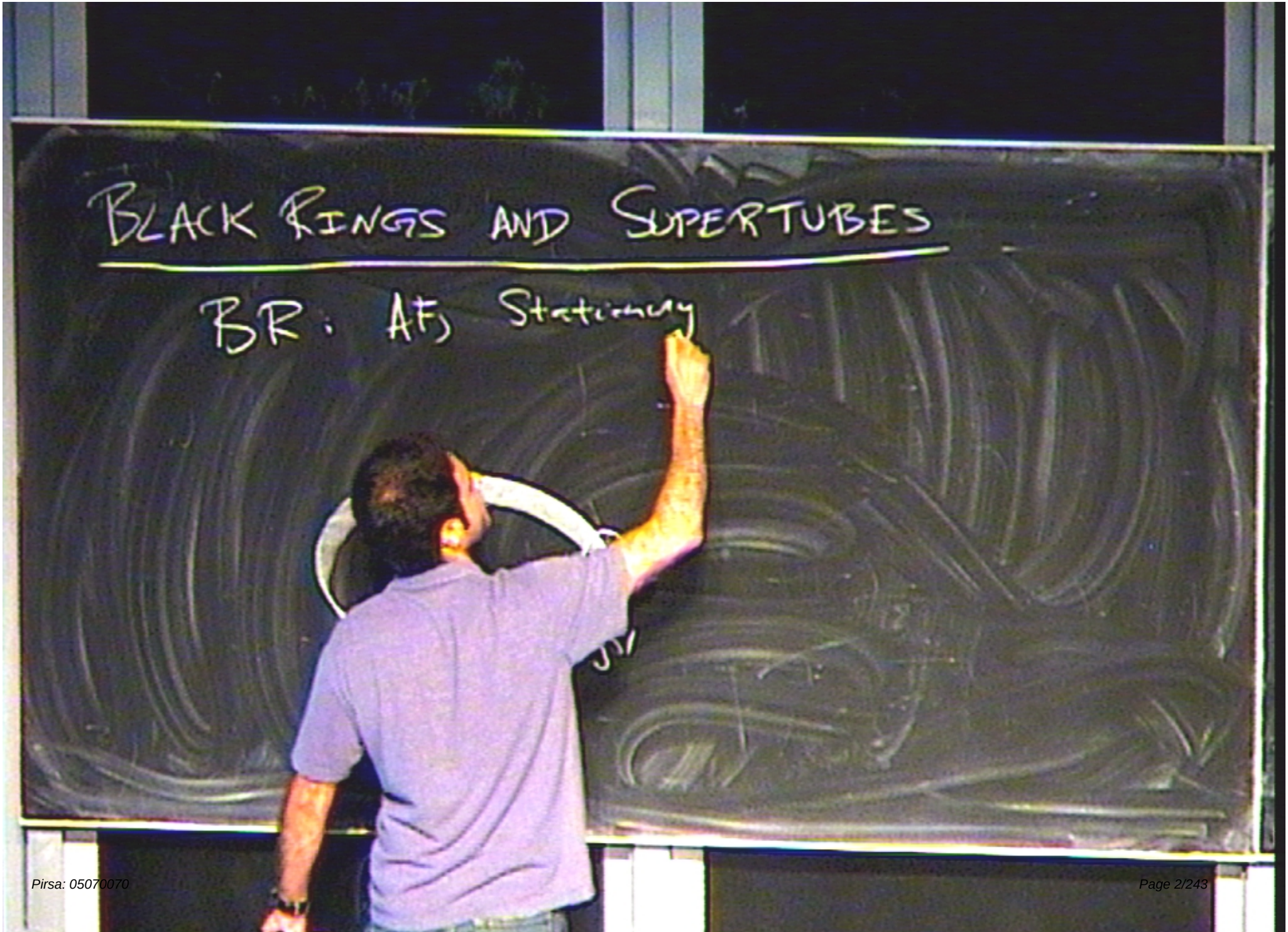
Title: Black Rings and Supertubes 1

Date: Jul 04, 2005 04:30 PM

URL: http://pirsa.org/05070070

Abstract:


BLACK RINGS AND SUPERTUBES
BR: AF; Stationary

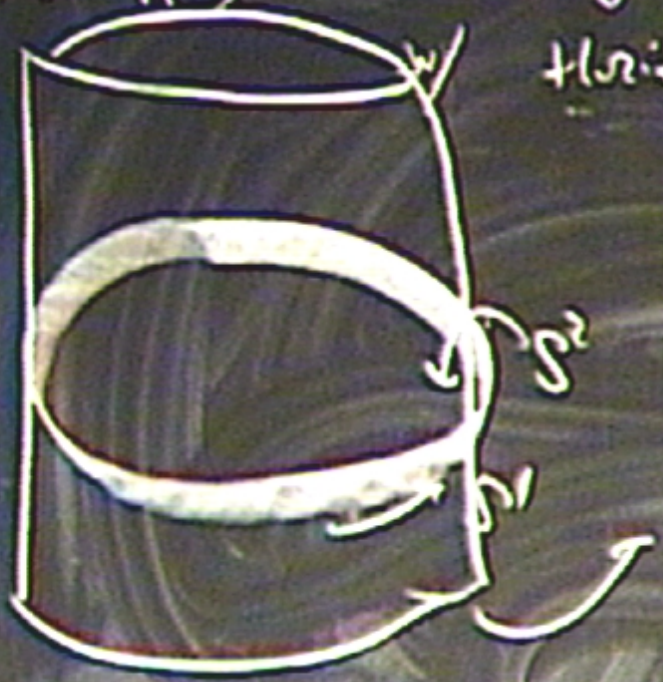
BLACK RINGS AND SUPERTUBES

BR. Asymptotically flat, stationary, BH solution in $D=5$ with horizon topology $S^1 \times S^2$



