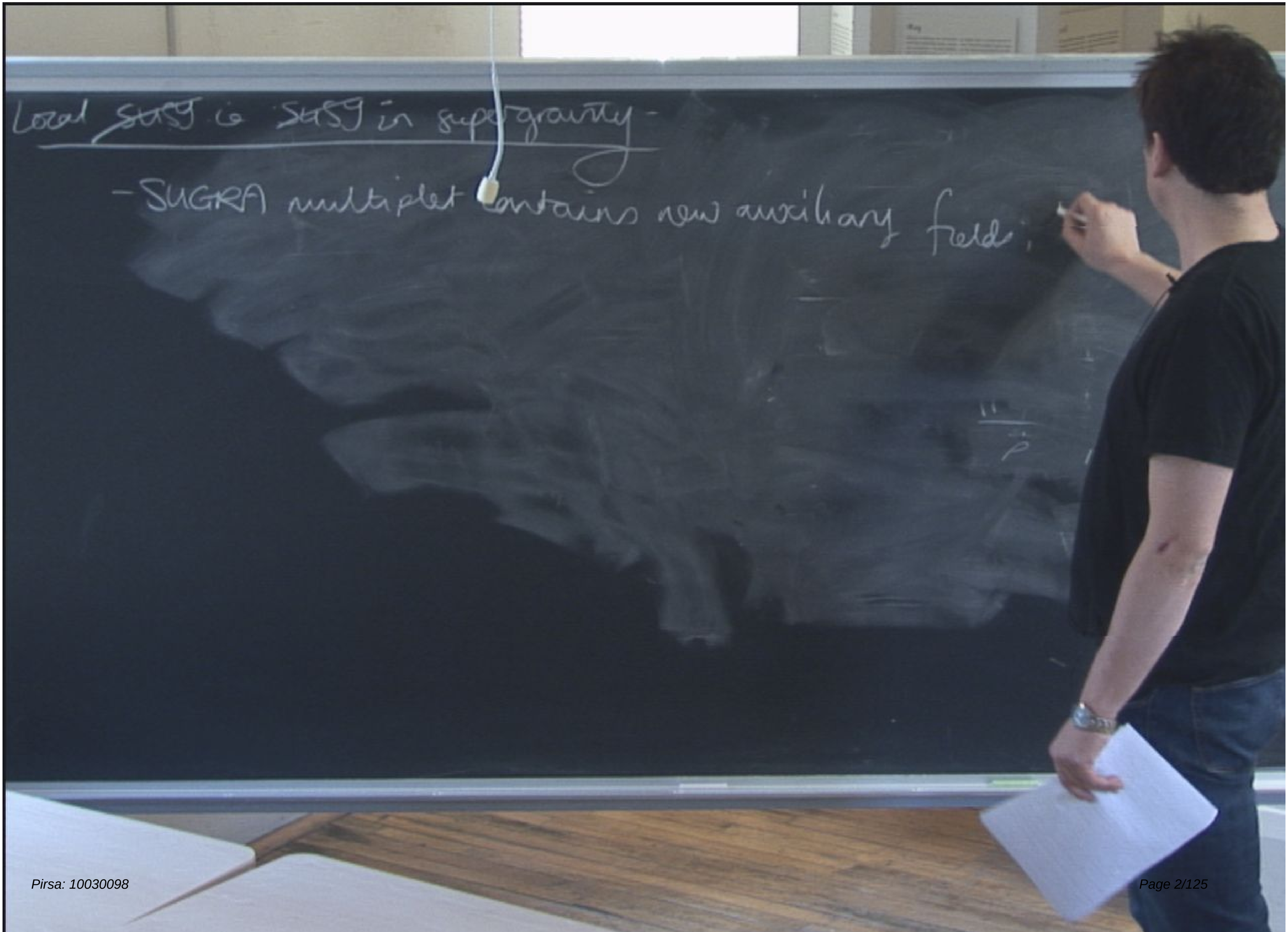
Title: Explorations in Particle Theory (PHYS 646) - Lecture 13

Date: Mar 30, 2010 10:10 AM

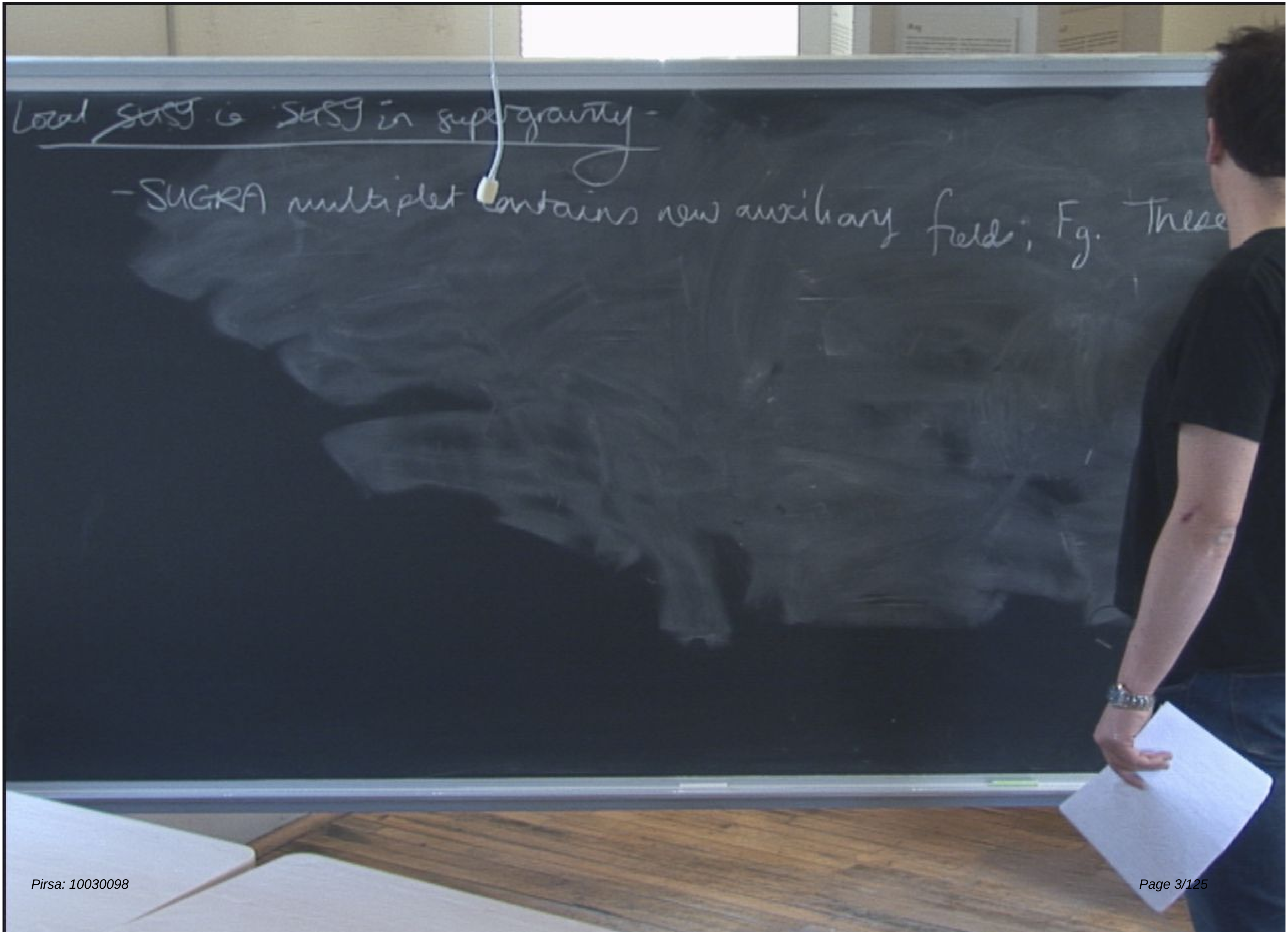
URL: http://pirsa.org/10030098

Abstract:



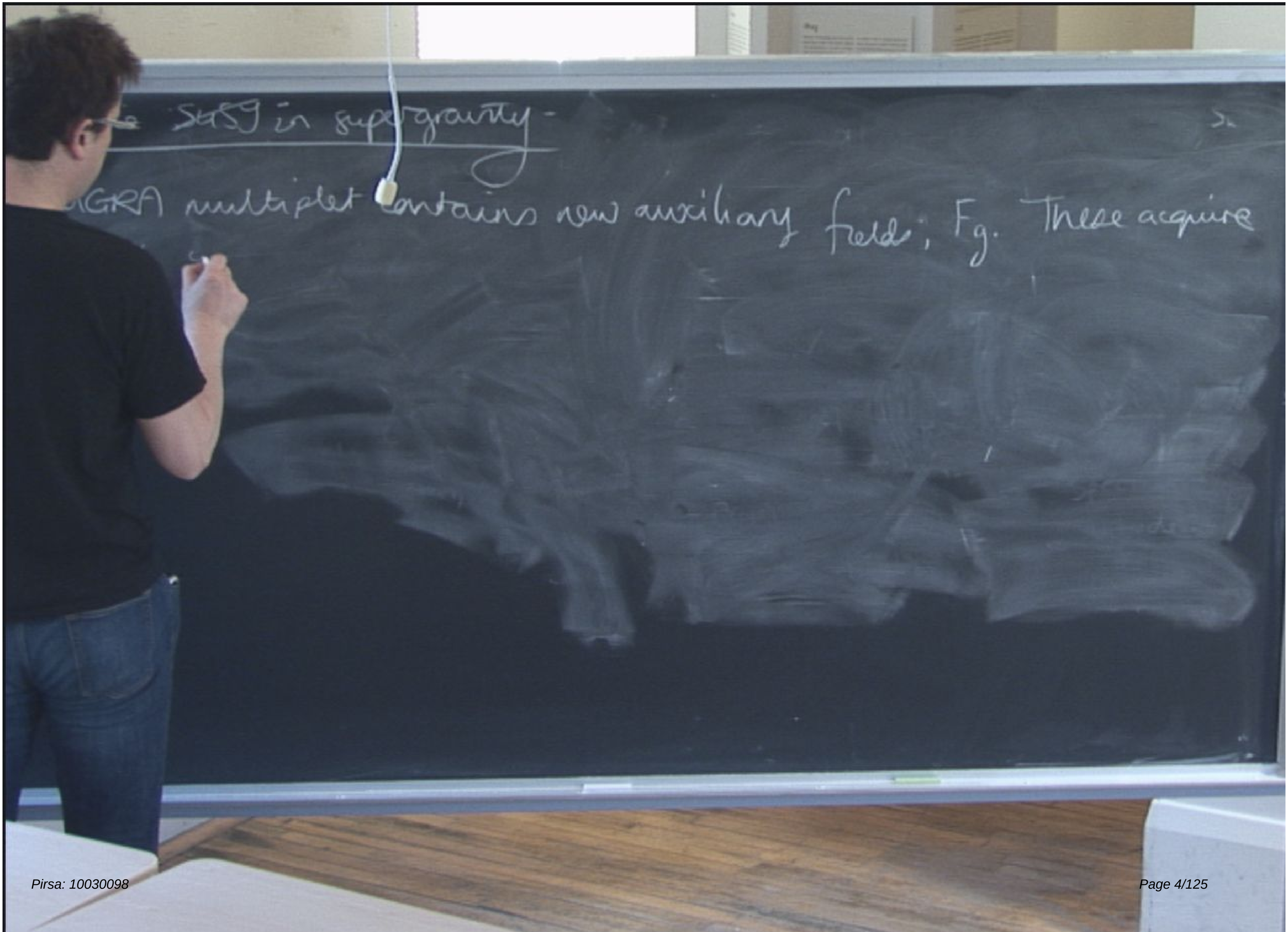
Local SUSY is SUSY in supergravity -

- SUGRA multiplet contains new auxiliary field:



Local SUSY is SUSY in supergravity.

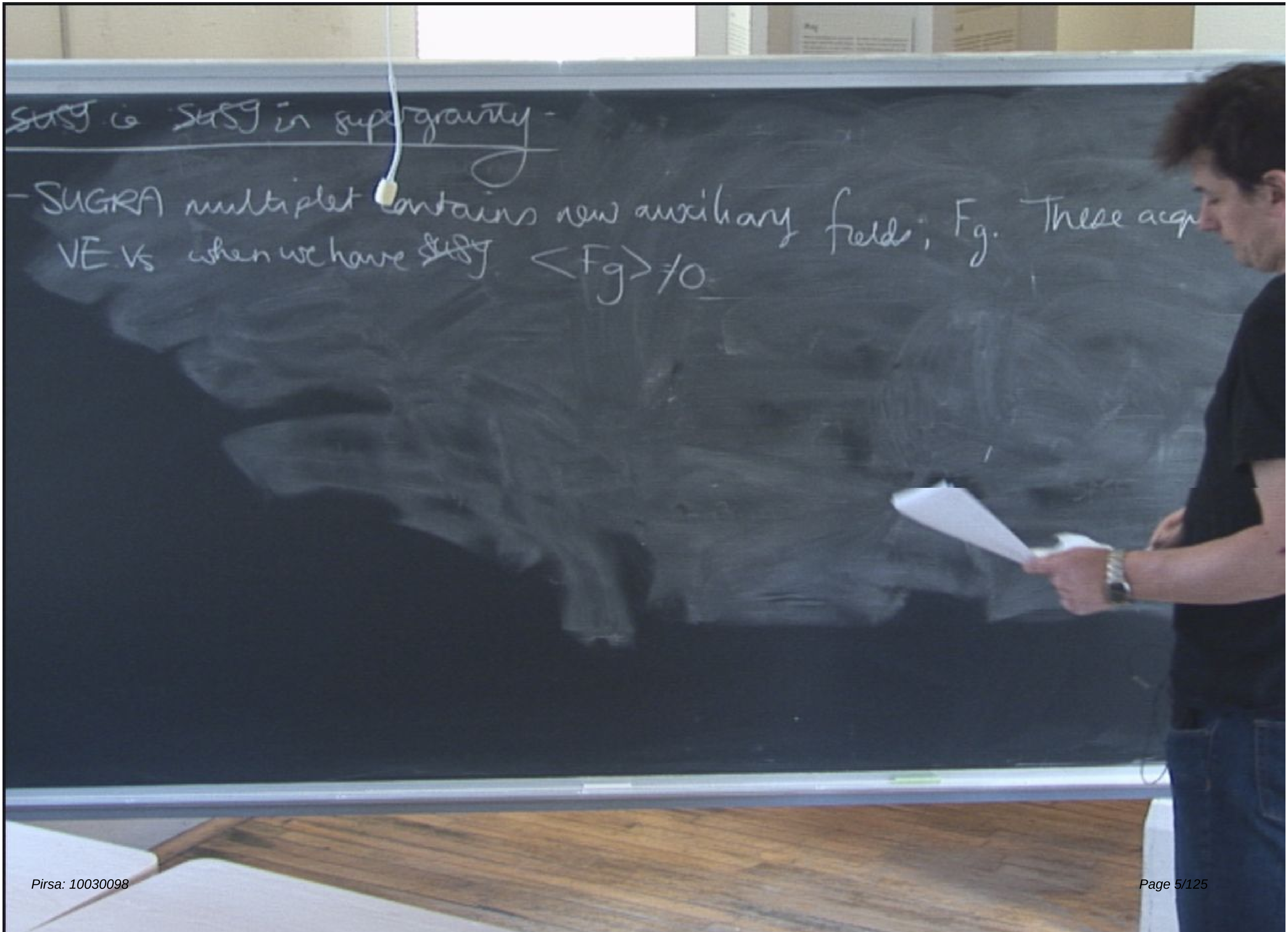
- SUGRA multiplet contains new auxiliary field; F_g. These



3.

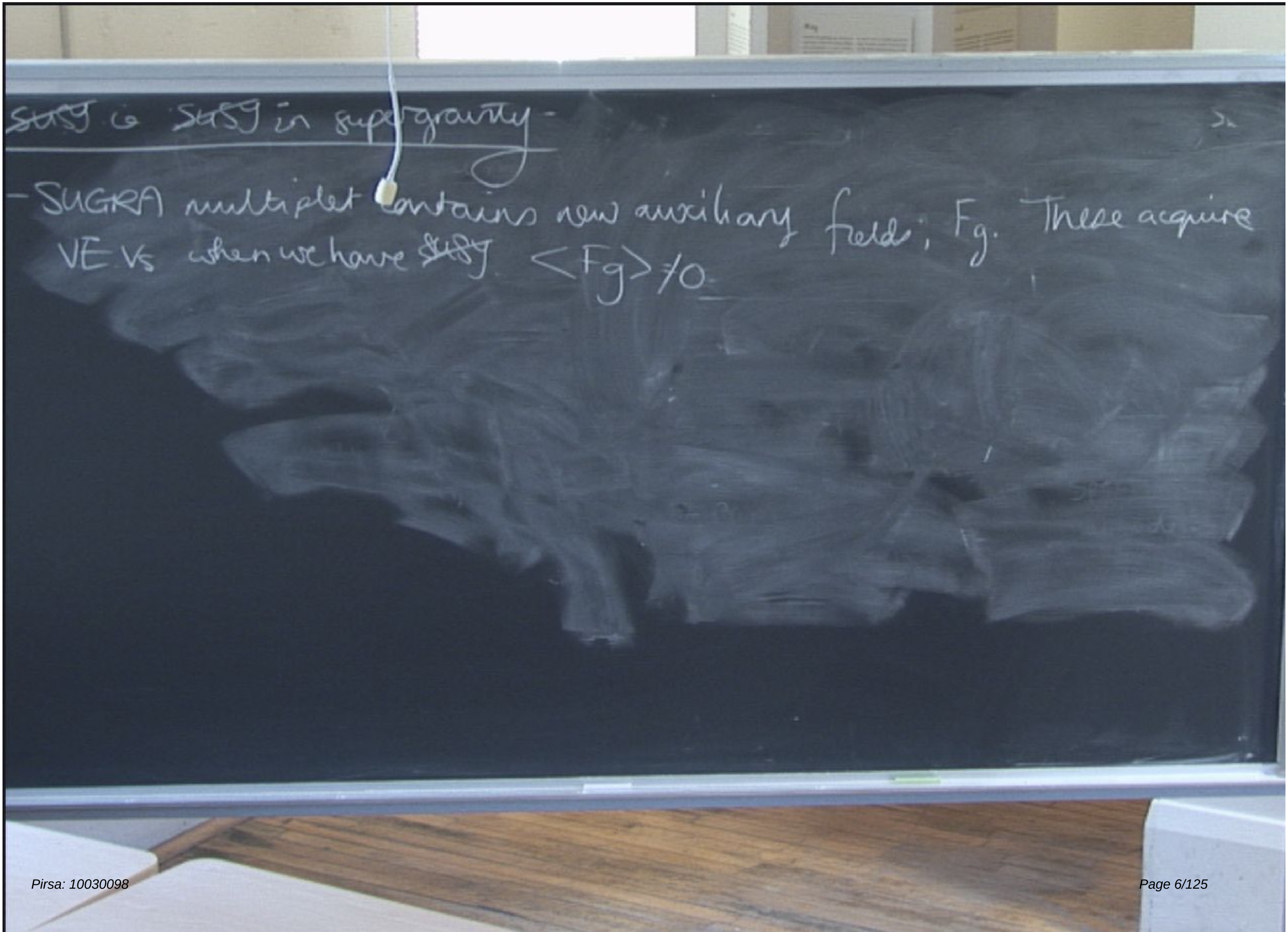
e SUSY in supergravity -

GRA multiplet contains new auxiliary fields; F_g. These acquire



~~SUSY~~ i.e. ~~SUSY~~ in supergravity -

- SUGRA multiplet contains new auxiliary fields; F_g. These acq
  VE.Vs when we have ~~SUSY~~ $\langle F_g \rangle \neq 0$



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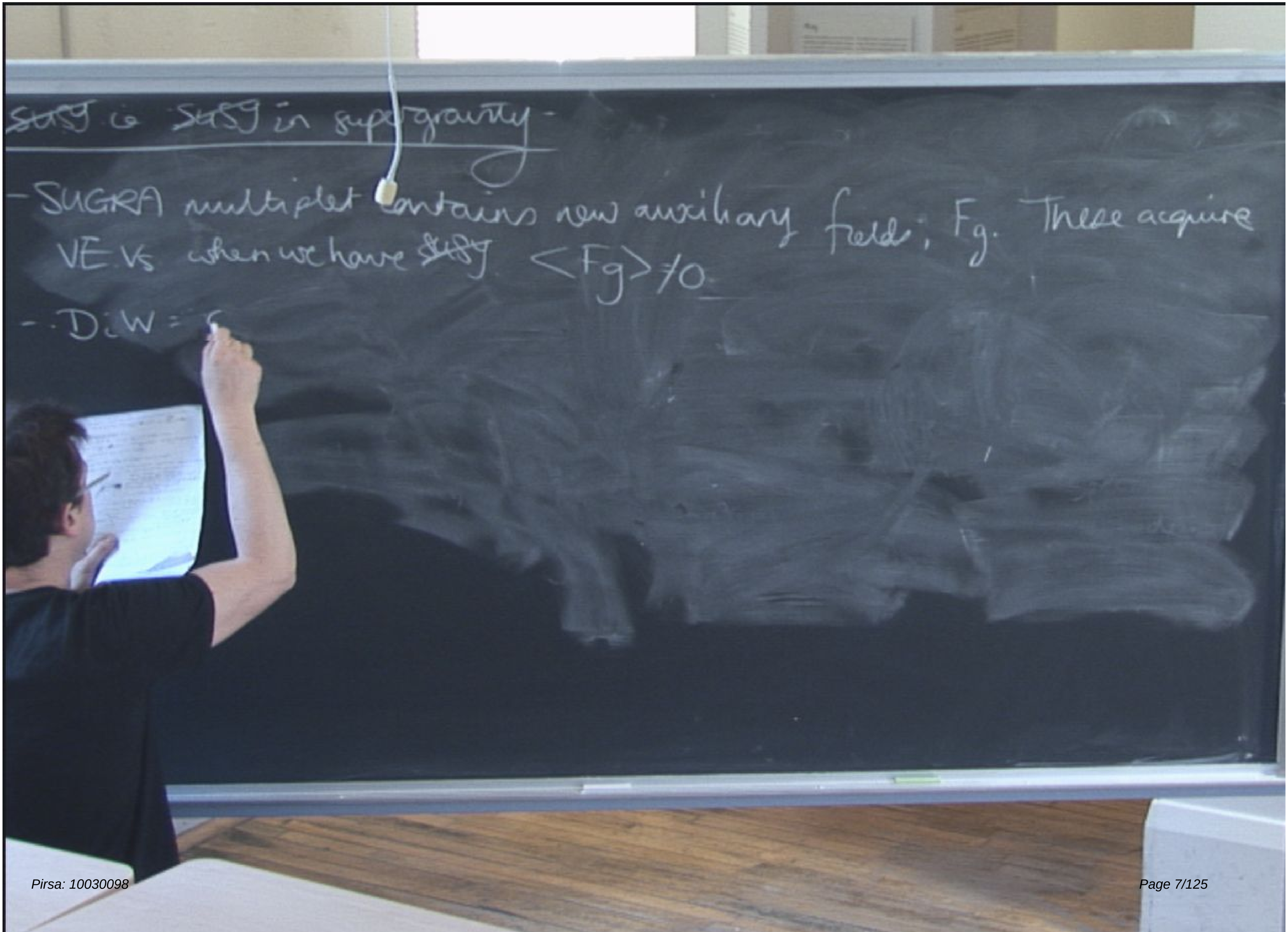

~~SUSY~~ ie ~~SUSY~~ in supergravity

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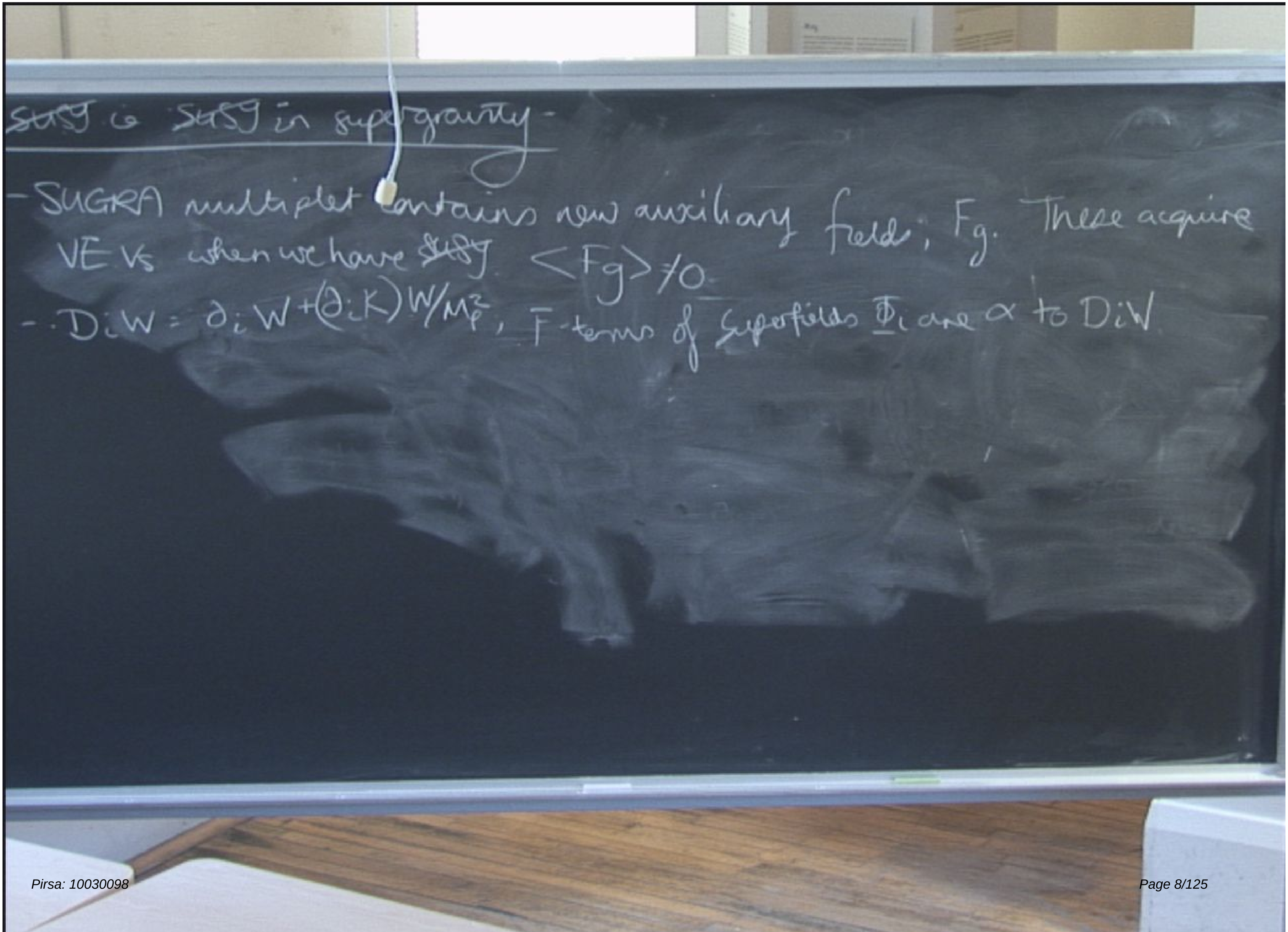
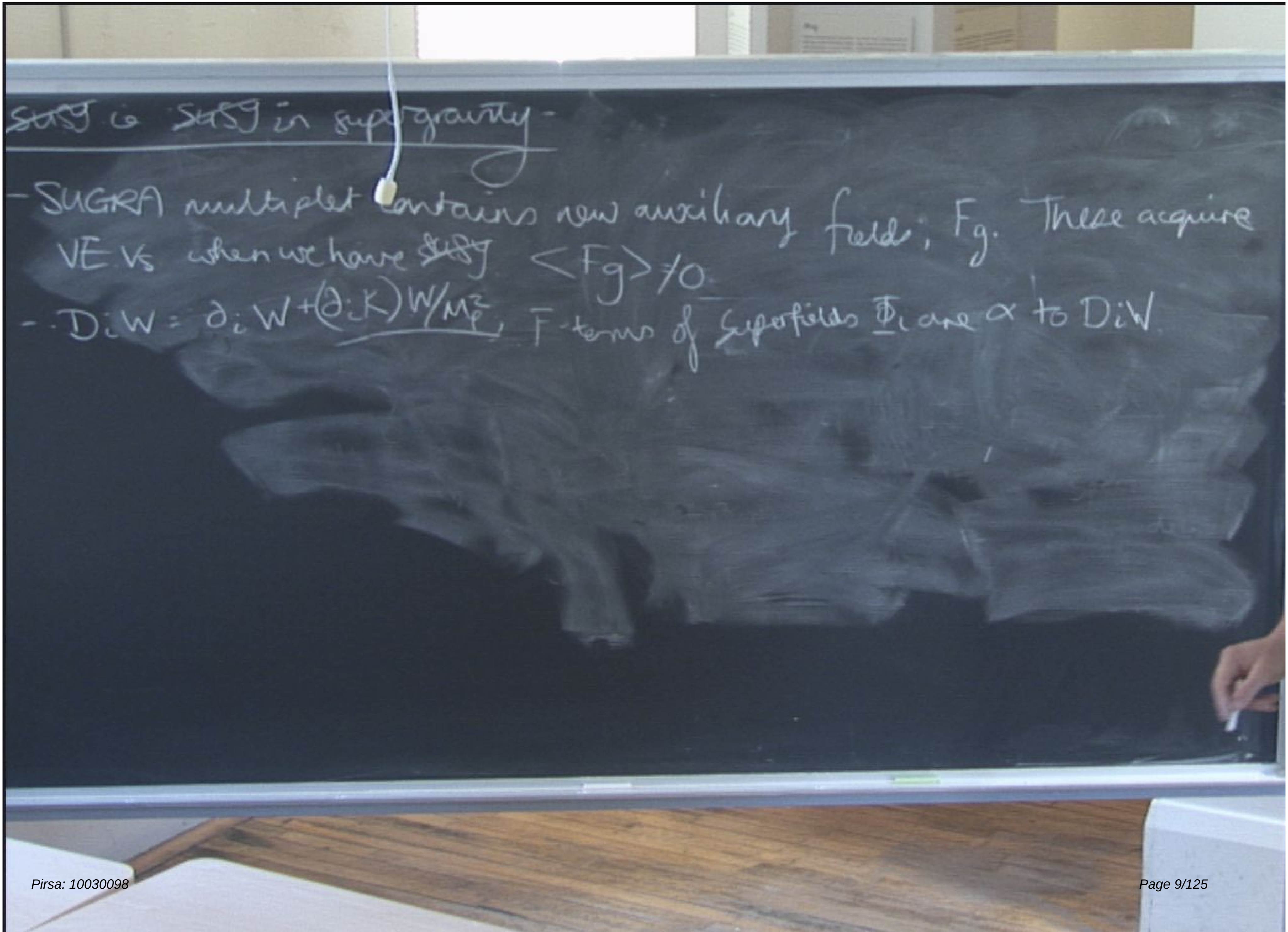
- $D_i W =$



~~SUSY~~ is ~~SUSY~~ in supergravity -

- SUGRA multiplet contains new auxiliary fields; F_g. These acquire VEVs when we have ~~SUSY~~ $\langle F_g \rangle \neq 0$.
- $D_i W = \partial_i W + (\partial_i K) W/M_p^2$, F-terms of superfields Φ_i are $\propto$ to $D_i W$



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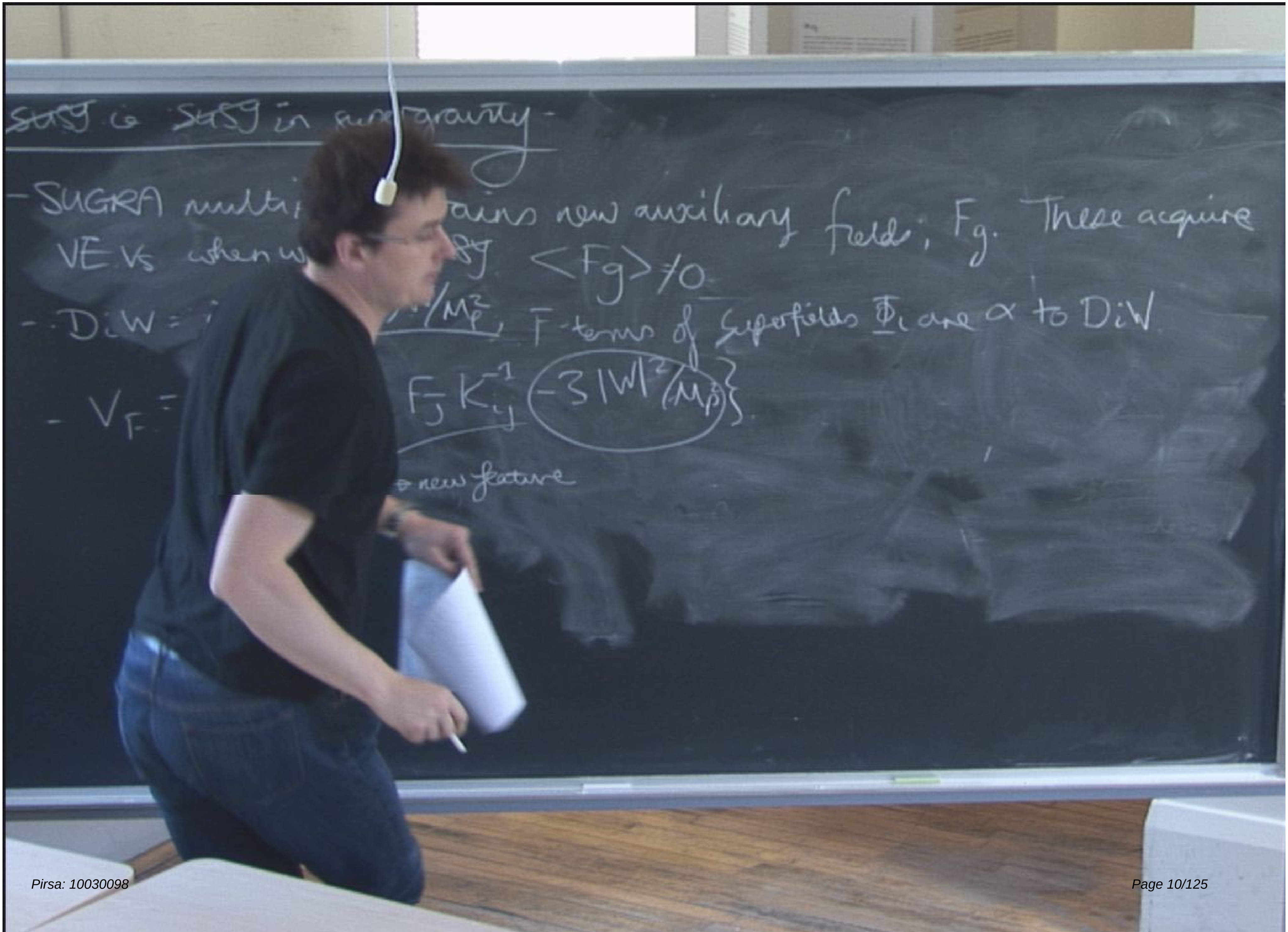


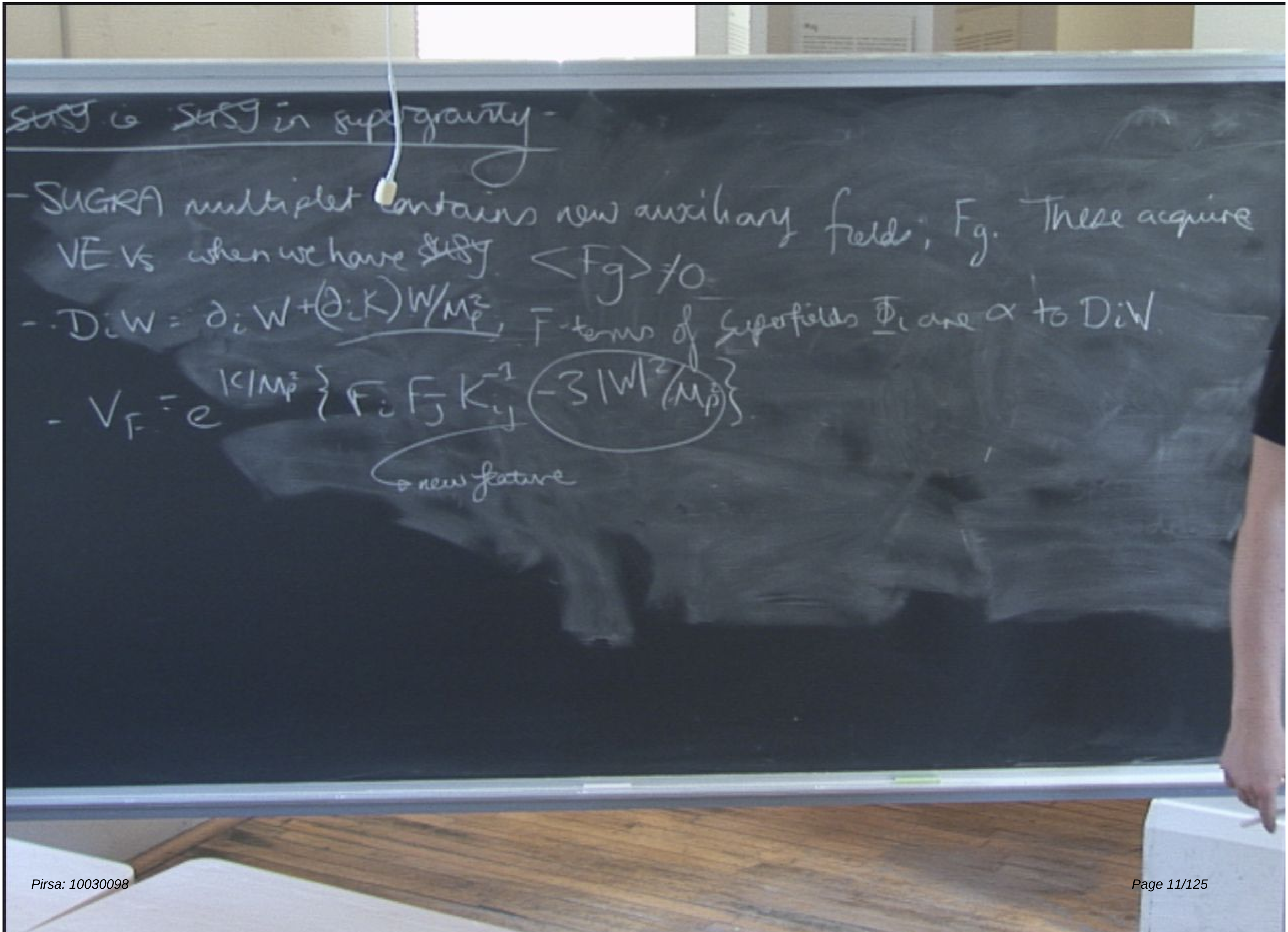
~~SUSY~~ is ~~SUSY~~ in supergravity -

- SUGRA multi[illegible]tains new auxiliary fields; F_g. These acquire VEVs when w[illegible]SY $\langle F_g \rangle \neq 0$

- $D_i W = $ [illegible] $/M_p^2$, F-terms of superfields Φ_i are $\propto$ to $D_i W$

- $V_F = $ [illegible] $F_j K^{-1}_{ij}$ $-3|W|^2/M_p^2 \}$

→ new feature



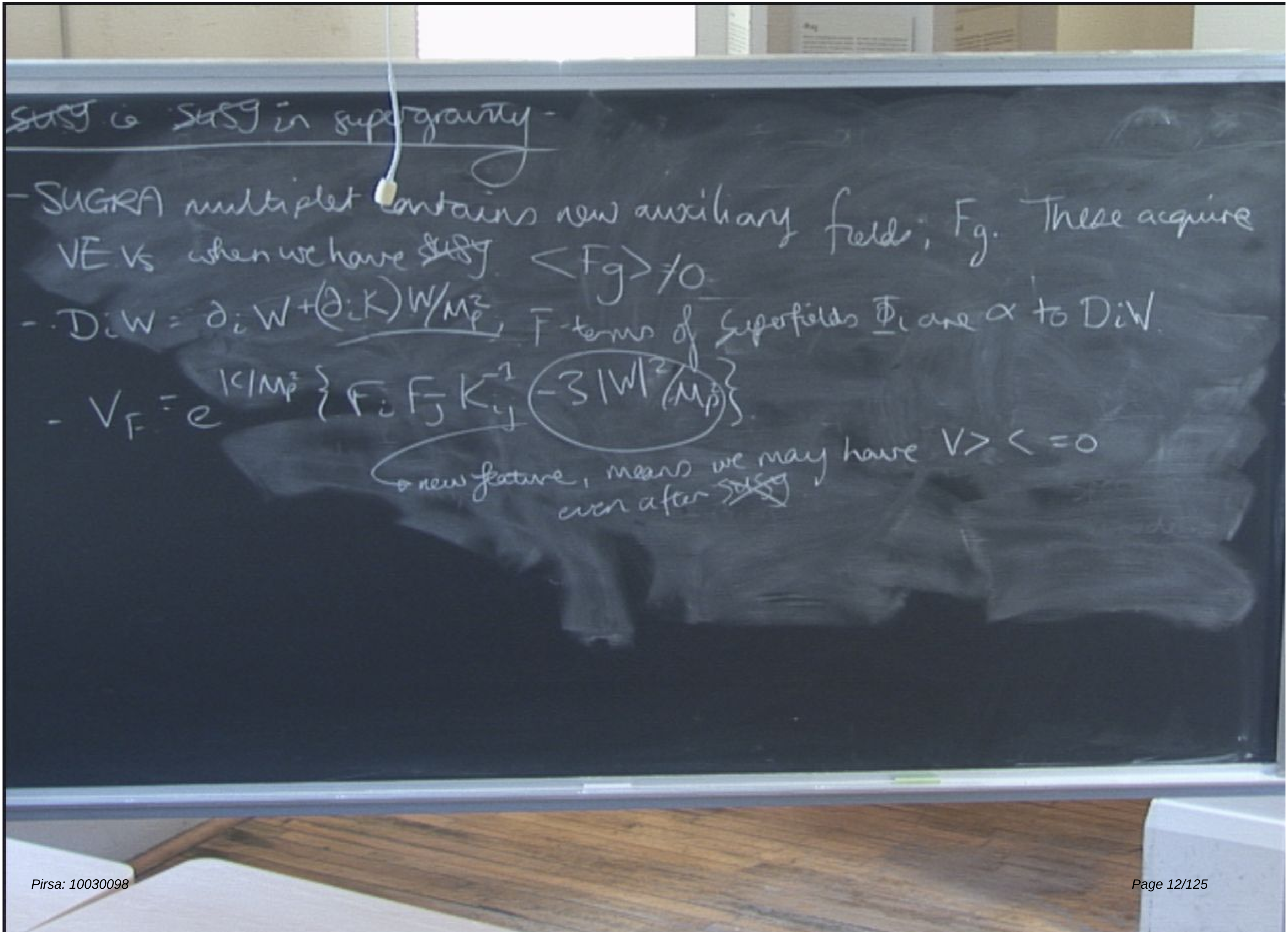
~~SUSY~~ & ~~SUSY~~ in supergravity -

- SUGRA multiplet contains new auxiliary field; F_g. These acquire VEVs when we have ~~SUSY~~ $\langle F_g \rangle \neq 0$

- $D_i W = \partial_i W + \underline{(\partial_i K) W / M_p^2}$, F-terms of superfields $\underline{\Phi}_i$ are $\propto$ to $D_i W$