BLACK RINGS AND SUPERTUBES

BR: AF Stationary, BH solution in D=5
horizon topology $S^1 \times S^2$



BLACK RINGS AND SUPERTUBES

BR. AF Stationary, BH solution in D=5
with horizon topology $S^1 \times S^2$



BLACK RINGS AND SUPERTUBES

BR. AF, Stationary, BH solution in D=5 w/ horizon topology $S^1 \times S^2$



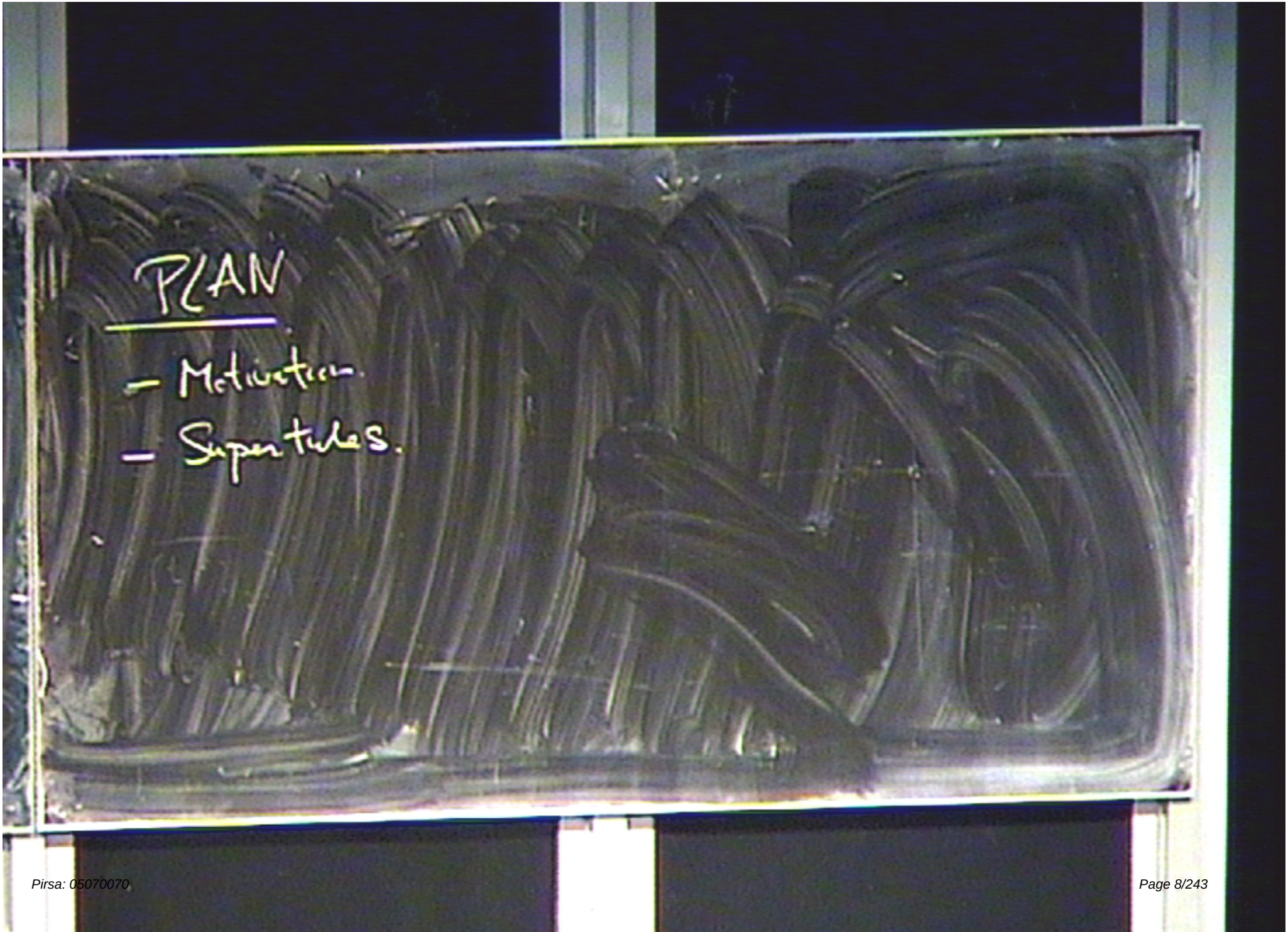