- $V_F = e^{K/M_p^2} \{ F_i F_{\bar{j}} K_{i\bar{j}}^{-1} \boxed{- 3|W|^2/M_p^2} \}$

new feature



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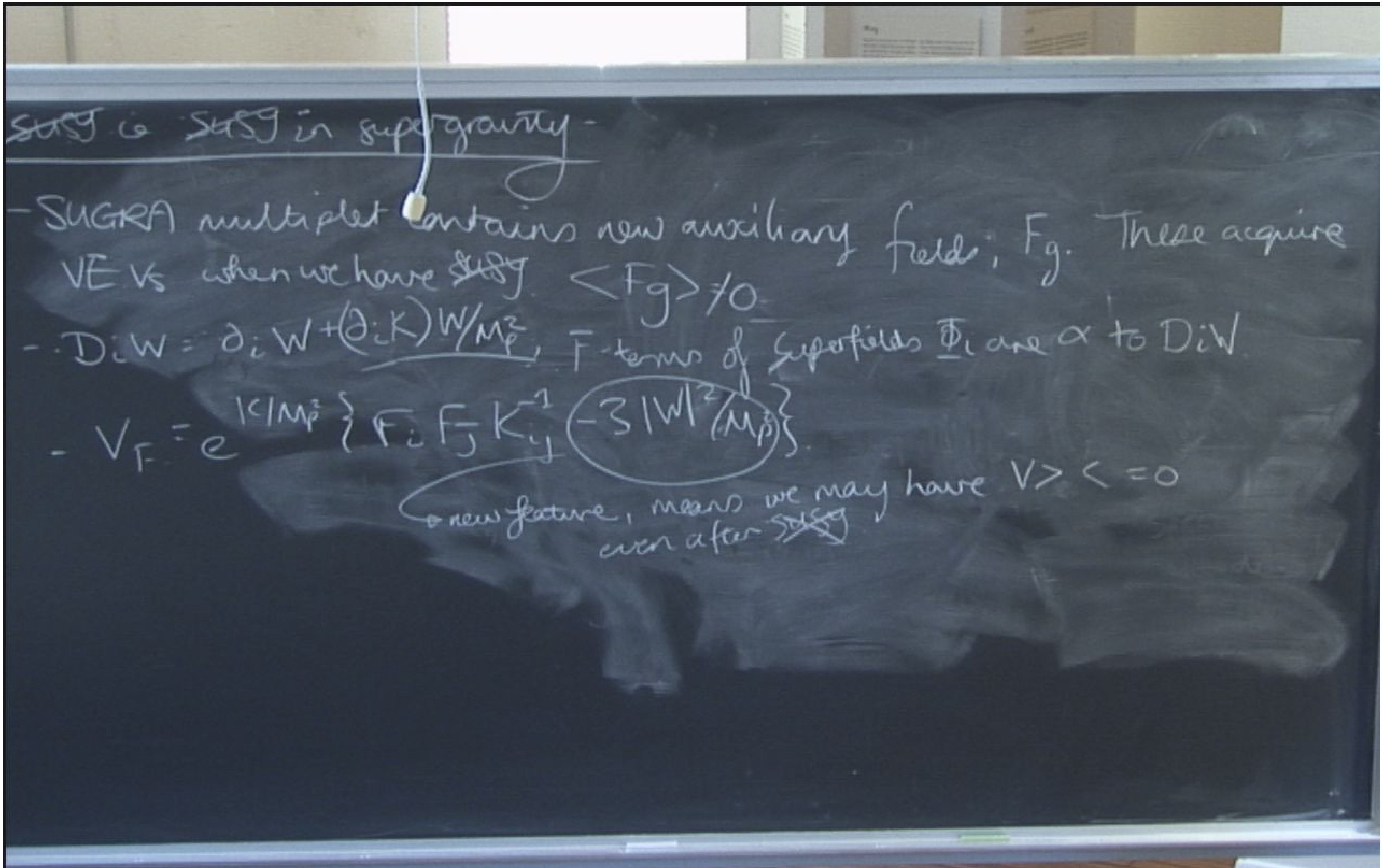
new feature, means we may have $V >< = 0$ even after ~~SUSY~~



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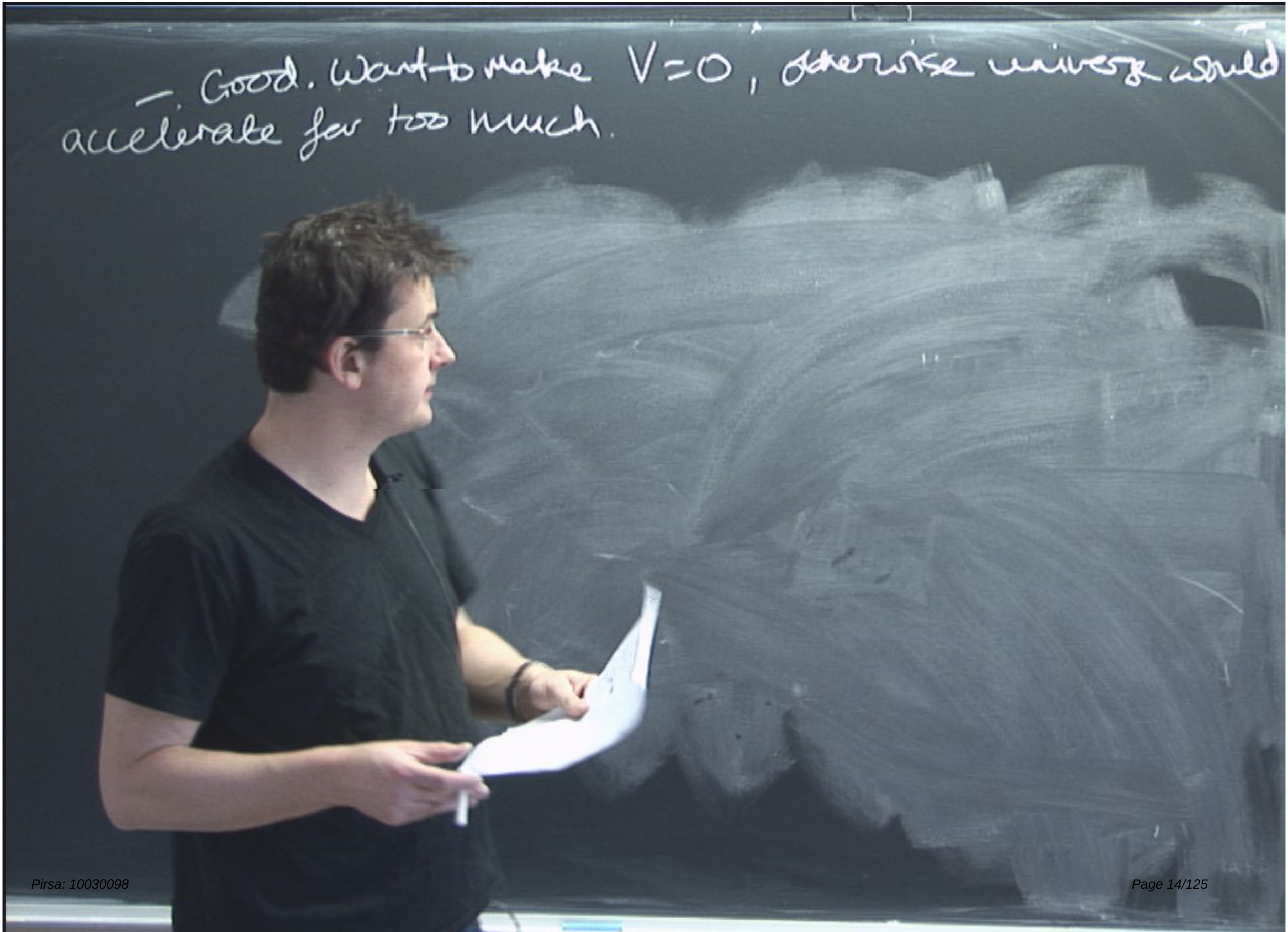

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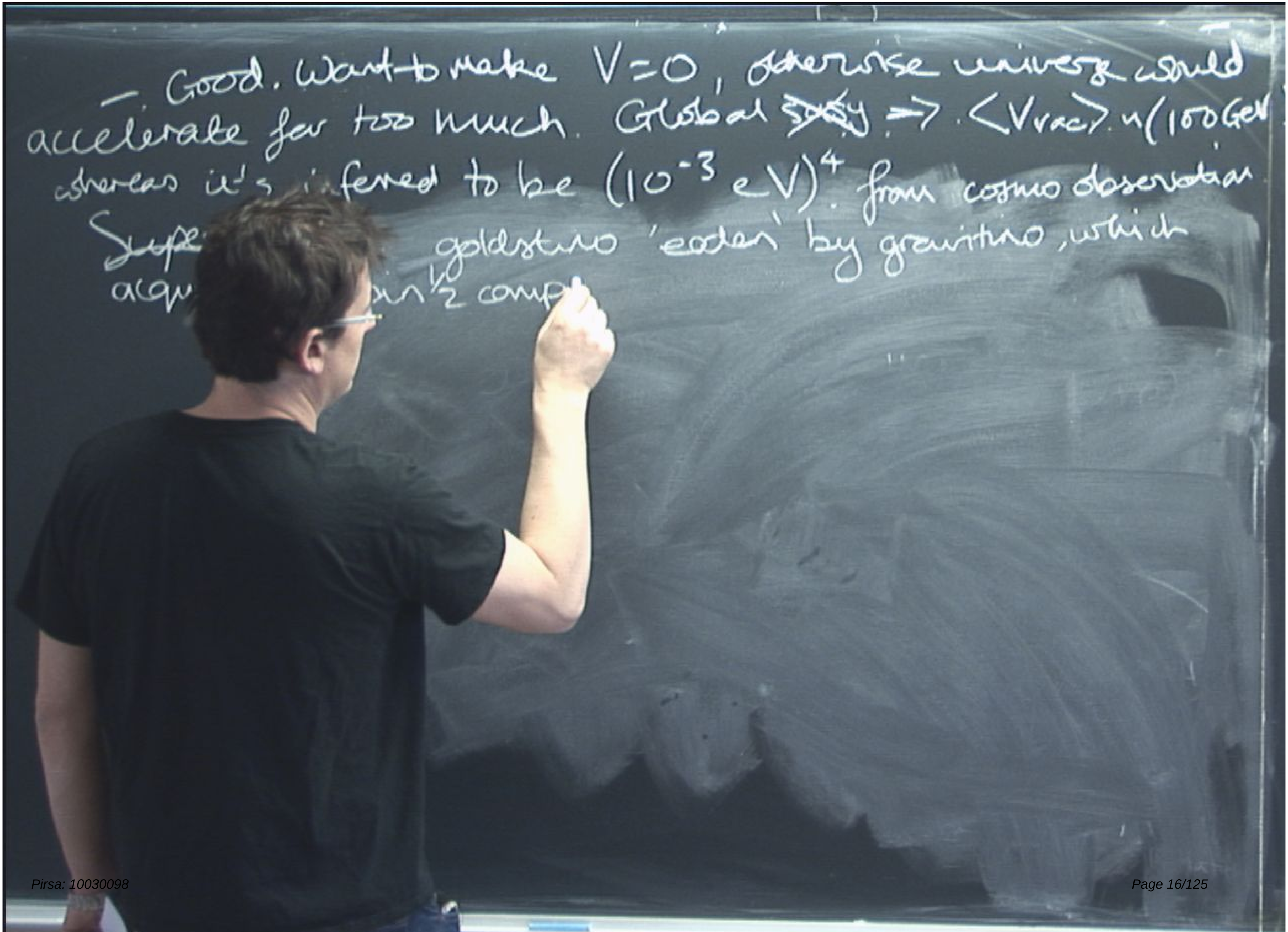
whereas it's inferred to be $(10^{-3}\,eV)^4$ from cosmo observation

Super-Higgs



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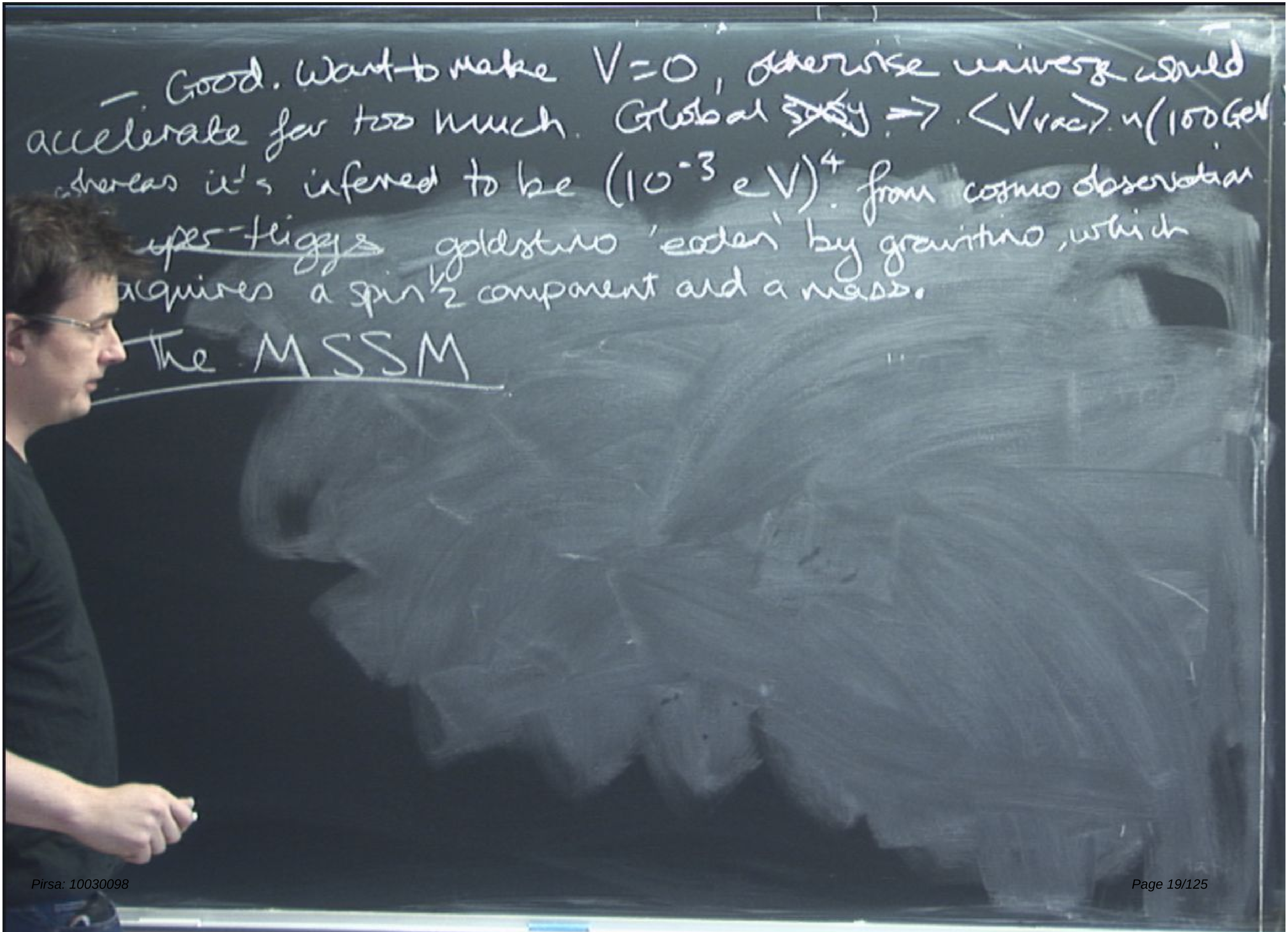

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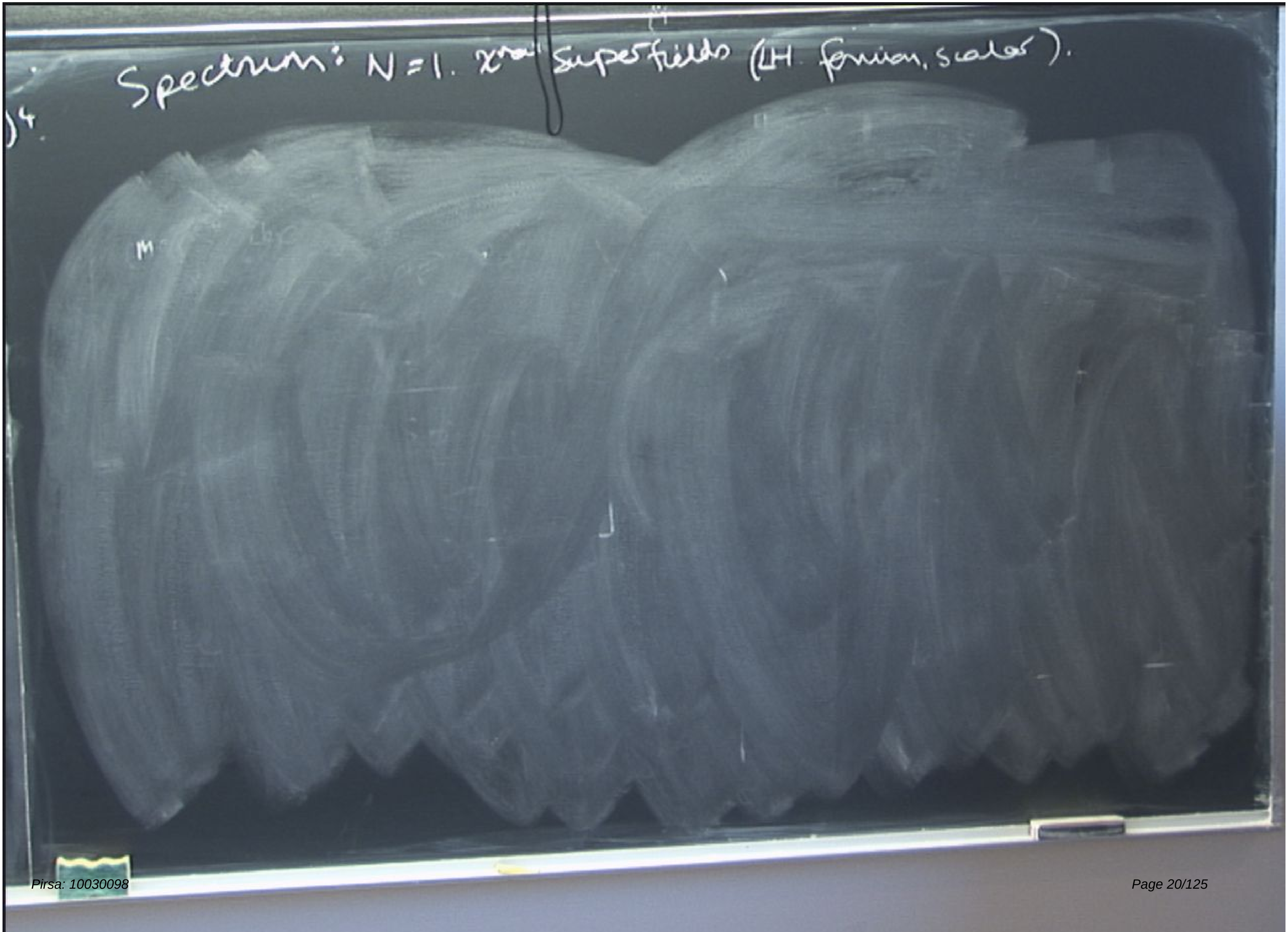
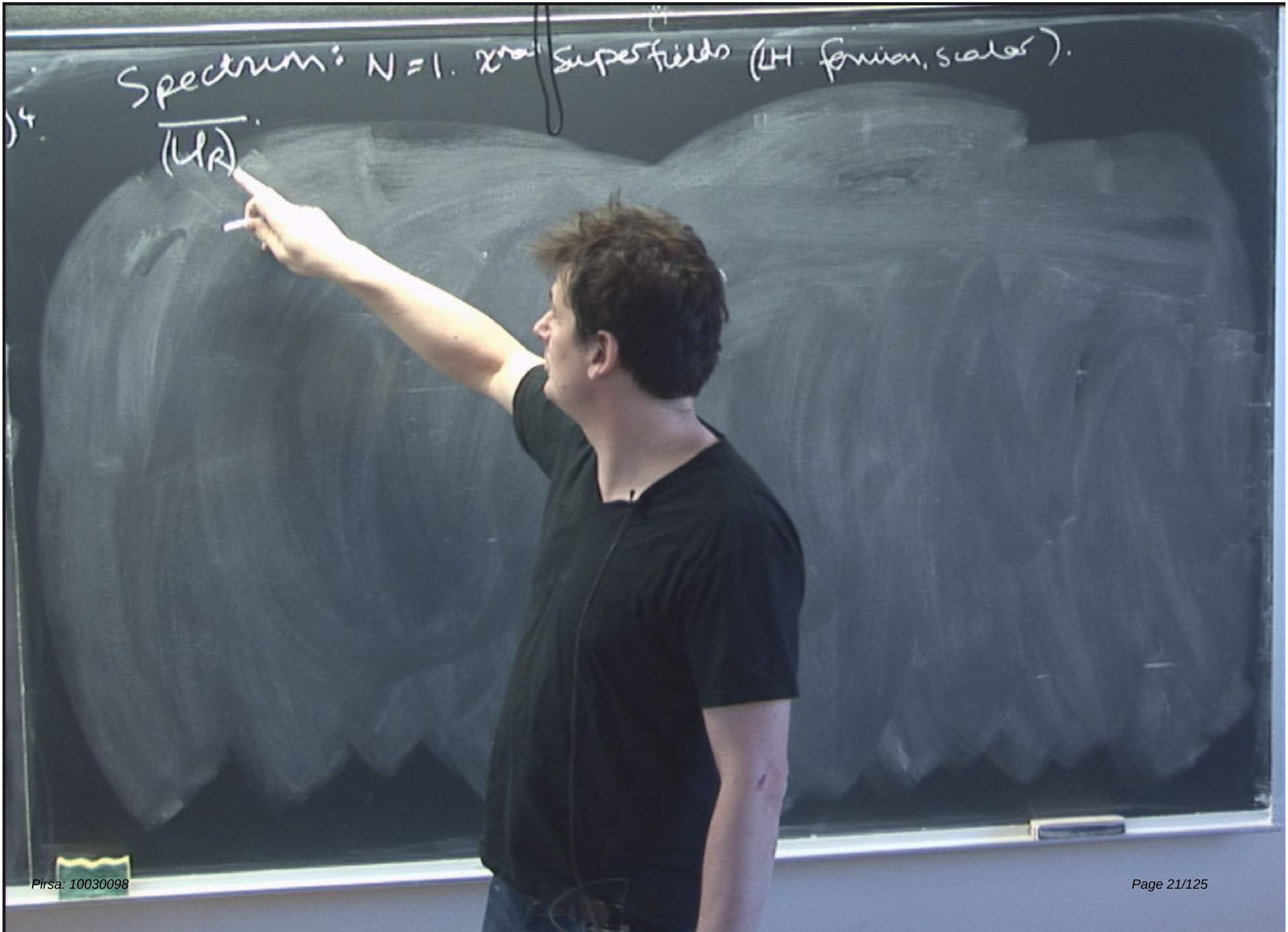
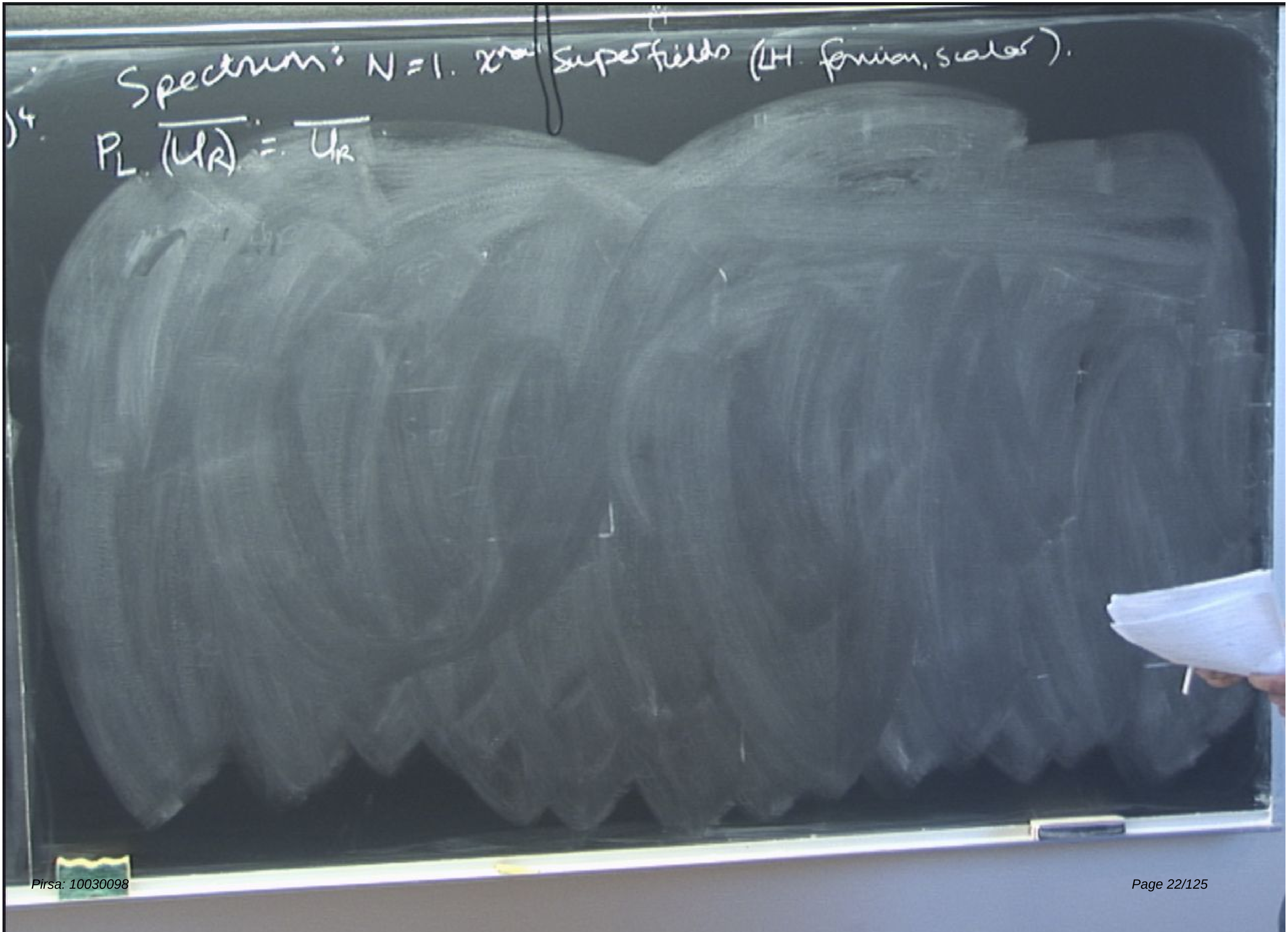
The MSSM



)^4.

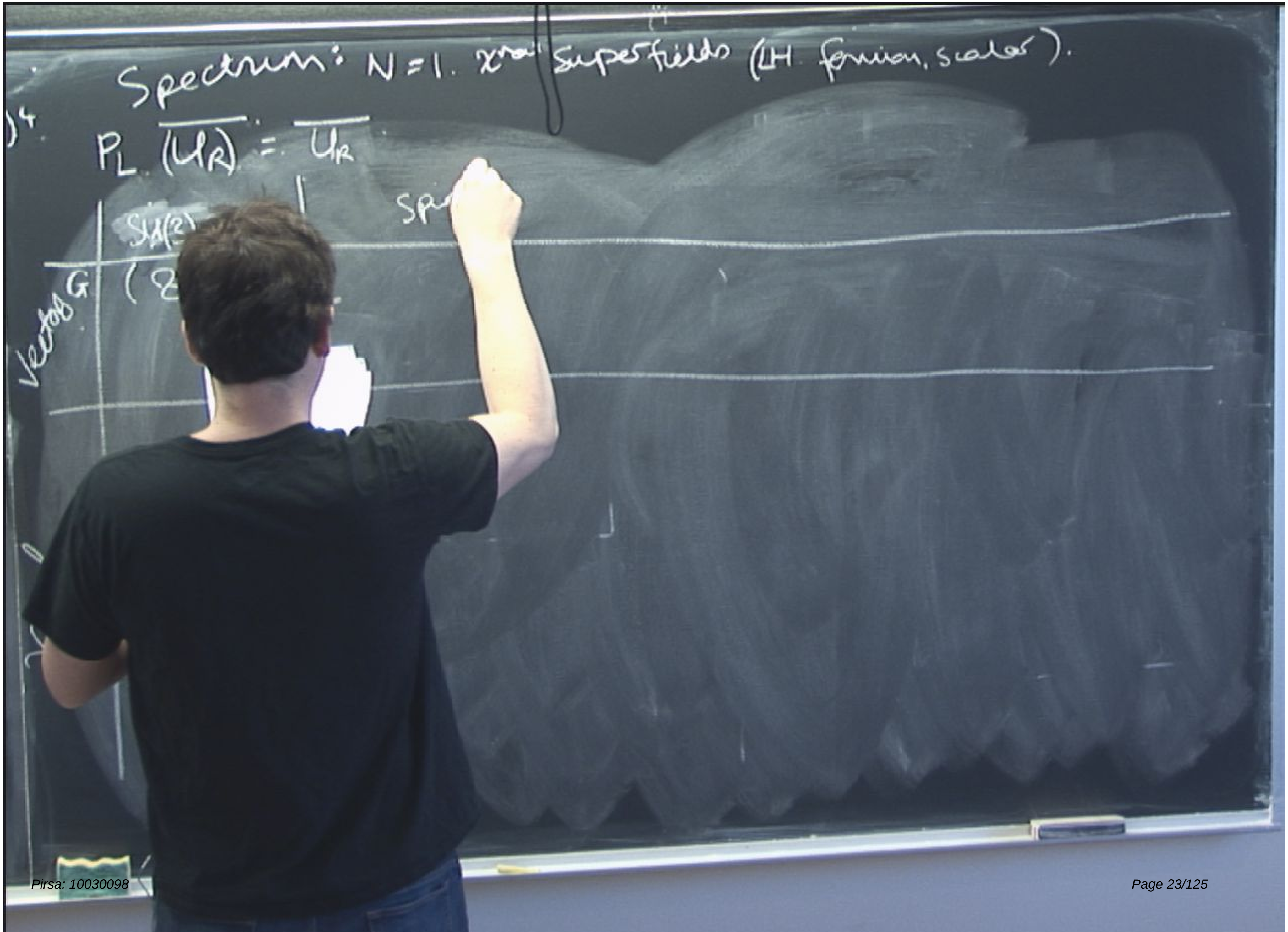
Spectrum: $N=1$. χ^{ral} superfields (LH. fermion, scalar).


)⁴.
Spectrum: N=1. χ^ral superfields (LH. fermion, scalar).
$\overline{(u_R)}$.



Spectrum: N = 1 χ^{ral} superfields (LH fermion, scalar).

$)^4$ $P_L \overline{(U_R)} = \overline{U_R}$



Spectrum: $N=1$. χ^{ral} superfields (LH. fermion, scalar).

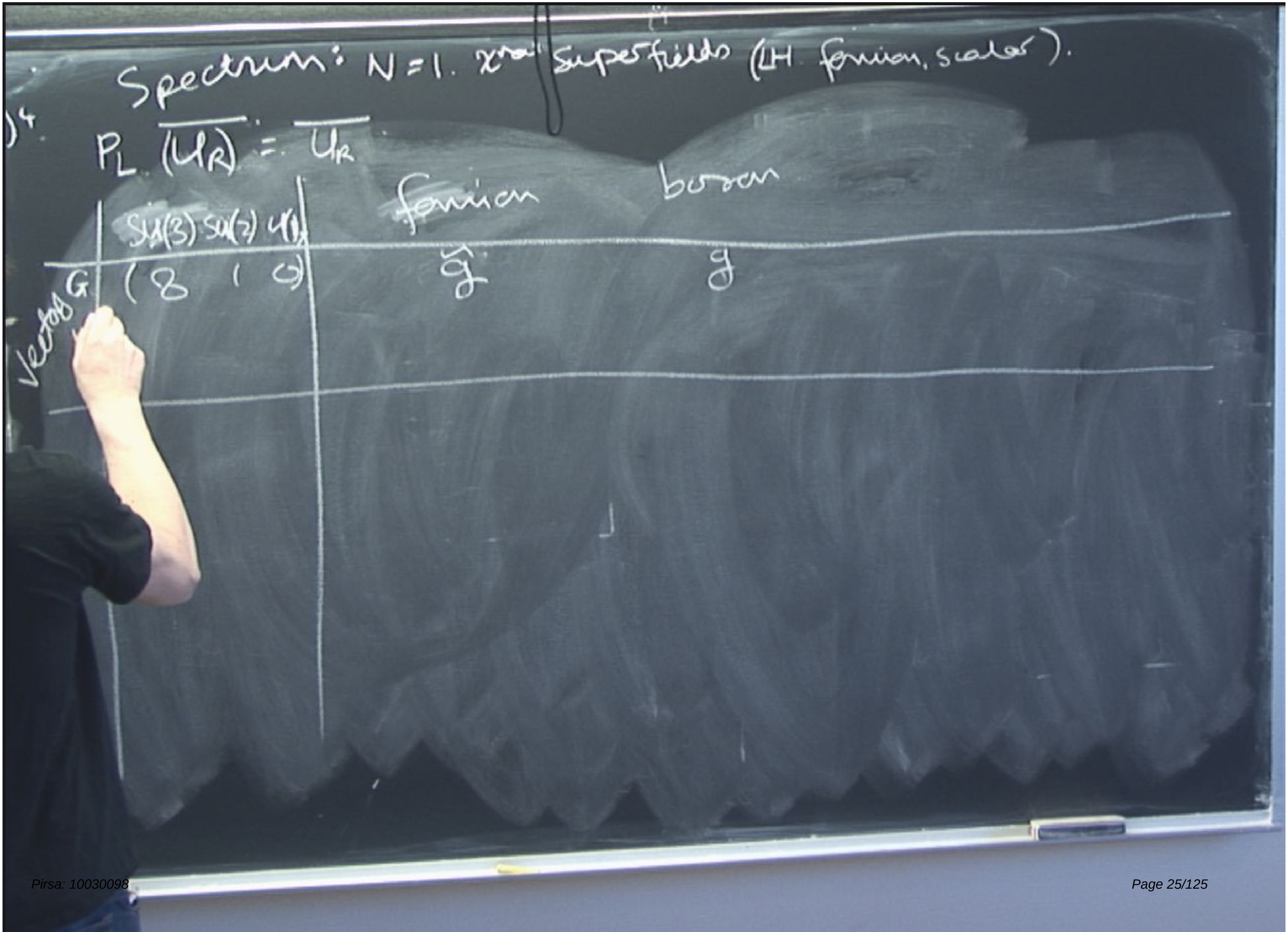
$P_L\,(\overline{U_R}) = \overline{U_R}$

$)^4$

Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(U_R)} = \overline{U_R}$

	SU(3) SU(2) U(1)	fermion	boson
G	(8 1 0)	$\tilde{g}$	g



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$P_L \overline{(u_R)} = \overline{u_R}$

	SU(3) SU(2) U(1)	fermion	boson
Vectors G	(8 1 0)	$\tilde{g}$	g

)^4

Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(U_R)} = \overline{U_R}$

		SU(3) SU(2) U(1)	fermion	boson
Vectors	G	(8 1 0)	gluino $\tilde{g}$	g
	W	(1 3 0)	wino $\tilde{W}$	W
χral				

Spectrum: $N=1$. χ^{ral} superfields (LH. fermion, scalar).

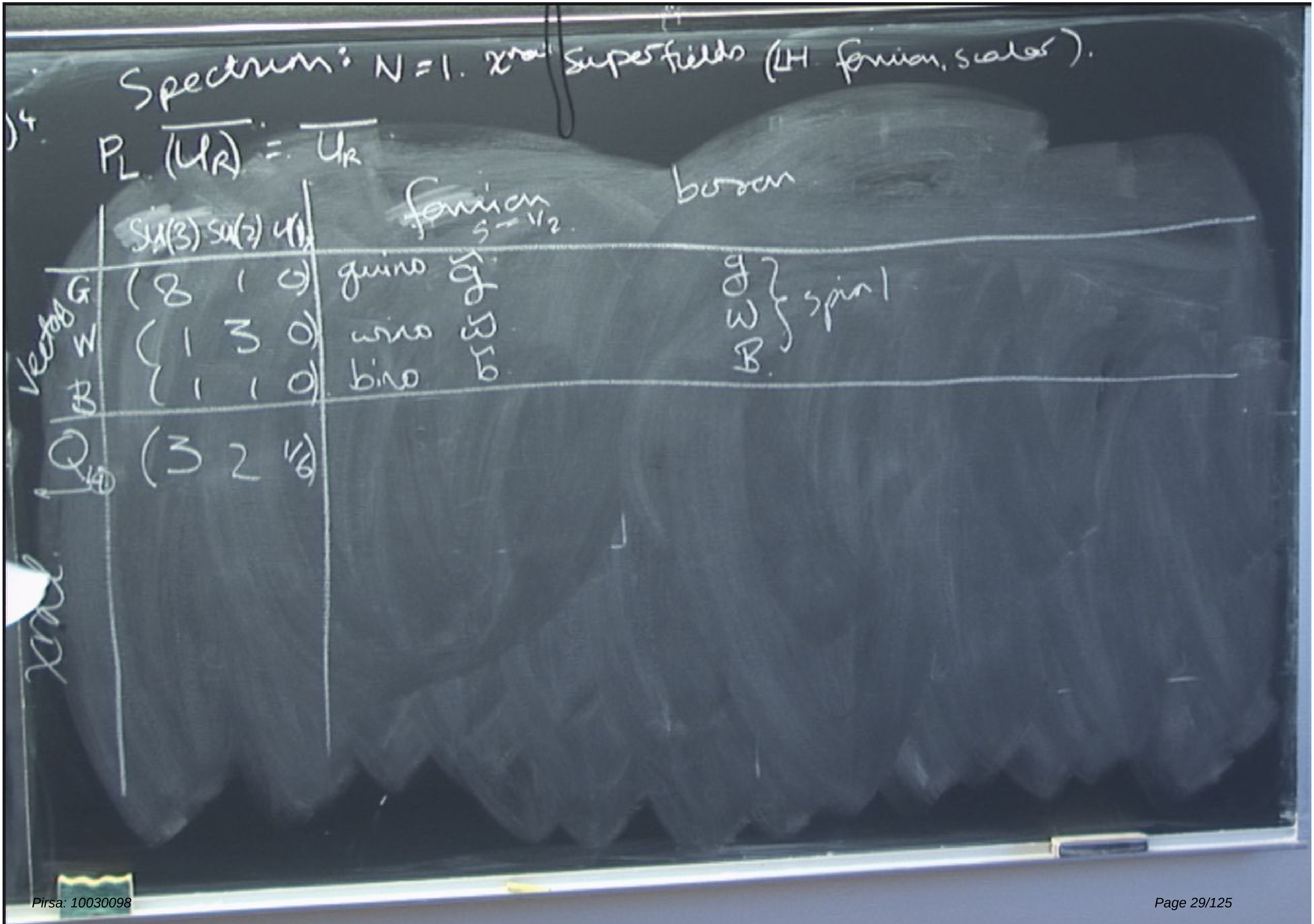
$$P_L\,\overline{(U_R)} = \overline{U_R}$$

		SU(3)	SU(2)	U(1)	fermion		boson
Vectors	G	(8	1	0)	gluino	$\tilde{g}$	g
	W	(1	3	0)	wino	$\tilde{W}$	W
	B	(1	1	0)	bino	$\tilde{B}$	B
χral							

Spectrum: $N=1$. χ^{ral} superfields (LH. fermion, scalar).

$P_L \, \overline{(u_R)} = \overline{u_R}$

		SU(3)	SU(2)	U(1)	fermion $s = 1/2$		boson	
Vectors	G	(8	1	0)	gluino	$\tilde{g}$	g	spin 1
	W	(1	3	0)	wino	$\tilde{W}$	W	
	B	(1	1	0)	bino	$\tilde{b}$	B	
Xral								



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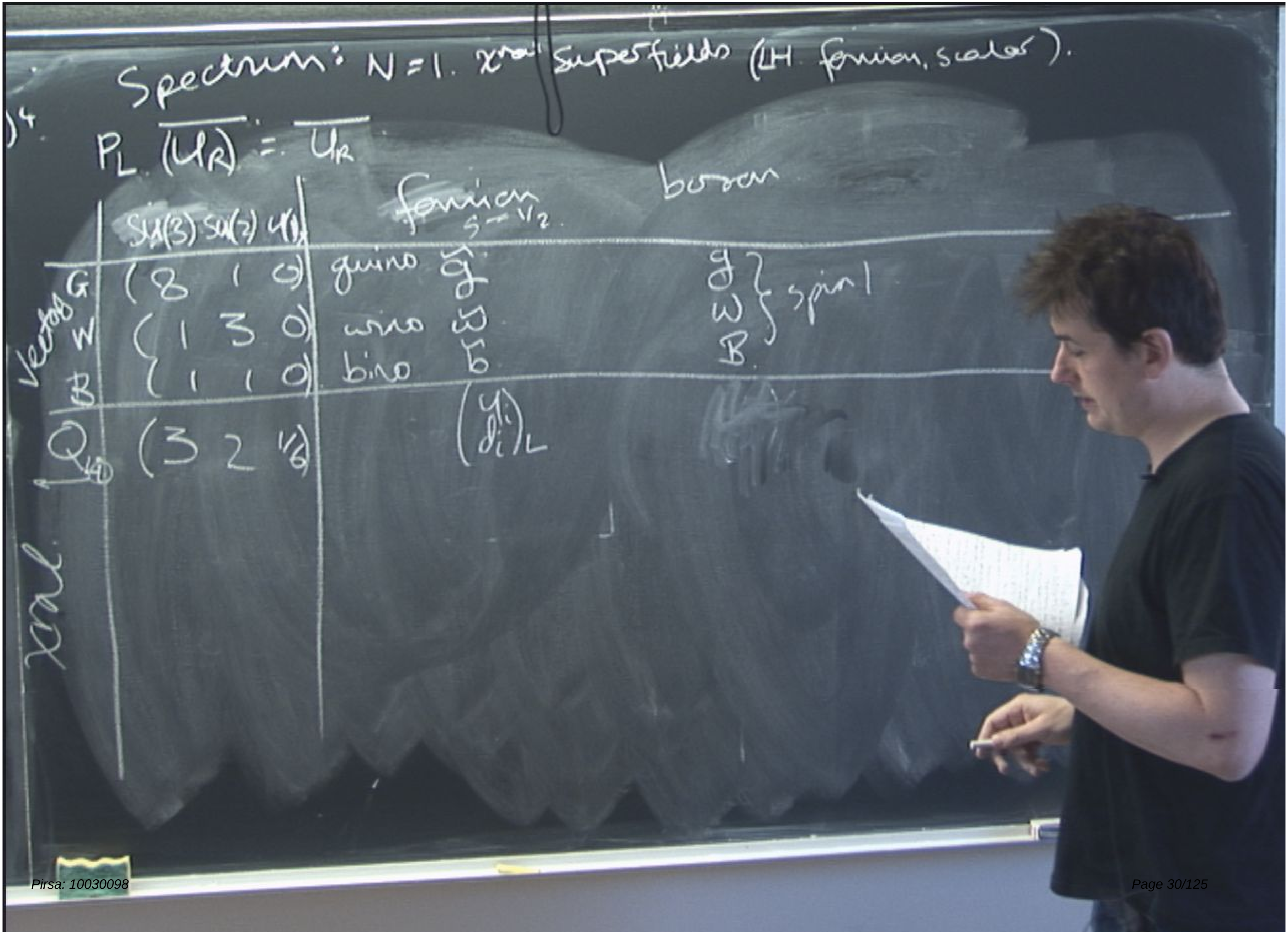
$$P_L \overline{(u_R)} = \overline{u_R}$$

		SU(3) SU(2) U(1)	fermion $s=1/2$		boson	
Vectors	G	(8 1 0)	gluino	$\tilde{g}$	g	spin 1
	W	(1 3 0)	wino	$\tilde{W}$	W	
	B	(1 1 0)	bino	$\tilde{B}$	B	
χral	$Q_{(L)}$	(3 2 1/6)				



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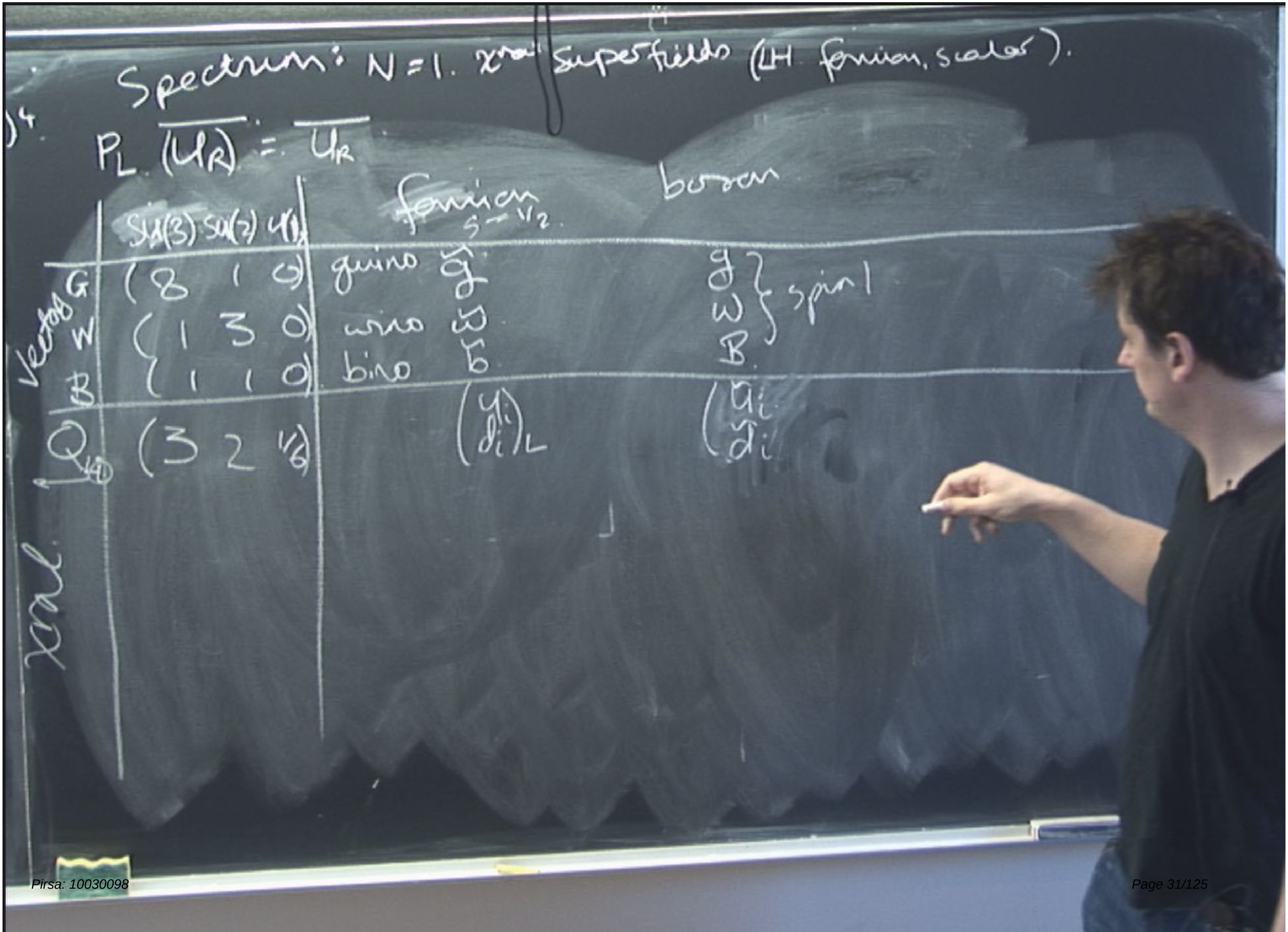
$P_L \overline{(u_R)} = \overline{u_R}$

		SU(3)	SU(2)	U(1)	fermion $s = 1/2$		boson	
Vectors	G	(8	1	0)	gluino	$\tilde{g}$	g	spin 1
	W	(1	3	0)	wino	$\tilde{W}$	W	
	B	(1	1	0)	bino	$\tilde{b}$	B	
χral	Q_L	(3	2	1/6)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$		



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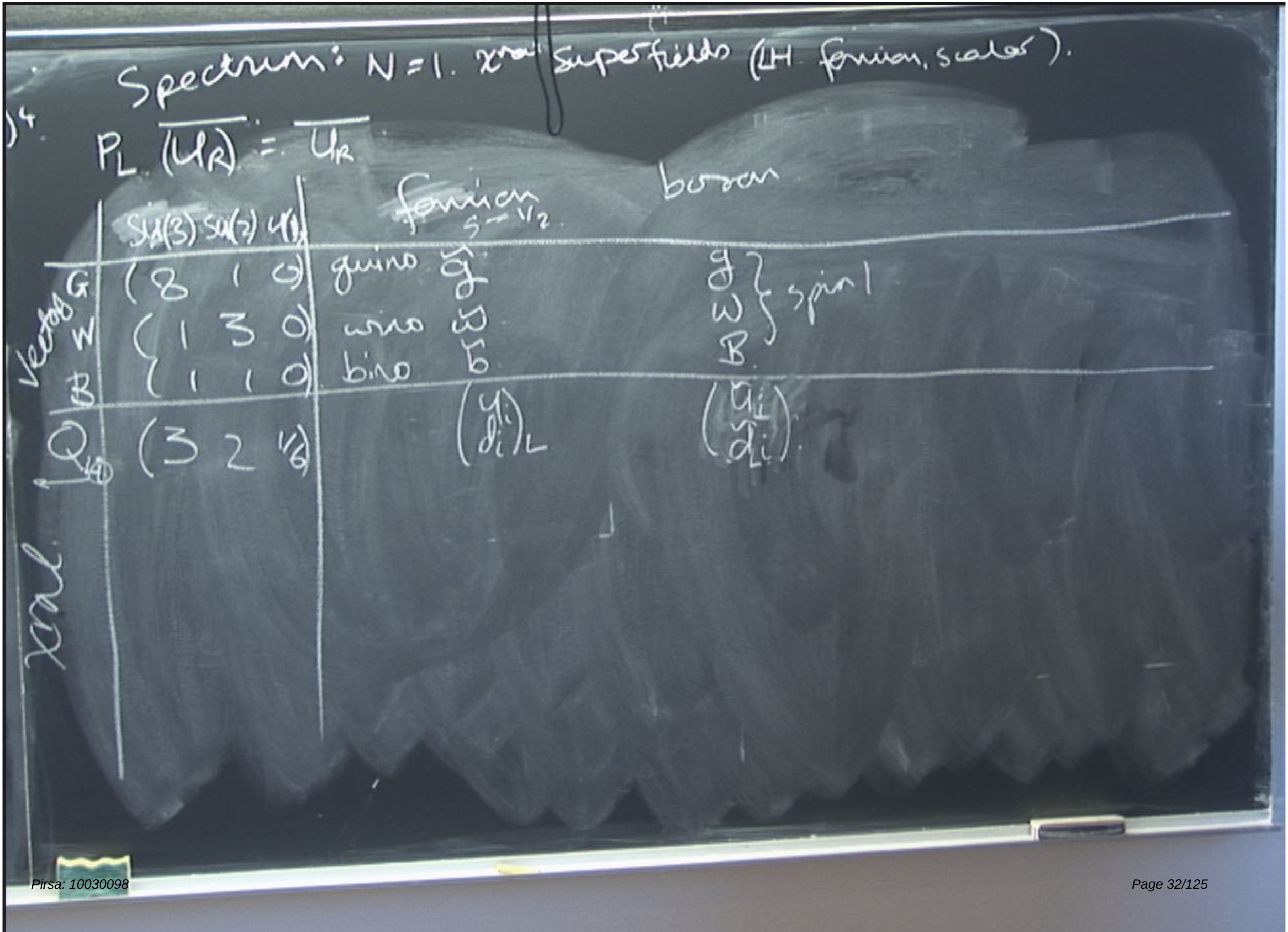
		SU(3)	SU(2)	U(1)	fermion $s=1/2$		boson	
Vectors	G	(8	1	0)	gluino	$\tilde{g}$	g	} spin 1
	W	(1	3	0)	wino	$\tilde{W}$	W	
	B	(1	1	0)	bino	$\tilde{B}$	B	
χral	$Q_{(i)}$	(3	2	1/6)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix}$	



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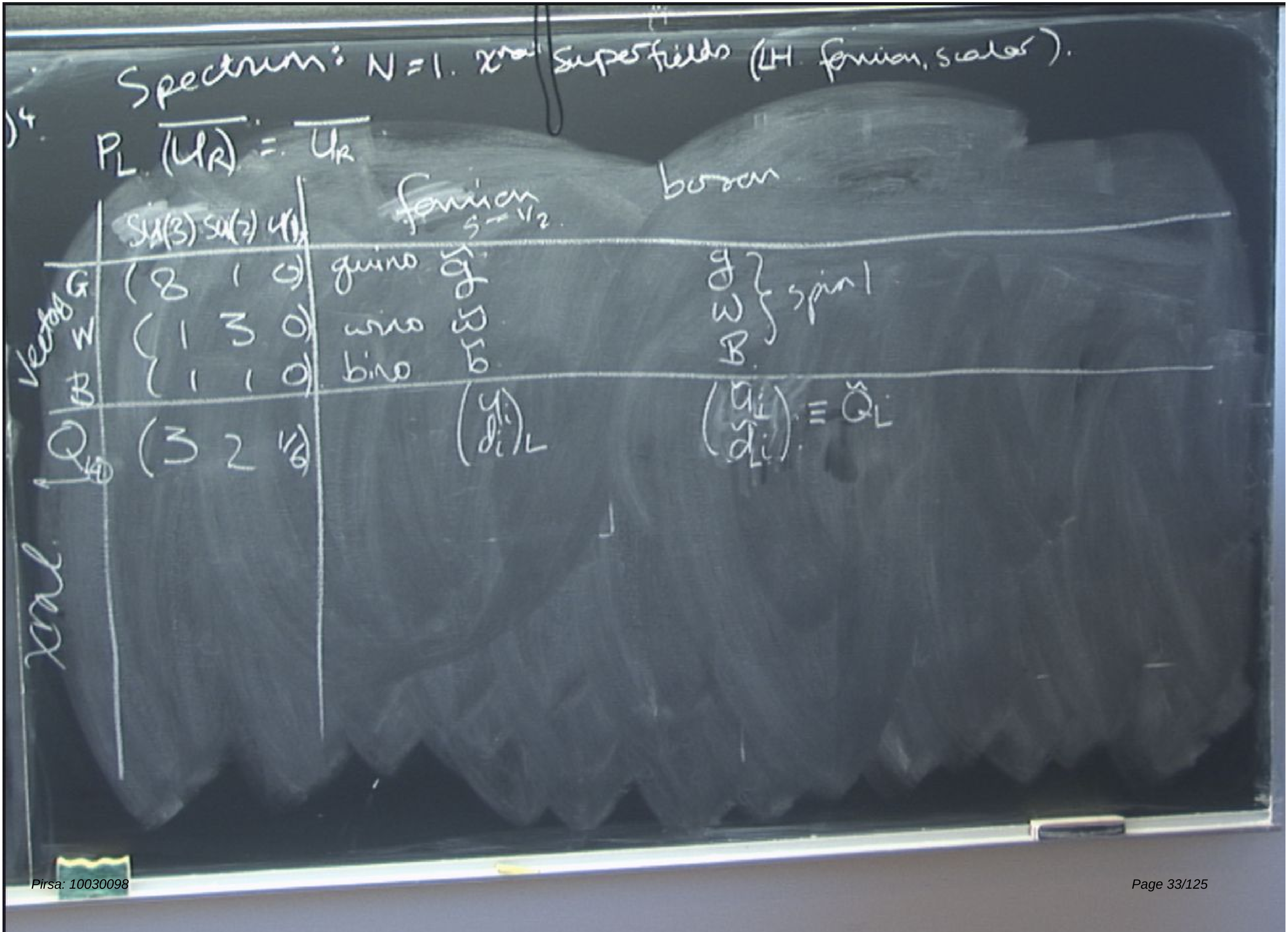
$P_L\,\overline{(u_R)} = \overline{u_R}$

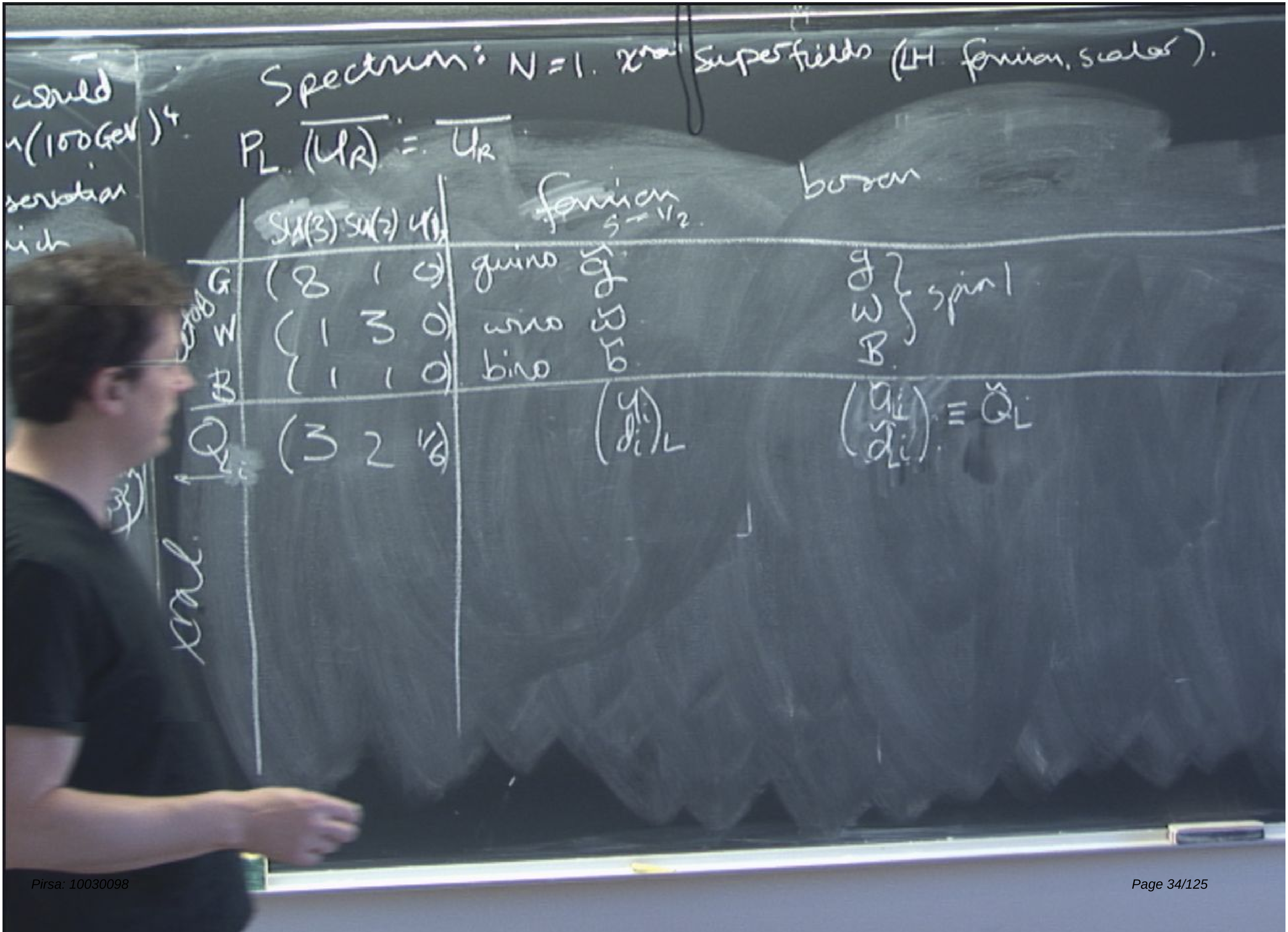
		SU(3)	SU(2)	U(1)	fermion $s=1/2$	boson
Vectors	G	(8	1	0)	gluino $\tilde{g}$	g } spin 1
	W	(1	3	0)	wino $\tilde{W}$	W
	B	(1	1	0)	bino $\tilde{B}$	B
χral	Q_i ④	(3	2	1/6)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix}_L$



)⁴ Spectrum: N = 1 χral superfields (LH fermion, scalar).

$P_L \, \overline{(u_R)} = \overline{u_R}$

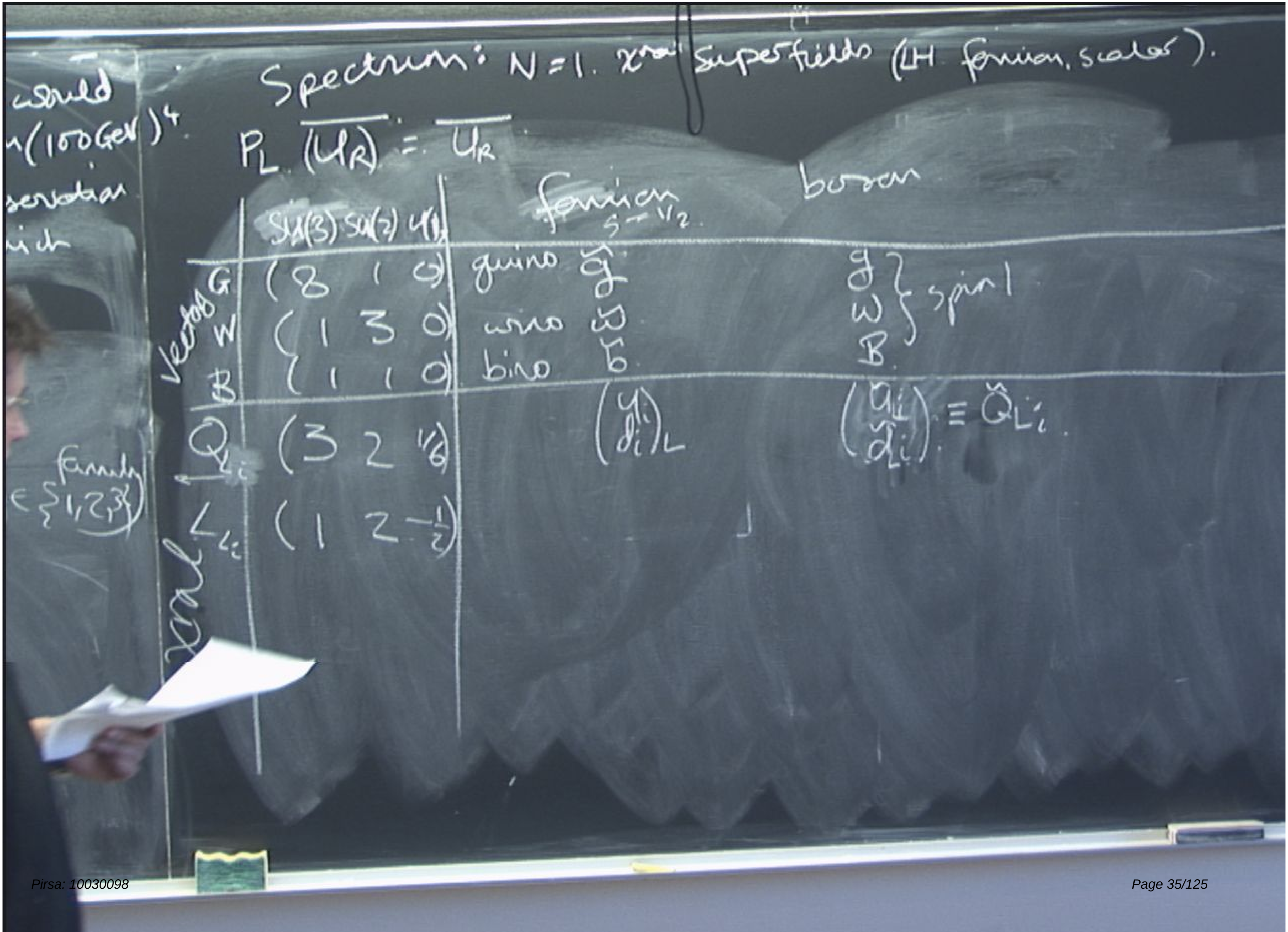
		SU(3)	SU(2)	U(1)	fermion $s=1/2$		boson
Vector	G	(8	1	0)	gluino	$\tilde g$	g } spin 1
	W	(1	3	0)	wino	$\tilde W$	W
	B	(1	1	0)	bino	$\tilde b$	B
χral	Q_{L} ④	(3	2	1/6)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde u_{Li} \\ \tilde d_{Li} \end{pmatrix} \equiv \tilde Q_L$



Spectrum: N=1. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

	SU(3) SU(2) U(1)	fermion $s=1/2$	boson
G	(8 1 0)	gluino $\tilde{g}$	g } spin 1
W	(1 3 0)	wino $\tilde{W}$	W
B	(1 1 0)	bino $\tilde{B}$	B
Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_{L_i} \\ \tilde{d}_{L_i} \end{pmatrix} \equiv \tilde{Q}_L$



would

$(100\,\mathrm{GeV})^4$

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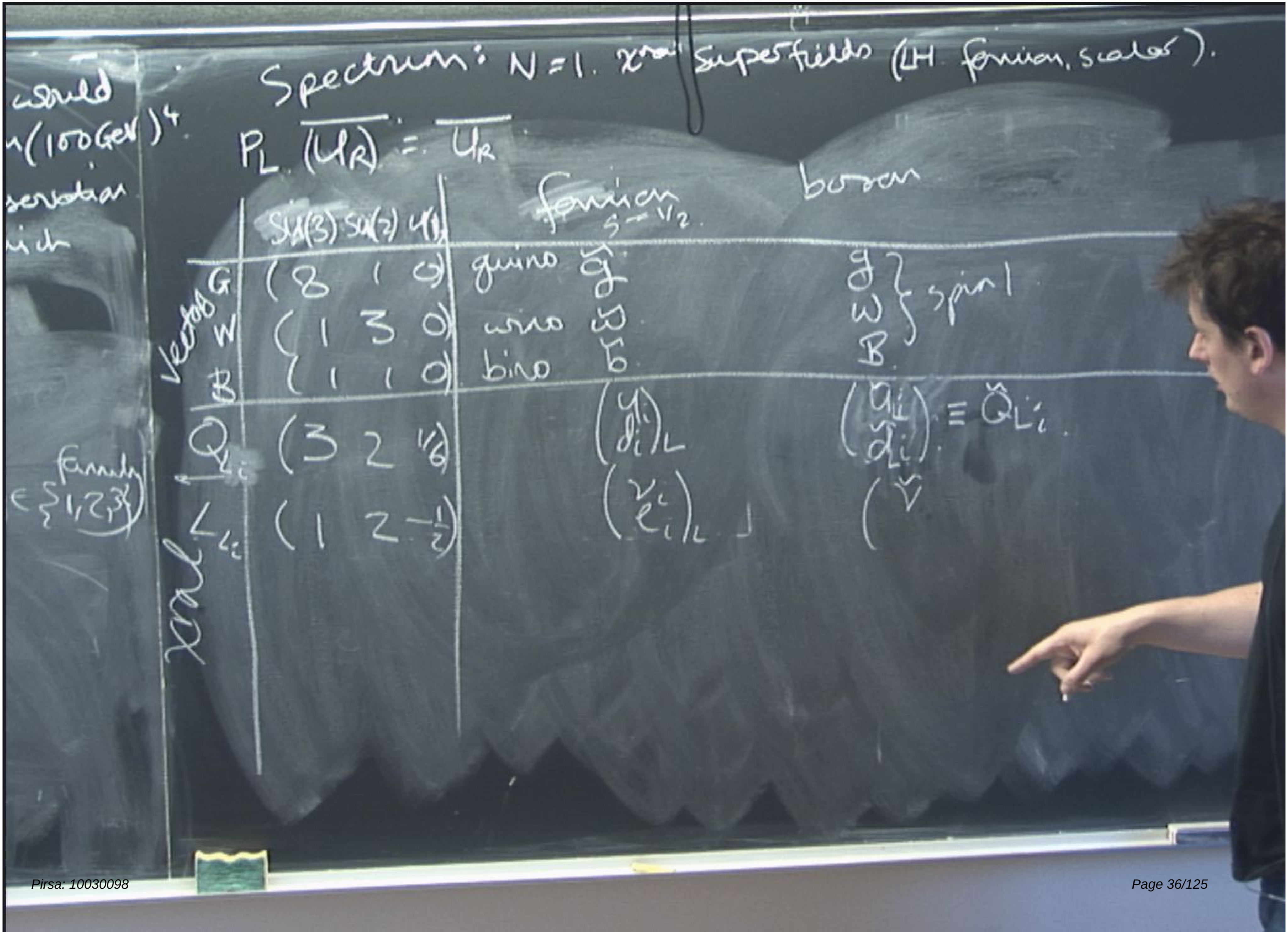
Spectrum: $N=1$. $\chi^{\rm ral}$ superfields (LH fermion, scalar).

$$P_L\,\overline{(u_R)} = \overline{u_R}$$

	SU(3) SU(2) U(1)	fermion $s=1/2$	boson
Vectors G	(8 1 0)	gluino $\tilde g$	g } spin 1
W	(1 3 0)	wino $\tilde W$	W
B	(1 1 0)	bino $\tilde b$	B
χral Q_{Li}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde u_{Li} \\ \tilde d_{Li} \end{pmatrix} \equiv \tilde Q_{Li}$
L_{Li}	(1 2 $-\frac{1}{2}$)		

family $i \in \{1,2,3\}$



would

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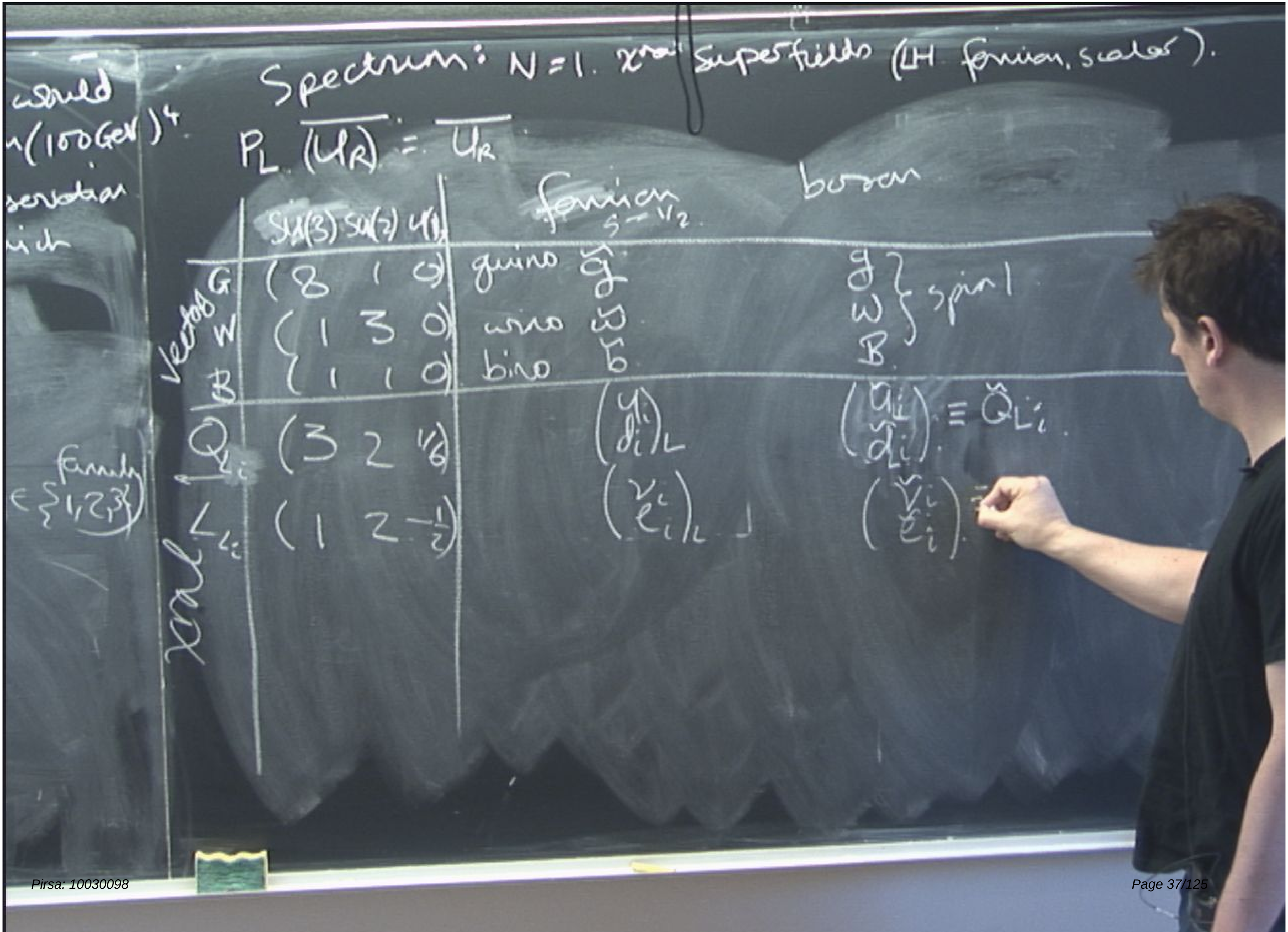
family $\in \{1,2,3\}$

Spectrum: $N=1$ χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

	SU(3) SU(2) U(1)	fermion $s=1/2$	boson
Vectors G	(8 1 0)	gluino $\tilde{g}$	g } spin 1
W	(1 3 0)	wino $\tilde{W}$	W
B	(1 1 0)	bino $\tilde{b}$	B
χral Q_{L_i}	$(3\ 2\ \tfrac{1}{6})$	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_L \\ \tilde{d}_L \end{pmatrix}_i \equiv \tilde{Q}_{L_i}$
L_{L_i}	$(1\ 2\ -\tfrac{1}{2})$	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$(\tilde{\nu}$



would

$(100\,\mathrm{GeV})^4$

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$i \in \{1,2,3\}$

Spectrum: N=1 χ^ral superfields (LH fermion, scalar).

$$P_L \overline{(u_R)} = \overline{u_R}$$

	SU(3) SU(2) U(1)	fermion $s=1/2$	boson
Vector G	(8 1 0)	gluino $\tilde{g}$	g } spin 1
W	(1 3 0)	wino $\tilde{W}$	W
B	(1 1 0)	bino $\tilde{b}$	B
χral Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix} \equiv \tilde{Q}_{L_i}$
L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix} \equiv$

would
$\sim(100\,\mathrm{GeV})^4$
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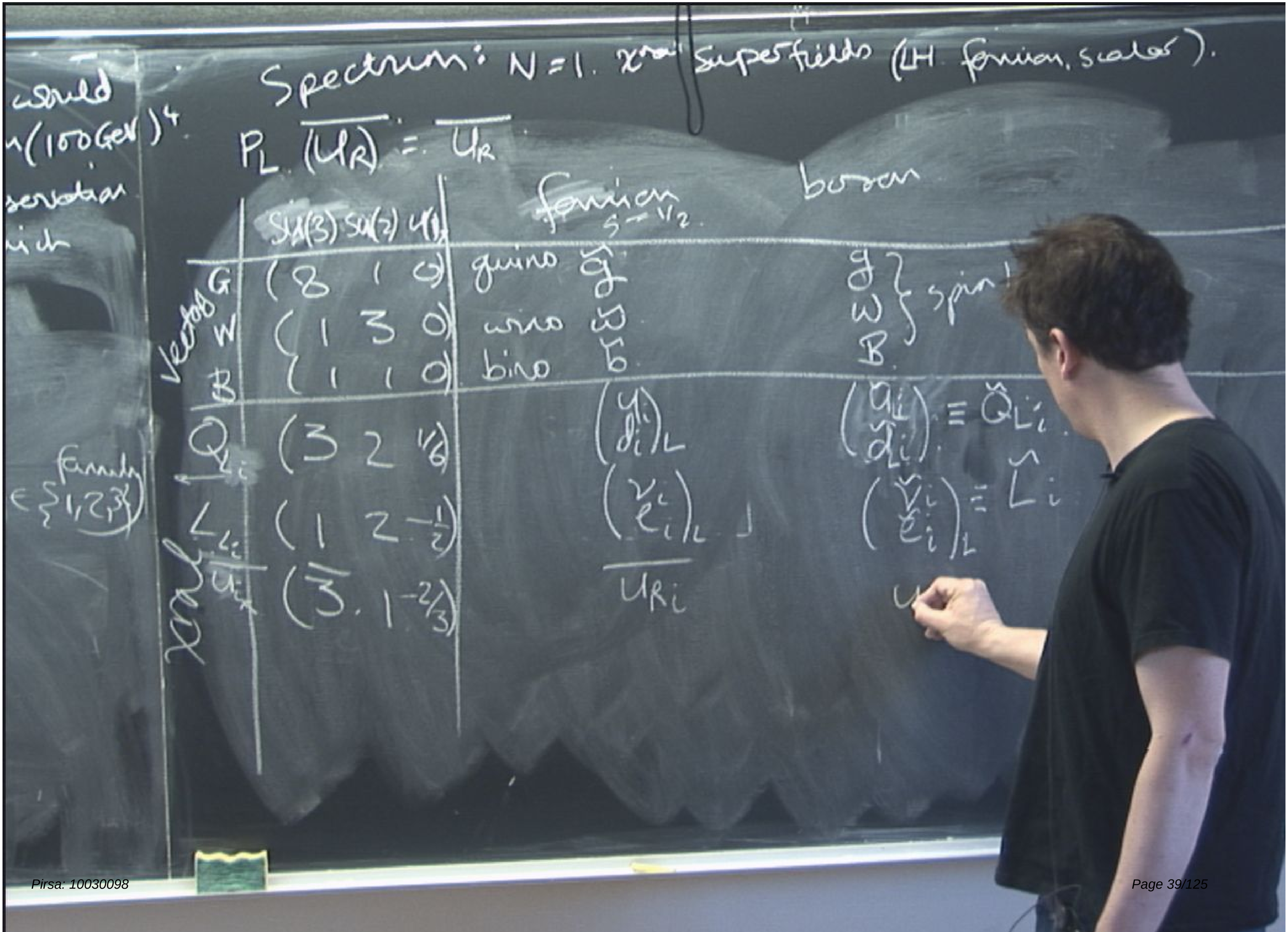
Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L\,\overline{(u_R)} = \overline{u_R}$

		SU(3) SU(2) U(1)	fermion $s=1/2$	boson
Vectors	G	(8 1 0)	gluino $\tilde{g}$	g } spin 1
	W	(1 3 0)	wino $\tilde{W}$	W
	B	(1 1 0)	bino $\tilde{b}$	B
χral	Q_{L_i}	(3 2 $1/6$)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_{L_i} \\ \tilde{d}_{L_i} \end{pmatrix} \equiv \hat{Q}_{L_i}$
	L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$

family $\in \{1,2,3\}$



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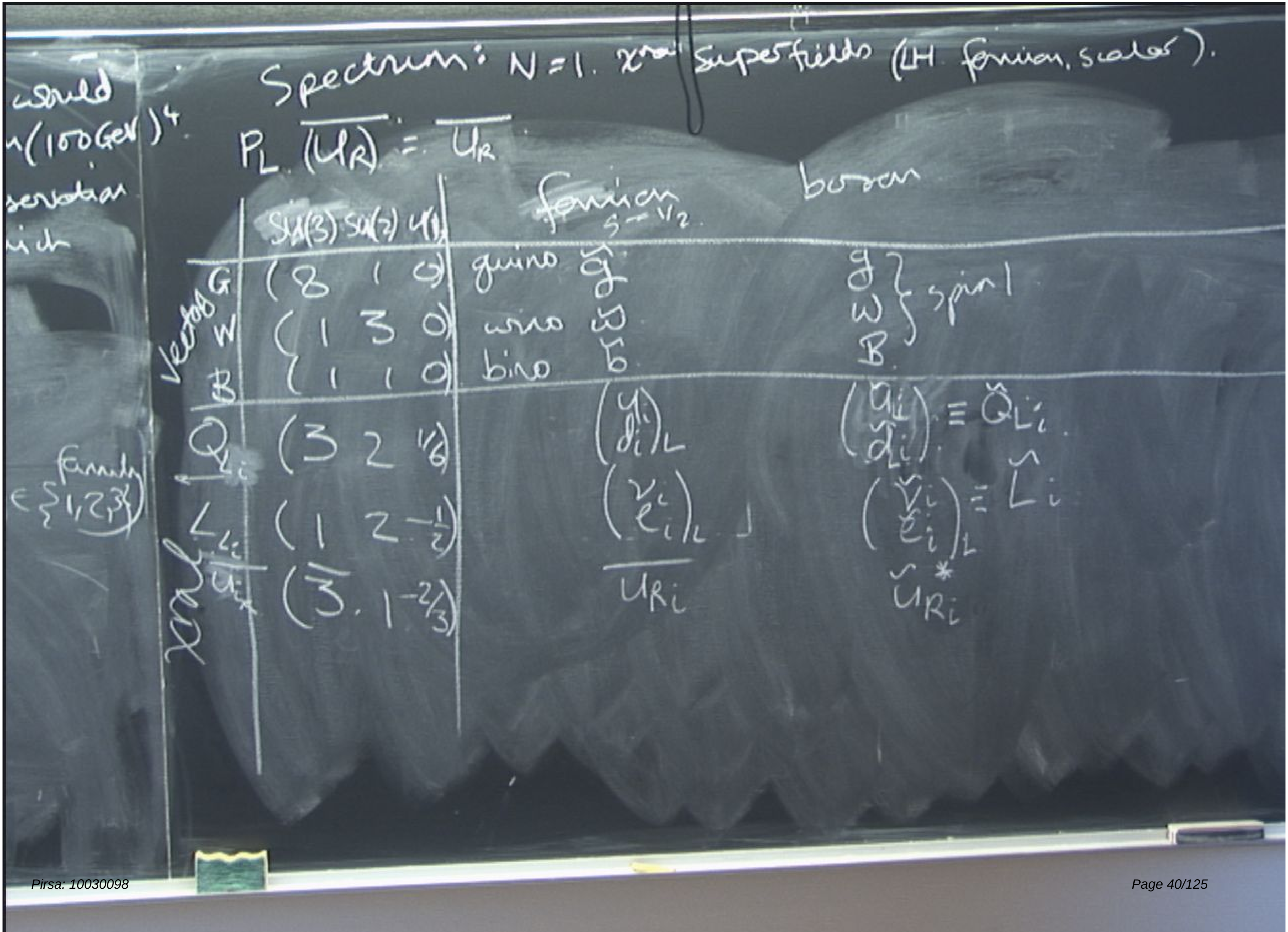
family $\in \{1,2,3\}$

Spectrum: N=1. $\chi^{\rm ral}$ superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

		SU(3) SU(2) U(1)	fermion $s=1/2$		boson
Vectors	G	(8 1 0)	gluino	$\tilde{g}$	g } spin 1
	W	(1 3 0)	wino	$\tilde{W}$	W
	B	(1 1 0)	bino	$\tilde{b}$	B
χral	Q_{L_i}	(3 2 1/6)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_L \\ \tilde{d}_L \end{pmatrix} \equiv \hat{Q}_{L_i}$
	L_{L_i}	(1 2 $-\frac{1}{2}$)		$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$
	$\overline{u}_i$	($\overline{3}$. 1 $-2/3$)		$\overline{u_{R_i}}$	u



would

$(100\,GeV)^4$

servation

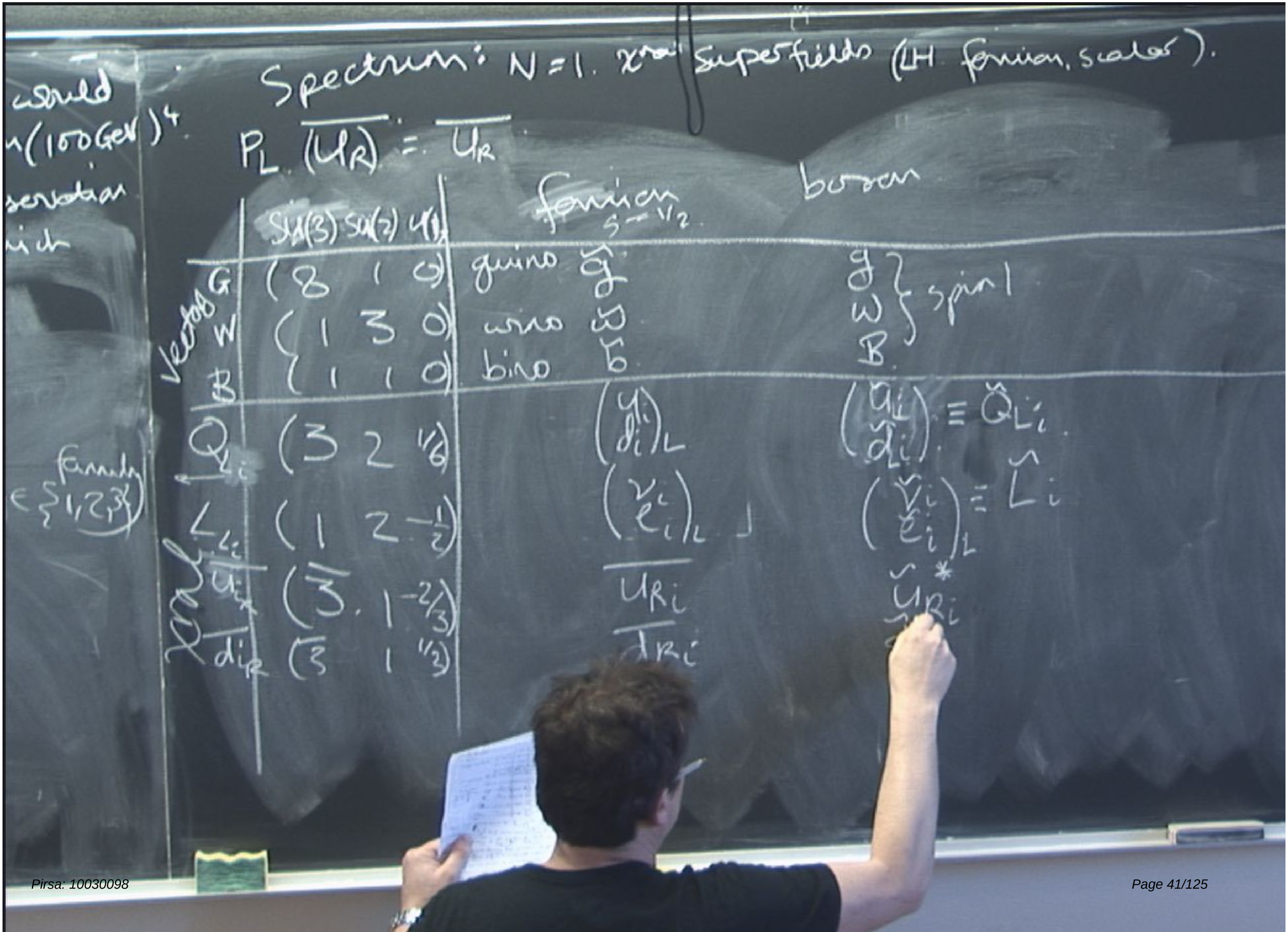
ich

Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

	$SU(3)\ SU(2)\ U(1)$	fermion $s=1/2$	boson
Vectors G	$(8\ 1\ 0)$	gluino $\tilde{g}$	g } spin 1
W	$(1\ 3\ 0)$	wino $\tilde{W}$	W
B	$(1\ 1\ 0)$	bino $\tilde{b}$	B
χral Q_{L_i}	$(3\ 2\ 1/6)$	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_{L_i} \\ \tilde{d}_{L_i} \end{pmatrix} \equiv \hat{Q}_{L_i}$
L_{L_i}	$(1\ 2\ -\frac{1}{2})$	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$
$\bar{u}_i$	$(\bar{3}.\ 1\ -2/3)$	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$

family $i \in \{1,2,3\}$



would

~(100 GeV)^4

servation

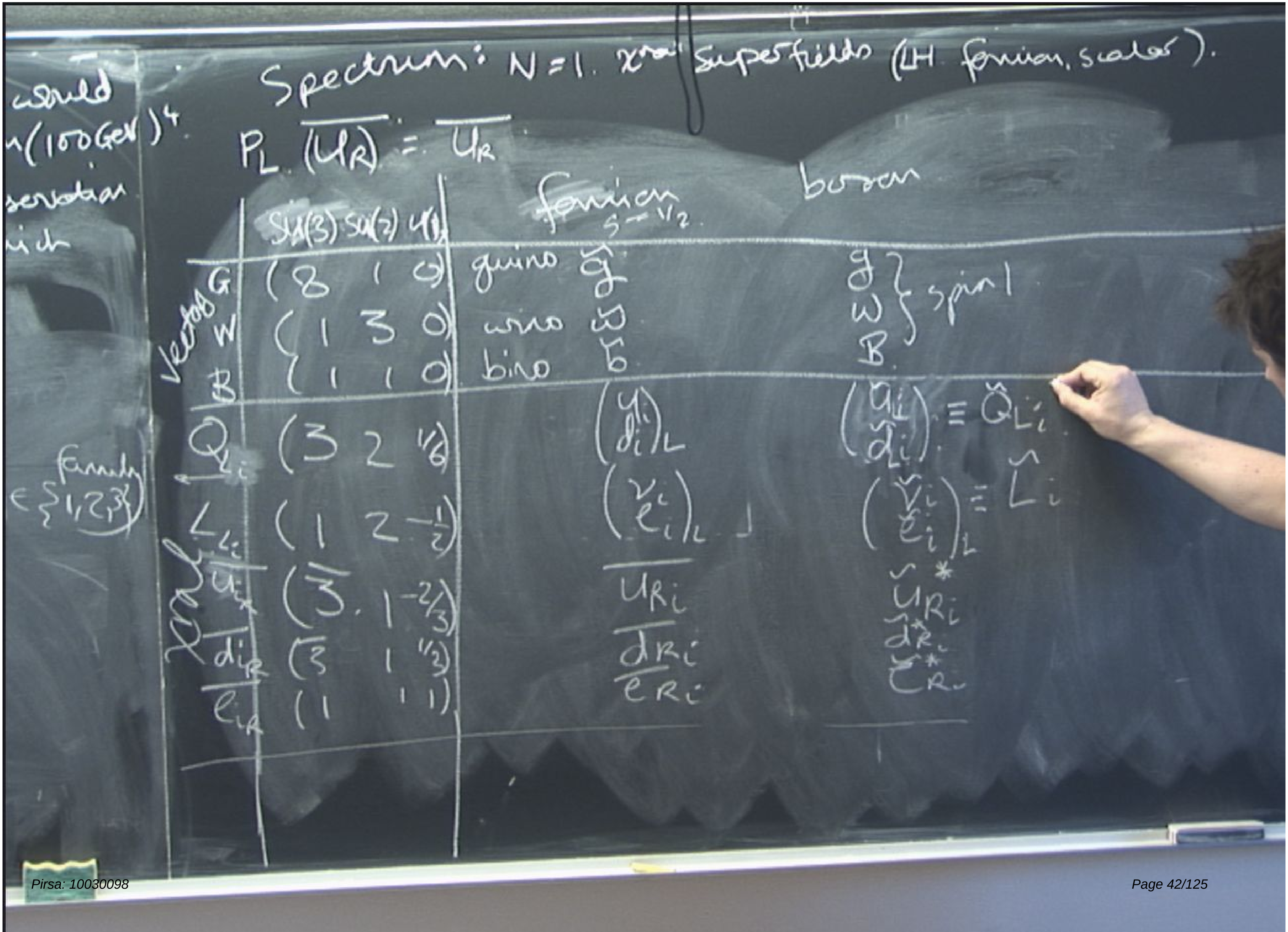
hich

family $i \in \{1,2,3\}$

Spectrum: N=1. χral superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

	SU(3) SU(2) U(1)	fermion $s=1/2$	boson
Vectors G	(8 1 0)	gluino $\tilde{g}$	g } spin 1
W	(1 3 0)	wino $\tilde{W}$	W
B	(1 1 0)	bino $\tilde{b}$	B
χral Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix}_L \equiv \hat{Q}_{L_i}$
L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$
$\bar{u}_i$	($\bar{3}$ 1 $-2/3$)	$\overline{u_{R_i}}$	$\tilde{u}_{R_i}^*$
$\bar{d}_{iR}$	($\bar{3}$ 1 1/3)	$\overline{d_{R_i}}$	~



would

n(100 GeV)^4

servation

nich

family $i \in \{1,2,3\}$

Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

		SU(3) SU(2) U(1)	fermion $s=1/2$	boson	
Vector	G	$(8\ 1\ 0)$	gluino $\tilde{g}$	g	} spin 1
	W	$(1\ 3\ 0)$	wino $\tilde{W}$	W	
	B	$(1\ 1\ 0)$	bino $\tilde{B}$	B	
χral	Q_{L_i}	$(3\ 2\ 1/6)$	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix} \equiv \hat{Q}_{L_i}$	
	L_{L_i}	$(1\ 2\ -\frac{1}{2})$	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$	
	$\overline{u_{iR}}$	$(\bar{3}.\ 1\ -2/3)$	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$	
	$\overline{d_{iR}}$	$(\bar{3}\ 1\ 1/3)$	$\overline{d_{R_i}}$	$\tilde{d}^*_{R_i}$	
	$\overline{e_{iR}}$	$(1\ 1\ 1)$	$\overline{e_{R_i}}$	$\tilde{e}^*_{R_i}$	

would
$n(100\,\text{GeV})^4$
servation
nich

family
$i \in \{1,2,3\}$

Spectrum: N=1. χ^ral superfields (LH fermion, scalar).