D=5

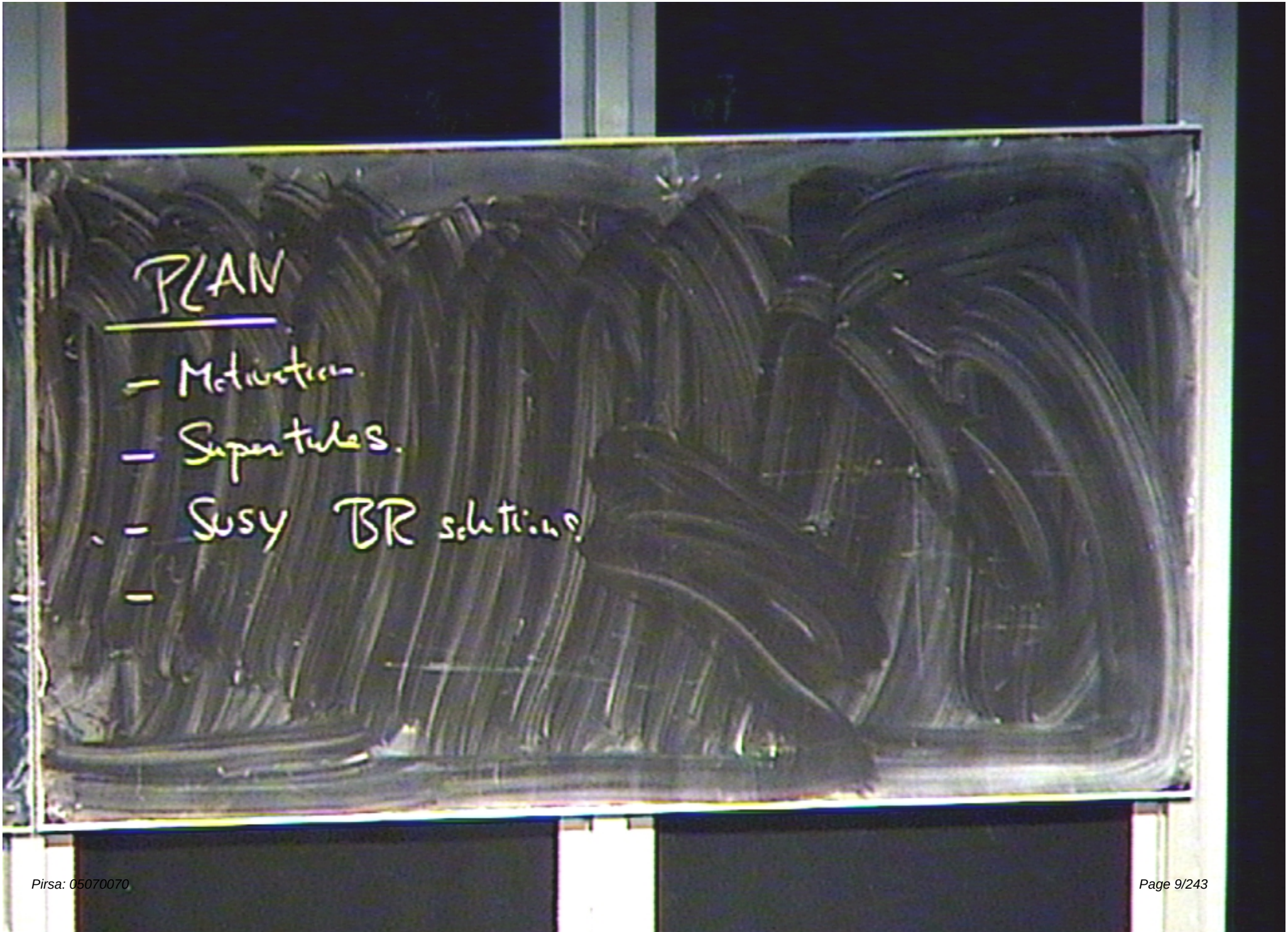
D=4

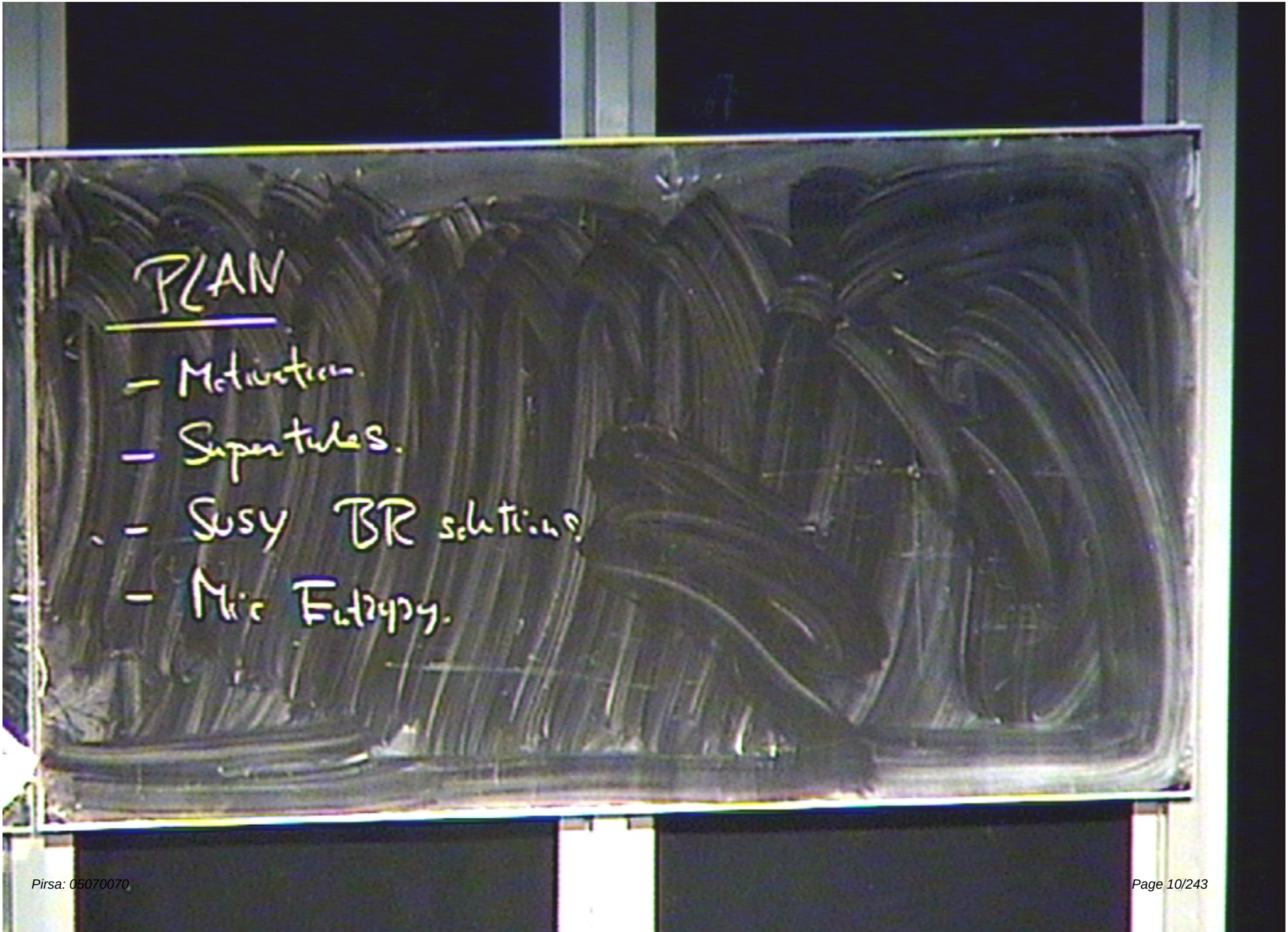


$S^2 \times S^1$

$\pi^{1,3} \times S^1$


PLAN
- Motivation.
- Superfields.


PLAN
- Motivation.
- Superfields.
- Susy BR solutions.
-

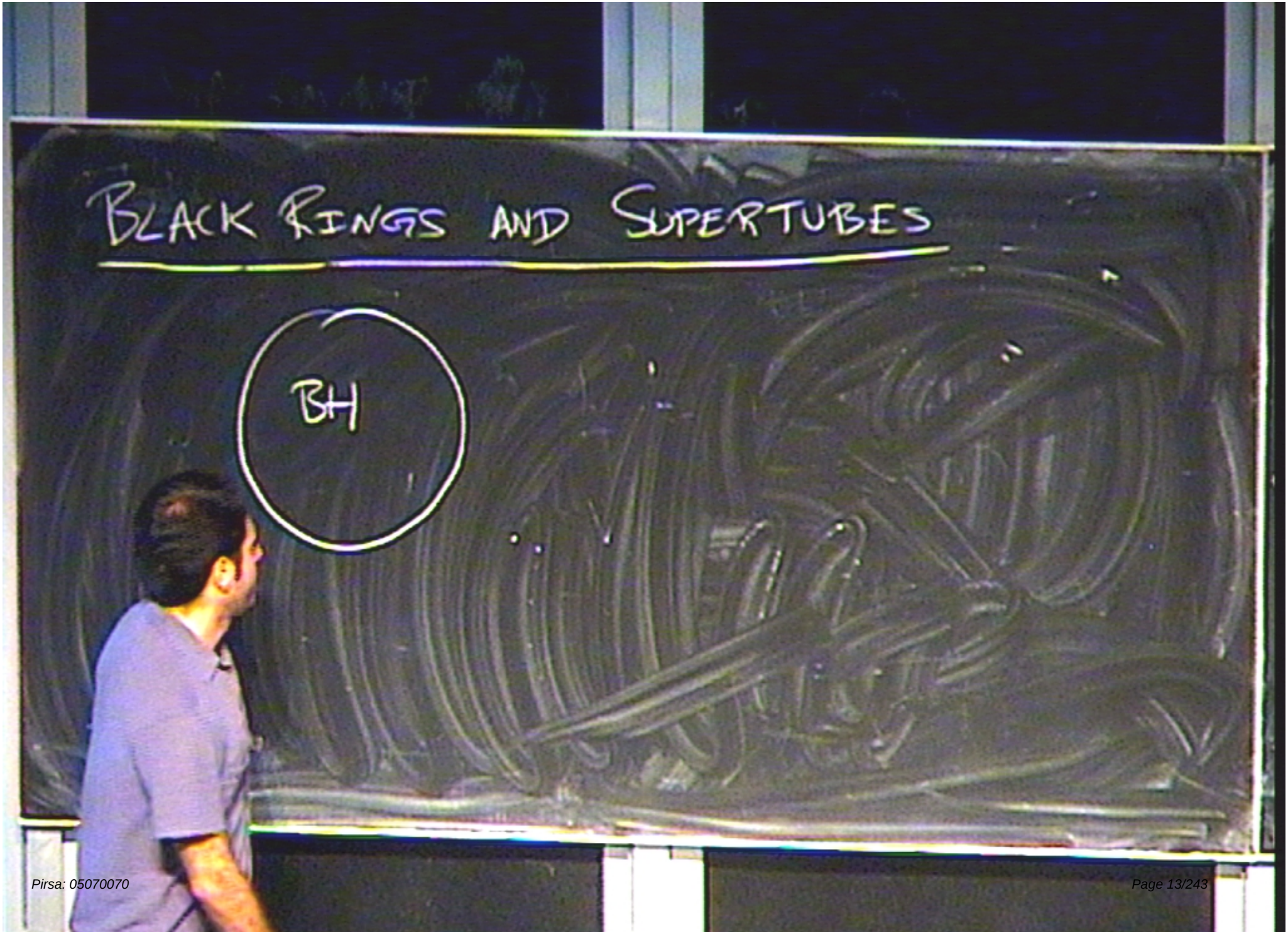

PLAN
- Motivation.
- Supertubes.
- Susy BR solutions.
- Mic Entropy.