$$P_L\,\overline{(u_R)} = \overline{u_R}$$

		SU(3) SU(2) U(1)	fermion $s = 1/2$	boson	
Vectors	G	(8 1 0)	gluino $\tilde{g}$	g	spin 1
	W	(1 3 0)	wino $\tilde{W}$	W	
	B	(1 1 0)	bino $\tilde{b}$	B	
χral	Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_L \\ \tilde{d}_L \end{pmatrix} \equiv \hat{Q}_{L_i}$	spin 0
	L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$	
	$\overline{u}_{iR}$	($\overline{3}$ 1 $-2/3$)	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$	
	$\overline{d}_{iR}$	($\overline{3}$ 1 1/3)	$\overline{d_{R_i}}$	$\tilde{d}^*_{R_i}$	
	$\overline{e}_{iR}$	(1 1 1)	$\overline{e_{R_i}}$	$\tilde{e}^*_{R}$	

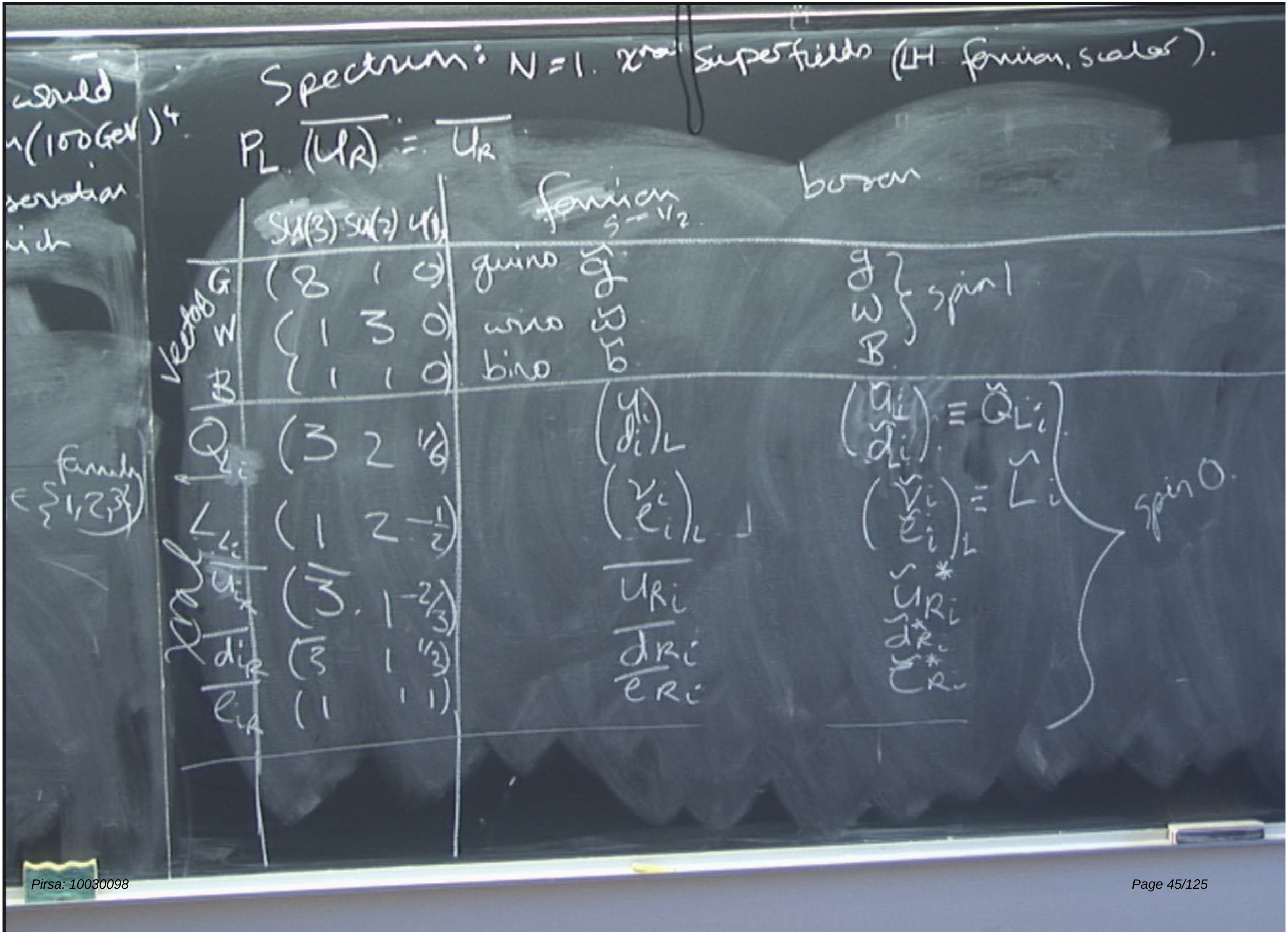
would
~(100 GeV)^4.
servation
ich

family
$\in \{1,2,3\}$

Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

		SU(3)	SU(2)	U(1)	fermion $s = 1/2$		boson	
Vector	G	(8	1	0)	gluino	$\tilde{g}$	g	spin 1
	W	(1	3	0)	wino	$\tilde{W}$	W	
	B	(1	1	0)	bino	$\tilde{b}$	B	
χral	Q_{Li}	(3	2	$1/6$)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix} \equiv \hat{Q}_{L i}$	spin 0.
	L_{Li}	(1	2	$-\frac{1}{2}$)		$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$	
	$\overline{u_{iR}}$	($\bar{3}$.	1	$-2/3$)		$\overline{u_{Ri}}$	$\tilde{u}^*_{Ri}$	
	$\overline{d_{iR}}$	($\bar{3}$	1	$1/3$)		$\overline{d_{Ri}}$	$\tilde{d}^*_{Ri}$	
	$\overline{e_{iR}}$	(1	1	1)		$\overline{e_{Ri}}$	$\tilde{e}^*_{Ri}$	



would

n(100GeV)^4.

servation

ich

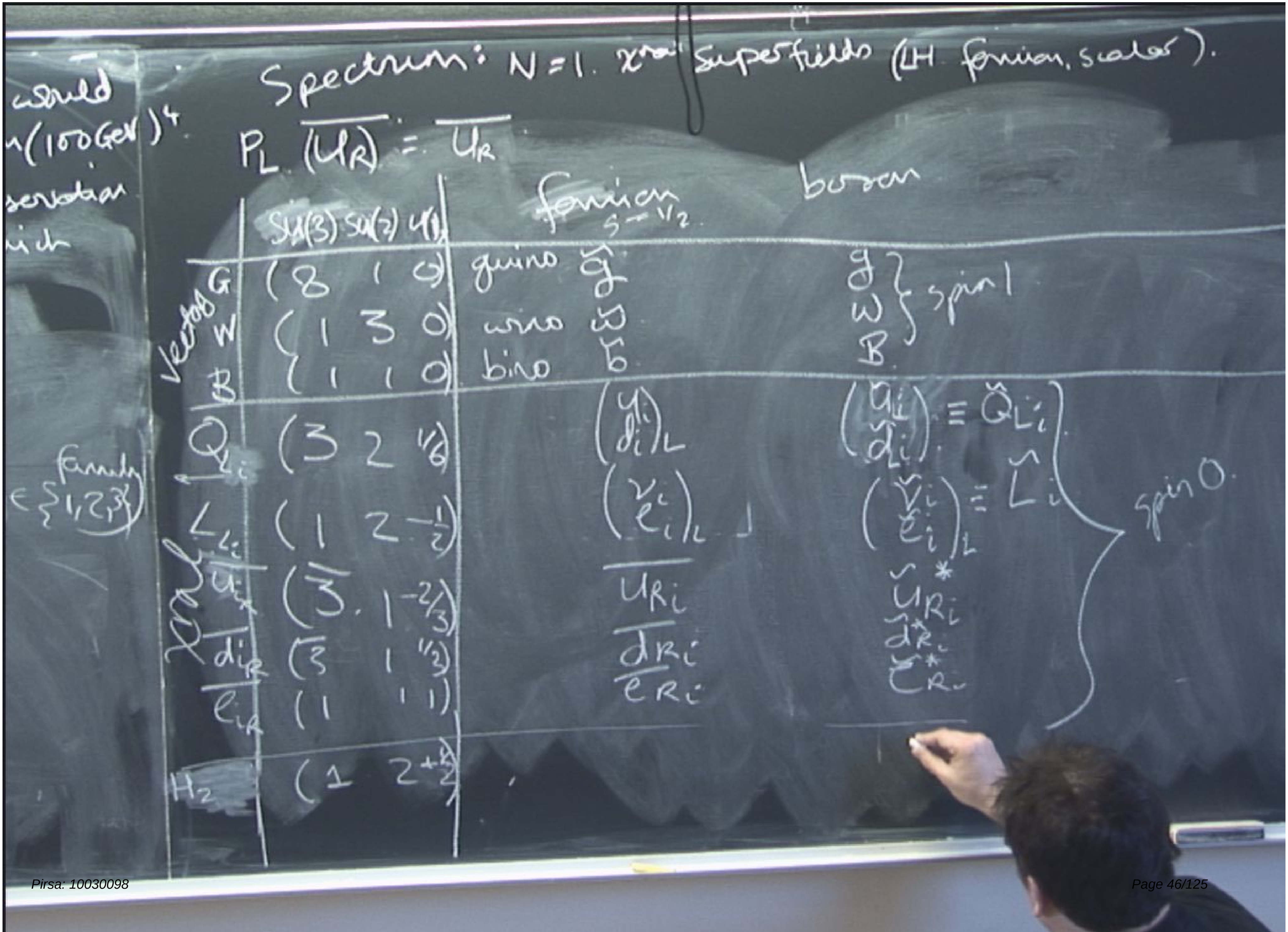
family

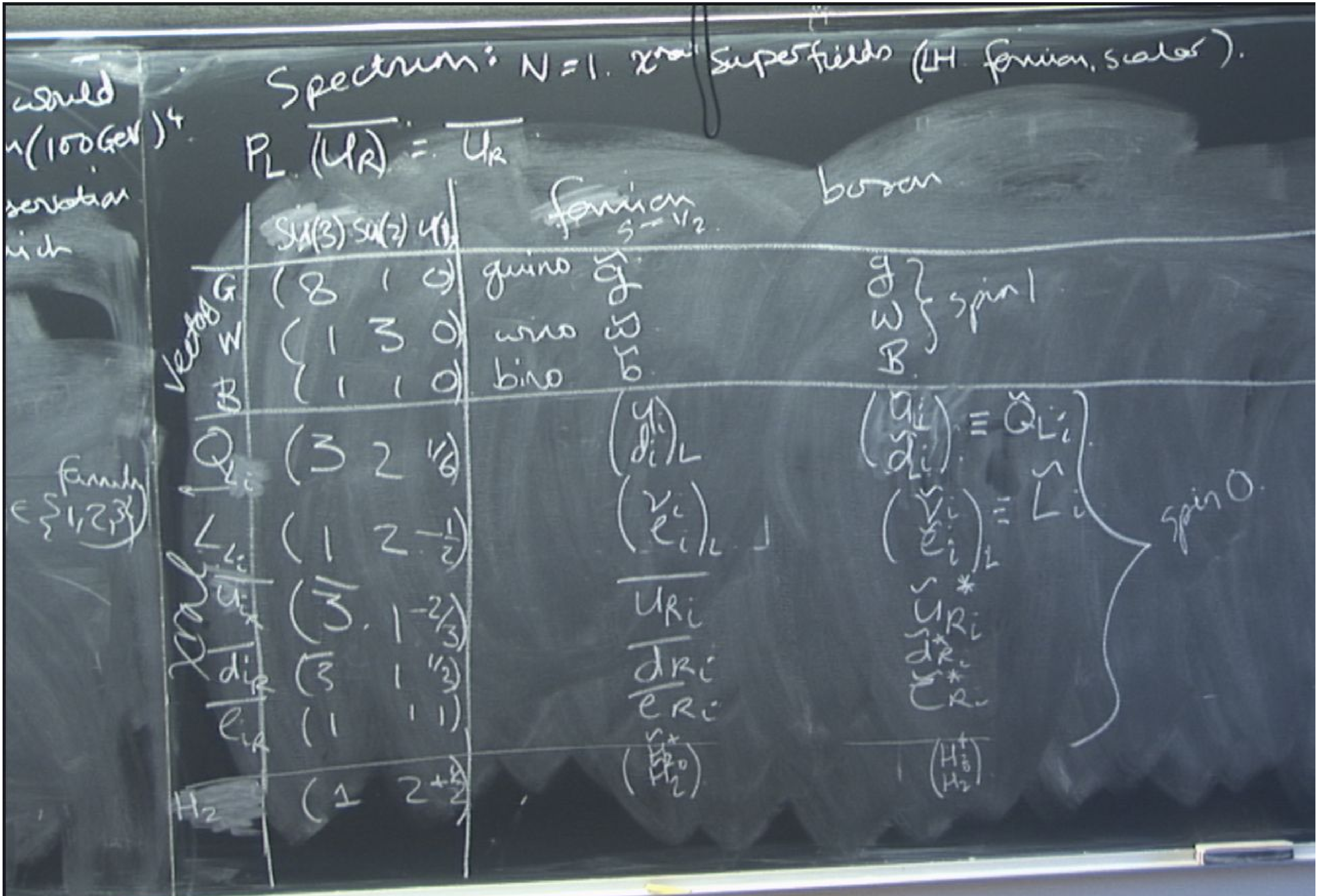
$\in\{1,2,3\}$

Spectrum: N=1. χ$^{\text{ral}}$ superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

	SU(3) SU(2) U(1)	fermion $s=1/2$		boson	
Vector G	(8 1 0)	gluino	$\tilde{g}$	g	spin 1
W	(1 3 0)	wino	$\tilde{W}$	W	
B	(1 1 0)	bino	$\tilde{B}$	B	
χral Q_{L_i}	(3 2 1/6)		$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix}_L \equiv \hat{Q}_{L_i}$	spin 0.
L_{L_i}	(1 2 $-\frac{1}{2}$)		$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$	
$\overline{u}_{iR}$	($\overline{3}$ 1 $-2/3$)		$\overline{u_{Ri}}$	$\tilde{u}^*_{Ri}$	
$\overline{d}_{iR}$	($\overline{3}$ 1 1/3)		$\overline{d_{Ri}}$	$\tilde{d}^*_{Ri}$	
$\overline{e}_{iR}$	(1 1 1)		$\overline{e_{Ri}}$	$\tilde{e}^*_{Ri}$	





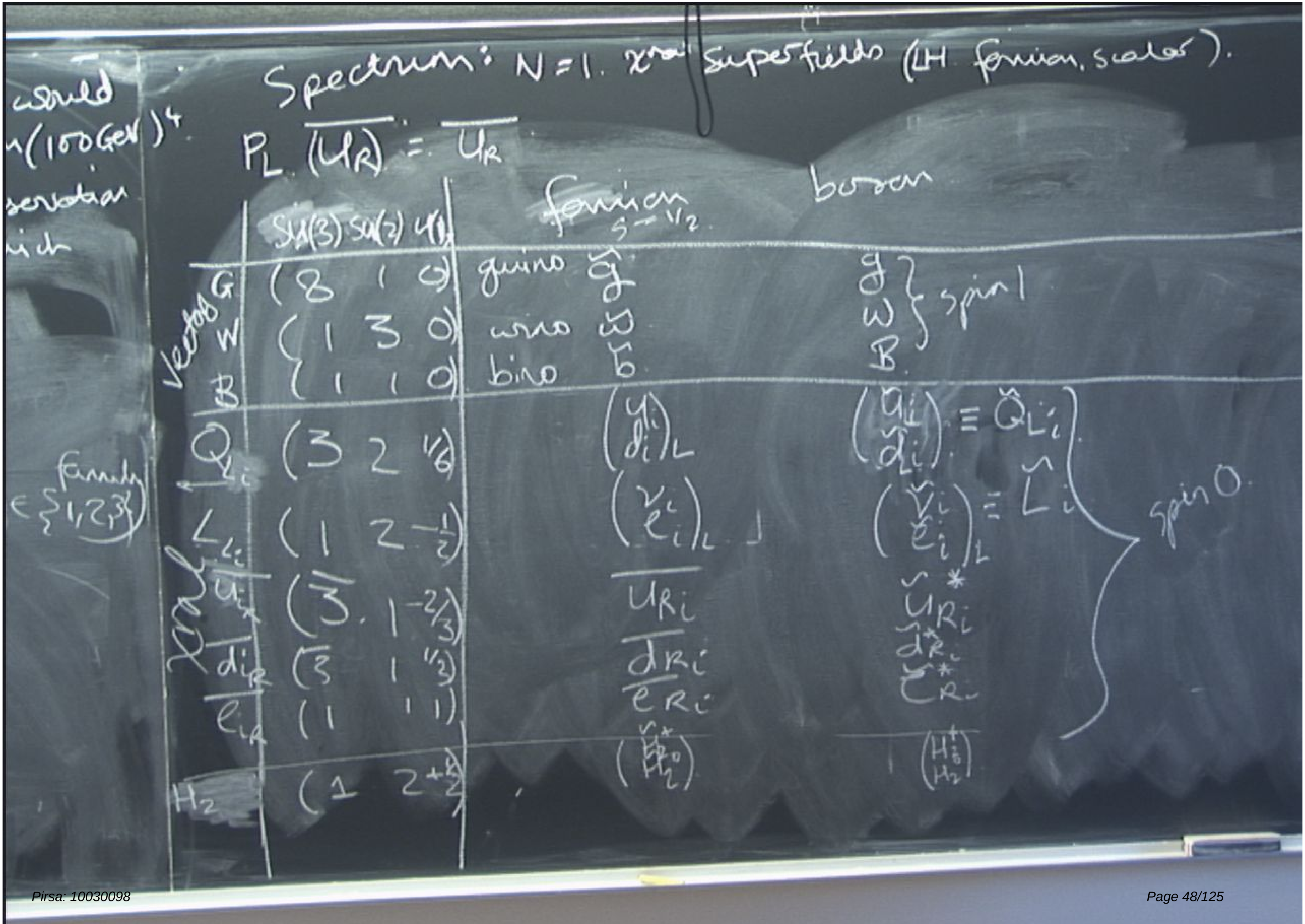
would
$(100 \text{GeV})^4$
servation
ich

family $\in \{1,2,3\}$

Spectrum: N=1. χral superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

		SU(3)	SU(2)	U(1)	fermion $s=1/2$	boson	
Vectors	G	(8	1	0)	gluino $\tilde g$	g	} spin 1
	W	(1	3	0)	wino $\tilde W$	W	
	B	(1	1	0)	bino $\tilde b$	B	
χral	Q_{L_i}	(3	2	$1/6$)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde u_{L_i} \\ \tilde d_{L_i} \end{pmatrix} \equiv \hat Q_{L_i}$	spin 0
	L_{L_i}	(1	2	$-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde \nu_i \\ \tilde e_i \end{pmatrix}_L \equiv \hat L_i$	
	$\overline{u_{iR}}$	($\overline{3}$	1	$-2/3$)	$\overline{u_{R_i}}$	$\tilde u^*_{R_i}$	
	$\overline{d_{iR}}$	($\overline{3}$	1	$1/3$)	$\overline{d_{R_i}}$	$\tilde d^*_{R_i}$	
	$\overline{e_{iR}}$	(1	1	1)	$\overline{e_{R_i}}$	$\tilde e^*_{R_i}$	
	H_2	(1	2	$+\frac{1}{2}$)	$\begin{pmatrix} \tilde H_2^{+} \\ \tilde H_2^0 \end{pmatrix}$	$\begin{pmatrix} H_2^{+} \\ H_2 \end{pmatrix}$	



would

n(100GeV)^4

servation

ich

family

$i \in \{1,2,3\}$

Spectrum: N=1. χral superfields (LH fermion, scalar).

$P_L \overline{(U_R)} = \overline{U_R}$

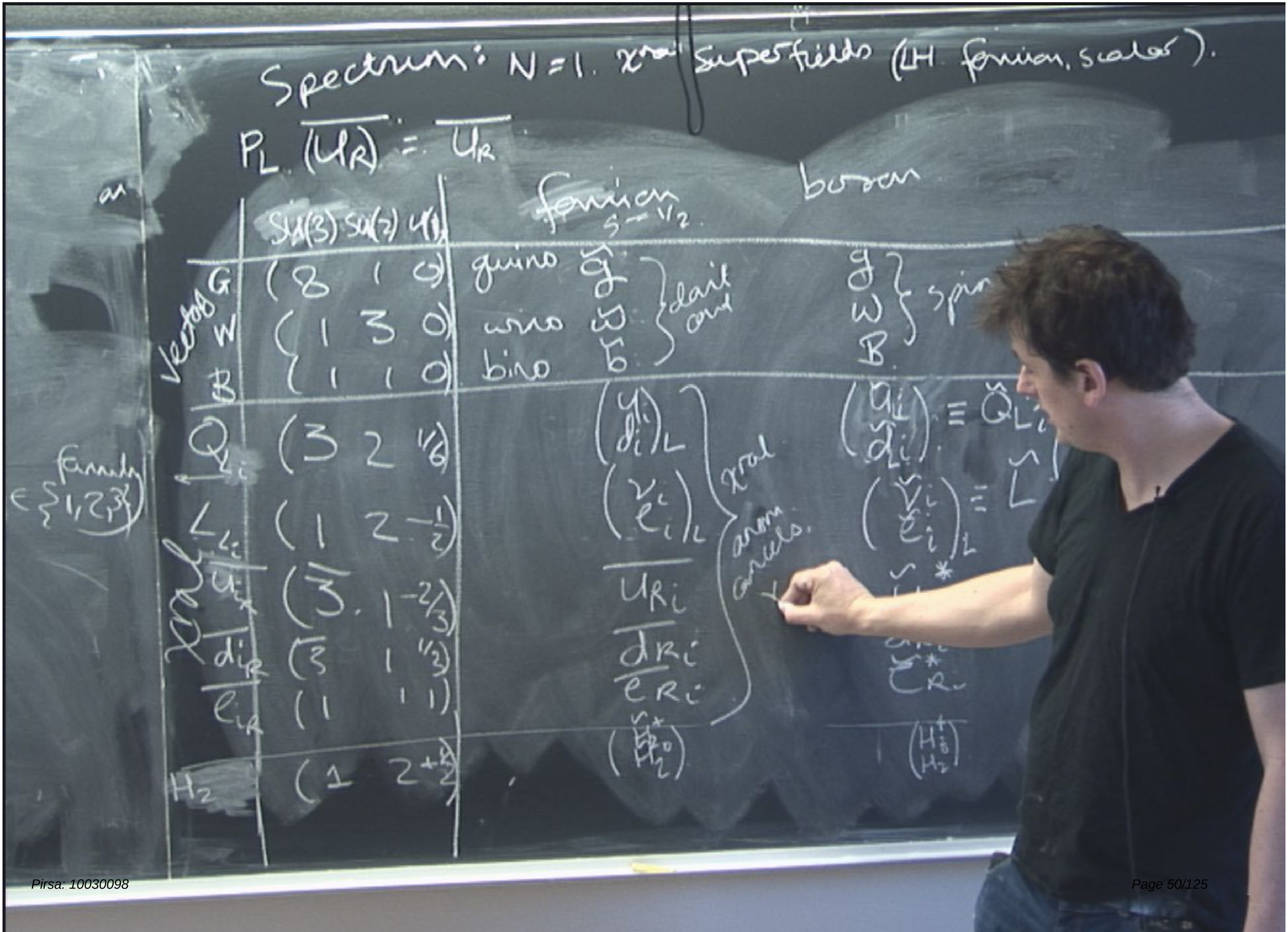
	SU(3) SU(2) U(1)	fermion $s=1/2$	boson	
Vectors G	(8 1 0)	gluino $\tilde{g}$	g	spin 1
W	(1 3 0)	wino $\tilde{W}$	W	
B	(1 1 0)	bino $\tilde{b}$	B	
χral Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix} \equiv \hat{Q}_{L_i}$	spin 0
L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$	
$\overline{u_{iR}}$	($\bar{3}$ 1 $-2/3$)	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$	
$\overline{d_{iR}}$	($\bar{3}$ 1 1/3)	$\overline{d_{R_i}}$	$\tilde{d}^*_{R_i}$	
$\overline{e_{iR}}$	(1 1 1)	$\overline{e_{R_i}}$	$\tilde{e}^*_{R_i}$	
H_2	(1 2 $+\frac{1}{2}$)	$\begin{pmatrix} \tilde{H}^+_2 \\ \tilde{H}^0_2 \end{pmatrix}$	$\begin{pmatrix} H^+_2 \\ H^0_2 \end{pmatrix}$	

Spectrum: N=1. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

an

		SU(3) SU(2) U(1)	fermion $s=1/2$	boson	
Vectors	G	(8 1 0)	gluino $\tilde g$	g	spin 1
	W	(1 3 0)	wino $\tilde W$	W	
	B	(1 1 0)	bino $\tilde b$	B	
χral	Q_{L_i}	(3 2 1/6)	$\begin{pmatrix}u_i\\ d_i\end{pmatrix}_L$	$\begin{pmatrix}\tilde u_L\\ \tilde d_L\end{pmatrix}_i \equiv \hat Q_{L_i}$	spin 0
family $\in \{1,2,3\}$	L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix}\nu_i\\ e_i\end{pmatrix}_L$	$\begin{pmatrix}\tilde\nu_i\\ \tilde e_i\end{pmatrix}_L \equiv \hat L_i$	
	$\overline{u_{iR}}$	($\bar 3$ 1 $-2/3$)	$\overline{u_{R_i}}$	$\tilde u^*_{R_i}$	
	$\overline{d_{iR}}$	($\bar 3$ 1 1/3)	$\overline{d_{R_i}}$	$\tilde d^*_{R_i}$	
	$\overline{e_{iR}}$	(1 1 1)	$\overline{e_{R_i}}$	$\tilde e^*_{R_i}$	
	H_2	(1 2 $+\frac{1}{2}$)	$\begin{pmatrix}\tilde H^{*}_{2_0}\\ \tilde H_2\end{pmatrix}$	$\begin{pmatrix}H^+_0\\ H_2\end{pmatrix}$	



Spectrum: N=1. χ^ral superfields (LH fermion, scalar).

$P_L \overline{(U_R)} = \overline{U_R}$

	SU(3) SU(2) U(1)	fermion $s = 1/2$	boson
G	(8 1 0)	gluino $\tilde{g}$	g
W	(1 3 0)	wino $\tilde{W}$	W
B	(1 1 0)	bino $\tilde{b}$	B
Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_i \\ \tilde{d}_i \end{pmatrix}_L \equiv \hat{Q}_{L_i}$
L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}$
$\overline{u_{iR}}$	($\bar{3}$. 1 $-2/3$)	$\overline{u_{R_i}}$	$\tilde{u}^*$
$\overline{d_{iR}}$	($\bar{3}$ 1 1/3)	$\overline{d_{R_i}}$	$\tilde{d}_{R_i}$
$\overline{e_{iR}}$	(1 1 1)	$\overline{e_{R_i}}$	$\tilde{e}^*_{R_i}$
H_2	(1 2 $+\frac{1}{2}$)	$\begin{pmatrix} \tilde{H}_2^{+} \\ \tilde{H}_2^{0} \end{pmatrix}^*$	$\begin{pmatrix} H_2^{+} \\ H_2^{0} \end{pmatrix}$

Vectors

χral

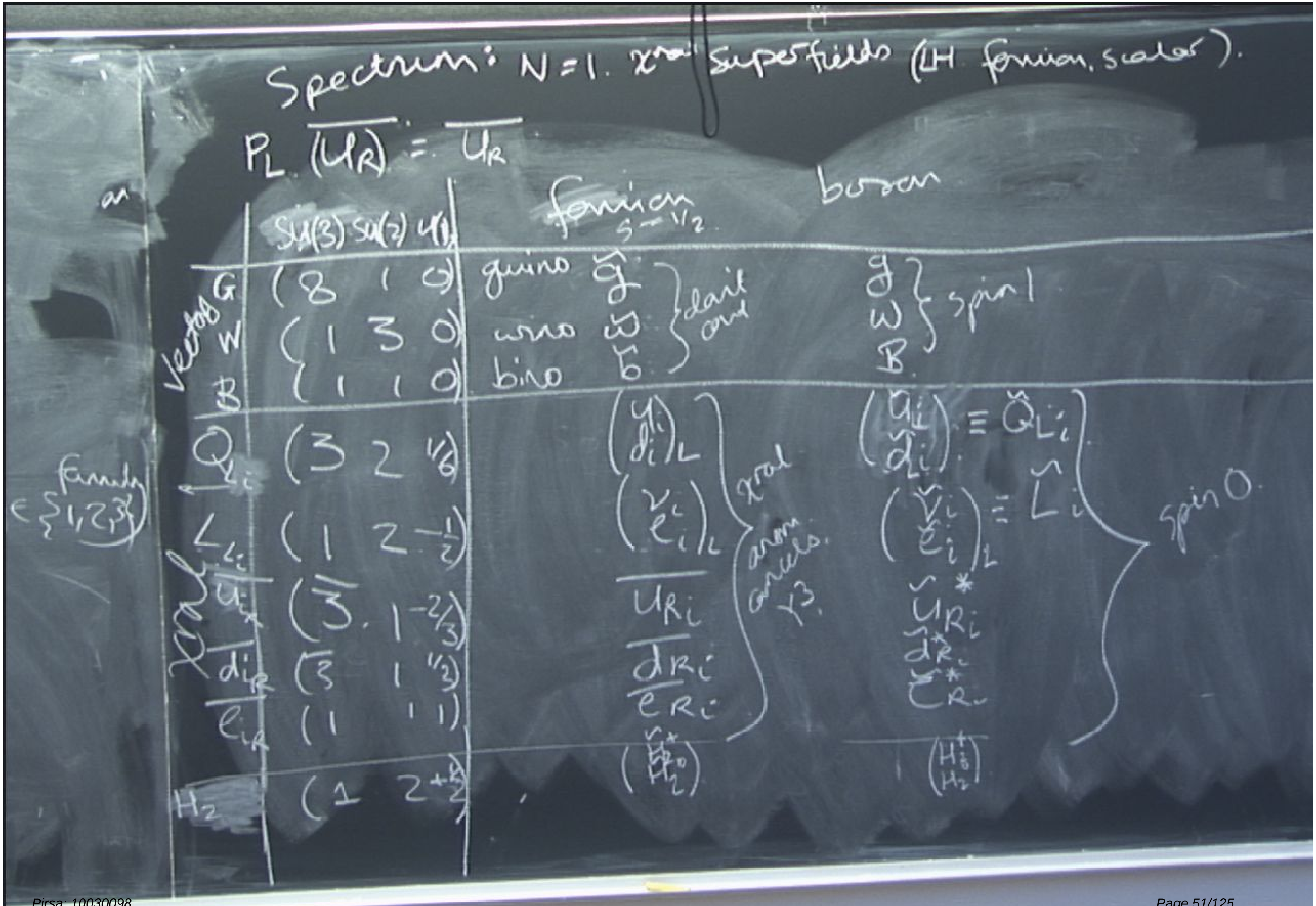
family $\in \{1, 2, 3\}$

dark cond

spin

χral

anom cancels.



Spectrum: N=1. χral superfields (LH fermion, scalar).

$P_L\,\overline{(u_R)} = \overline{u_R}$

	SU(3) SU(2) U(1)	fermion $s=1/2$	boson
G	(8 1 0)	gluino $\tilde{g}$	g
W	(1 3 0)	wino $\tilde{W}$	W
B	(1 1 0)	bino $\tilde{B}$	B
Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_{L_i} \\ \tilde{d}_{L_i} \end{pmatrix} \equiv \hat{Q}_{L_i}$
L_{L_i}	(1 2 $-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$
$\overline{u_{iR}}$	($\bar{3}$. 1 $-2/3$)	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$
$\overline{d_{iR}}$	($\bar{3}$ 1 1/3)	$\overline{d_{R_i}}$	$\tilde{d}^*_{R_i}$
$\overline{e_{iR}}$	(1 1 1)	$\overline{e_{R_i}}$	$\tilde{e}^*_{R_i}$
H_2	(1 2 $+\frac{1}{2}$)	$\begin{pmatrix} \tilde{H}^+_2 \\ \tilde{H}^0_2 \end{pmatrix}$	$\begin{pmatrix} H^+_2 \\ H^0_2 \end{pmatrix}$

Vectors

χral

family ∈ {1,2,3}

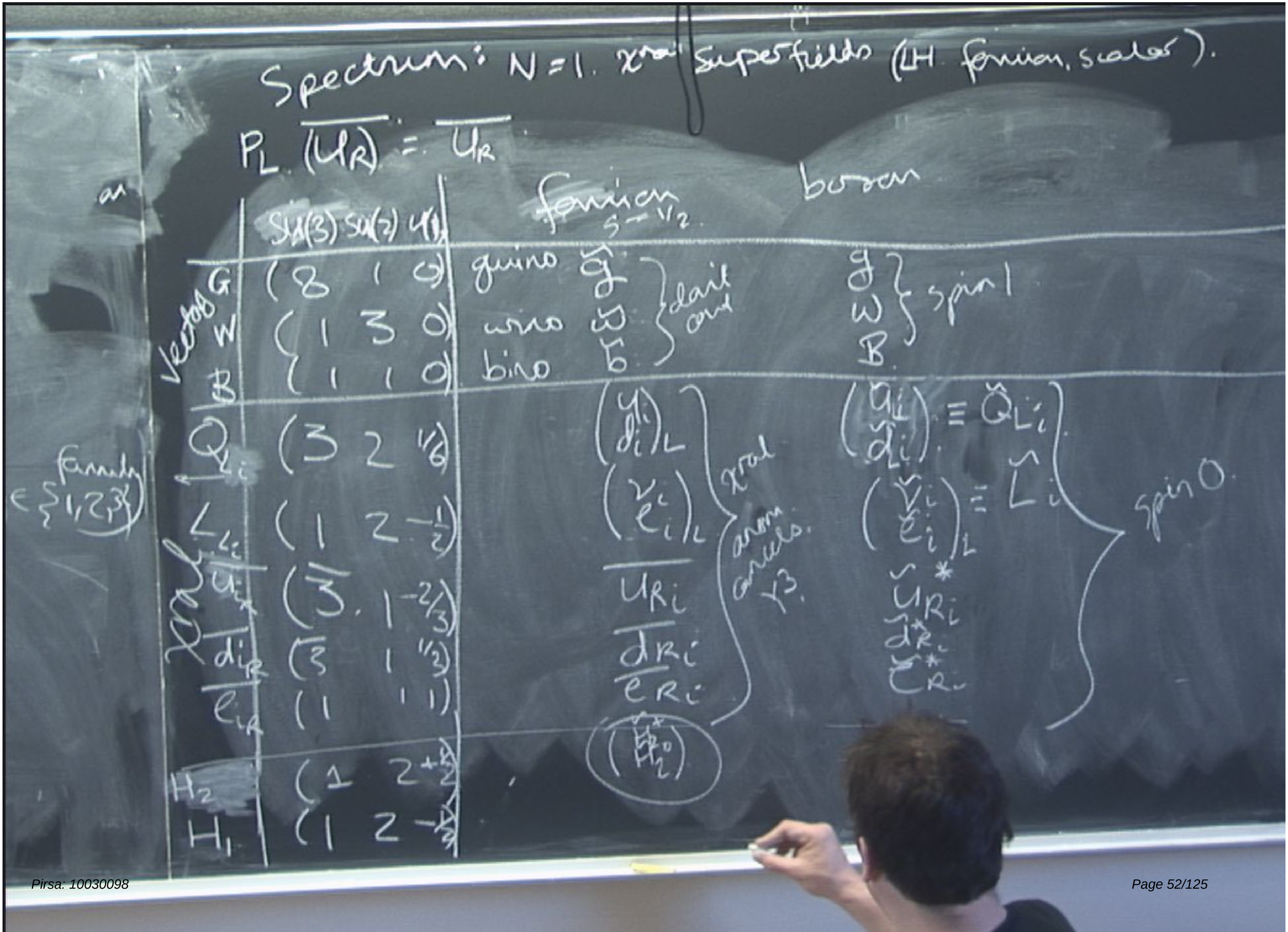
dark cond

spin 1

χral

anom. cancels. ×3.

spin 0.



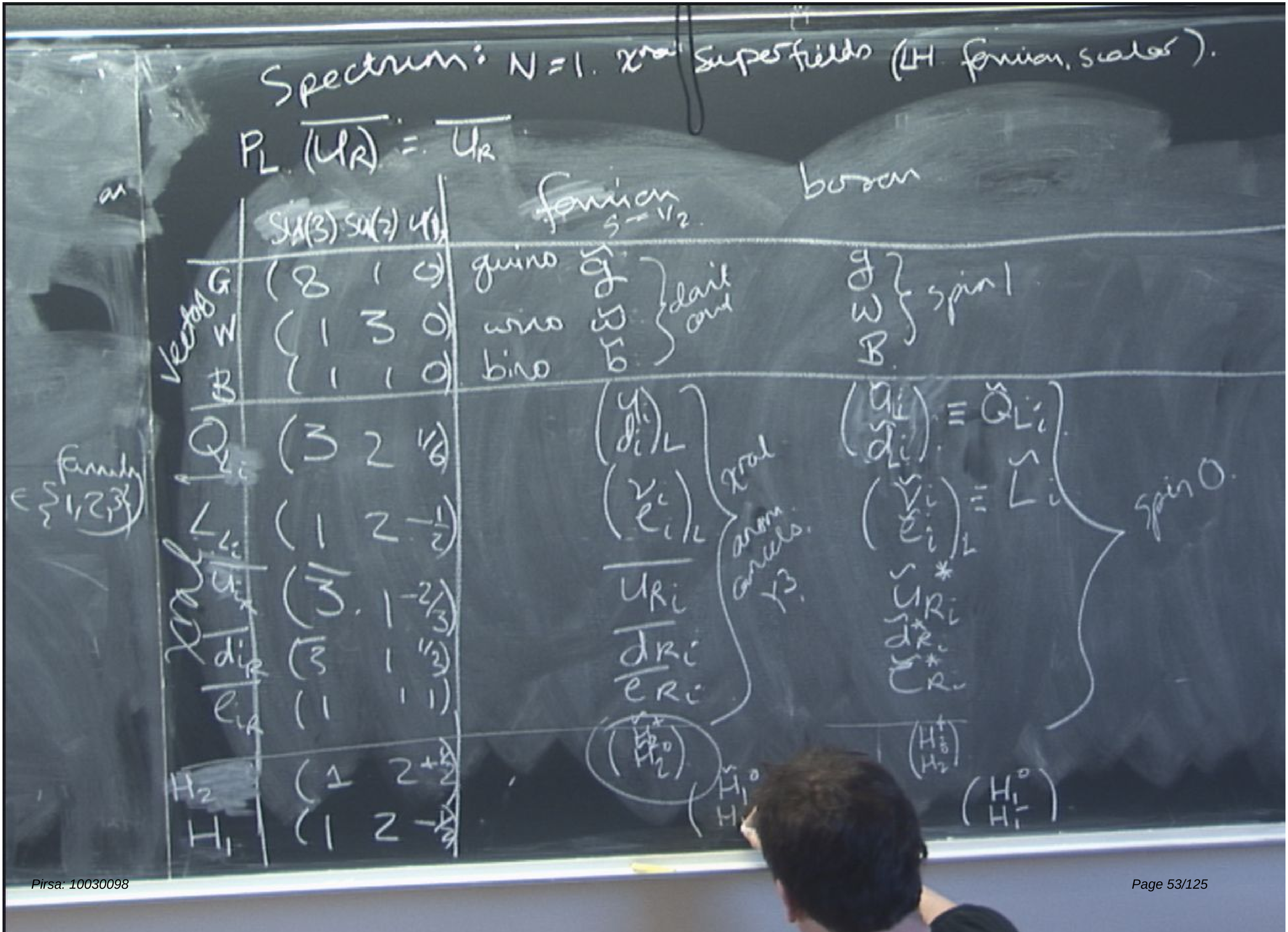
Spectrum: $N=1$ χ^{ral} superfields (LH fermion, scalar).

$P_L\,\overline{(u_R)} = \overline{u_R}$

		SU(3) SU(2) U(1)	fermion $s=1/2$		boson	
Vectors	G	(8 1 0)	gluino $\tilde g$	} dirac cond	g	} spin 1
	W	(1 3 0)	wino $\tilde W$		W	
	B	(1 1 0)	bino $\tilde b$		B	
χral	Q_{L_i}	(3 2 1/6)	$\binom{u_i}{d_i}_L$	} χral anom. cancels. ×3.	$\binom{\tilde u_i}{\tilde d_i}_L \equiv \hat Q_{L_i}$	} spin 0.
	L_{L_i}	(1 2 $-\frac{1}{2}$)	$\binom{\nu_i}{e_i}_L$		$\binom{\tilde \nu_i}{\tilde e_i}_L \equiv \hat L_i$	
	$\overline{u_{iR}}$	($\bar 3$ 1 $-2/3$)	$\overline{u_{R_i}}$		$\tilde u^*_{R_i}$	
	$\overline{d_{iR}}$	($\bar 3$ 1 1/3)	$\overline{d_{R_i}}$		$\tilde d^*_{R_i}$	
	$\overline{e_{iR}}$	(1 1 1)	$\overline{e_{R_i}}$		$\tilde e^*_{R_i}$	
	H_2	(1 2 $+\frac{1}{2}$)	$\binom{\tilde H_2^+}{\tilde H_2^0}$			
	H_1	(1 2 $-\frac{1}{2}$)				

family $\in \{1,2,3\}$

an

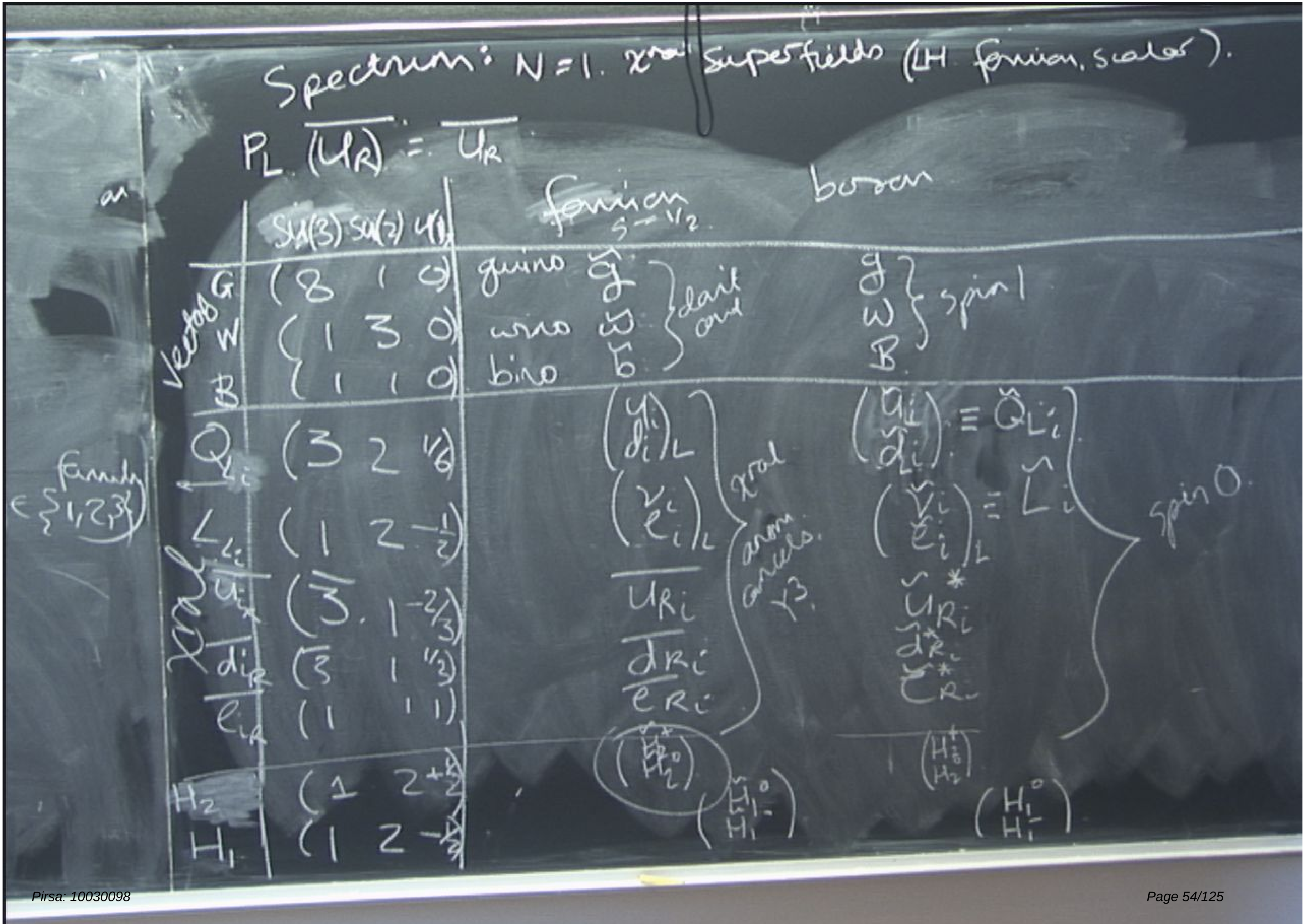


Spectrum: N = 1. χral superfields (LH fermion, scalar).

$$P_L\,\overline{(u_R)} = \overline{u_R}$$

		SU(3) SU(2) U(1)	fermion $s = 1/2$		boson	
Vectors	G	(8 1 0)	guino $\tilde g$	} dark cand	g	} spin 1
	W	(1 3 0)	wino $\tilde W$		W	
	B	(1 1 0)	bino $\tilde b$		B	
χral family $\in \{1,2,3\}$	Q_{L_i}	(3 2 1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	} χral anom cancels. ×3	$\begin{pmatrix} \tilde u_i \\ \tilde d_i \end{pmatrix}_L \equiv \hat Q_{L_i}$	} spin 0
	L_{L_i}	$(1\ 2\ -\frac{1}{2})$	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$		$\begin{pmatrix} \tilde \nu_i \\ \tilde e_i \end{pmatrix}_L \equiv \hat L_i$	
	$\overline{u_{iR}}$	$(\bar 3.\ 1\ -2/3)$	$\overline{u_{R_i}}$		$\tilde u^*_{R_i}$	
	$\overline{d_{iR}}$	$(\bar 3\ 1\ 1/3)$	$\overline{d_{R_i}}$		$\tilde d^*_{R_i}$	
	$\overline{e_{iR}}$	(1 1 1)	$\overline{e_{R_i}}$		$\tilde e^*_{R_i}$	
	H_2	$(1\ 2\ +\frac{1}{2})$	$\begin{pmatrix} \tilde H_2^+ \\ \tilde H_2^0 \end{pmatrix}$		$\begin{pmatrix} H_2^+ \\ H_2^0 \end{pmatrix}$	
	H_1	$(1\ 2\ -\frac{1}{2})$	$\begin{pmatrix} \tilde H_1^0 \\ \tilde H_1^- \end{pmatrix}$		$\begin{pmatrix} H_1^0 \\ H_1^- \end{pmatrix}$	

an



Spectrum: $N=1$. χral superfields (LH fermion, scalar).

$P_L\,\overline{(u_R)} = \overline{u_R}$

		SU(3)	SU(2)	U(1)	fermion $s=1/2$	boson
Vectors	G	8	1	0	gluino $\tilde{g}$	g
	W	1	3	0	wino $\tilde{W}$	W
	B	1	1	0	bino $\tilde{b}$	B
χral	Q_{L_i}	3	2	$1/6$	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_{L_i} \\ \tilde{d}_{L_i} \end{pmatrix} \equiv \hat{Q}_{L_i}$
	L_{L_i}	1	2	$-\frac{1}{2}$	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \hat{L}_i$
	$\overline{u}_{iR}$	$\overline{3}$	1	$-2/3$	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$
	$\overline{d}_{iR}$	$\overline{3}$	1	$1/3$	$\overline{d_{R_i}}$	$\tilde{d}^*_{R_i}$
	$\overline{e}_{iR}$	1	1	1	$\overline{e_{R_i}}$	$\tilde{e}^*_{R_i}$
	H_2	1	2	$+\frac{1}{2}$	$\begin{pmatrix} \tilde{H}_2^+ \\ \tilde{H}_2^0 \end{pmatrix}$	$\begin{pmatrix} H_2^+ \\ H_2^0 \end{pmatrix}$
	H_1	1	2	$-\frac{1}{2}$	$\begin{pmatrix} \tilde{H}_1^0 \\ \tilde{H}_1^- \end{pmatrix}$	$\begin{pmatrix} H_1^0 \\ H_1^- \end{pmatrix}$

$\tilde{g}, \tilde{W}, \tilde{b}$: dark cand

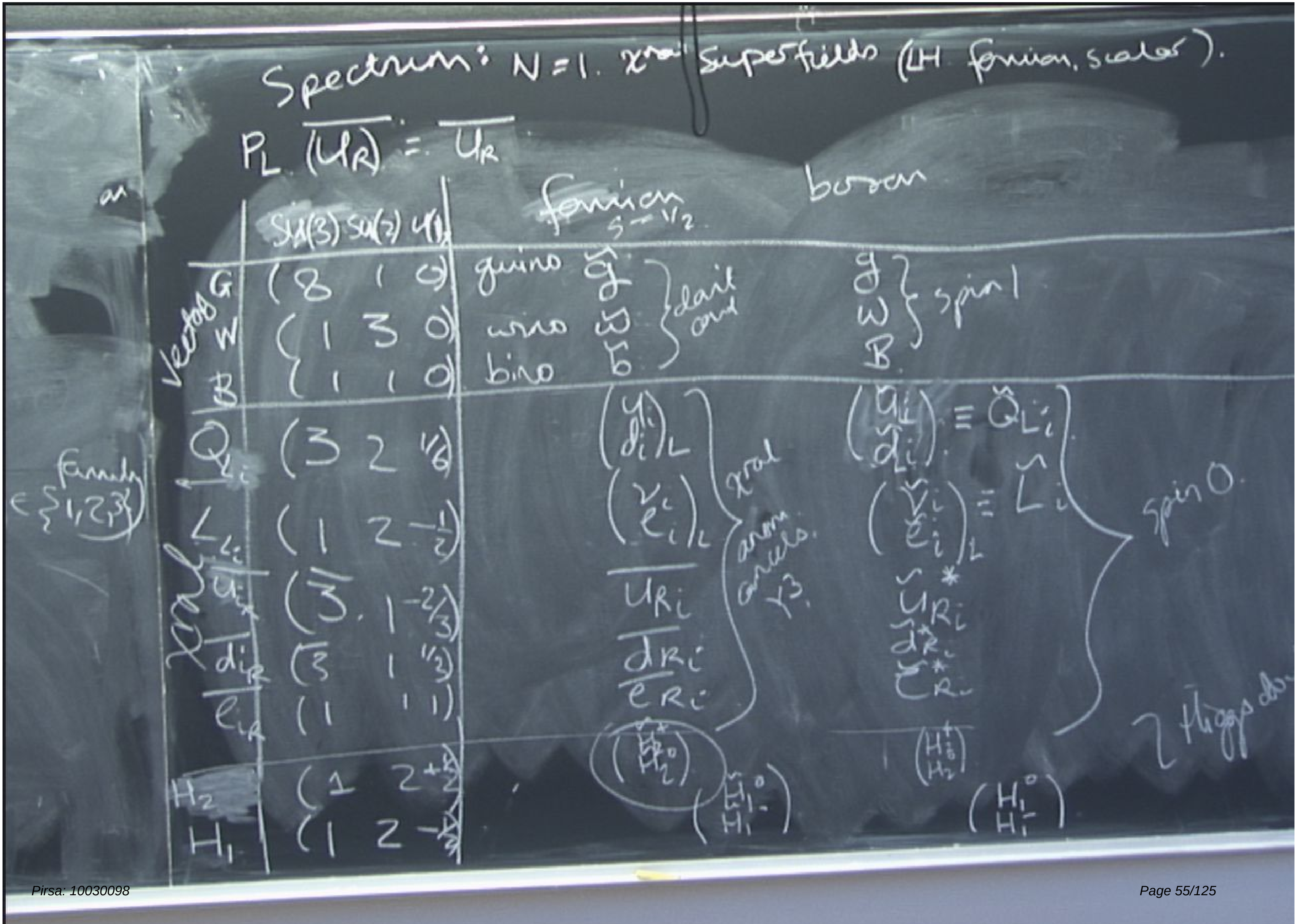
g, W, B: spin 1

χral, anom cancels. $\times 3$.

spin 0.

family $\in \{1,2,3\}$

an



Spectrum: $N=1$. χ^{ral} superfields (LH fermion, scalar).

$P_L \overline{(u_R)} = \overline{u_R}$

	SU(3)	SU(2)	U(1)	fermion $s = 1/2$	boson
G	(8	1	0)	gluino $\tilde{g}$	g
W	(1	3	0)	wino $\tilde{W}$	W
B	(1	1	0)	bino $\tilde{b}$	B
Q_{L_i}	(3	2	1/6)	$\begin{pmatrix} u_i \\ d_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{u}_L^i \\ \tilde{d}_L^i \end{pmatrix} \equiv \tilde{Q}_{L_i}$
L_{L_i}	(1	2	$-\frac{1}{2}$)	$\begin{pmatrix} \nu_i \\ e_i \end{pmatrix}_L$	$\begin{pmatrix} \tilde{\nu}_i \\ \tilde{e}_i \end{pmatrix}_L \equiv \tilde{L}_i$
$\overline{u_{iR}}$	($\bar{3}$.	1	$-2/3$)	$\overline{u_{R_i}}$	$\tilde{u}^*_{R_i}$
$\overline{d_{iR}}$	($\bar{3}$	1	1/3)	$\overline{d_{R_i}}$	$\tilde{d}^*_{R_i}$
$\overline{e_{iR}}$	(1	1	1)	$\overline{e_{R_i}}$	$\tilde{e}^*_{R_i}$
H_2	(1	2	$+\frac{1}{2}$	$\begin{pmatrix} \tilde{H}_2^+ \\ \tilde{H}_2^0 \end{pmatrix}$	$\begin{pmatrix} H_2^+ \\ H_2^0 \end{pmatrix}$
H_1	(1	2	$-\frac{1}{2}$	$\begin{pmatrix} \tilde{H}_1^0 \\ \tilde{H}_1^- \end{pmatrix}$	$\begin{pmatrix} H_1^0 \\ H_1^- \end{pmatrix}$

Vectors

χral

family $\in \{1,2,3\}$

dark cand

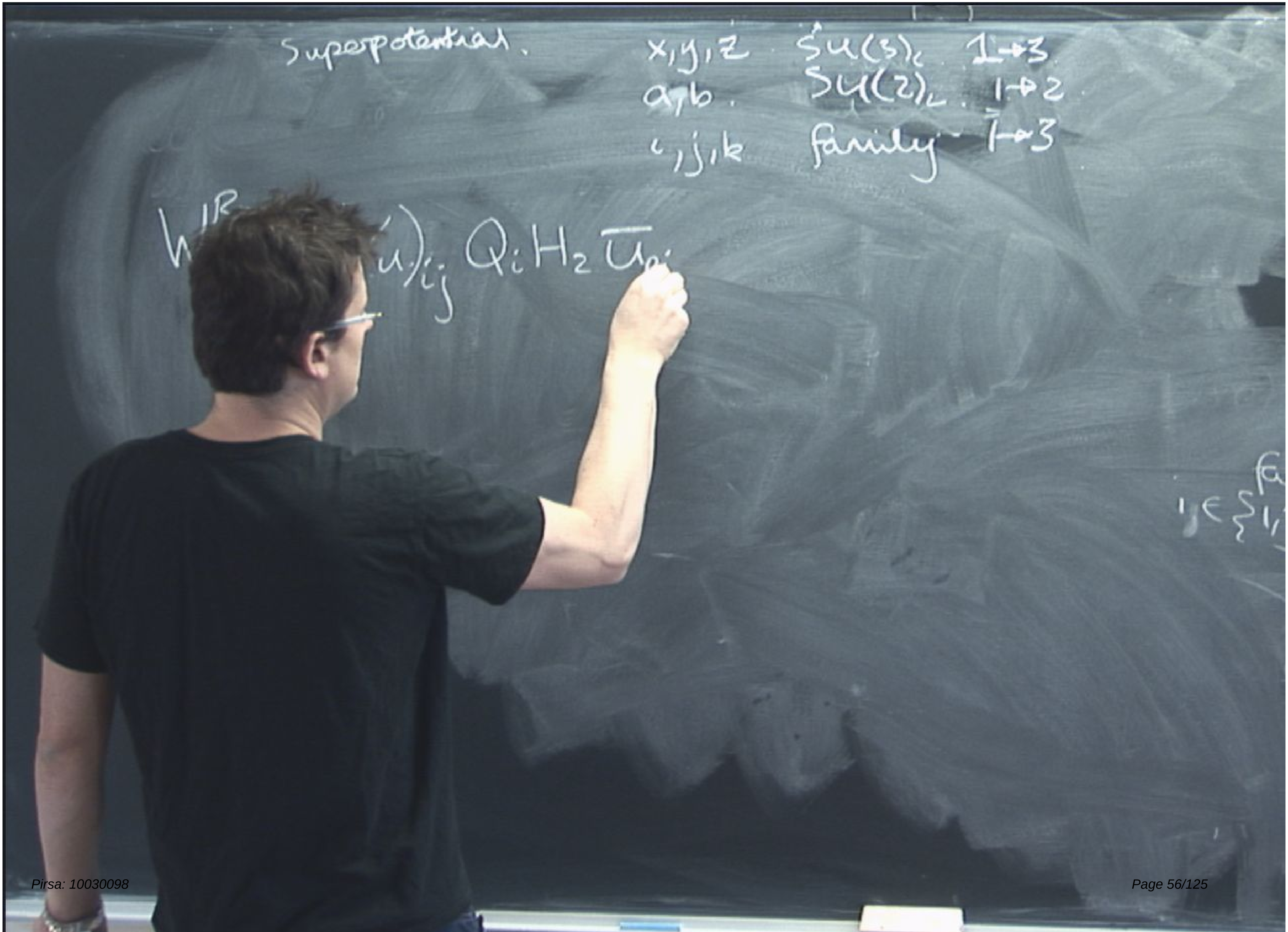
χral

anom cancels $\times 3$.

spin 1

spin 0.

2 Higgs do



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

a, b. $SU(2)_L$. $1 \to 2$

i, j, k family $1 \to 3$

$W^{R} \ldots u)_{ij}\, Q_i H_2 \overline{u}_{a}$

fa

$i, j \in \{1,$

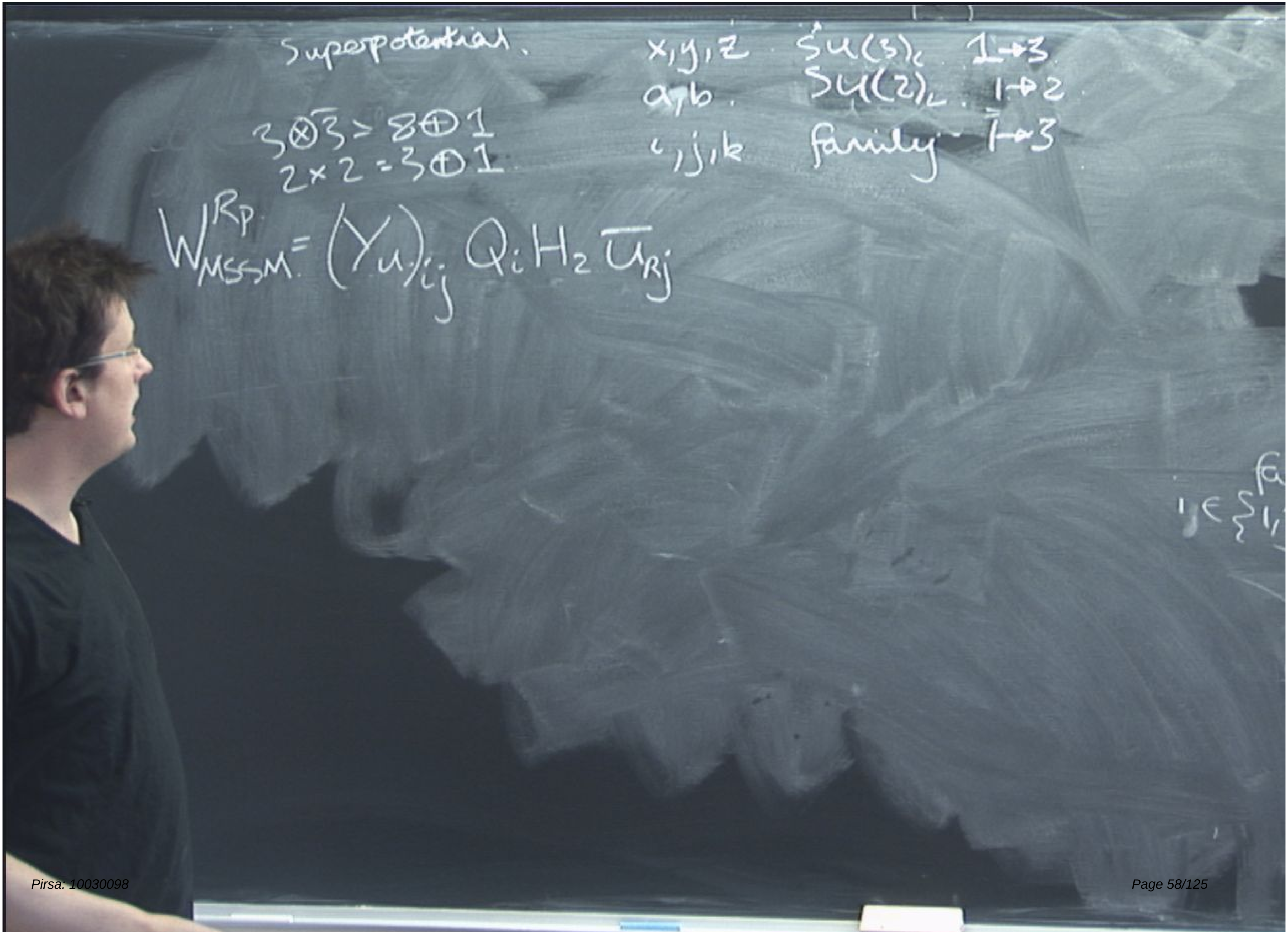
Superpotential.

x, y, z	$SU(3)_c$	$1 \to 3$
a, b	$SU(2)_L$	$1 \to 2$
i, j, k	family	$1 \to 3$

$$W^{R_p}_{MSSM} = (Y_u)_{ij}\, Q_i H_2 \overline{u}_{Rj}$$

fa

$i, j \in \{1,$



Superpotential.

x, y, z . $SU(3)_c$ $1 \to 3$

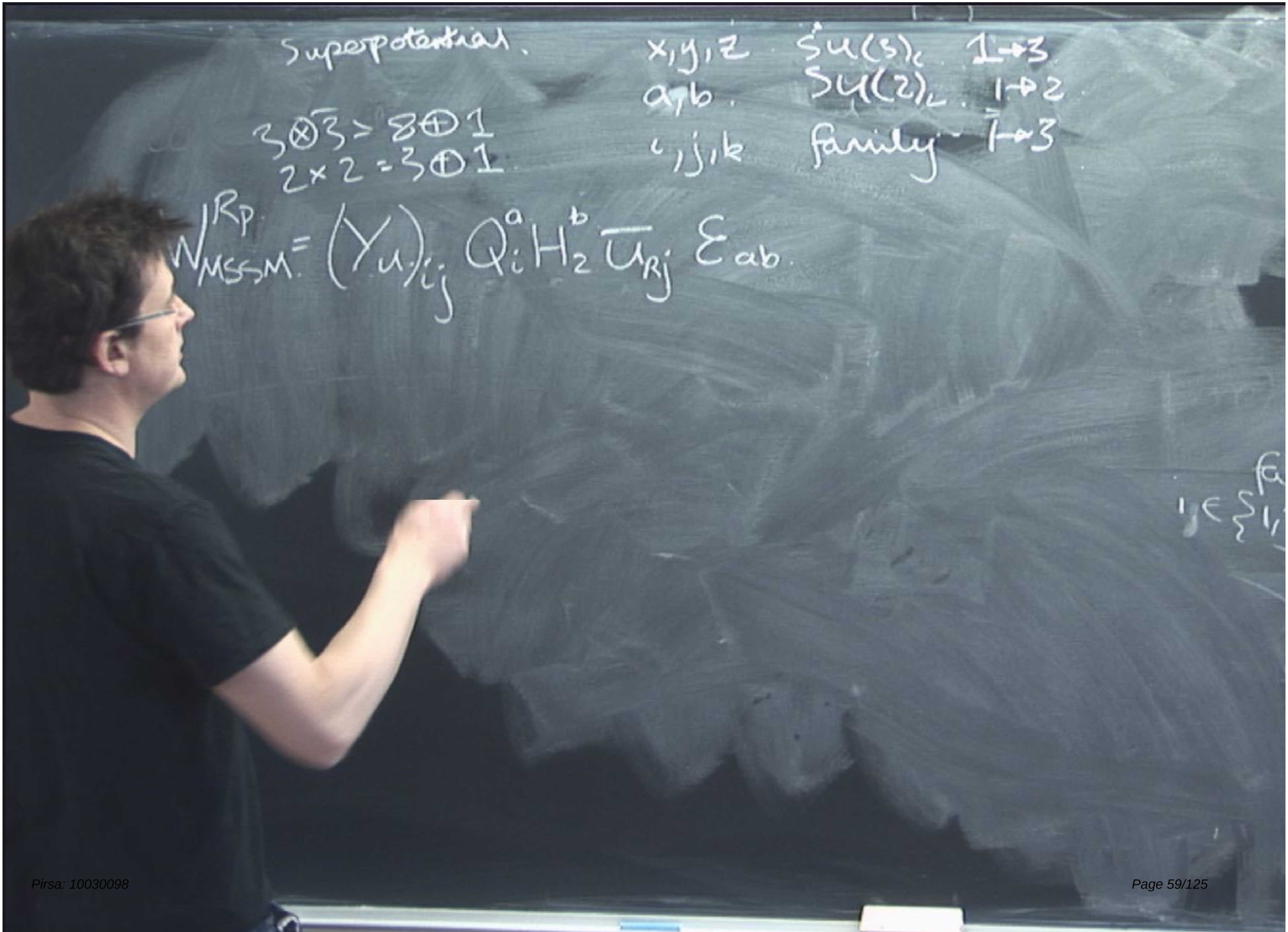
a, b . $SU(2)_L$. $1 \to 2$

i, j, k family $1 \to 3$

$$3 \otimes \bar{3} = 8 \oplus 1$$

$$2 \times 2 = 3 \oplus 1$$

$$W^{R_p}_{MSSM} = (Y_u)_{ij} \, Q_i H_2 \overline{u}_{Rj}$$



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

$a, b.$ $SU(2)_L$. $1 \to 2$

i, j, k family $1 \to 3$

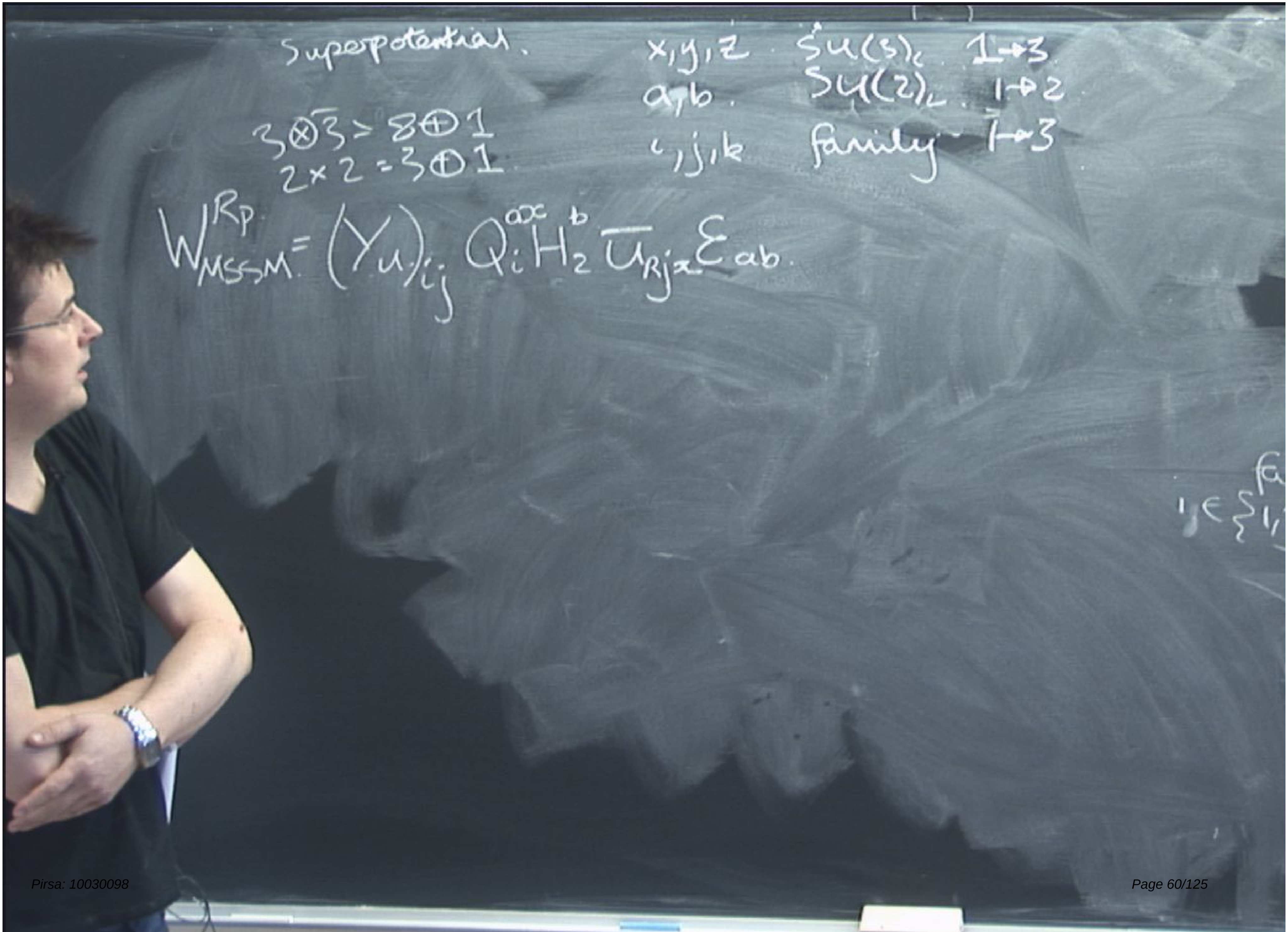
$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

$$W^{R_P}_{MSSM} = (Y_u)_{ij} \, Q^a_i H^b_2 \, \overline{u}_{Rj} \, \varepsilon_{ab}.$$

fa

$i, j \in \{1,$



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

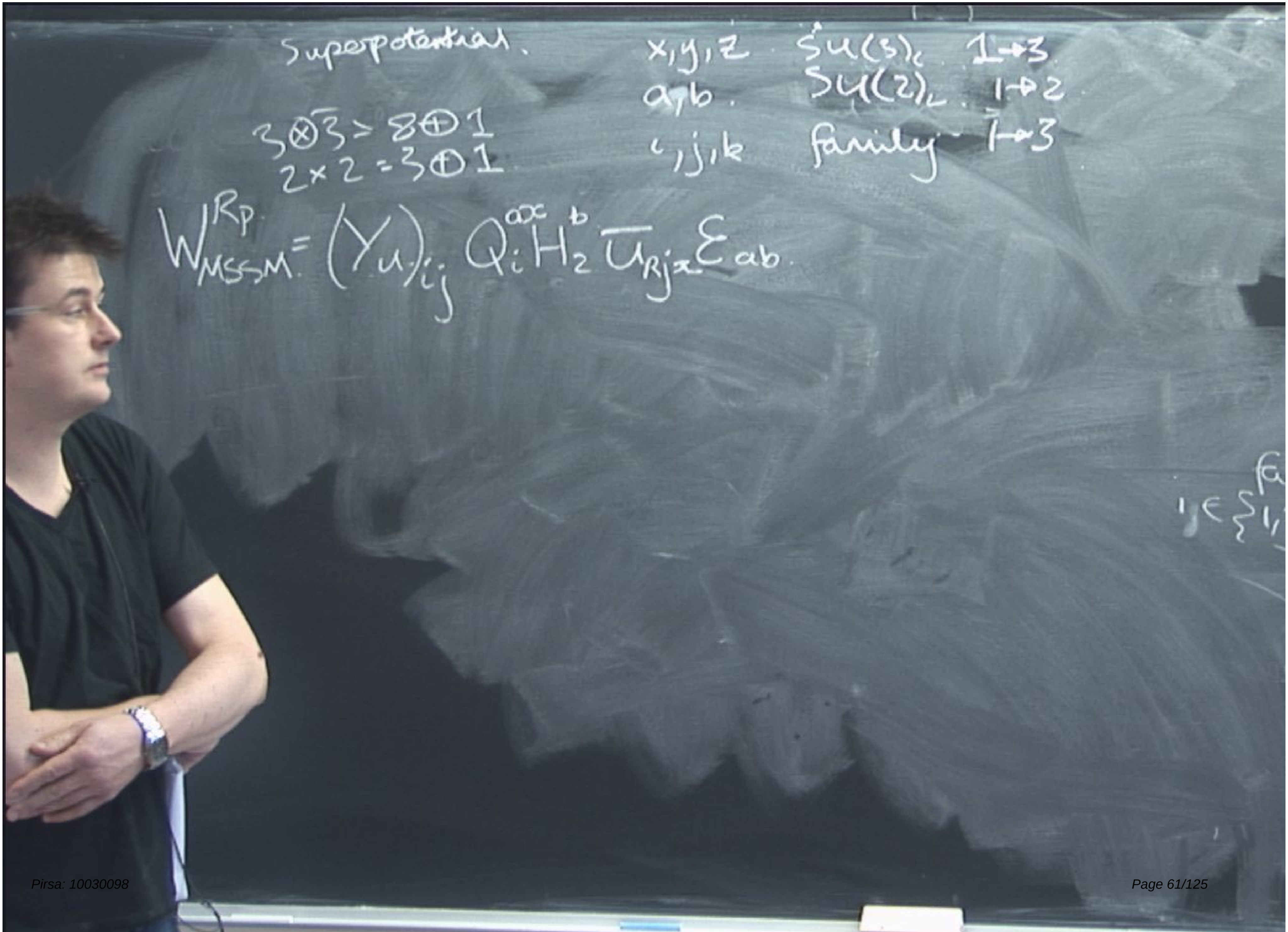
$a, b.$ $SU(2)_L$ $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

$$W^{R_p}_{MSSM} = (Y_u)_{ij} \, Q^{ax}_i H^b_2 \, \overline{u}_{Rjx} \varepsilon_{ab}.$$



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

$a, b.$ $SU(2)_L$ $1 \to 2$

i, j, k family $1 \to 3$

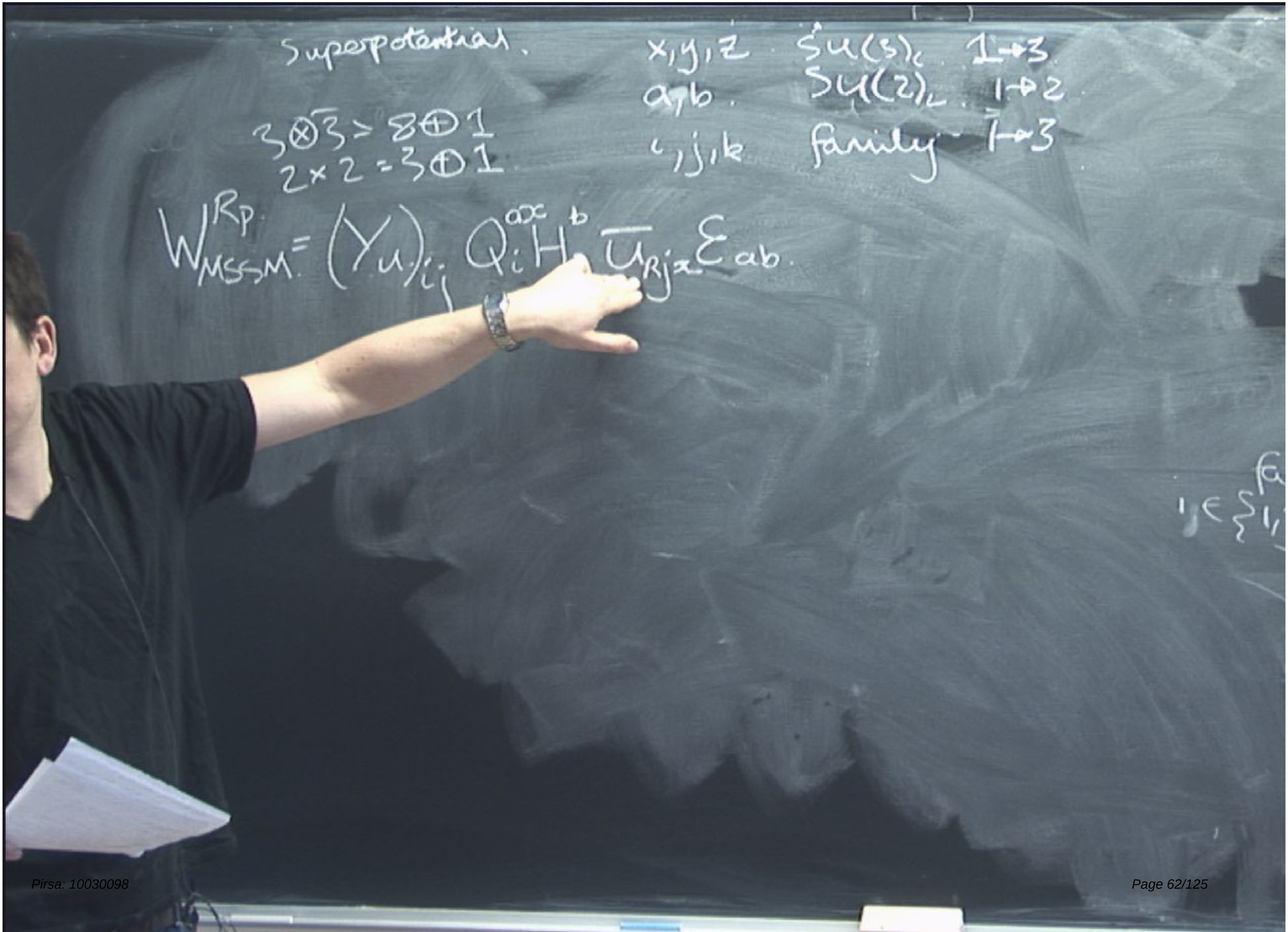
$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

$$W^{Rp}_{MSSM} = (Y_u)_{ij} Q_i^{ax} H_2^b \overline{u}_{Rjx} \varepsilon_{ab}.$$

fa

$i, j \in \{1,$



Superpotential.

$3\otimes\bar{3} = 8\oplus 1$

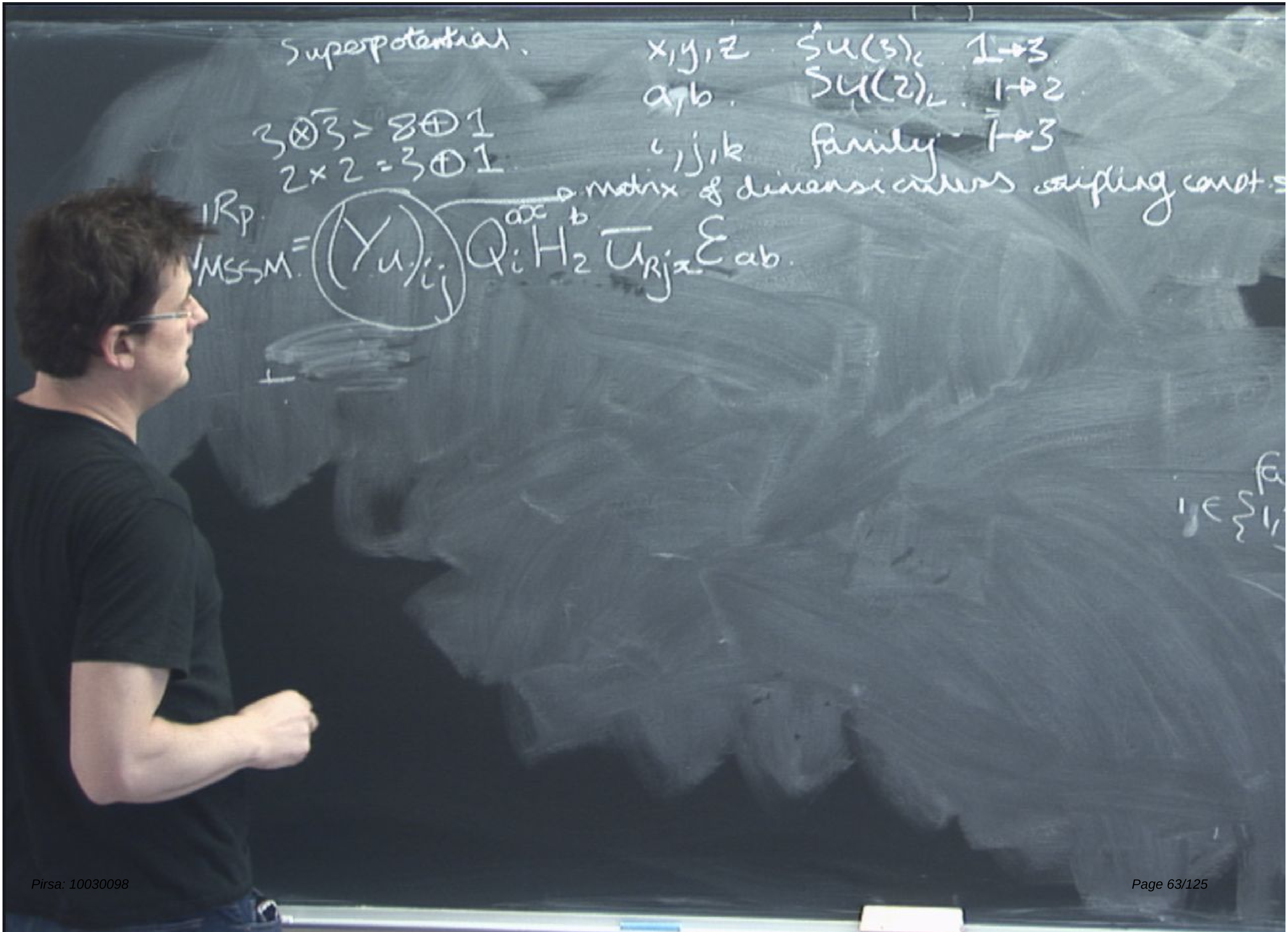
$2\times 2 = 3\oplus 1$

x, y, z $SU(3)_c$ 1→3

a, b. $SU(2)_L$ 1→2

i, j, k family 1→3

$$W^{R_p}_{MSSM} = (Y_u)_{ij}\, Q^{ax}_i H^b \,\overline{u}_{Rjx}\, \varepsilon_{ab}.$$



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

$a, b.$ $SU(2)_L$ $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

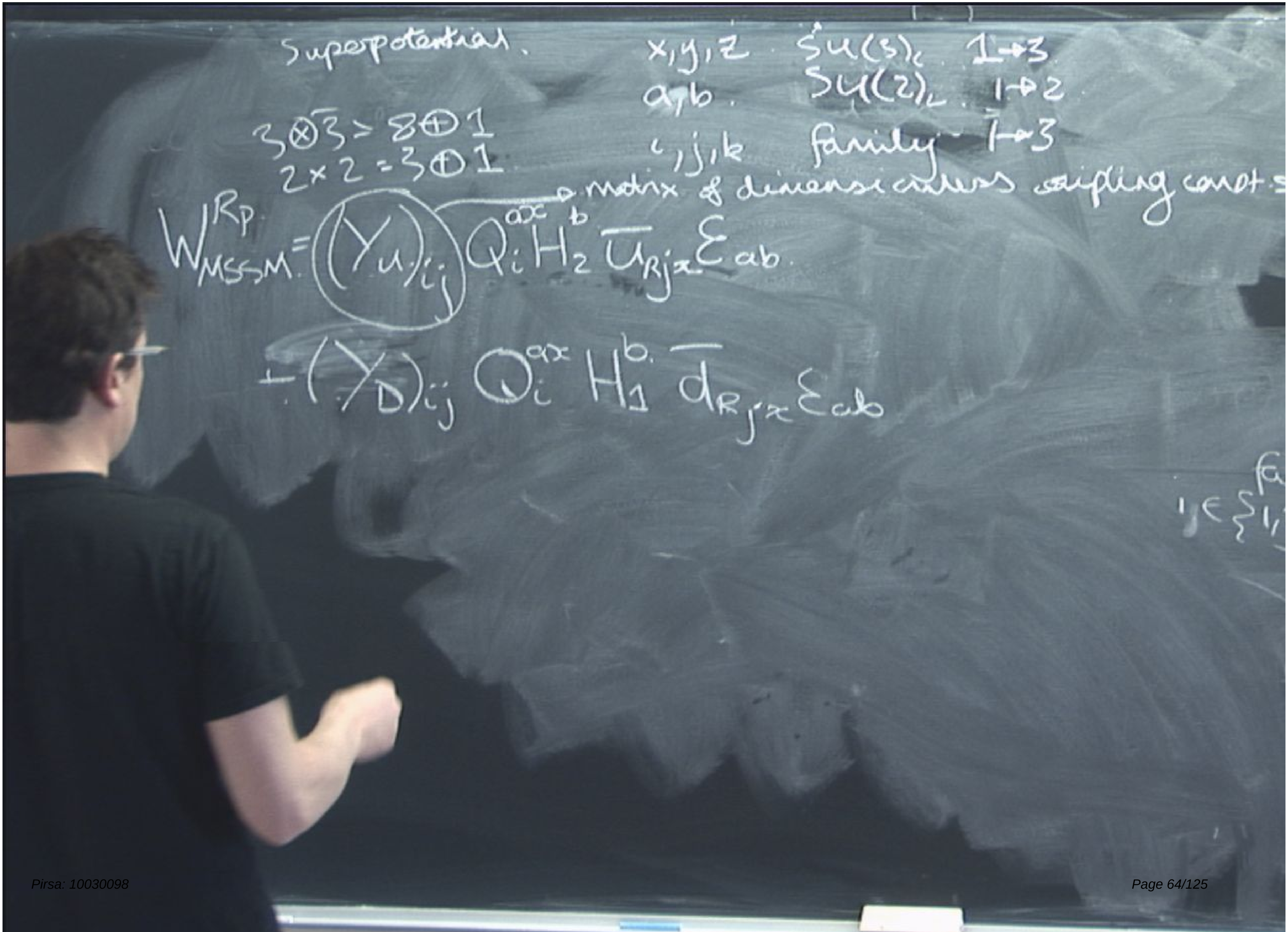
$2 \times 2 = 3 \oplus 1$

→ matrix of dimensionless coupling const.s

$$W_{MSSM}^{RP} = \boxed{(Y_u)_{ij}}\, Q_i^{ax} H_2^{b}\, \overline{u}_{Rjx}\, \varepsilon_{ab}.$$

fa

$i \in \{1,$



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

a, b. $SU(2)_L$. $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

→ matrix of dimensionless coupling const.