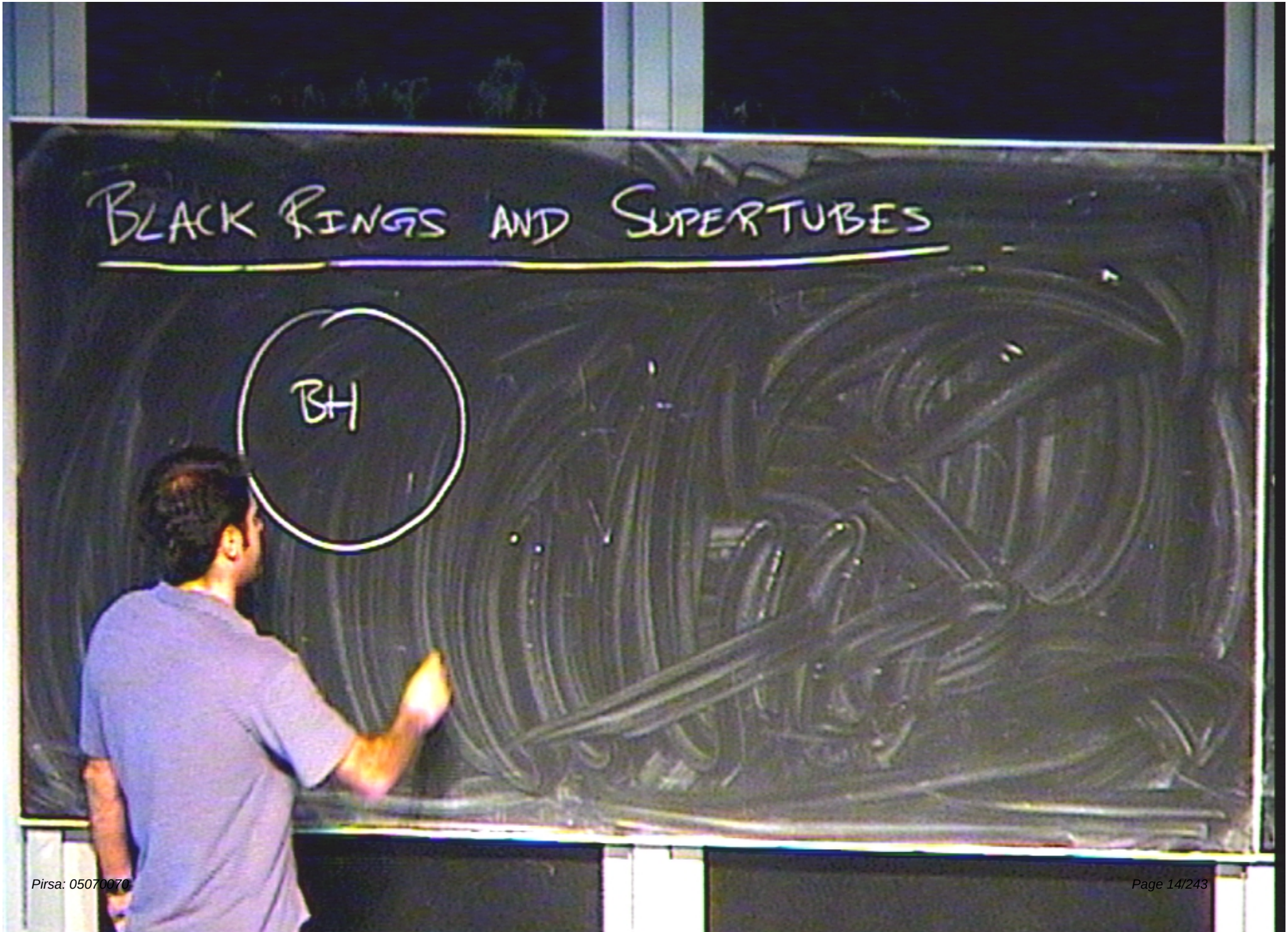
PLAN

- Motivation.
- Supertubes.
- Susy BR solutions.
- Micro Entropy.
- Connection to 4D BHs.

PLAN

- Motivation.
- Superstrings.
- Susy BR solutions.
- Min Entropy.
- Connection to 4D BHs.
- AdS/CFT Description.


BLACK RINGS AND SUPERTUBES
BH


BLACK RINGS AND SUPERTUBES
BH

BLACK RINGS AND SUPERTUBES



$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

$\therefore$ Quant. microstates ?

BLACK RINGS AND SUPERTUBES



$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

.. Quant. microstates ?

BLACK RINGS AND SUPERTUBES



$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

$\therefore$ Quant. microstates?

BLACK RINGS AND SUPERTUBES



$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

$\therefore$ Quant. microstates ?

BLACK RINGS AND SUPERTUBES



Bek. Haw '73 '74

$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

.. Quant. microstates ?

$\Downarrow$

SV. '96. Dijk et al. D.E.

BLACK RINGS AND SUPERTUBES



B.K. Haw '75 '74

$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

.. Quant. microstates ?

$\Downarrow$

SV. '96. Balls et P. Dte.

BLACK RINGS AND SUPERTUBES



Bek. Haw '73 '74

$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

.. Quant. microstates ?

$\Downarrow$

SV. '96. Dijk et al. D.E.

BLACK RINGS AND SUPERTUBES



Bek. Haw '73 '74

$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

.. Quant. microstates ?

$\Downarrow$

SV. '96. Mald et P. Tate.

BLACK RINGS AND SUPERTUBES



Bek. Haw '73 '74

$\Rightarrow S = \frac{A}{4G}$

$\Downarrow$

.. Quant. microstates ?

$\Downarrow$

SV. '96. Dijk et P. Date.

Why in D=5?

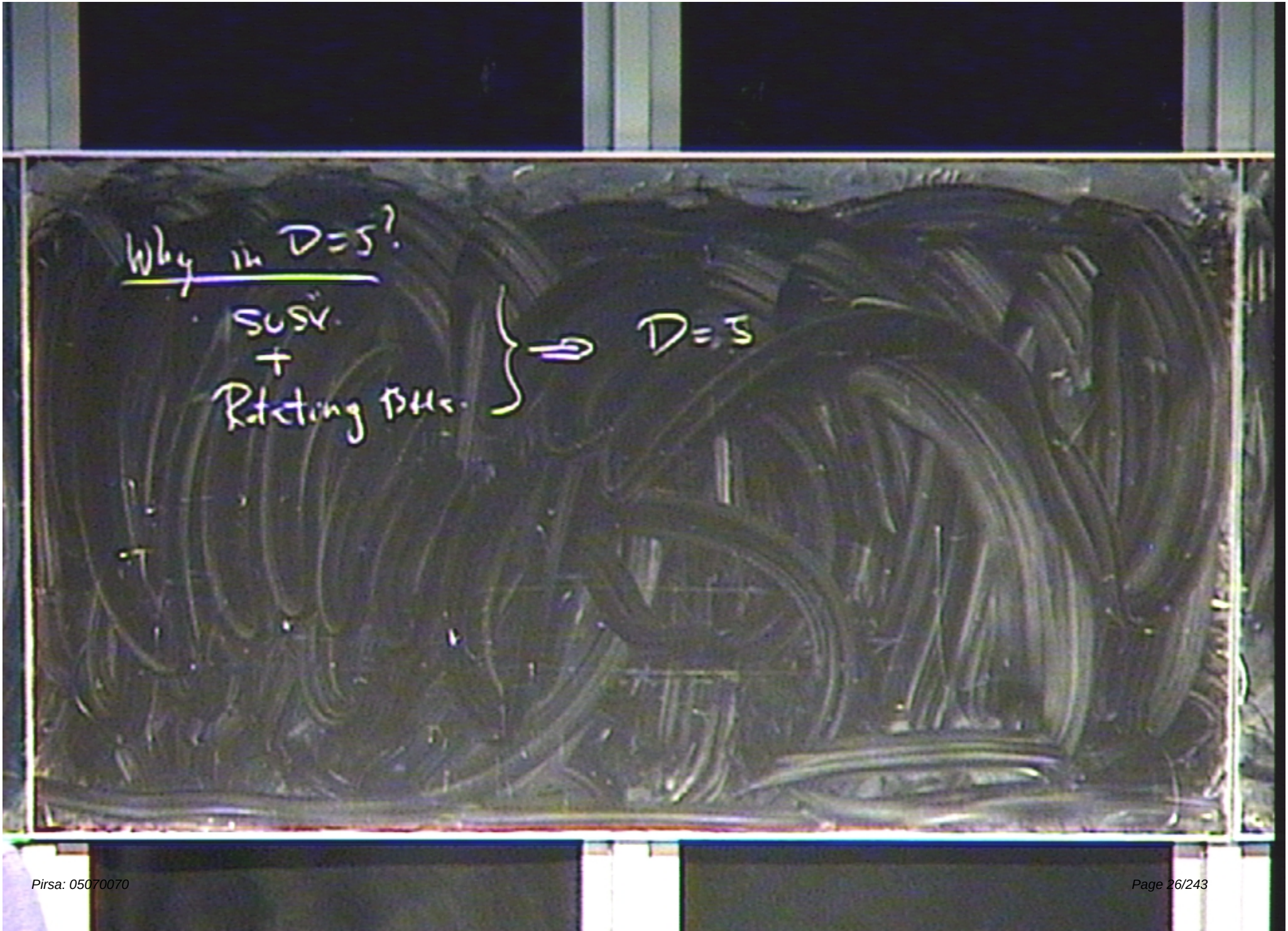
SUSY

Why in D=5?