$$W^{Rp}_{MSSM} = (Y_u)_{ij} Q_i^{ax} H_2^{b} \overline{u}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_D)_{ij} Q_i^{ax} H_1^{b} \overline{d}_{Rjx} \varepsilon_{ab}$$

fa

$i \in \{1,$

Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

a, b. $SU(2)_L$ $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

$$W^{R_P}_{MSSM} = \underbrace{(Y_u)_{ij}}_{} Q^{ax}_i H^b_2 \overline{u}_{Rjx} \varepsilon_{ab}$$

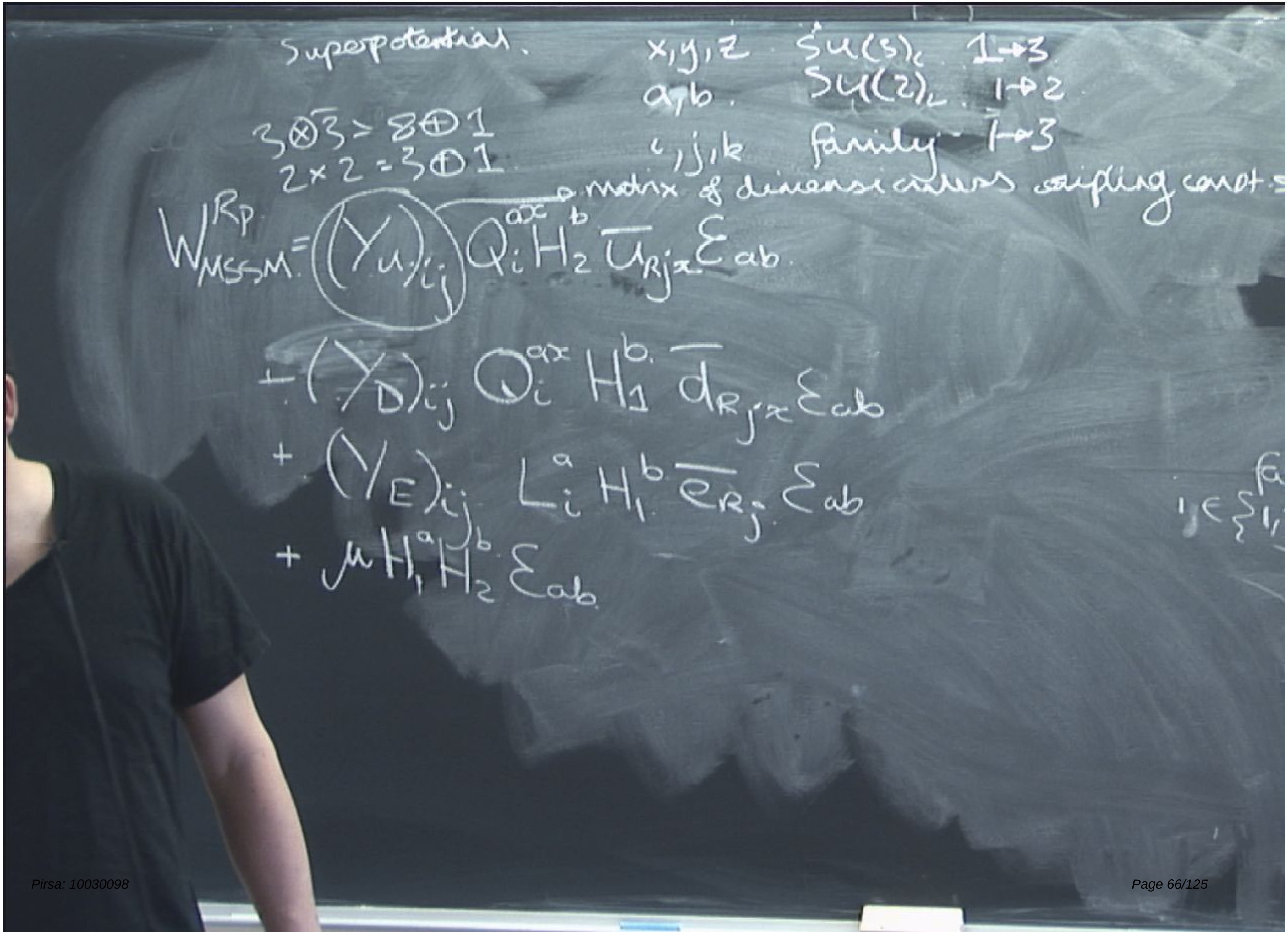
→ matrix of dimensionless coupling const

$$+ (Y_D)_{ij} Q^{ax}_i H^b_1 \overline{d}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_E)_{ij} L^a_i H^b_1 \overline{e}_{Rj} \varepsilon_{ab}$$

fa

$i \in \{1,$



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

a, b. $SU(2)_L$ $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

matrix of dimensionless coupling const.s

$$W^{R_p}_{MSSM} = (Y_u)_{ij} Q^{ax}_i H^b_2 \bar{u}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_D)_{ij} Q^{ax}_i H^b_1 \bar{d}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_E)_{ij} L^a_i H^b_1 \bar{e}_{Rj} \varepsilon_{ab}$$

$$+ \mu H^a_1 H^b_2 \varepsilon_{ab}$$

fa

$i, j \in \{1,$

Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

a, b. $SU(2)_L$. $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

$$W^{R_P}_{MSSM} = \boxed{(Y_u)_{ij}} \, Q^{ax}_i H^b_2 \, \bar{u}_{Rjx} \, \varepsilon_{ab} \quad \to \text{matrix of dimensionless coupling const.s}$$

$$+ (Y_D)_{ij} \, Q^{ax}_i H^b_1 \, \bar{d}_{Rjx} \, \varepsilon_{ab}$$

$$+ (Y_E)_{ij} \, L^a_i H^b_1 \, \bar{e}_{Rj} \, \varepsilon_{ab}$$

$$+ \boxed{\mu} \, H^a_1 H^b_2 \, \varepsilon_{ab} \to [\mu] = 1.$$

fa

$i \in \{1,$

Superpotential.

x, y, z	$SU(3)_c$	$1 \to 3$
a, b	$SU(2)_L$	$1 \to 2$
i, j, k	family	$1 \to 3$

$$3 \otimes \bar{3} = 8 \oplus 1$$

$$2 \times 2 = 3 \oplus 1$$

→ matrix of dimensionless coupling const. s

$$W^{R_p}_{MSSM} = \bigcirc\!\!\!\!(Y_u)_{ij}\, Q_i^{ax} H_2^b\, \overline{u}_{Rjx}\, \varepsilon_{ab}$$

$$+ (Y_D)_{ij}\, Q_i^{ax} H_1^b\, \overline{d}_{Rjx}\, \varepsilon_{ab}$$

$$+ (Y_E)_{ij}\, L_i^a H_1^b\, \overline{e}_{Rj}\, \varepsilon_{ab}$$

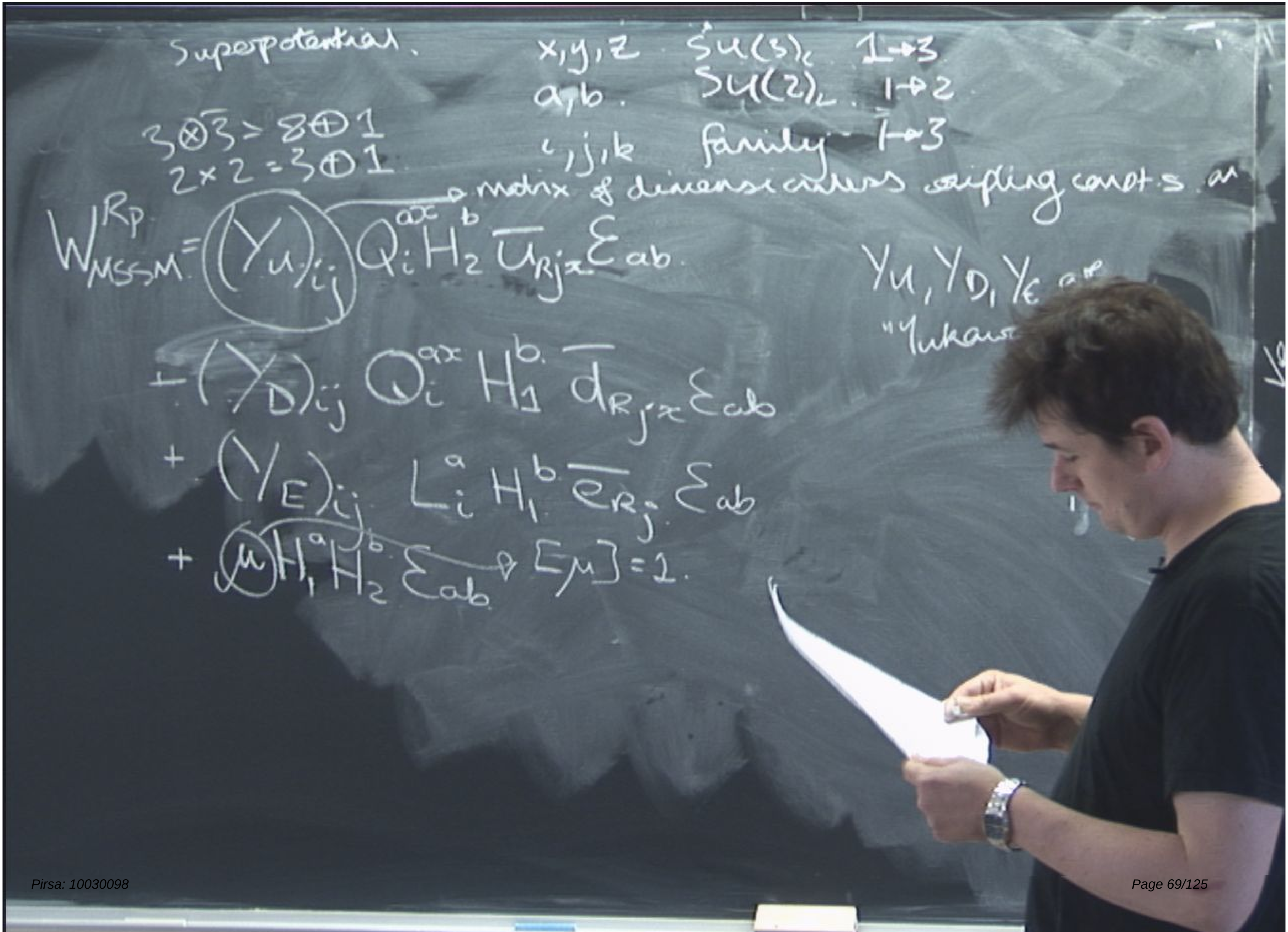
$$+ \mu\, H_1^a H_2^b\, \varepsilon_{ab} \to [\mu] = 1.$$

Y_u, Y_D, Y_E are "

"Yukawa couplings.

fa

$i \in \{1,$



Superpotential.

x,y,z $SU(3)_c$ $1 \to 3$

$a,b.$ $SU(2)_L$ $1 \to 2$

i,j,k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

→ matrix of dimensionless coupling consts. ar

$$W^{R_p}_{MSSM} = (Y_u)_{ij} Q^{ax}_i H^b_2 \overline{u}_{R j x} \epsilon_{ab}$$

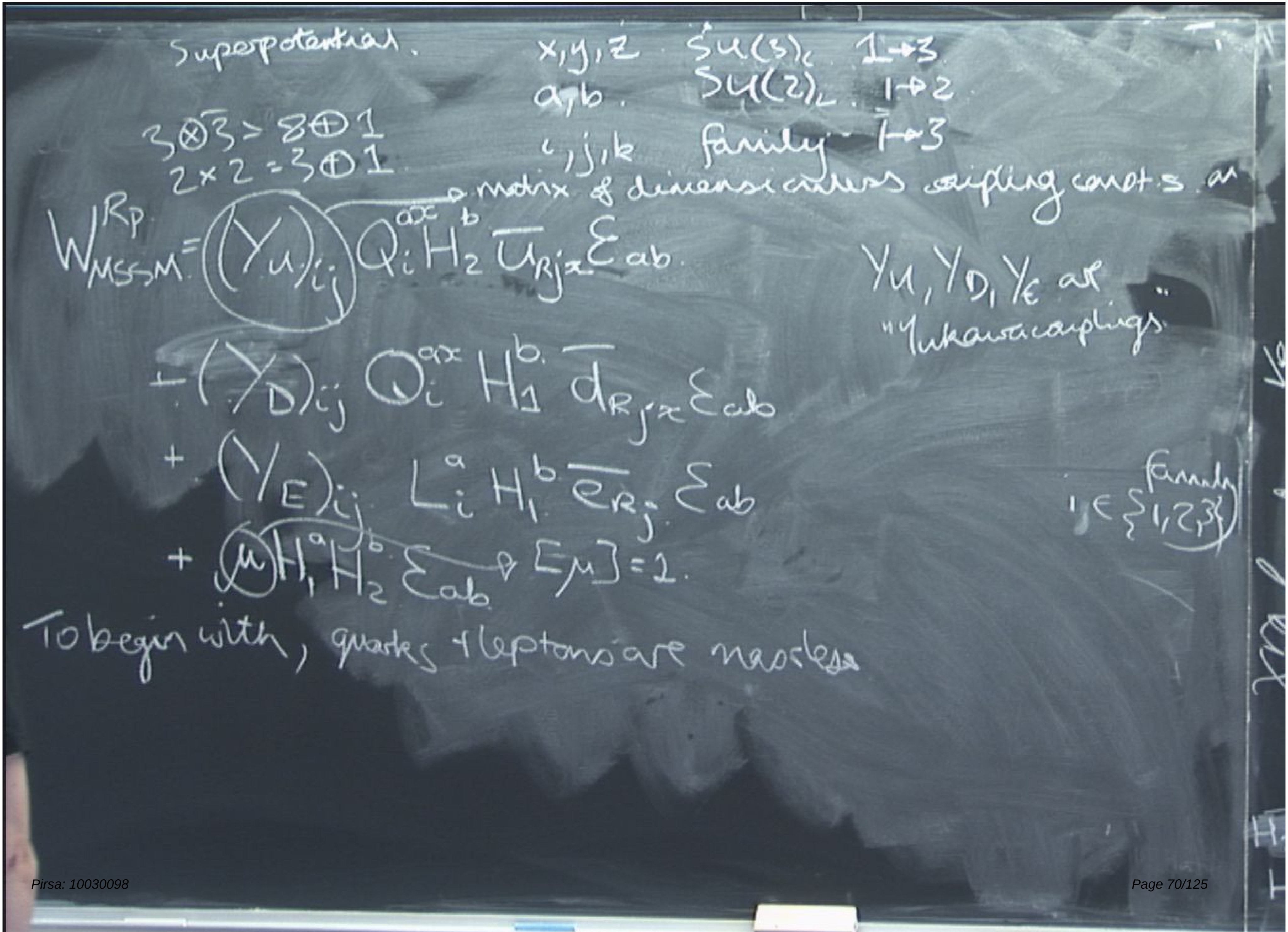
$$+ (Y_D)_{ij} Q^{ax}_i H^b_1 \overline{d}_{R j x} \epsilon_{ab}$$

$$+ (Y_E)_{ij} L^a_i H^b_1 \overline{e}_{R j} \epsilon_{ab}$$

$$+ \mu H^a_1 H^b_2 \epsilon_{ab} \rightarrow [\mu] = 1.$$

Y_u, Y_D, Y_E are

"Yukaw



Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

$a, b.$ $SU(2)_L$. $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

→ matrix of dimensionless coupling consts. ar

$$W^{Rp}_{MSSM} = \boxed{(Y_u)_{ij}} Q_i^{ax} H_2^b \overline{u}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_D)_{ij} Q_i^{ax} H_1^b \overline{d}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_E)_{ij} L_i^a H_1^b \overline{e}_{Rj} \varepsilon_{ab}$$

$$+ \boxed{\mu} H_1^a H_2^b \varepsilon_{ab} \to [\mu] = 1.$$

Y_u, Y_D, Y_E are "Yukawa couplings"

$i, j \in \{1, 2, 3\}$ family

To begin with, quarks + leptons are massless

Superpotential.

x,y,z $SU(3)_c$ $1 \to 3$

a,b. $SU(2)_L$. $1 \to 2$

i,j,k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

$\longrightarrow$ matrix of dimensionless coupling consts. ar

$$W^{Rp}_{MSSM} = (Y_u)_{ij} Q_i^{ax} H_2^b \overline{u}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_D)_{ij} Q_i^{ax} H_1^b \overline{d}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_E)_{ij} L_i^a H_1^b \overline{e}_{Rj} \varepsilon_{ab}$$

$$+ \mu H_1^a H_2^b \varepsilon_{ab} \longrightarrow [\mu] = 1.$$

Y_U, Y_D, Y_E are "Yukawa couplings"

family

$i \in \{1,2,3\}$

To begin with, quarks + leptons are massless

Superpotential.

x, y, z $SU(3)_c$ $1 \to 3$

$a, b.$ $SU(2)_L.$ $1 \to 2$

i, j, k family $1 \to 3$

$3 \otimes \bar{3} = 8 \oplus 1$

$2 \times 2 = 3 \oplus 1$

→ matrix of dimensionless coupling consts. ar

$$W^{R_p}_{MSSM} = \boxed{(Y_u)_{ij}}\, Q^{ax}_i H^b_2 \overline{u}_{Rjx} \varepsilon_{ab}$$

$$+ (Y_D)_{ij} Q^{ax}_i H^b_1 \overline{d}_{Rjx} \varepsilon_{ab}$$

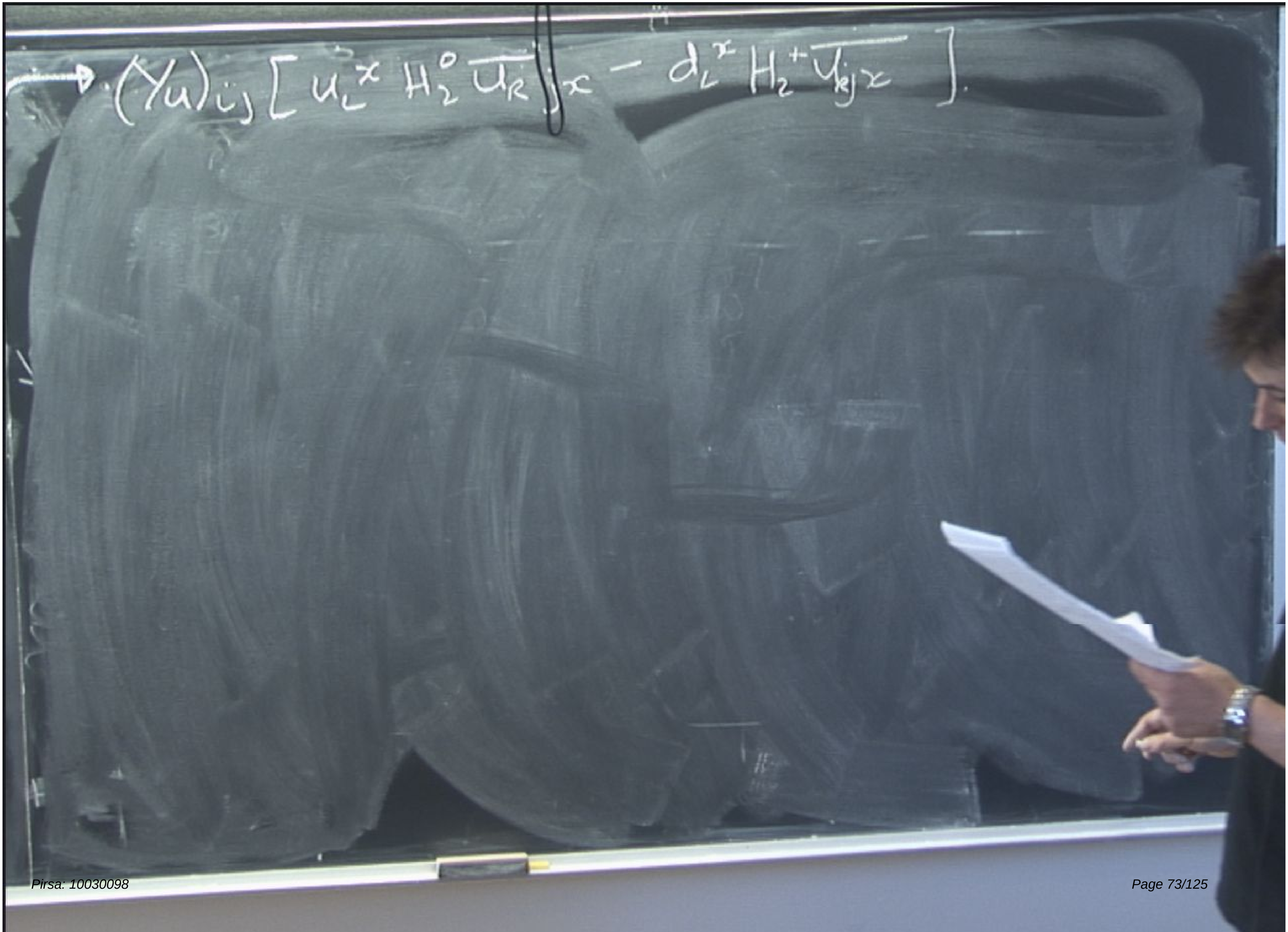
$$+ (Y_E)_{ij} L^a_i H^b_1 \overline{e}_{Rj} \varepsilon_{ab}$$

$$+ \boxed{\mu} H^a_1 H^b_2 \varepsilon_{ab} \to [\mu] = 1.$$

Y_u, Y_D, Y_E are "Yukawa couplings.

family $i \in \{1, 2, 3\}$

To begin with, quarks + leptons are massless



$$\rightarrow (Y_u)_{ij}\left[u_L^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx}\right].$$

$$\rightarrow (Y_u)_{ij} \left[u_L^x H_2^0 \overline{u_R}_{j x} - d_L^x H_2^+ \overline{u_R}_{j x} \right].$$

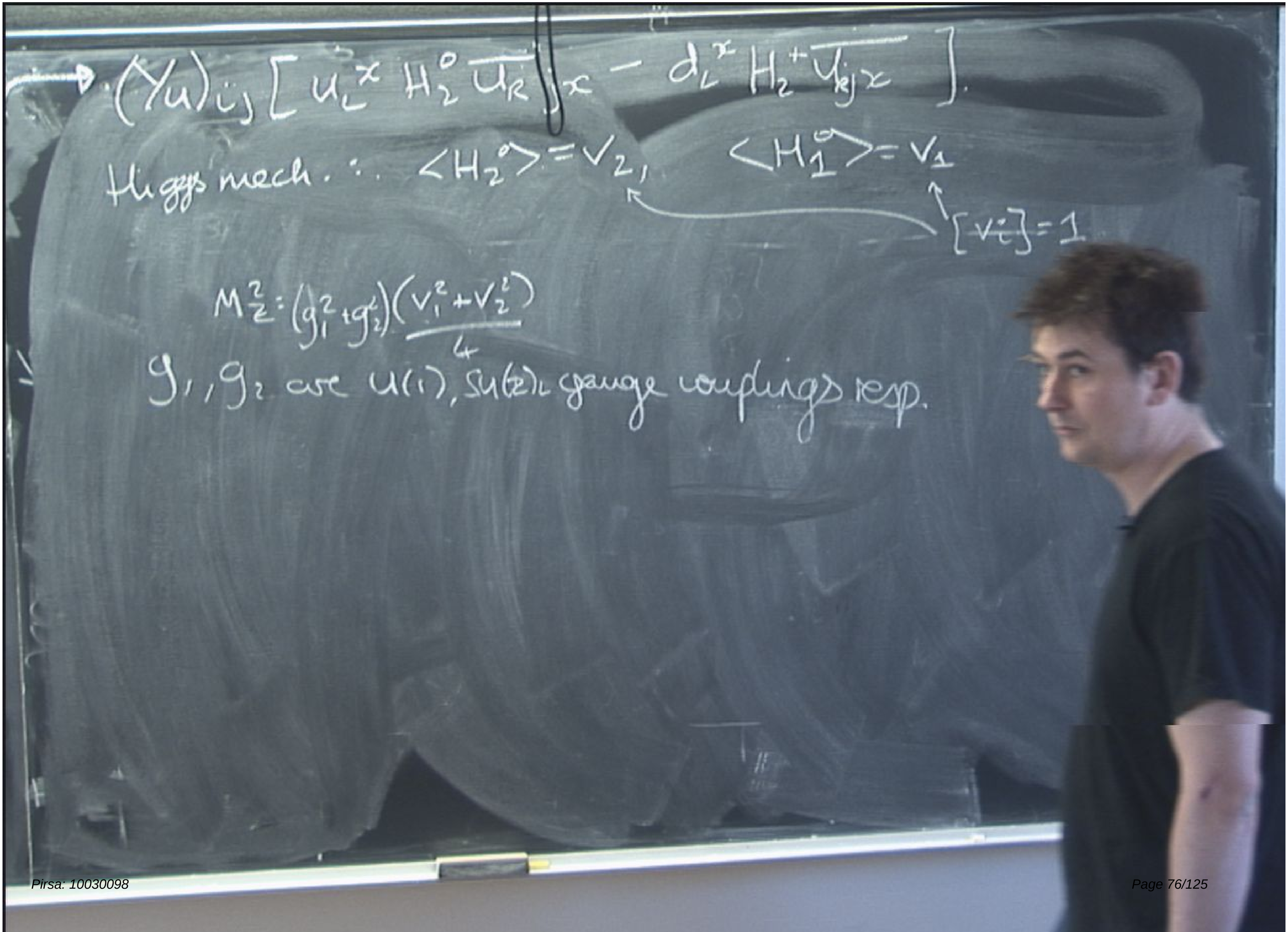
Higgs mech. : $\langle H_2^0 \rangle = v_2, \quad \langle H_1^0 \rangle = v_1$

h_2

$$\rightarrow (Y_u)_{ij}\left[u_L^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_{Rj}}_{x} \right].$$

Higgs mech.: $\langle H_2^0 \rangle = v_2, \quad \langle H_1^0 \rangle = v_1$

$[v_i] = 1$



$$(Y_u)_{ij}\left[u_L^{x} H_2^{0} \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx} \right].$$

Higgs mech.: $\langle H_2^0 \rangle = v_2, \quad \langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2+g_2^2)\frac{(v_1^2+v_2^2)}{4}$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$\to (Y_u)_{ij}\left[u_L^{x} H_2^0 \overline{u_R}_{j x} - d_L^{x} H_2^+ \overline{u_R}_{j x} \right].$$

Higgs mech. : $\langle H_2^0 \rangle = v_2$, $\quad \langle H_1^0 \rangle = v_1$

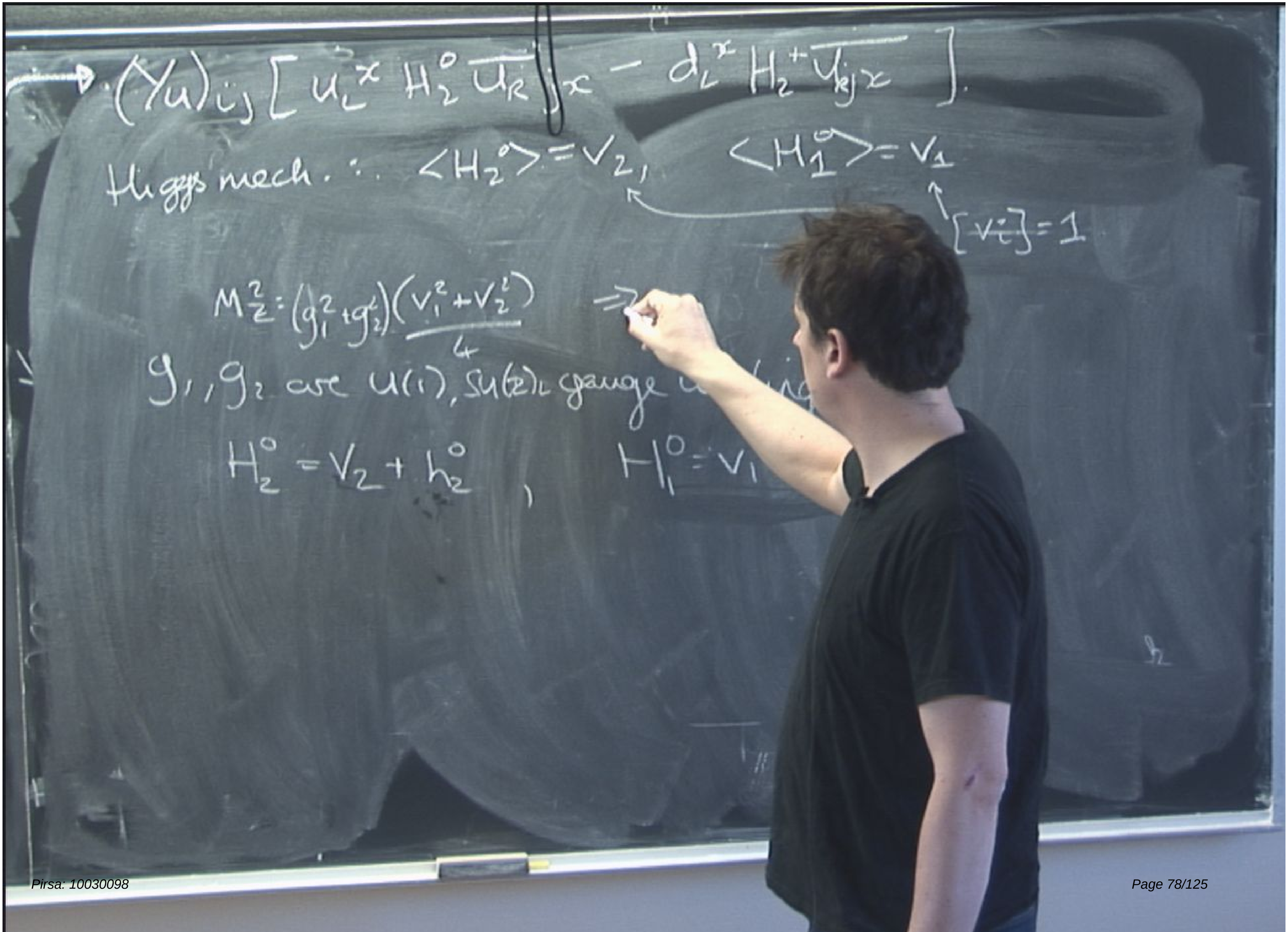
$[v_i] = 1$

$$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4}$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$H_2^0 = v_2 + h_2^0$$

h_2



$\rightarrow (Y_u)_{ij}[u_L^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_R}_{jx}]$.

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

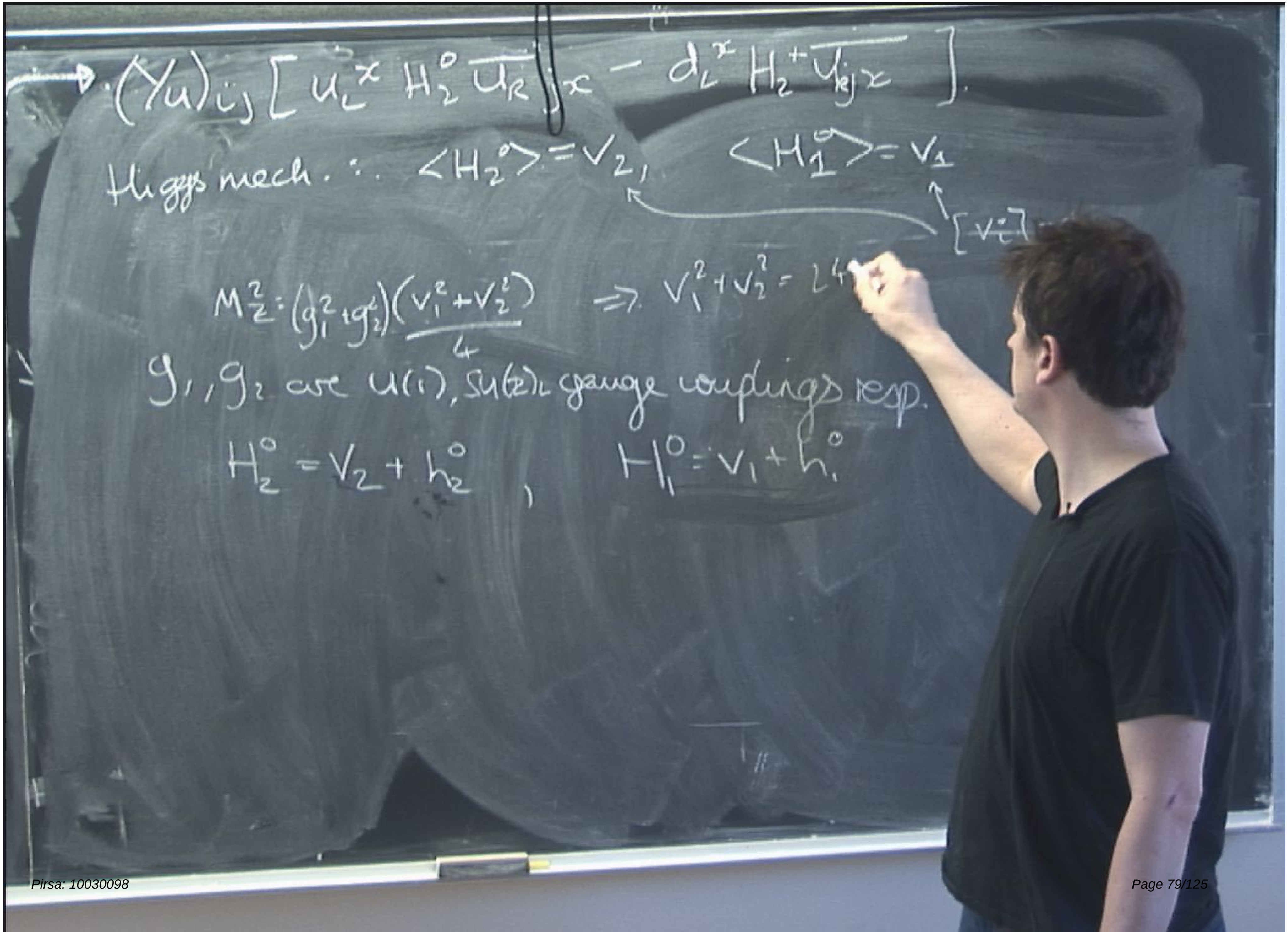
$[v_i] = 1$

$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow$

g_1, g_2 are U(1), SU(2)$_L$ gauge [illegible]

$H_2^0 = v_2 + h_2^0$, $H_1^0 = v_1$

h_2



$$\to (Y_u)_{ij}\left[u_L^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_R}_{jx} \right].$$

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$ $[v_i]$

$$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow v_1^2 + v_2^2 = 24$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$H_2^0 = v_2 + h_2^0 \quad , \quad H_1^0 = v_1 + h_1^0$$

$$\rightarrow (Y_u)_{ij}\left[u_L^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^+ \overline{u_R}_{jx} \right].$$

Higgs mech. : $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow v_1^2 + v_2^2 = (246\,\text{GeV})^2$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$H_2^0 = v_2 + h_2^0$, $H_1^0 = v_1 + h_1^0$

h_2

$$\rightarrow (Y_u)_{ij} \left[u_L^{x} H_2^0 \overline{u_R}{}_{jx} - d_L^{x} H_2^{+} \overline{u_R}{}_{jx} \right].$$

Higgs mech. : $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow v_1^2 + v_2^2 = (246\,\mathrm{GeV})^2.$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$H_2^0 = v_2 + h_2^0 \quad , \quad H_1^0 = v_1 + h_1^0$$

h_2

$$\to (Y_u)_{ij}\left[u_L^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx} \right].$$

Higgs mech. : $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2+g_2^2)\frac{(v_1^2+v_2^2)}{4} \Rightarrow v_1^2+v_2^2 = (246\,\text{GeV})^2$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$H_2^0 = v_2 + h_2^0, \qquad H_1^0 = v_1 + h_1^0$$

h_2

$$\rightarrow (Y_u)_{ij} \left[u_L^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_{Rj}}_x \right].$$

Higgs mech. : $\langle H_2^0 \rangle = v_2, \quad \langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2+g_2^2)\frac{(v_1^2+v_2^2)}{4} \Rightarrow v_1^2+v_2^2 = (246\,\text{GeV})^2$$

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$H_2^0 = v_2 + h_2^0, \quad H_1^0 = v_1 + h_1^0$$

$$\tan\beta = \frac{v_2}{v_1}$$

h_2

$$\to (Y_u)_{ij}\left[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_{kj}}_{x} \right].$$

Higgs mech. $\therefore$ $\langle H_2^0 \rangle = v_2, \quad \langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow v_1^2 + v_2^2 = (246\,\mathrm{GeV})^2$$

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h_2

$(Y_u)_{ij}\left[u_{L_i}^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_{R}}_{jx} \right].$

Higgs mech. : $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

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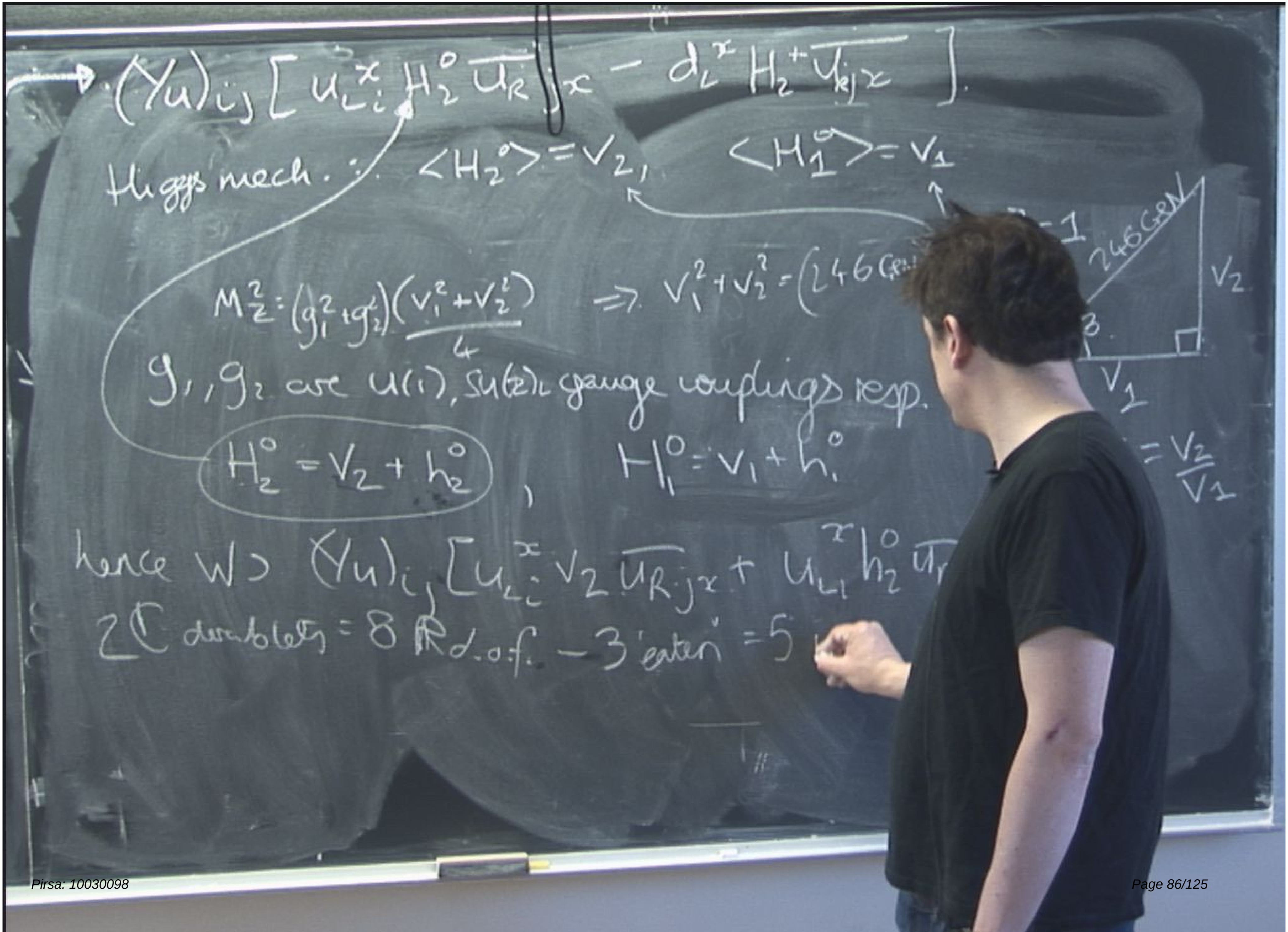
$2\,\mathbb{C}$ doublets $= 8\,\mathbb{R}$ d.o.f.

h_2



$(Y_u)_{ij} [u_{L_i}^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_R}_{jx}]$.