SUSY

+

Rotating BHs.


Why in D=5?
susy
+
Rotating BHs.
D=5

Why in D=5?

SUSY
+
Rotating BHs. } ⇒ D=5

D=4



Why in D=5?

SUSY
+
Rotating BHs. } ⇒ D=5

D=4



Why in $D=5$?

susy
+
Rotating BHs.
$\Rightarrow$ $D=5$

$D=4$



Hor. $= S^2$

Why in $D=5$?

SUSY
+
Rotating BHs. $\Rightarrow$ $D=5$

$D=4$



Hor. $= S^2$
Uniqueness

Why in $D=5$?

SUSY
+
Rotating BHs. $\Big\} \Rightarrow$ $D=5$

$D=4$



$H_{n.} = S^2$

Uniqueness M, Q, J

Why in $D=5$?

SUSY + Rotating BHs. $\Rightarrow$ $D=5$

$D=4$



Hor. $= S^2$

Uniqueness M, Q, J

$D=5$





Why in $D=5$?

SUSY
+
Rotating BHs. $\Rightarrow$ $D=5$

$D=4$



$H_{n.} = S^2$

Uniqueness M, Q, J

$D=5$





Why in $D=5$?

SUSY + Rotating BHs. $\Rightarrow$ $D=5$

$D=4$



Hor. $= S^2$

Uniqueness M, Q, J

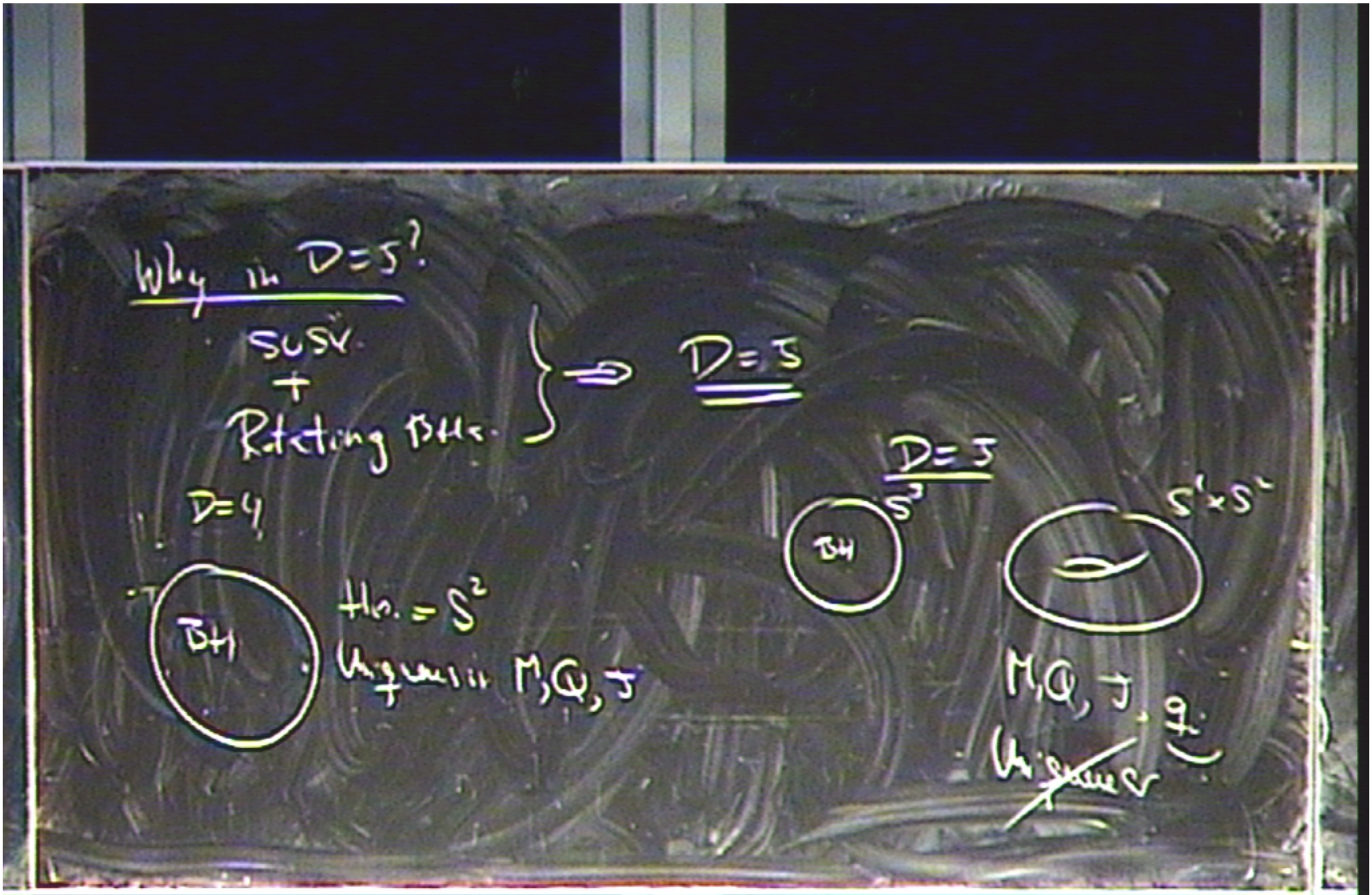
$D=5$

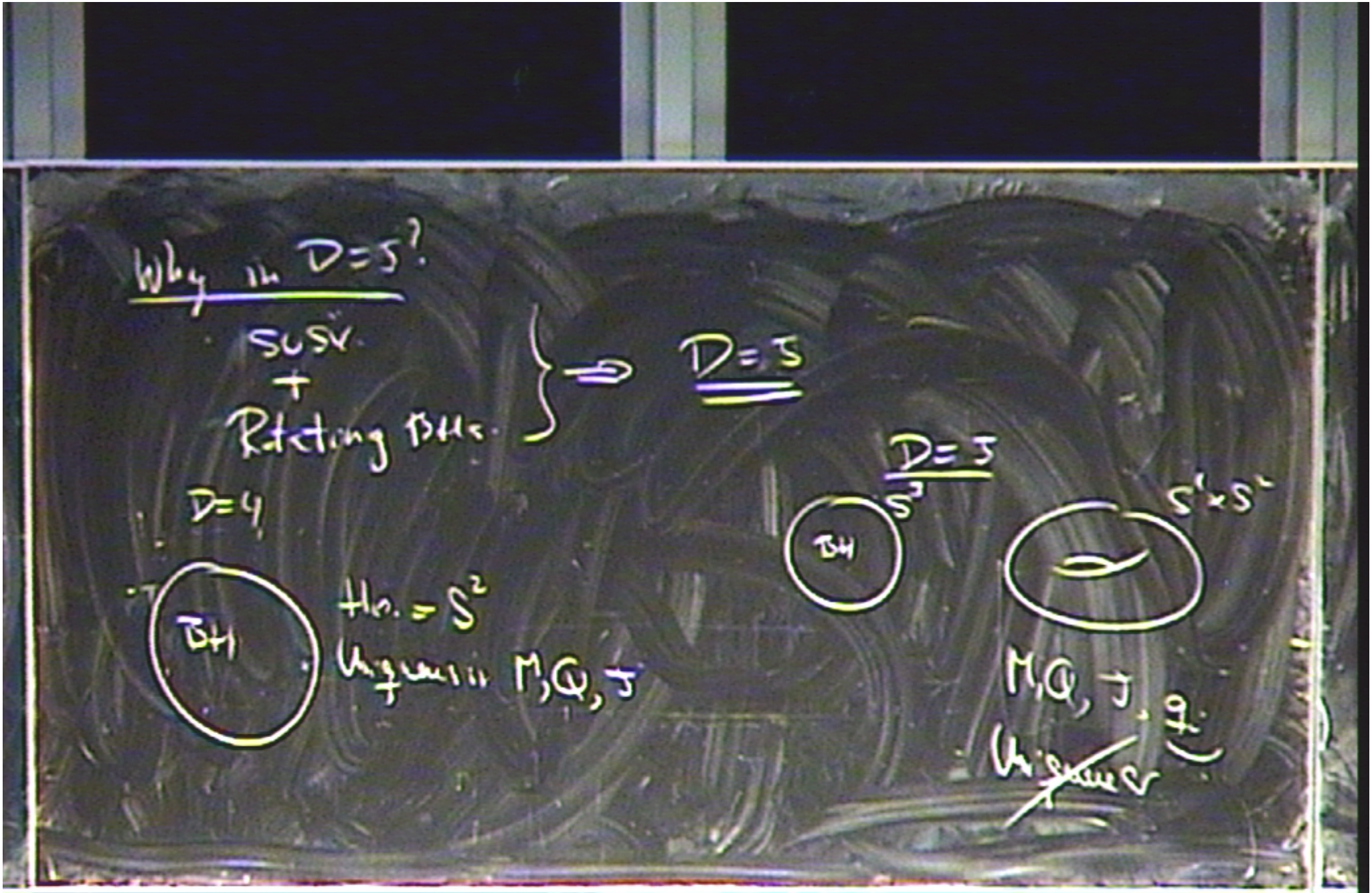


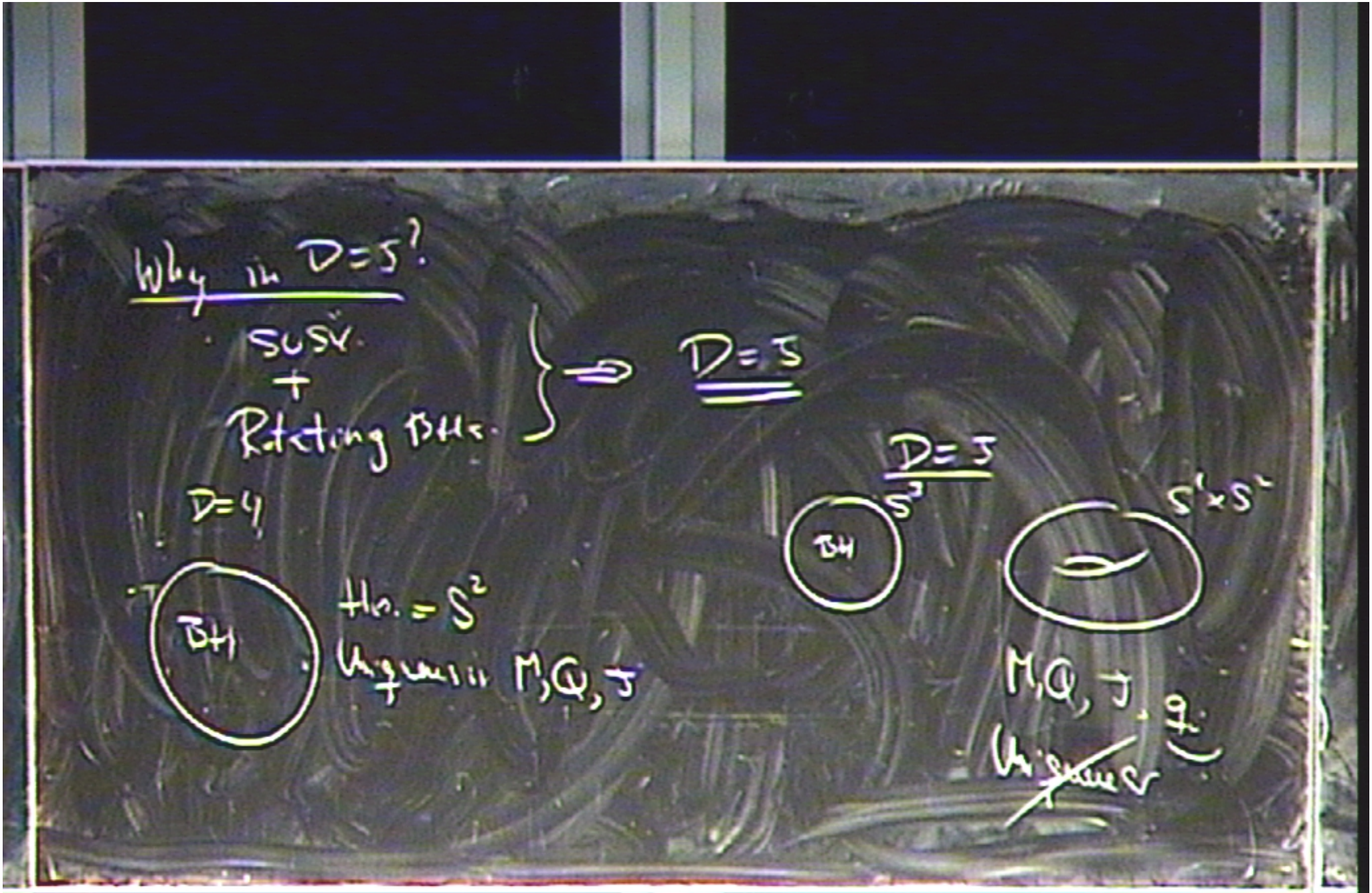


$M, Q, J, ?$

Uniqueness


Why in D=5?
susy
+
Rotating BHs.
D=5
D=4
BH
Hor. = S²
Uniqueness M,Q,J
D=5
S³
BH
S¹×S²
M,Q,J,q
Uniqueness


Why in D=5?
susy
+
Rotating BHs.
⇒ D=5
D=4
BH
Hor. = S²
Uniqueness M,Q,J
D=5
S³
BH
S¹×S²
M,Q,J,q
Uniqueness


Why in D=5?
susy
+
Rotating BHs.
D=5
D=4
BH
Hor. = S²
Uniqueness M,Q,J
D=5
S³
BH
S¹×S²
M,Q,J,q
Uniqueness

Why in $D=5$?