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

$= 1$

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g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$\boxed{H_2^0 = v_2 + h_2^0}$, $H_1^0 = v_1 + h_1^0$

$= \frac{v_2}{v_1}$

hence $W \supset (Y_u)_{ij} [u_{L_i}^x v_2 \overline{u_R}_{jx} + u_{L_i}^x h_2^0 \overline{u_R}$

2 $\mathbb{C}$ doublets = 8 $\mathbb{R}$ d.o.f. − 3 'eaten' = 5

$$\to (Y_u)_{ij}\left[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx} \right].$$

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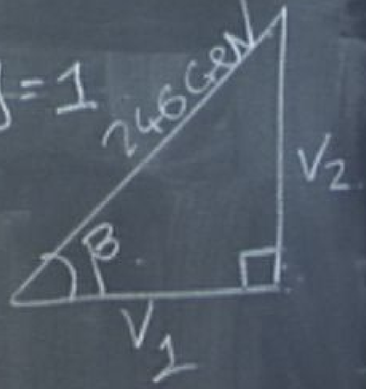
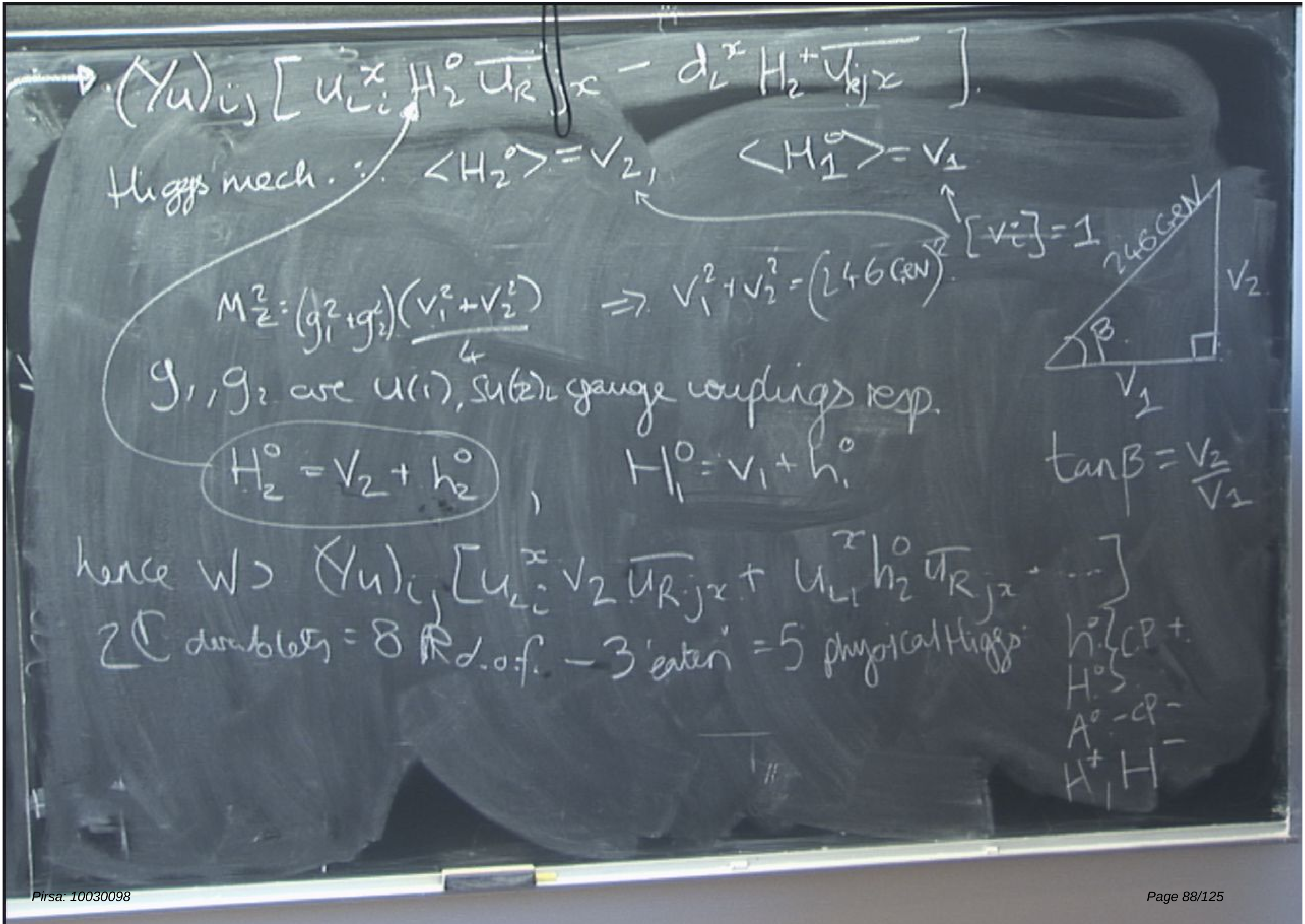


$$\tan\beta = \frac{v_2}{v_1}$$

hence $W \supset (Y_u)_{ij}\left[u_{L_i}^{x} v_2 \overline{u_R}_{jx} + u_{L_i}^{x} h_2^0 \overline{u_R}_{jx} + \dots \right]$

2 ℂ doublets = 8 ℝ d.o.f. − 3 'eaten' = 5 physical Higgs:

h^0
H^0
A^0
H^+, H^-



$(Y_u)_{ij} [u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_{Rj}}_{x}]$

Higgs mech. : $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

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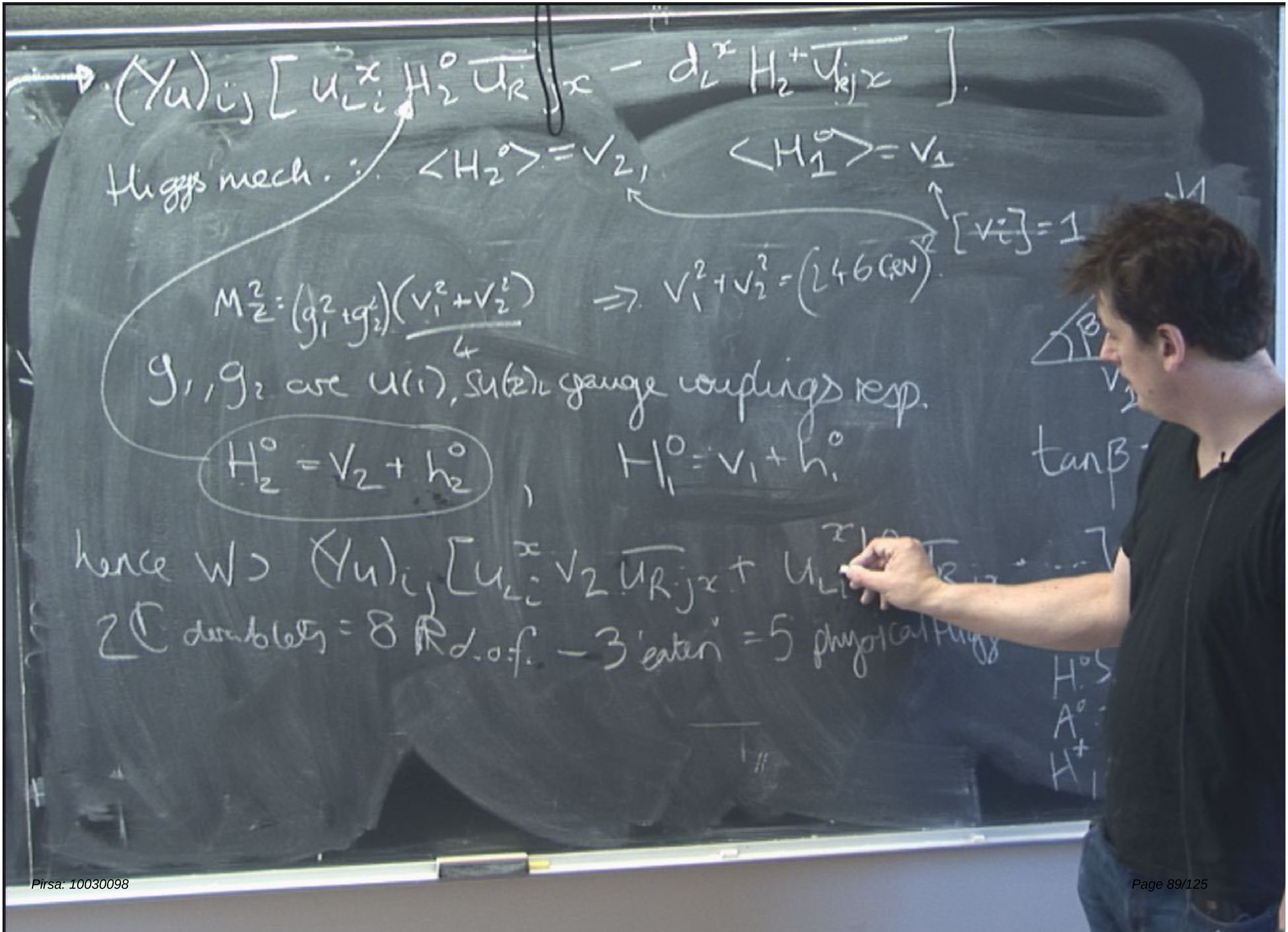
2 $\mathbb{C}$ doublets = 8 $\mathbb{R}$ d.o.f. − 3 'eaten' = 5 physical Higgs:

h^0, H^0 } CP +

A^0 − CP −

H^+, H^-



$\rightarrow (Y_u)_{ij} [u_{L_i}^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_R}_{jx}]$.

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

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$2\,\mathbb{C}$ doublets $= 8\,\mathbb{R}$ d.o.f. $- 3$ 'eaten' $= 5$ physical Higgs

β

v_2

$\tan\beta$

H^0

A^0

H^+

$(Y_u)_{ij}[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx}]$.

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H^+, H^-

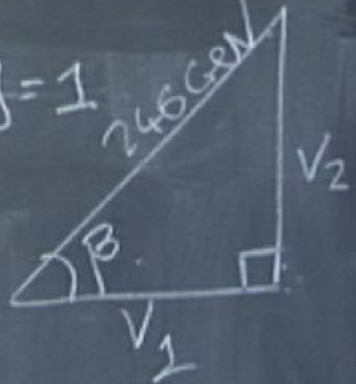
$(Y_u)_{ij} [u_{L_i}^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_{R}}_{jx}]$.

$M_{\varphi_{ij}} \sim \frac{\partial^2 W}{\partial\varphi_i \partial\varphi_j}$

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

$[\cancel{v_i}] = 1$

$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow v_1^2 + v_2^2 = (246\,\text{GeV})^2$



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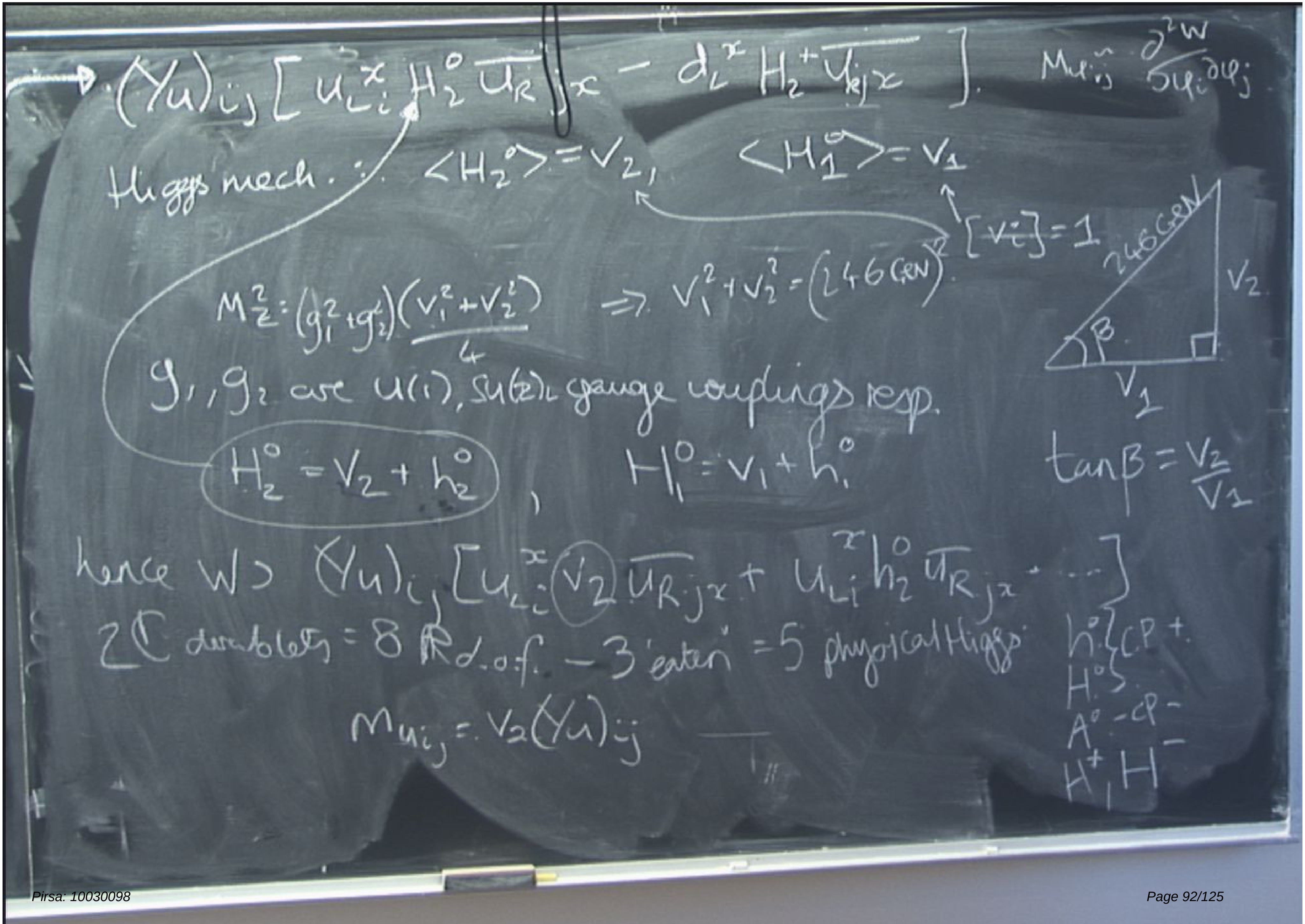
2 $\mathbb{C}$ doublets = 8 $\mathbb{R}$ d.o.f. − 3 'eaten' = 5 physical Higgs: $\left.\begin{matrix} h^0 \\ H^0 \end{matrix}\right\}$ CP +

A^0 − CP −

H^+, H^-



$$(Y_u)_{ij}\left[u_{L_i}^x H_2^0 \overline{u_R}_{jx} - d_L^x H_2^+ \overline{u_R}_{jx}\right].$$

$$M_{\varphi_{ij}} \sim \frac{\partial^2 W}{\partial \varphi_i \partial \varphi_j}$$

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

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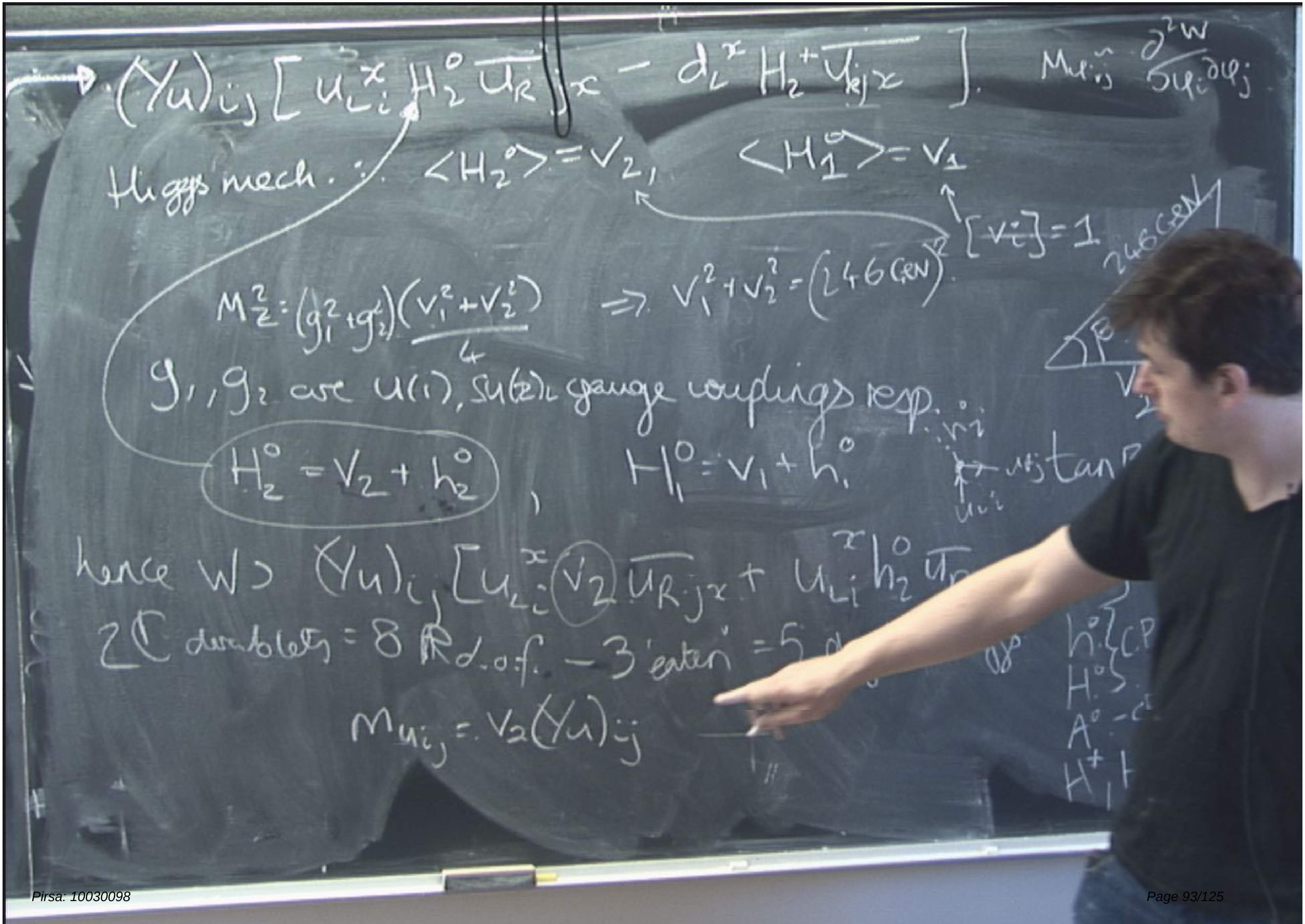
$2\,\mathbb{C}$ doublets $= 8\,\mathbb{R}$ d.o.f. $- 3$ 'eaten' $= 5$ physical Higgs:

h^0, H^0 } CP +

A^0 – CP –

H^+, H^-

$$M_{u_{ij}} = v_2 (Y_u)_{ij}$$



$(Y_u)_{ij}\,[\,u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx}\,].$ $\quad M_{\varphi_{ij}} \sim \frac{\partial^2 W}{\partial\varphi_i \partial\varphi_j}$

Higgs mech.: $\langle H_2^0 \rangle = v_{2}, \quad \langle H_1^0 \rangle = v_1$

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$\boxed{H_2^0 = v_2 + h_2^0}, \quad H_1^0 = v_1 + h_1^0$

hence $W \supset (Y_u)_{ij}[u_{L_i}^x \boxed{v_2} \overline{u_R}_{jx} + u_{L_i}^x h_2^0 \overline{u_R}$

2 ℂ doublets = 8 ℝ d.o.f. − 3 'eaten' = 5 d

$M_{u_{ij}} = v_2 (Y_u)_{ij}$

246 GeV

β

v_2

v_1

u_{L_i}

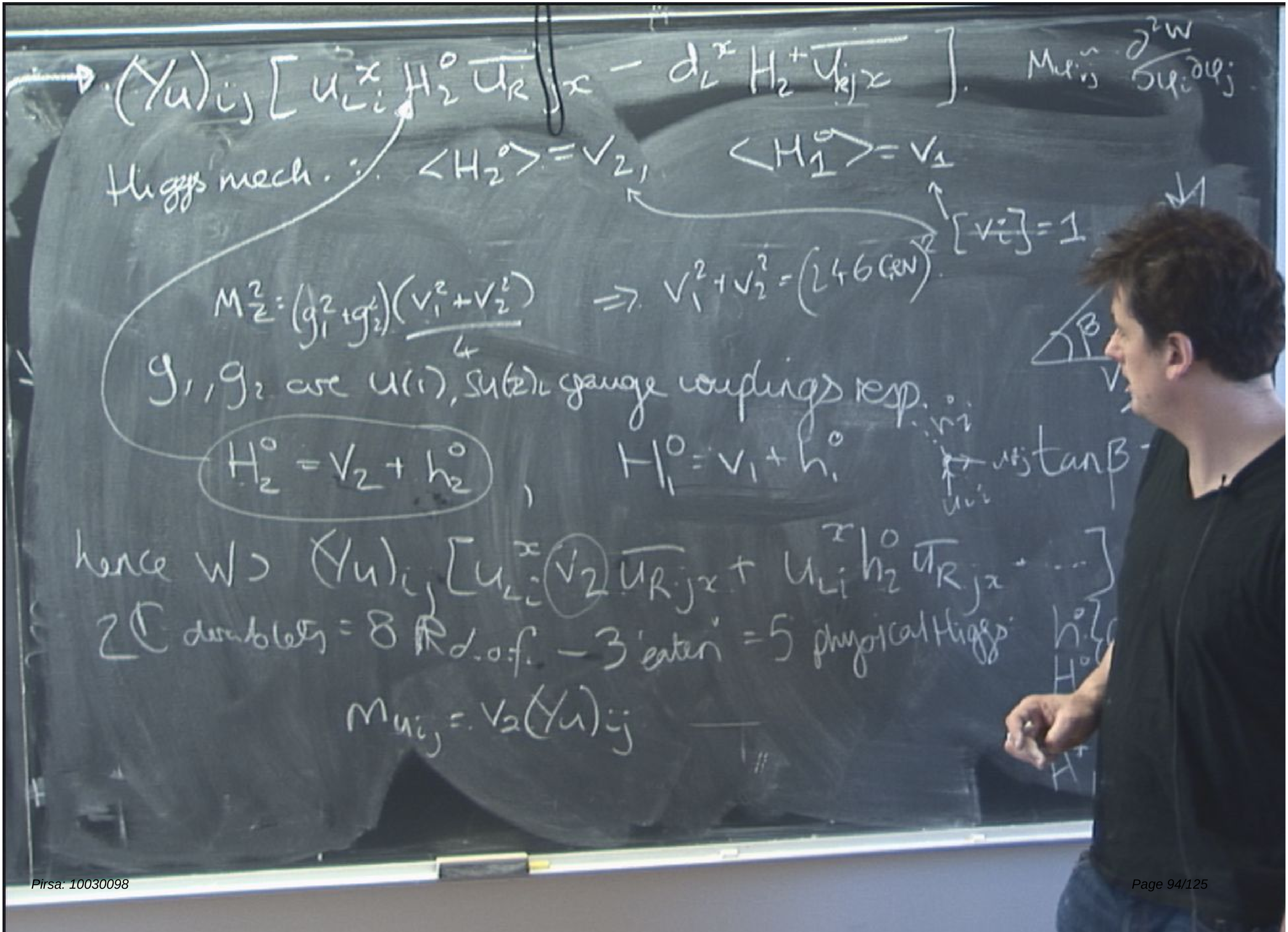
$\tan\beta$

h^0 } C.P

H^0 }

A^0 − C

H_1^+, H



$$\rightarrow (Y_u)_{ij}\left[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx}\right].$$

$M_{\varphi_{ij}} \sim \frac{\partial^2 W}{\partial\varphi_i \partial\varphi_j}$

Higgs mech.: $\langle H_2^0 \rangle = v_2, \quad \langle H_1^0 \rangle = v_1$

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$$\boxed{H_2^0 = v_2 + h_2^0}, \quad H_1^0 = v_1 + h_1^0$$

$v_{ij} \tan\beta$

hence $W \supset (Y_u)_{ij}\left[u_{L_i}^{x} \boxed{v_2} \overline{u_R}_{jx} + u_{L_i}^{x} h_2^0 \overline{u_R}_{jx} + \ldots\right]$

$2\,\mathbb{C}$ doublets $= 8\,\mathbb{R}$ d.o.f. $- 3$ 'eaten' $= 5$ physical Higgs

h^0, H^0, H^+

$$m_{u_{ij}} = v_2 (Y_u)_{ij}$$

$$\to (Y_u)_{ij}\left[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx}\right].$$

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2 $\mathbb{C}$ doublets = 8 $\mathbb{R}$ d.o.f. − 3 'eaten' = 5 physical Higgs:

h^0, H^0 } CP +

A^0 − CP −

H^+, H^-

$$M_{u_{ij}} = v_2 (Y_u)_{ij}$$

$$\rightarrow (Y_u)_{ij}\left[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx} \right].$$

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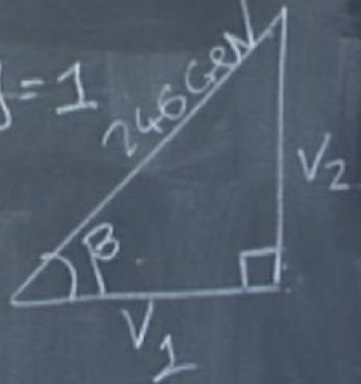

g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

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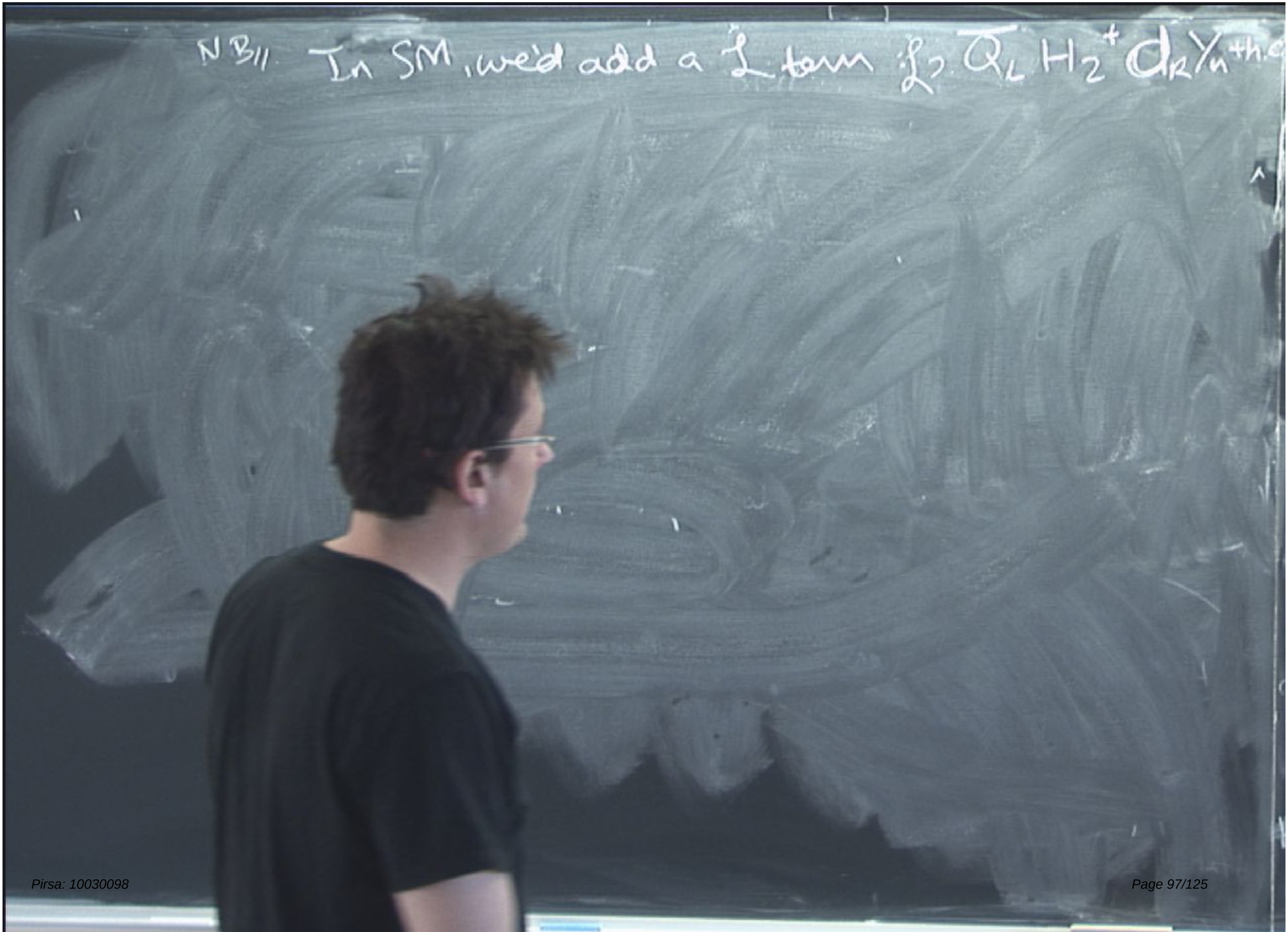
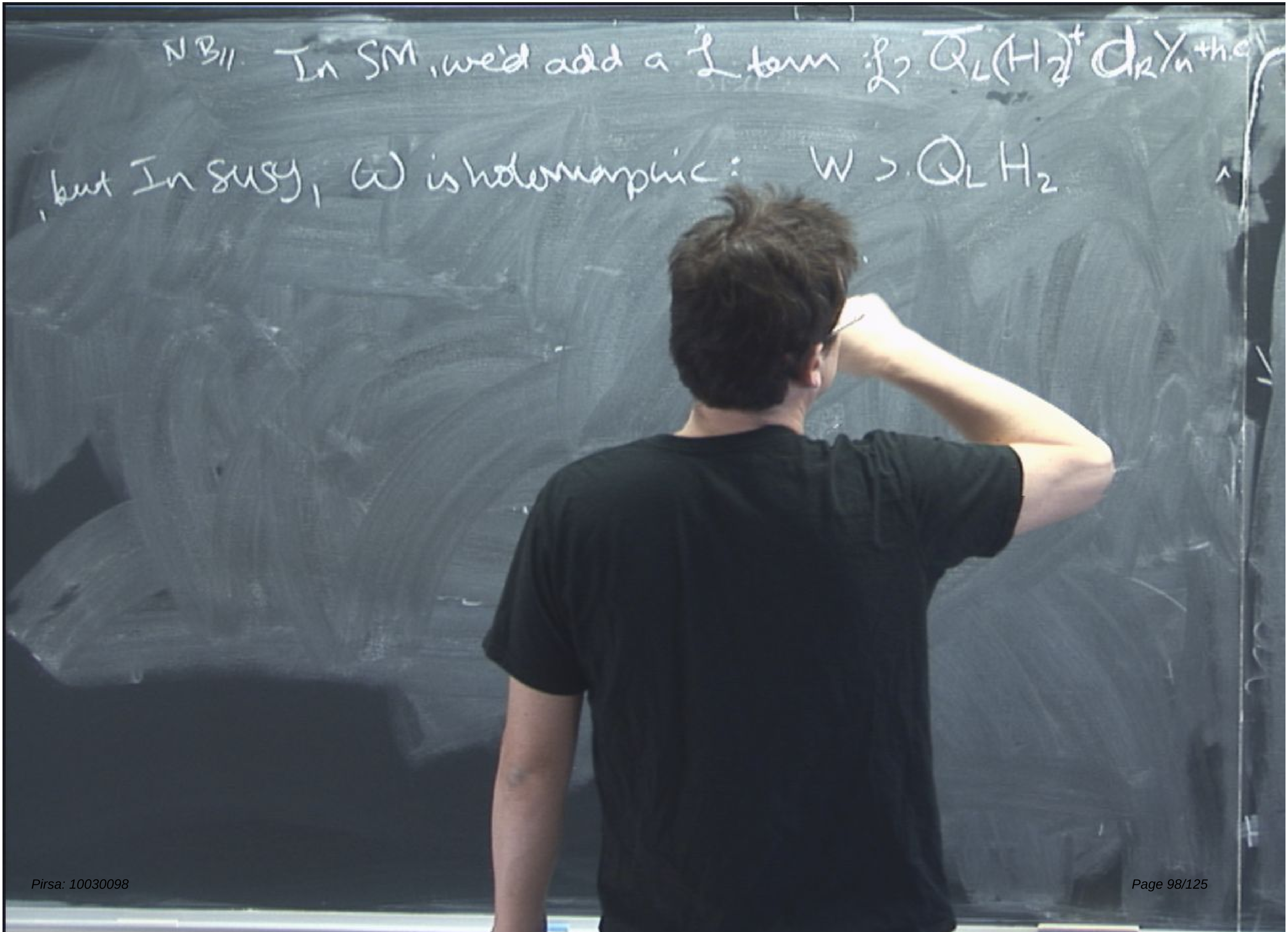
$2\,\mathbb{C}$ doublets $= 8\,\mathbb{R}$ d.o.f. $- 3$ 'eaten' $= 5$ physical Higgs:

$h^0 \} CP+$
$H^0 \}$
$A^0 - CP -$
H^+, H^-

$$M_{u_{ij}} = v_2 (Y_u)_{ij}$$

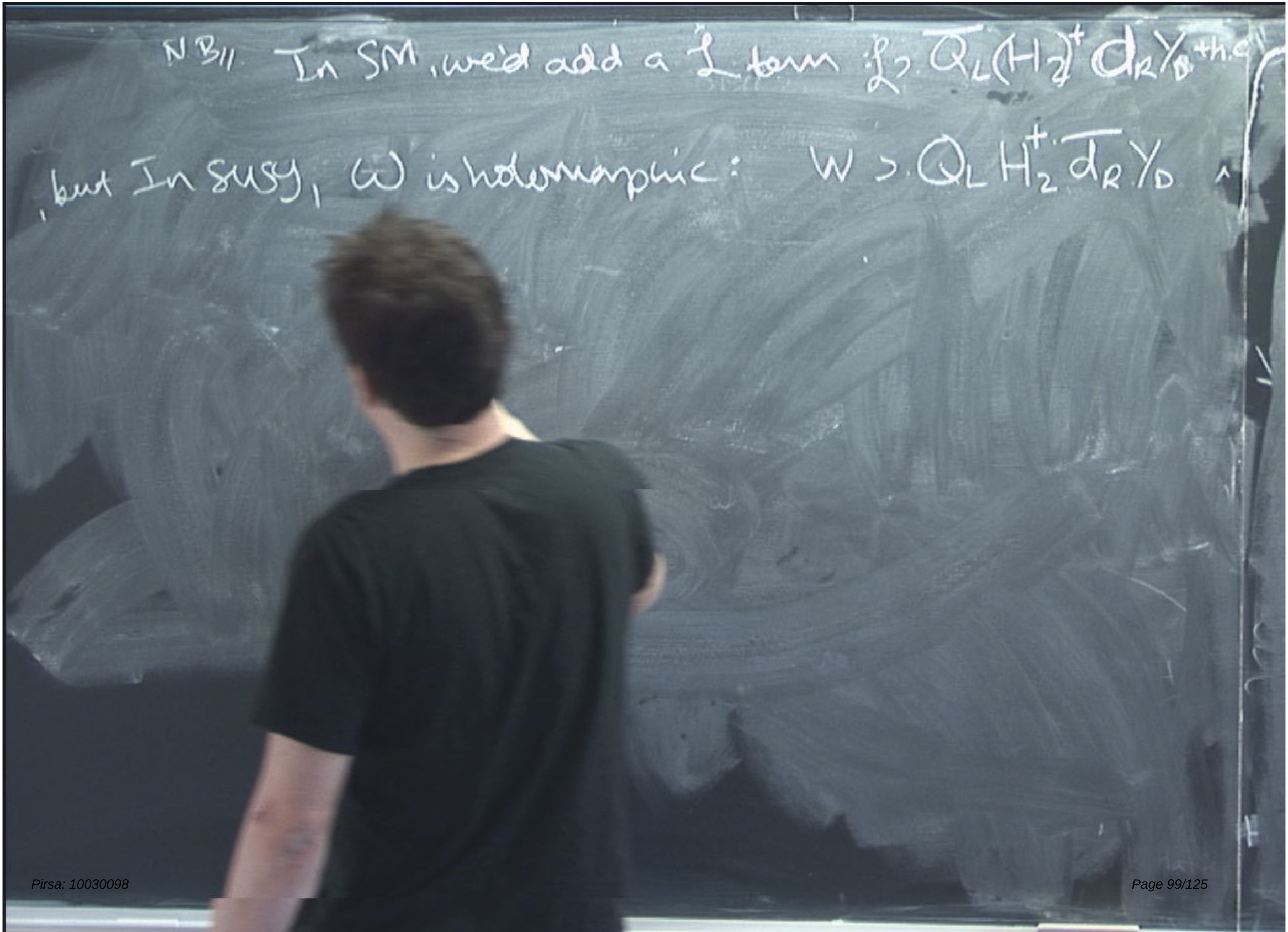


NB!! In SM, we'd add a $\mathcal{L}$ term $\mathcal{L} \supset \overline{Q_L} H_2^{\dagger} d_R Y_u + h.$



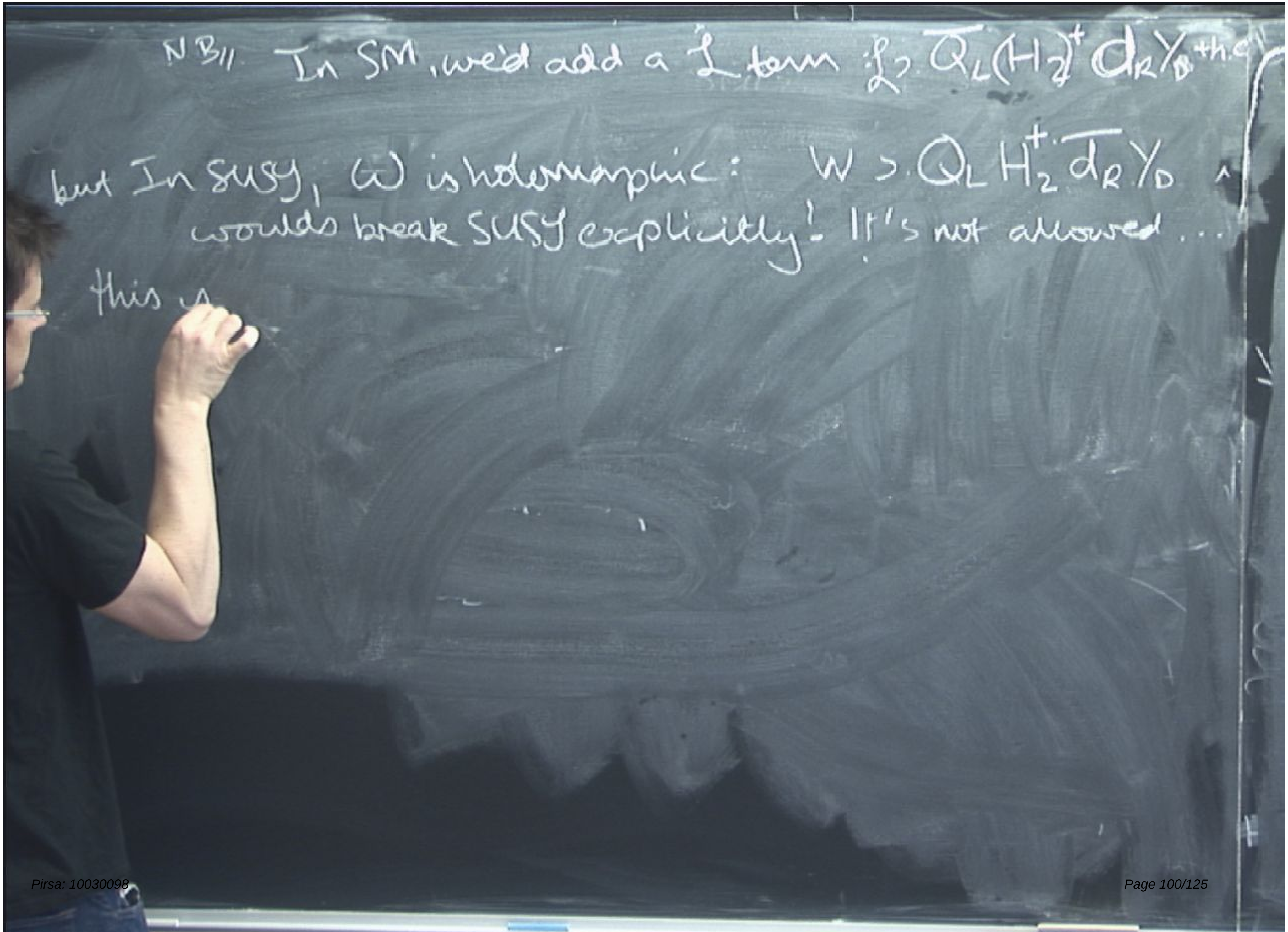
N.B. II. In SM, we'd add a $\mathcal{L}$ term $\mathcal{L} \supset \overline{Q_L}(H_2)^\dagger d_R Y_u + h.c.$

, but In SUSY, W is holomorphic: $W \supset Q_L H_2$



NB!! In SM, we'd add a $\mathcal{L}$ term $\mathcal{L} \supset \overline{Q_L} (H_2)^{+} d_R Y_D + h.c.$

, but In susy, W is holomorphic: $W \supset Q_L H_2^{+} \overline{d_R} Y_D$



N.B. II In SM, we'd add a $\mathcal{L}$ term $\mathcal{L} \supset \overline{Q_L}(H_2)^\dagger d_R Y_D$ + h.c

but In SUSY, W is holomorphic: $W \supset Q_L H_2^\dagger \overline{d_R} Y_D$ ^
would break SUSY explicitly! It's not allowed ...

this

N.B.!! In SM, we'd add a '$\mathcal{L}$' term: $\mathcal{L} \supset \overline{Q_L} (H_2)^\dagger d_R Y_D$ + h.c.

but In SUSY, W is holomorphic: $W \supset Q_L H_2^\dagger \overline{d_R} Y_D$
would break SUSY explicitly! It's not allowed ...

this is another reason for an additional Higgs doublet with opposite Y.

N.B.!! In SM, we'd add a "$\mathcal{L}$" term: $\mathcal{L} \supset \overline{Q_L} (H_2)^{\dagger} d_R Y_D + h.c.$

but In SUSY, W is holomorphic: $W \supset Q_L H_2^{\dagger} \overline{d_R} Y_D$ ^ would break SUSY explicitly! It's not allowed ...

this is another reason for an additional Higgs doublet with opposite Y.

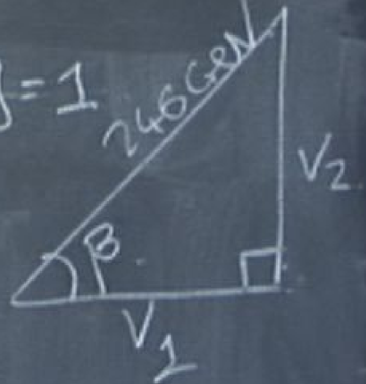
$$(Y_u)_{ij}\left[u_{L_i}^{x} H_2^0 \overline{u_R}_{jx} - d_L^{x} H_2^{+} \overline{u_R}_{jx} \right].$$

$M_{\varphi_{ij}} \sim \frac{\partial^2 W}{\partial\varphi_i \partial\varphi_j}$

Higgs mech.: $\langle H_2^0 \rangle = v_2$, $\langle H_1^0 \rangle = v_1$

$[v_i] = 1$

$$M_Z^2 = (g_1^2 + g_2^2)\frac{(v_1^2 + v_2^2)}{4} \Rightarrow v_1^2 + v_2^2 = (246\,\text{GeV})^2$$



g_1, g_2 are $U(1)$, $SU(2)_L$ gauge couplings resp.

$$H_2^0 = v_2 + h_2^0, \quad H_1^0 = v_1 + h_1^0$$

$$\tan\beta = \frac{v_2}{v_1}$$

hence $W \supset (Y_u)_{ij}\left[u_{L_i}^{x} \boxed{v_2}\, \overline{u_R}_{jx} + u_{L_i}^{x} h_2^0 \overline{u_R}_{jx} + \dots \right]$

2 $\mathbb{C}$ doublets = 8 $\mathbb{R}$ d.o.f. − 3 'eaten' = 5 physical Higgs

h^0, H^0 } CP +

A^0 − CP −

H^+, H^-

$$M_{u_{ij}} = v_2 (Y_u)_{ij}$$

NB!! In SM, we'd add a $\mathcal{L}$ term: $\mathcal{L} \supset \overline{Q_L}(H_2)^{\dagger} d_R$

, but In SUSY, W is holomorphic: $W \supset Q_L H_2^{\dagger} \overline{d}_R Y_D$

would break SUSY explicitly! It's not allowed

this is another reason for an additional Higgs dou

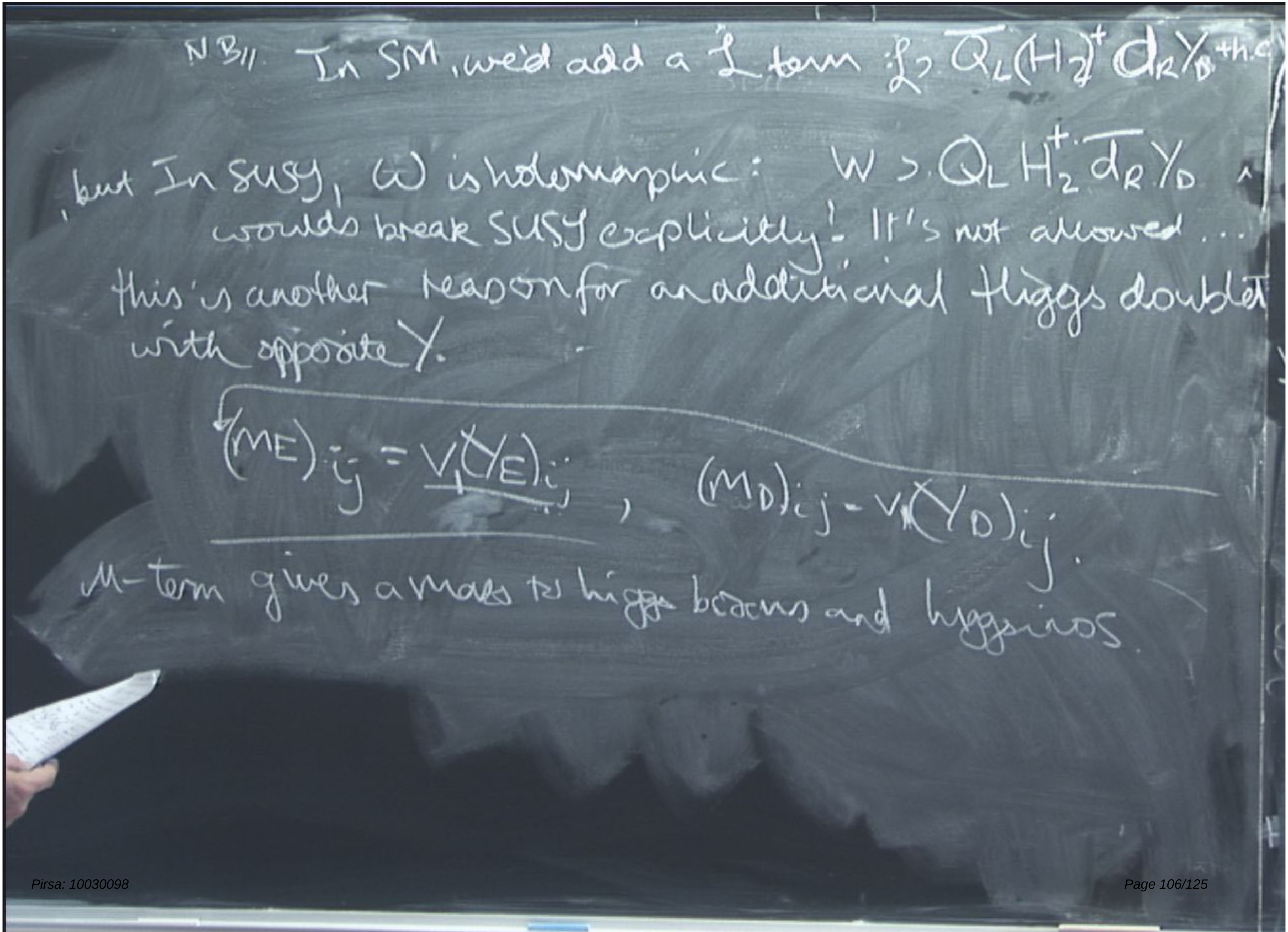
with opposite Y.

$$(M_E)_{ij} = \underline{v_1 (Y_E)_{ij}} \,, \qquad (M_D)_{ij} = v_1 (Y_D)_{ij} .$$

NB II. In SM, we'd add a $\mathcal{L}$ term: $\mathcal{L} \supset \overline{Q_L}(H_2)^\dagger d_R Y_D + h.c.$

but In SUSY, W is holomorphic: $W \supset Q_L H_2^\dagger \overline{d}_R Y_D$ ^ would break SUSY explicitly! It's not allowed ... this is another reason for an additional Higgs doublet with opposite Y.

$$(M_E)_{ij} = \underline{v_1 (Y_E)_{ij}} \quad , \quad (M_D)_{ij} = v_1 (Y_D)_{ij} .$$



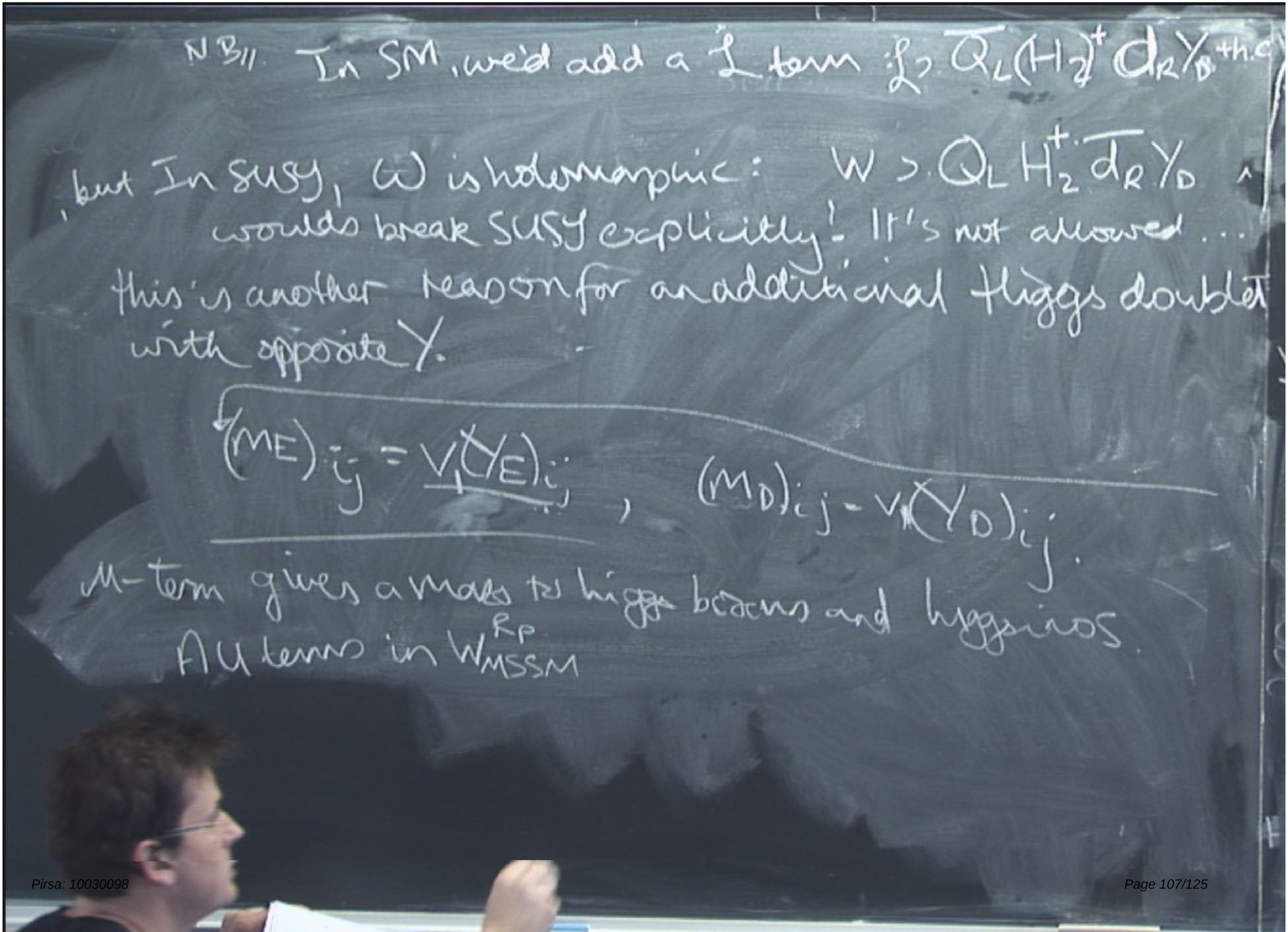
NB11. In SM, we'd add a $\mathcal{L}$ term: $\mathcal{L} \supset \overline{Q_L}(H_2)^\dagger d_R Y_D$ + h.c

but In SUSY, W is holomorphic: $W \supset Q_L H_2^\dagger \overline{d_R} Y_D$ ^ would break SUSY explicitly! It's not allowed ...

this is another reason for an additional Higgs doublet with opposite Y.

$$(M_E)_{ij} = \underline{v_1 (Y_E)_{ij}} \quad , \quad (M_D)_{ij} = v_1 (Y_D)_{ij} .$$

μ-term gives a mass to higgs bosons and higgsinos.