SUSY + Rotating BHs. $\Rightarrow$ $D=5$

$D=4$



$H_n = S^2$

Uniqueness M, Q, J

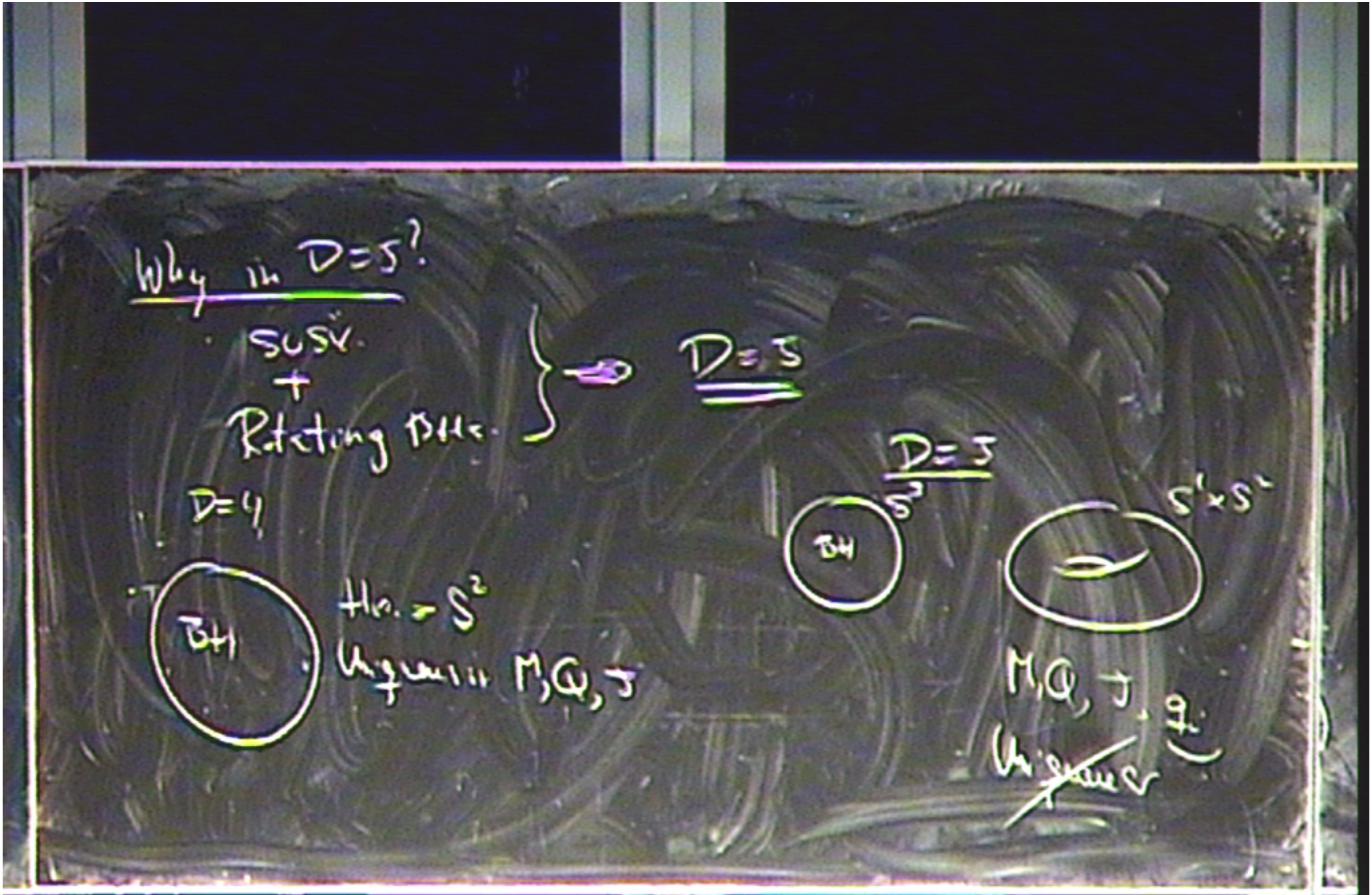
$D=5$

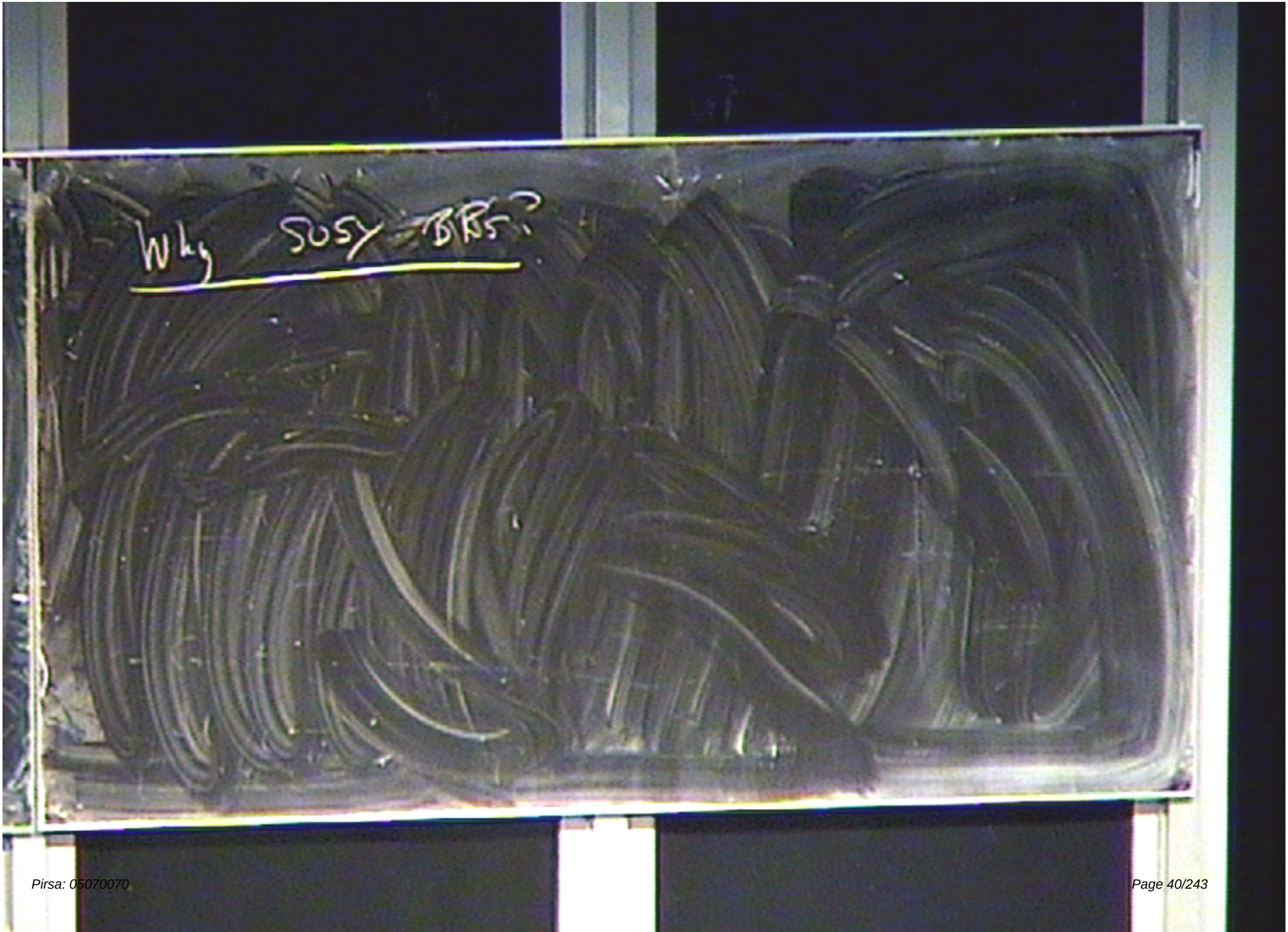


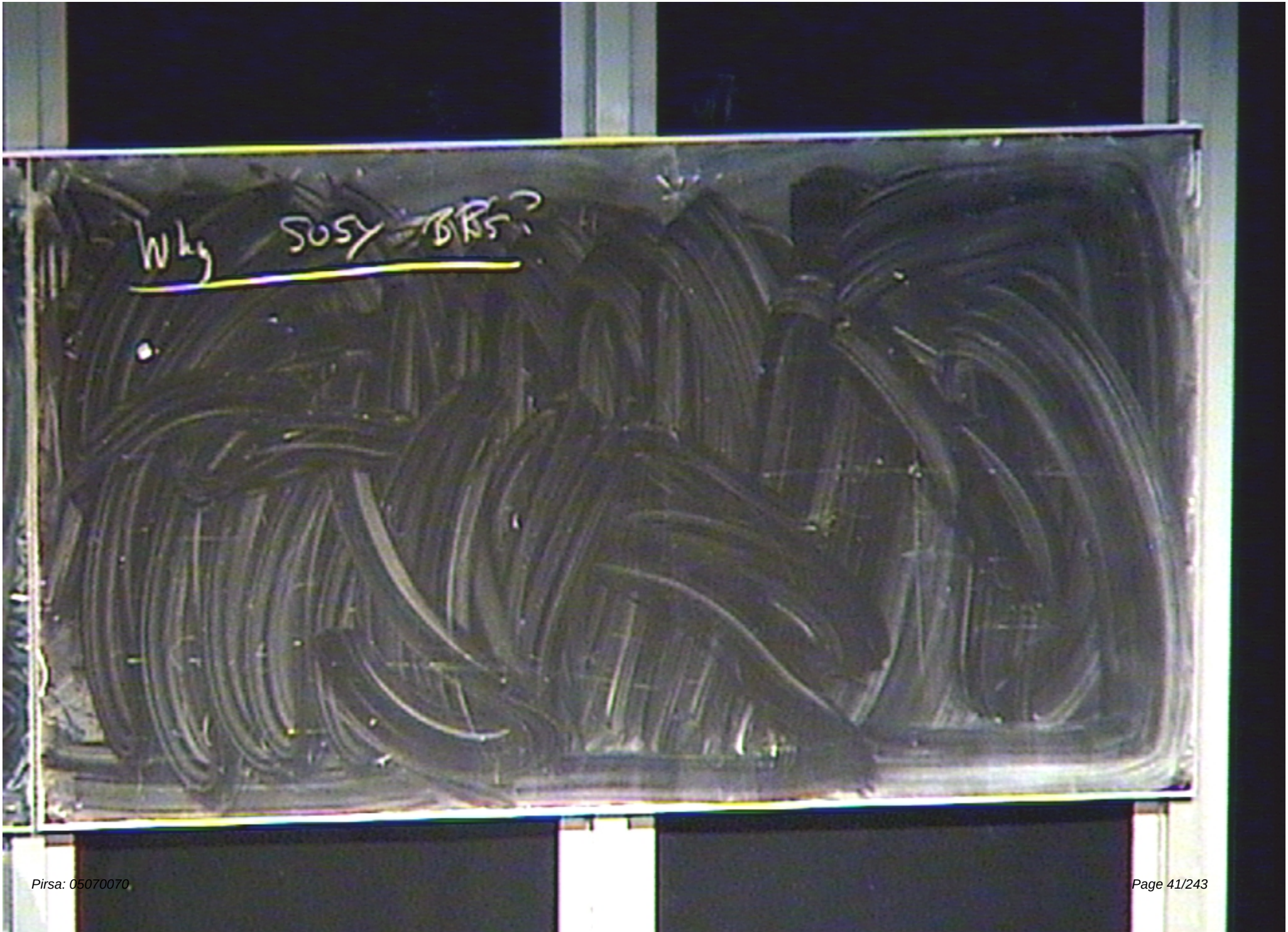


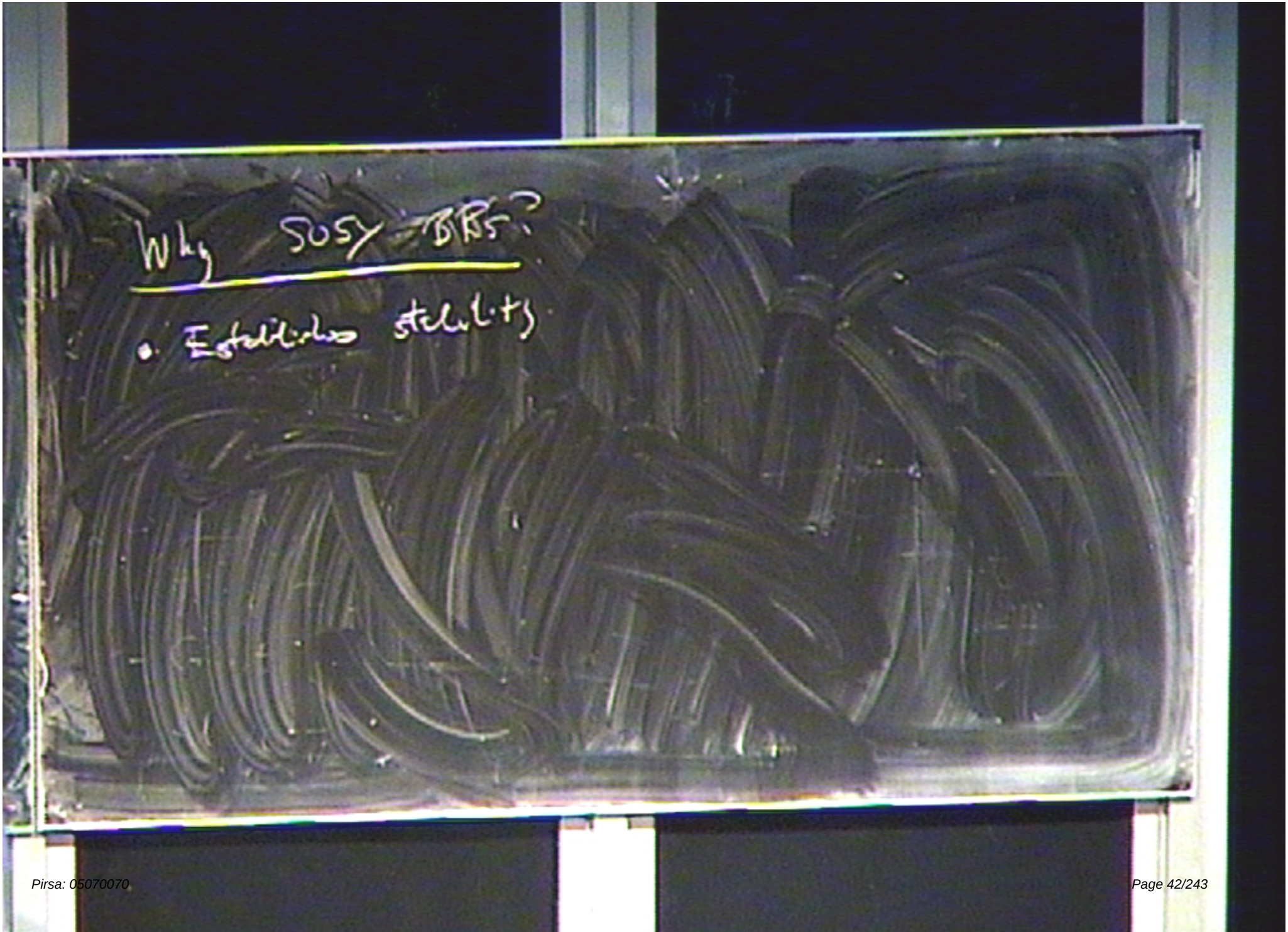
M, Q, J, q

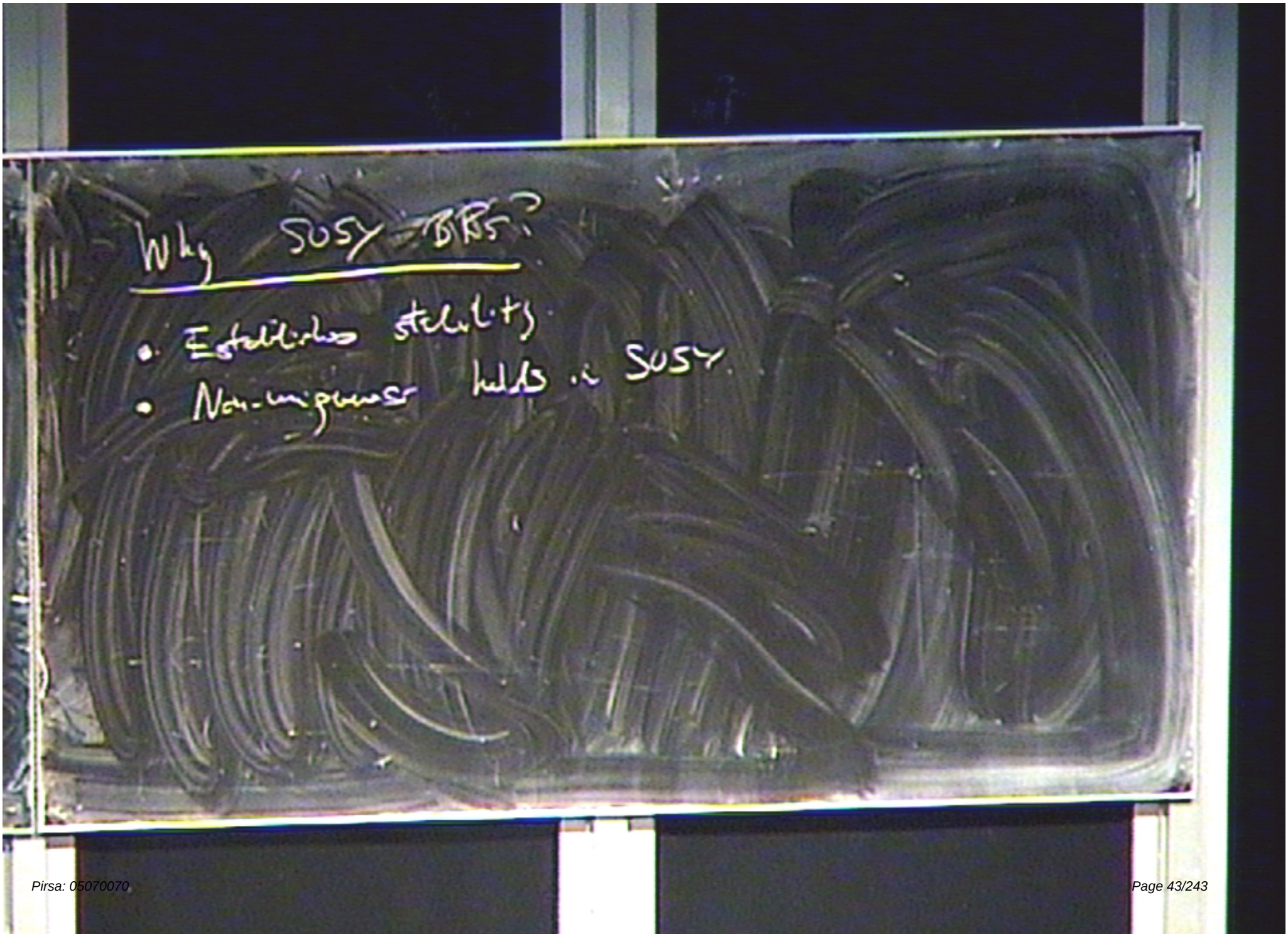
Uniqueness


Why in D=5?
susy
+
Rotating Bhs.
D=5
D=4
BH
Hor. = S^2
Uniqueness M,Q,J
D=5
S^3
BH
$S^1 \times S^2$
M,Q,J,$\vec{q}$
Uniqueness


Why SUSY @ BRs?


Why SUSY - BRs?


Why SUSY - BRS?
• Establishes stability


Why SUSY - BRS?
• Establishes stability
• Non-renormalization thms. in SUSY

Why SUSY BRS?

- Establishes stability
- Non-renormalization holds in SUSY
- Implications for microcounting of the entropy in S.T.

Why SUSY BRS?

- Establishes stability
- Non-renormalization holds in SUSY
- Implications for microcounting of the entropy in S.T.
-

Why SUSY BRS?

- Establishes stability
- Non-renormalization holds in SUSY