N.B.// In SM, we'd add a $\mathcal{L}$ term: $\mathcal{L} \supset \overline{Q_L}(H_2)^{\dagger} d_R Y_D + h.c$

but In SUSY, W is holomorphic: $W \supset Q_L H_2^{\dagger} \overline{d_R} Y_D$ ^ would break SUSY explicitly! It's not allowed ...

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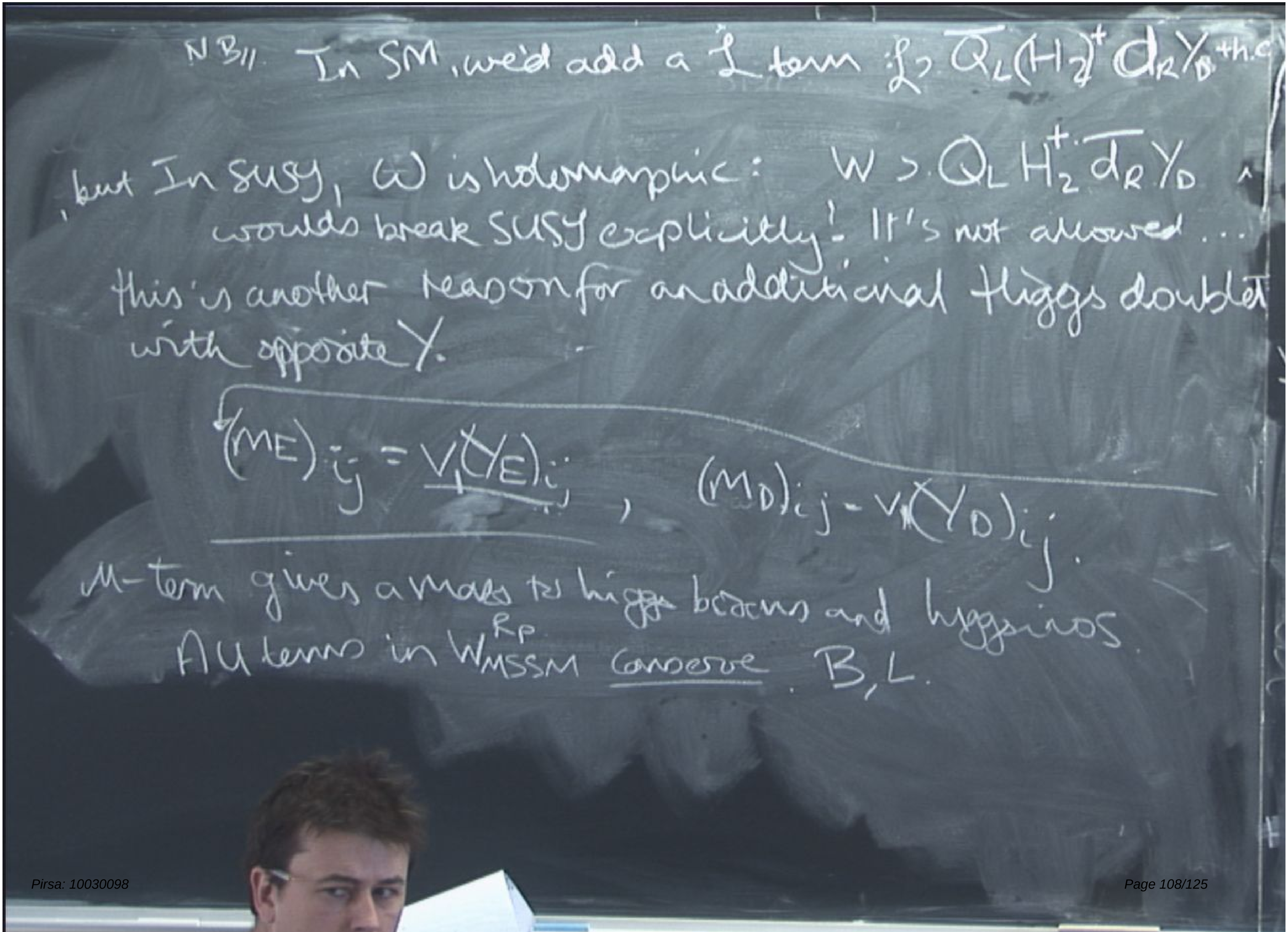

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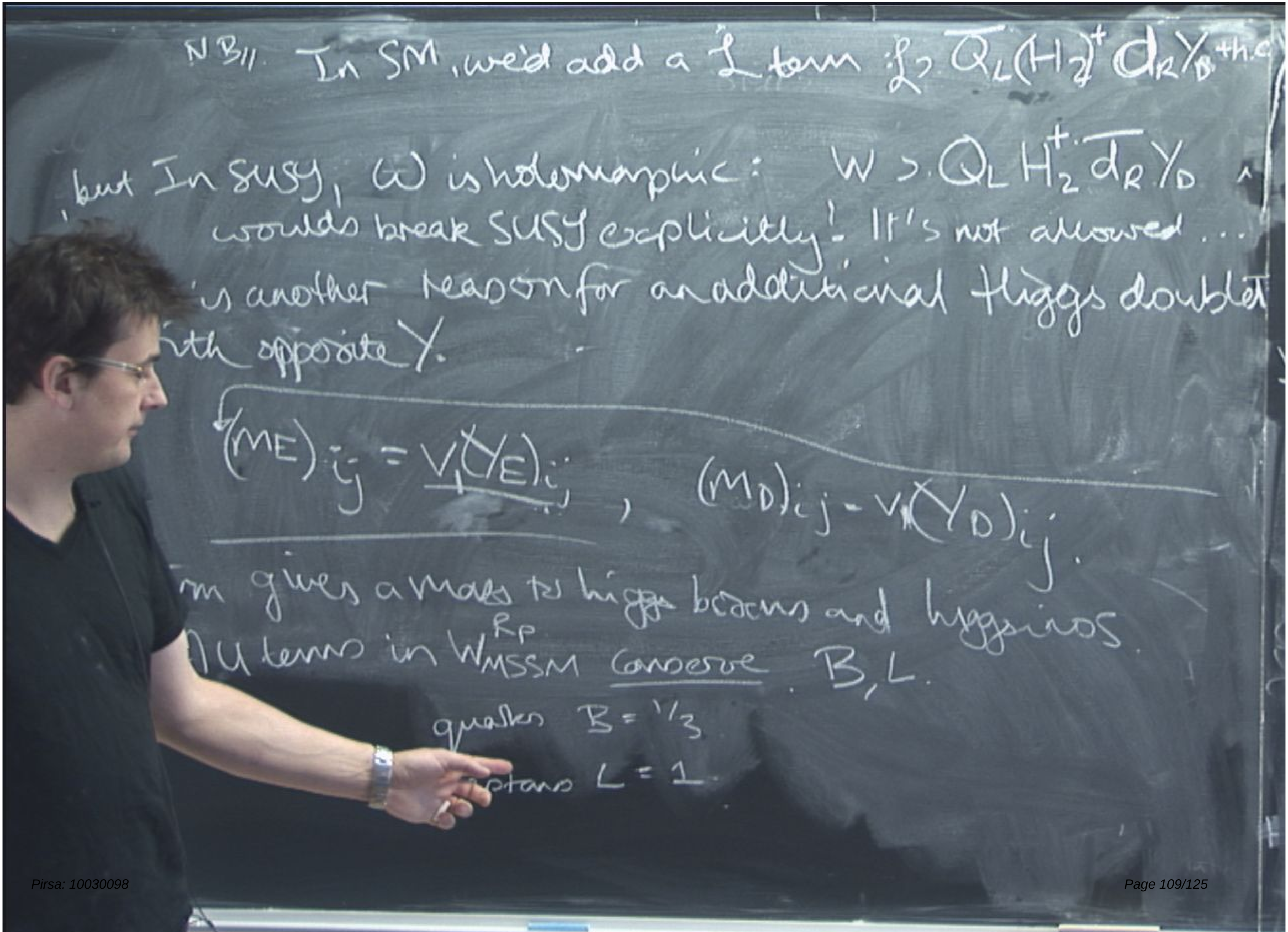

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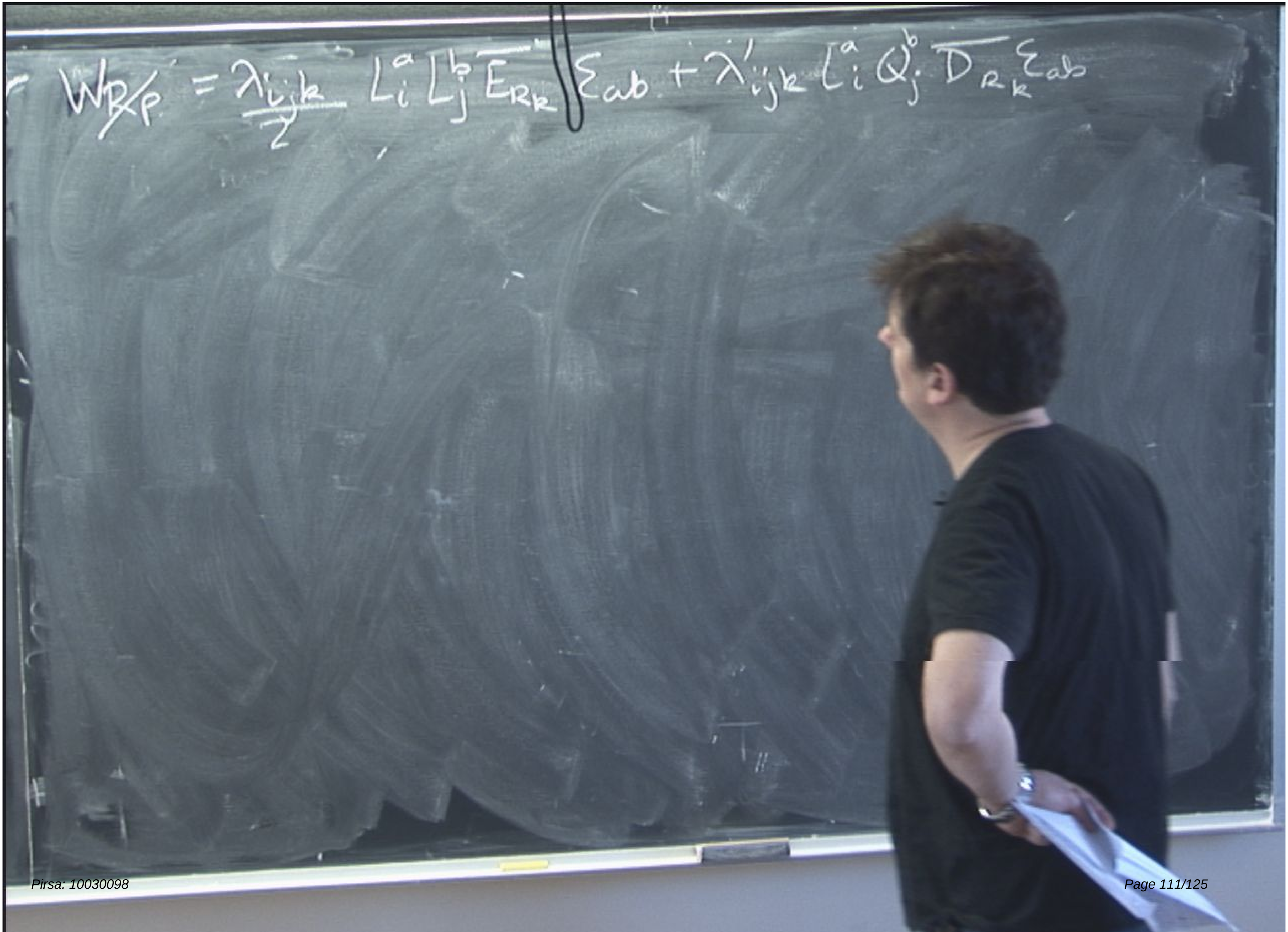
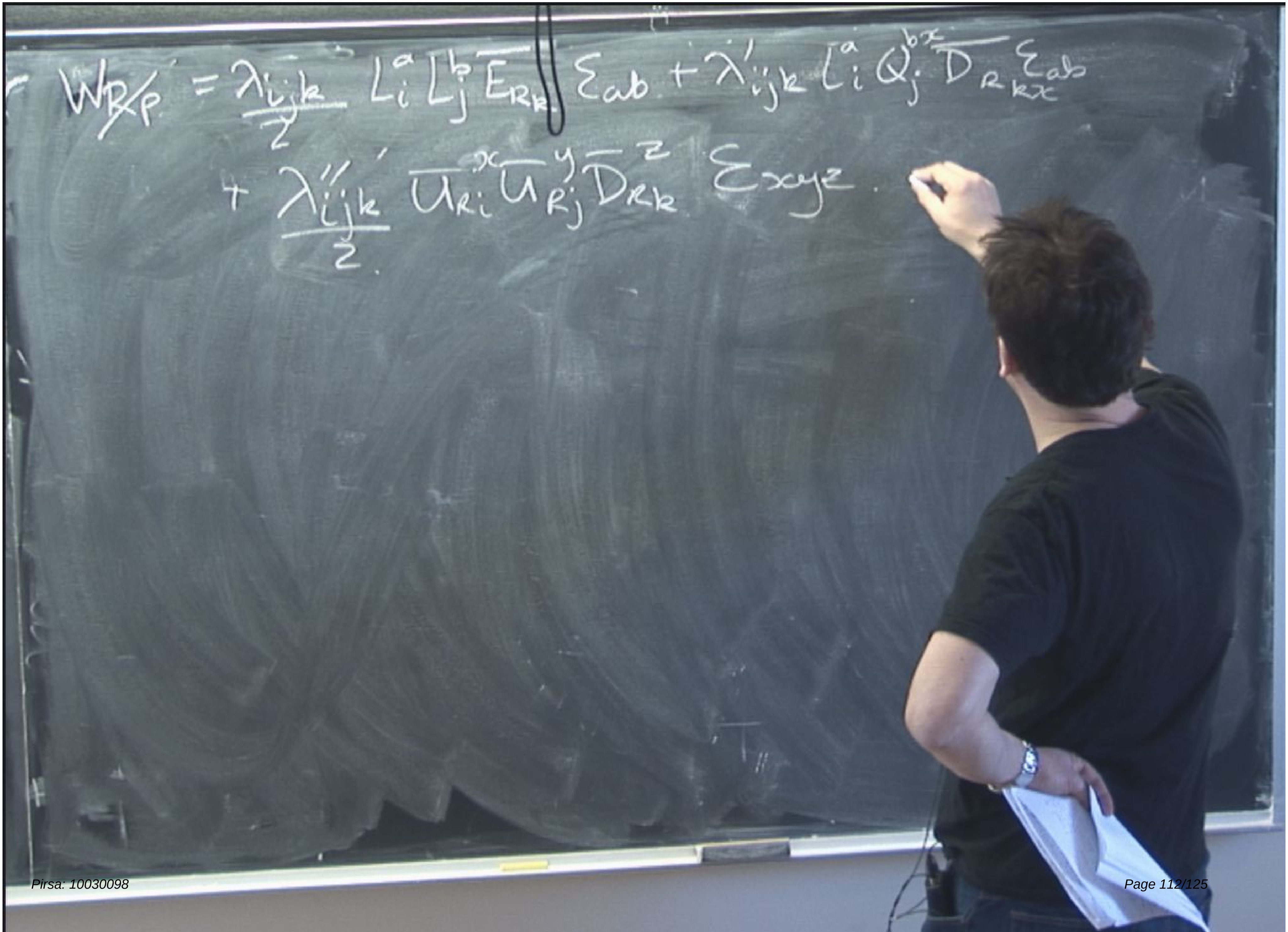


$$W_{\cancel{R}_p} = \frac{\lambda_{ijk}}{2} L^a_i L^b_j \overline{E}_{R_k} \varepsilon_{ab} + \lambda'_{ijk} L^a_i Q^b_j \overline{D}_{R_k} \varepsilon_{ab}$$



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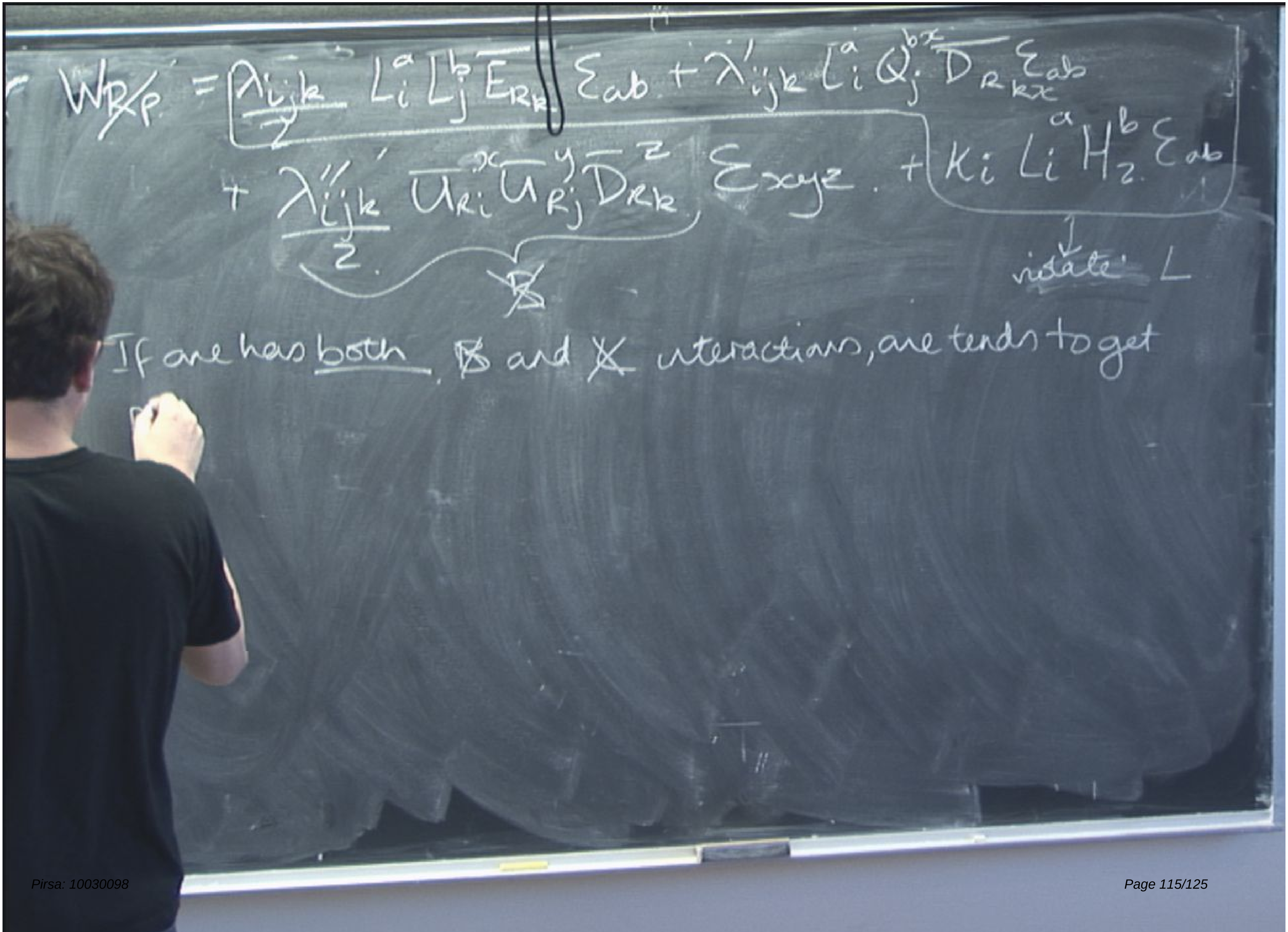

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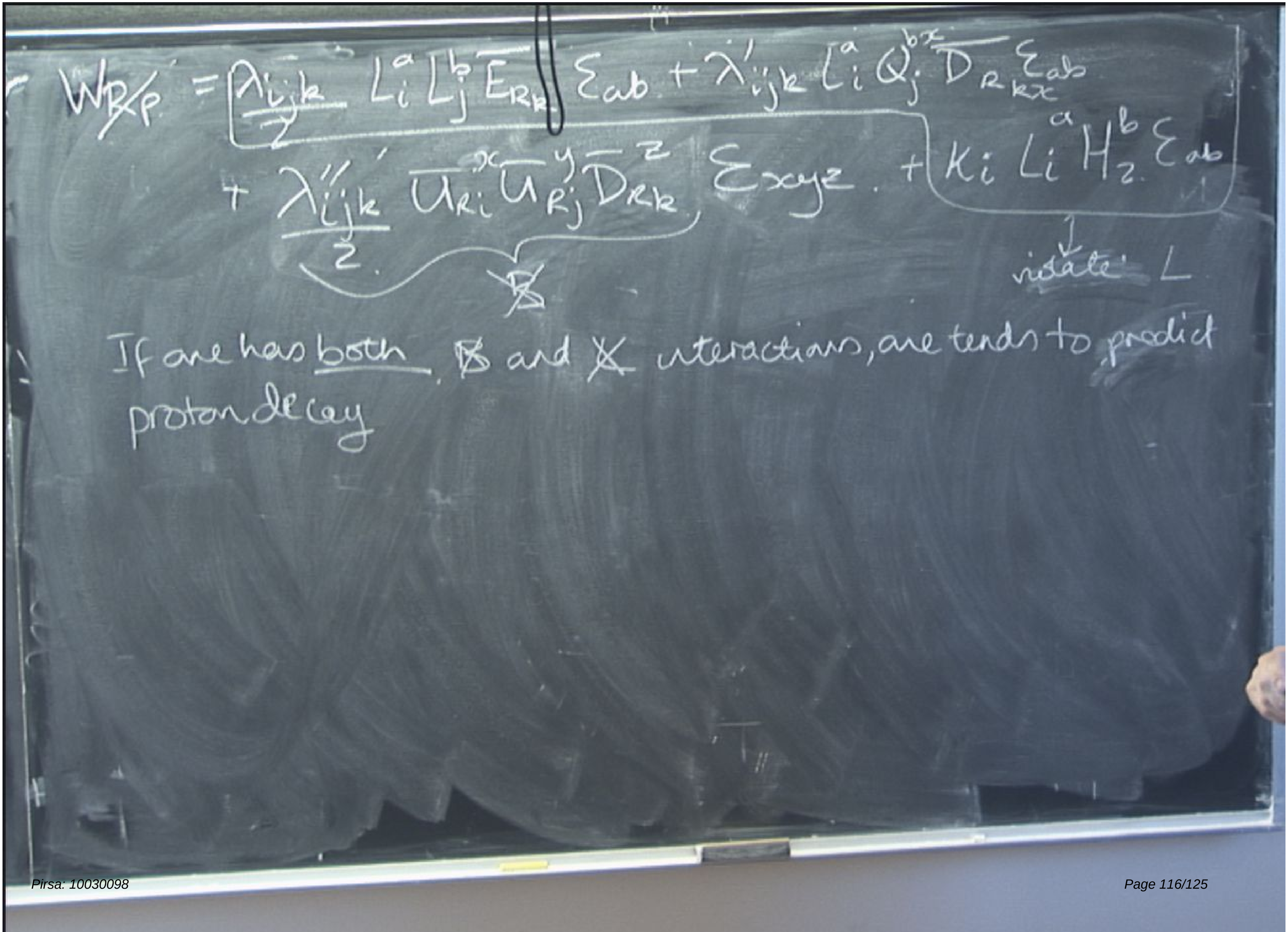
$\cancel{B}$

violate L

If one has both $\cancel{B}$ and $\cancel{L}$ interactions, one tends to get



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violate L

If one has <u>both</u> $\not{B}$ and $\not{L}$ interactions, one tends to predict proton decay

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$\downarrow$ violate L

If one has both $\not B$ and $\not L$ interactions, one tends to predict proton decay $\tau_p > 10^{35}$ years.

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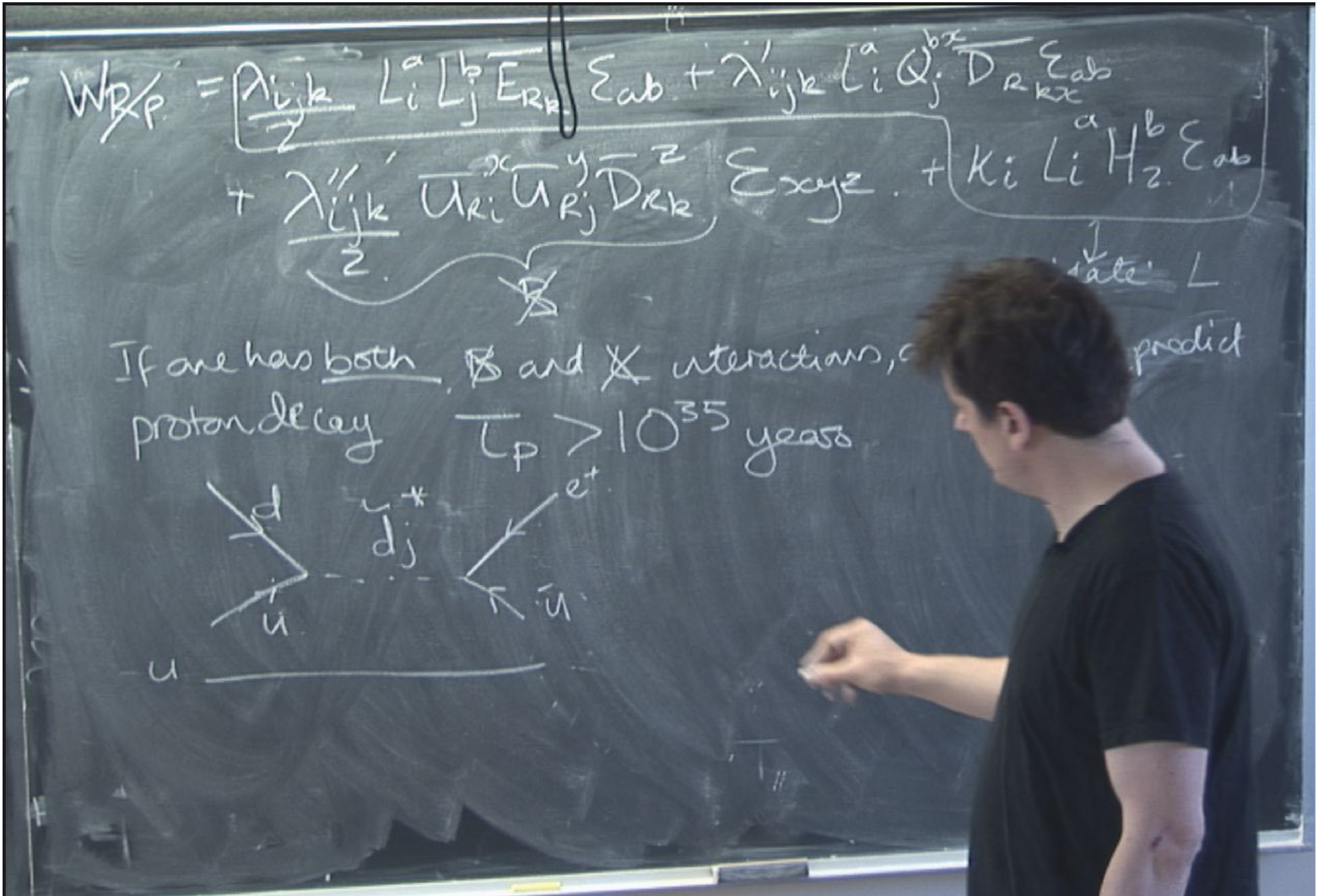

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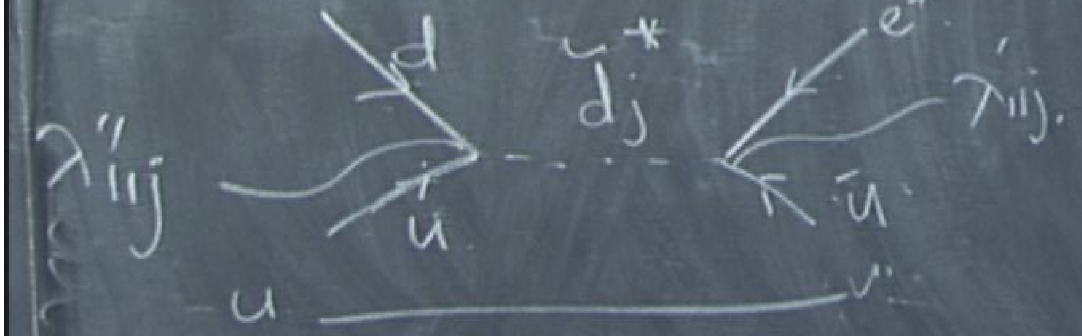

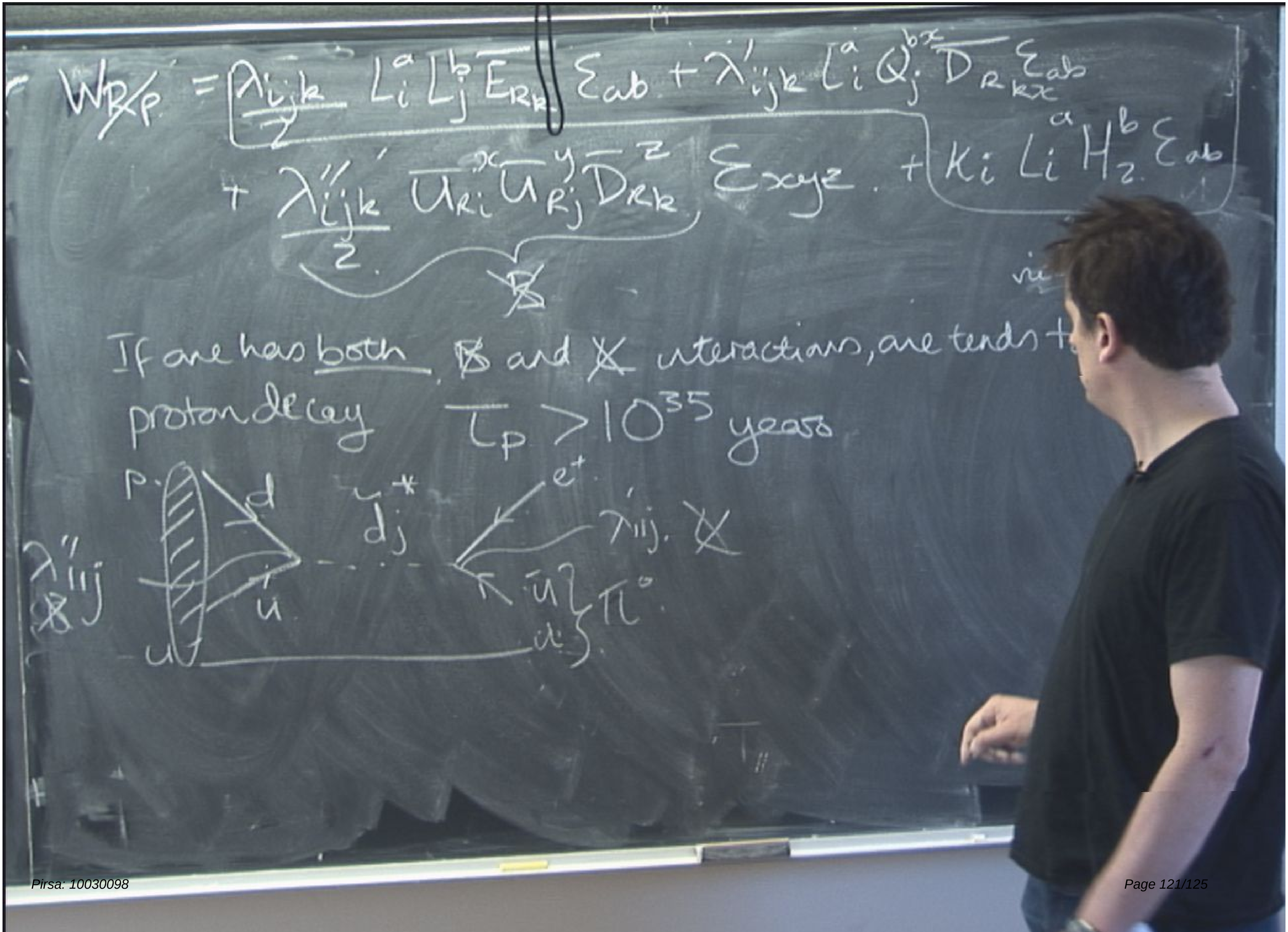

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vi

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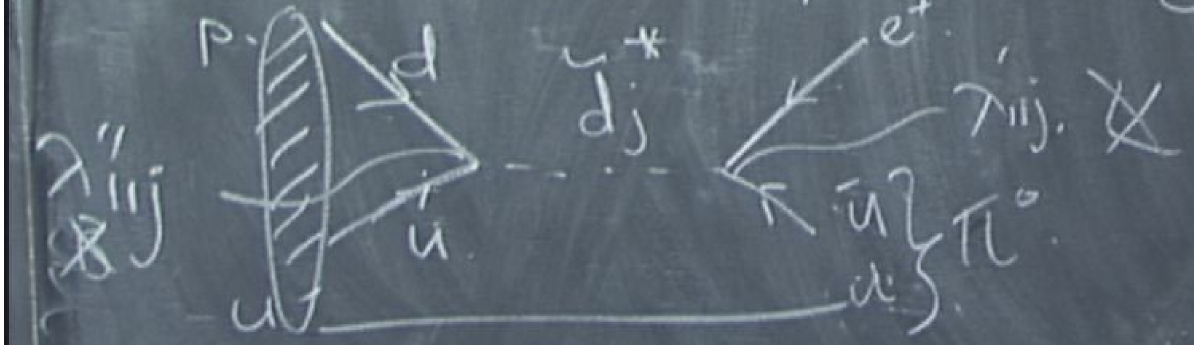

predicts

$p \to \pi^0 e^+$

decay rate predicted is ~O(1 sec)

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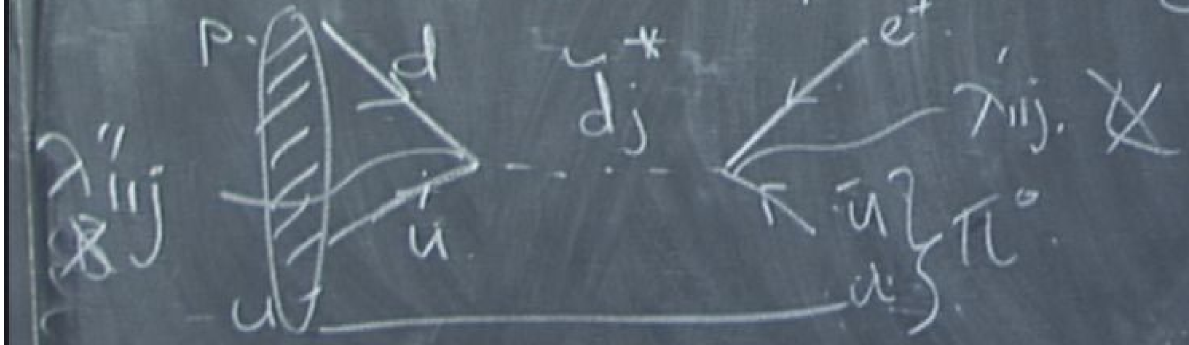

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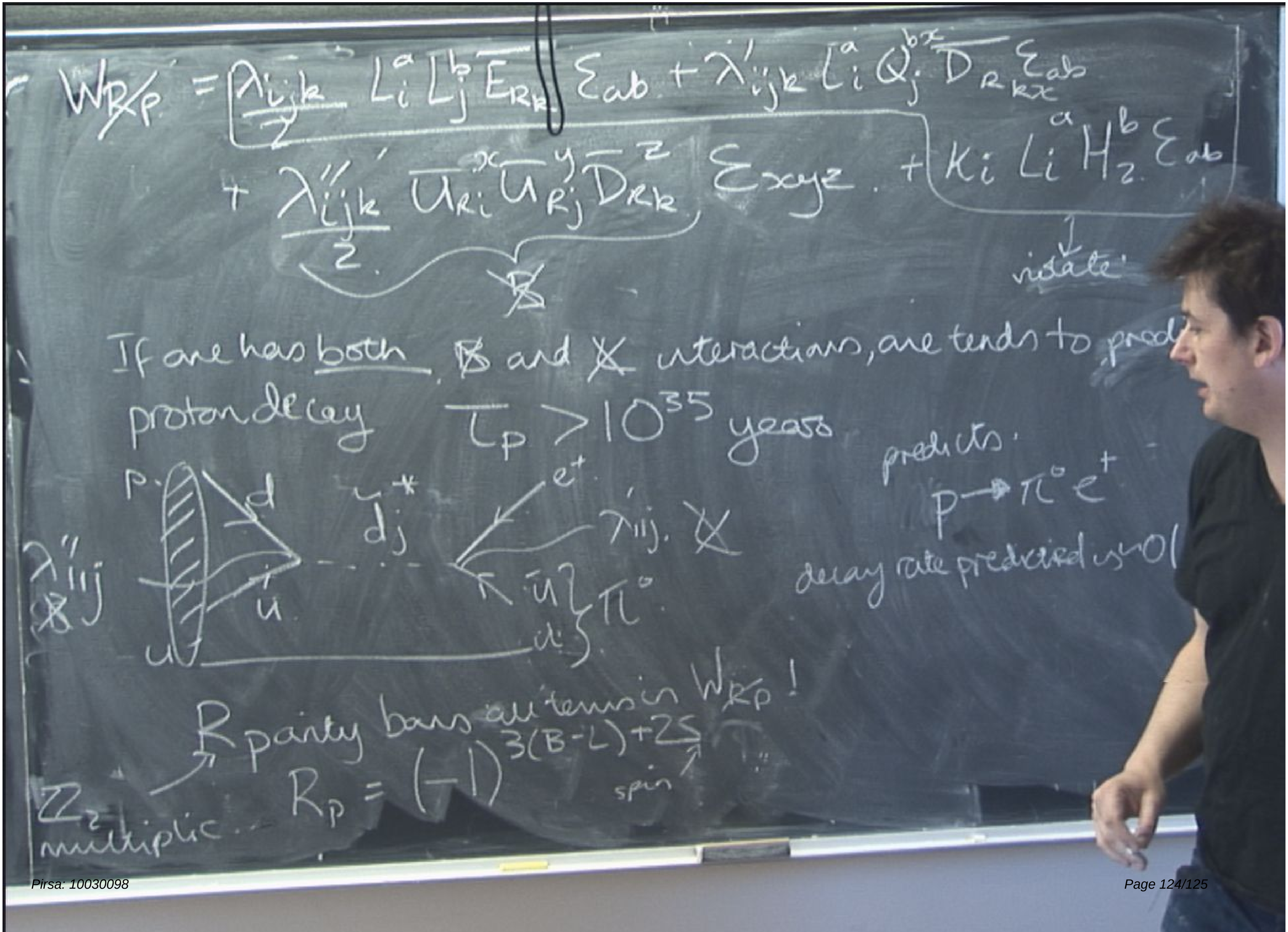

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spin

$\mathbb{Z}_2$ multiplic...

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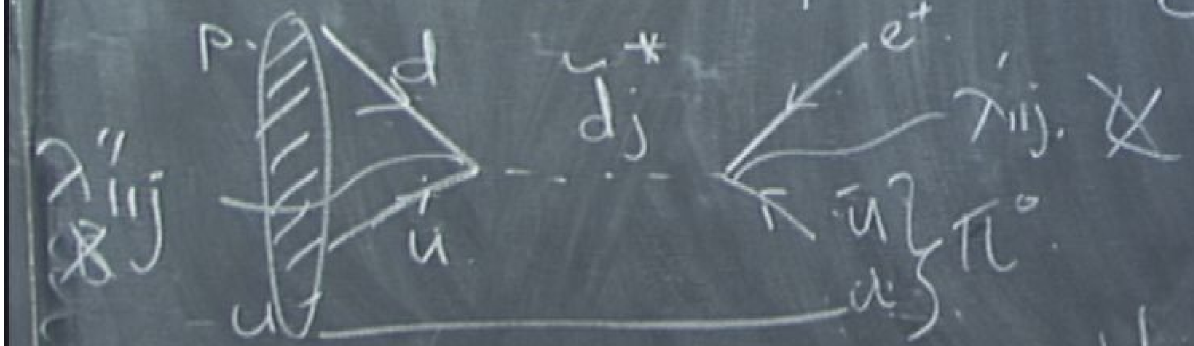

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