- Implications for microscopic counting of the entropy in S.T.
-

Why SUSY BRS?

- Establishes stability
- Non-renormalization holds in SUSY
- Implications for microcounting of the entropy in S.T.
-

Why SUSY BHs?

- Establishes stability
- Non-uniqueness holds in SUSY
- Implications for microscopic counting of the entropy in S.T.
- Ideal arena.

Why SUSY BRS?

- Establishes stability
- Non-renormalization thms in SUSY
- Implications for microscopic counting of black hole entropy in S.T.
- Ward identities.
- Connection to 4D BRST.

Why SUSY BRS?

- Establishes stability
- Non-renormalization thms in SUSY
- Implications for microscopic counting of black hole entropy :: S.T.
- Ideal arena.
- Connections to 4D BH thm.
-

Why SUSY BHs?

- Establishes stability
- Non-uniqueness holds in SUSY
- Implications for microscopic counting of the entropy in S.T.
- Ideal arena.
- Connections to 4D BHs.
- BHs in D>4?

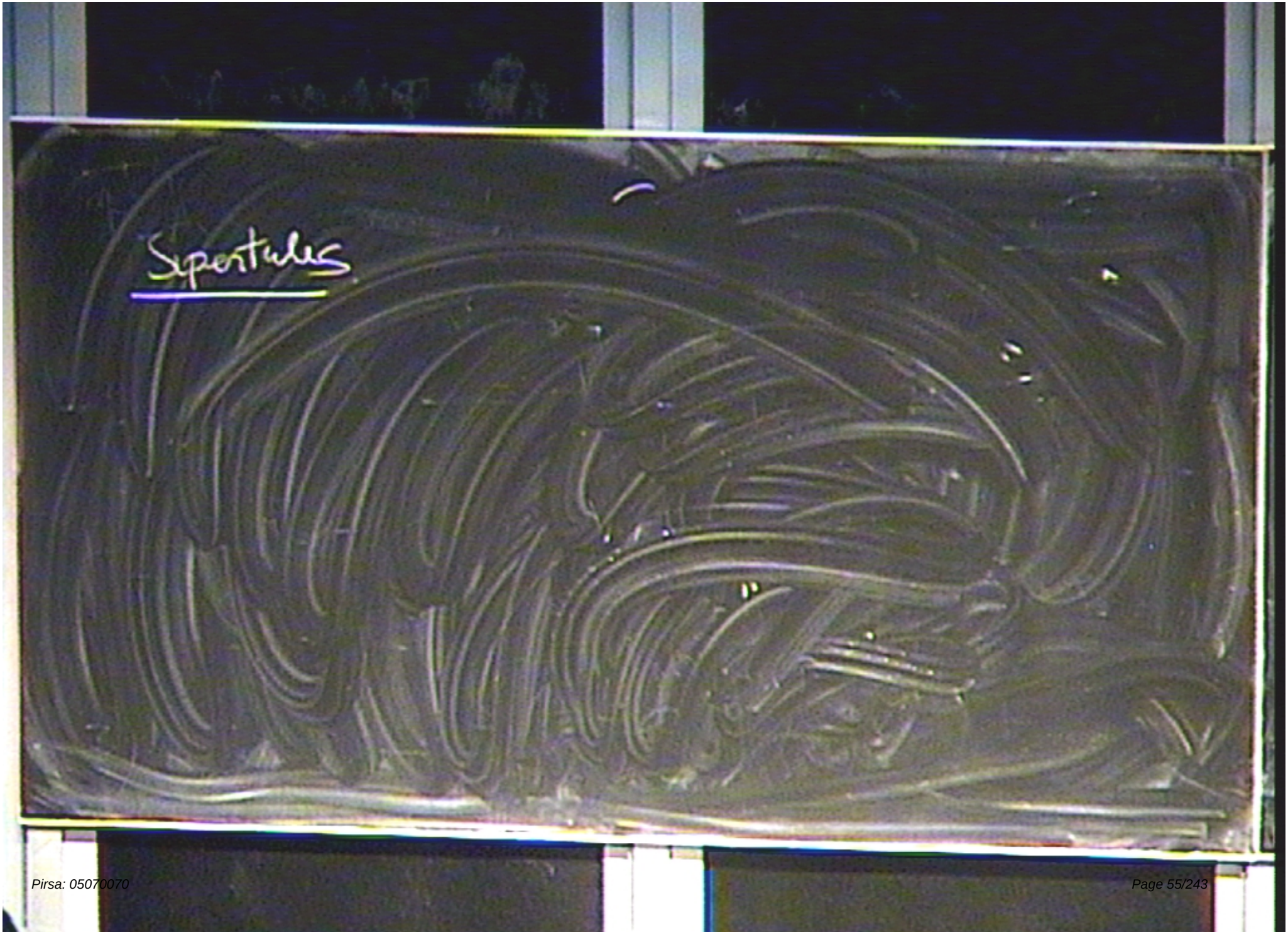
Why SUSY BHs?

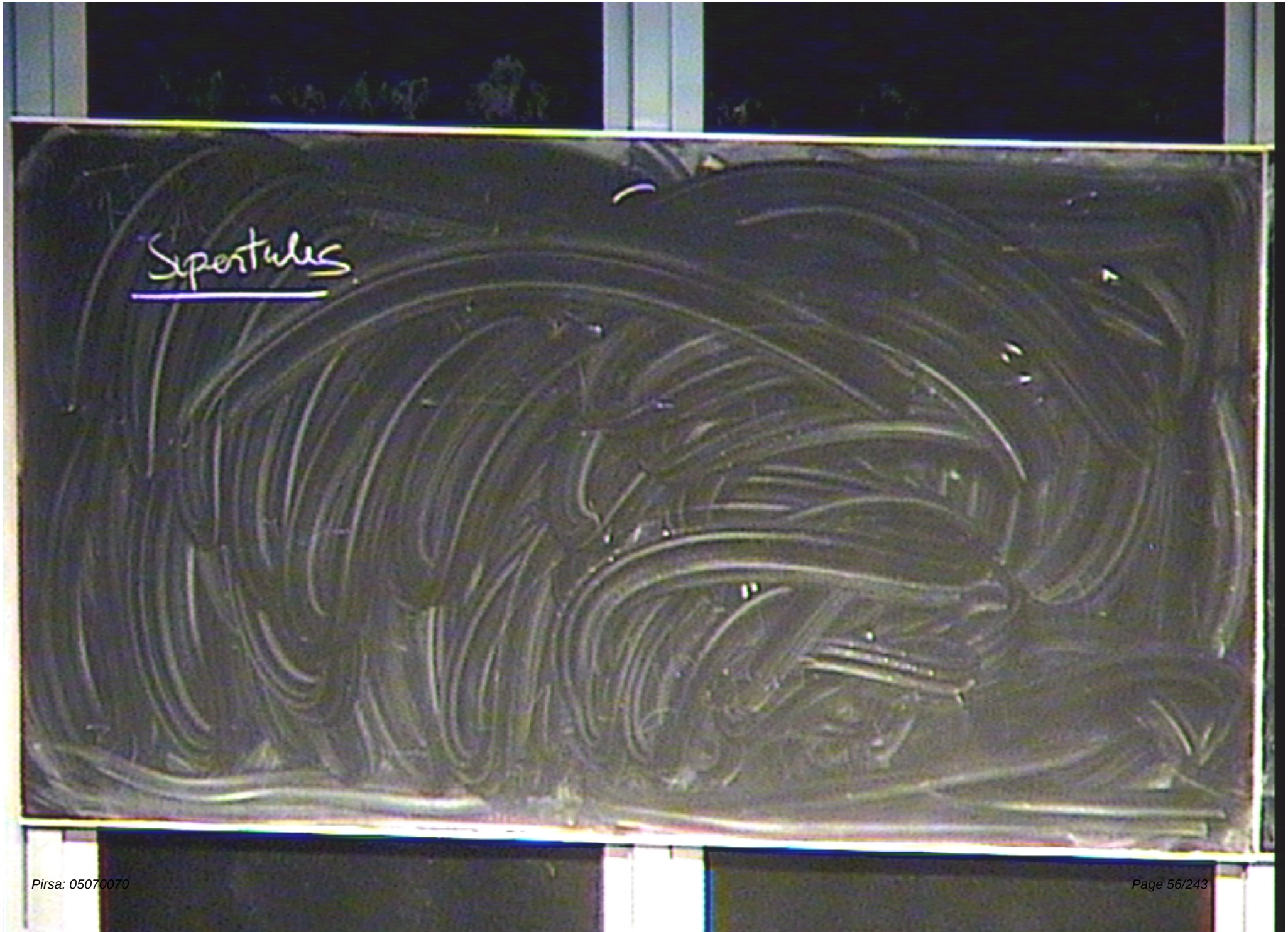
- Establishes stability
- Non-uniqueness holds in SUSY
- Implications for microscopic counting of the entropy in S.T.
- Ideal arena.
- Connections to 4D BHs.
- BHs in D>4?

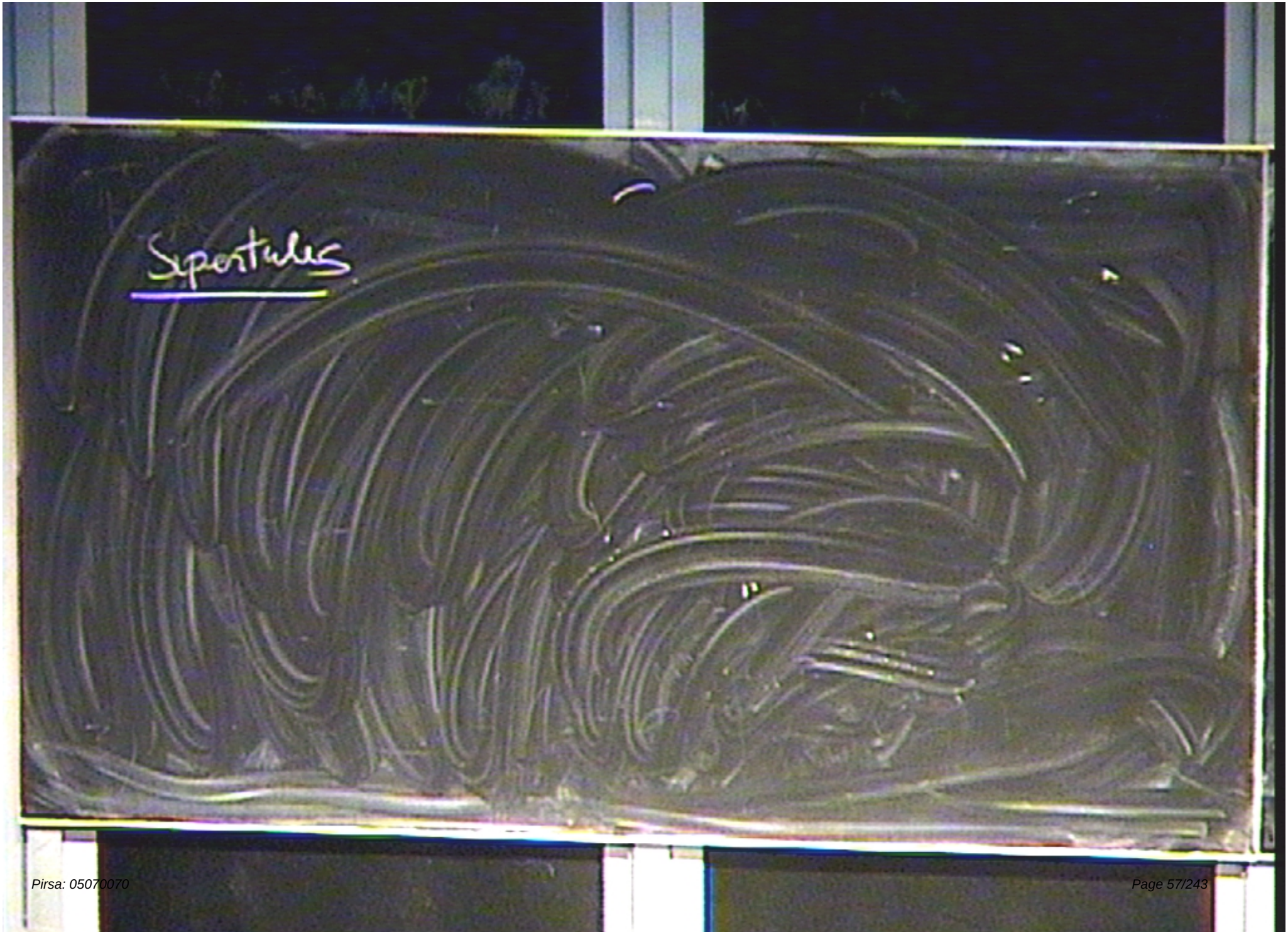
Why SUSY BHs?

- Establishes stability
- Non-uniqueness holds in SUSY
- Implications for microscopic counting of the entropy in S.T.
- Ideal arena.
- Connections to 4D BHs.
- BHs in D>4?




Spectules


Spectules

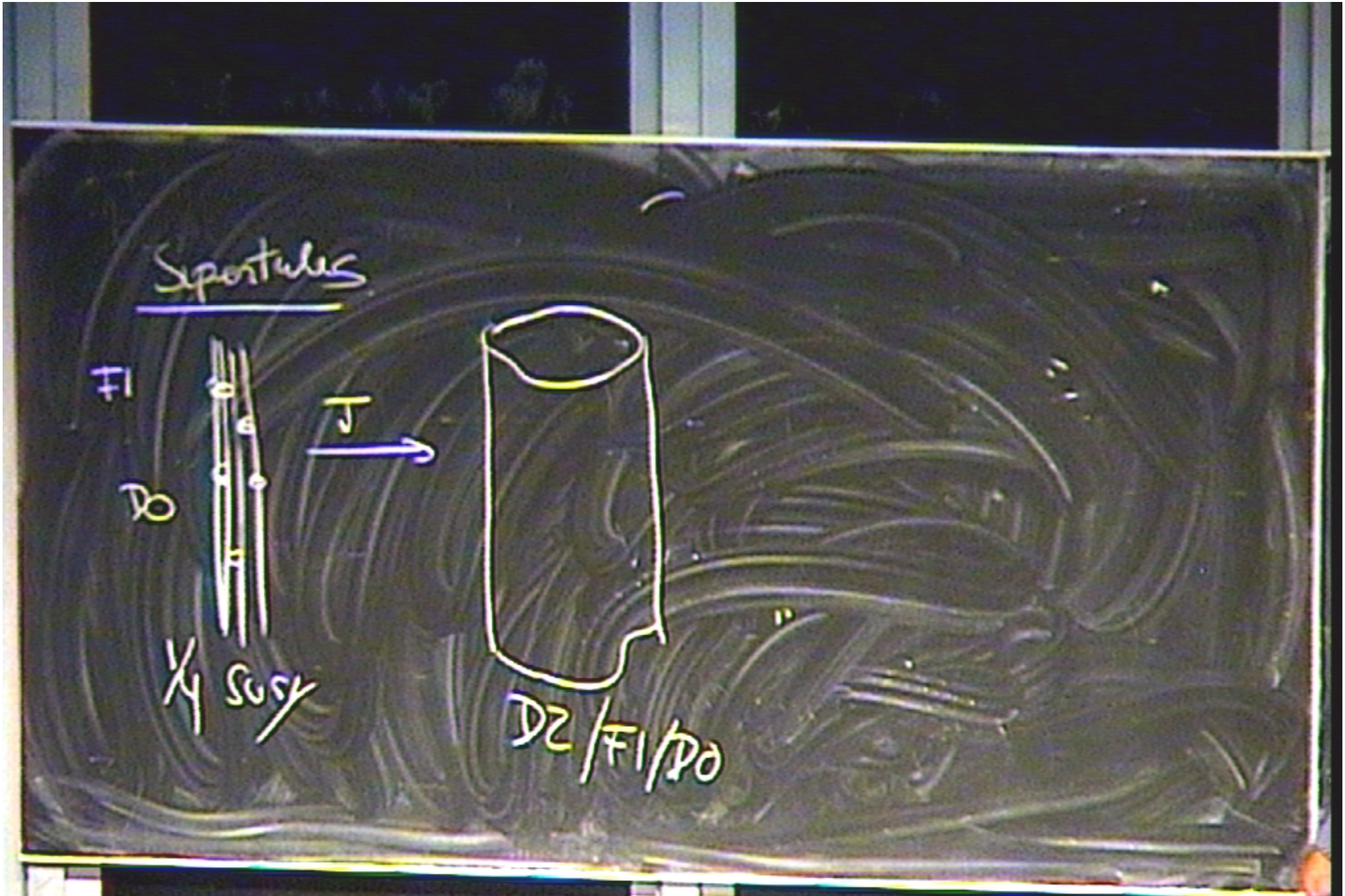

Spectules

Sportules



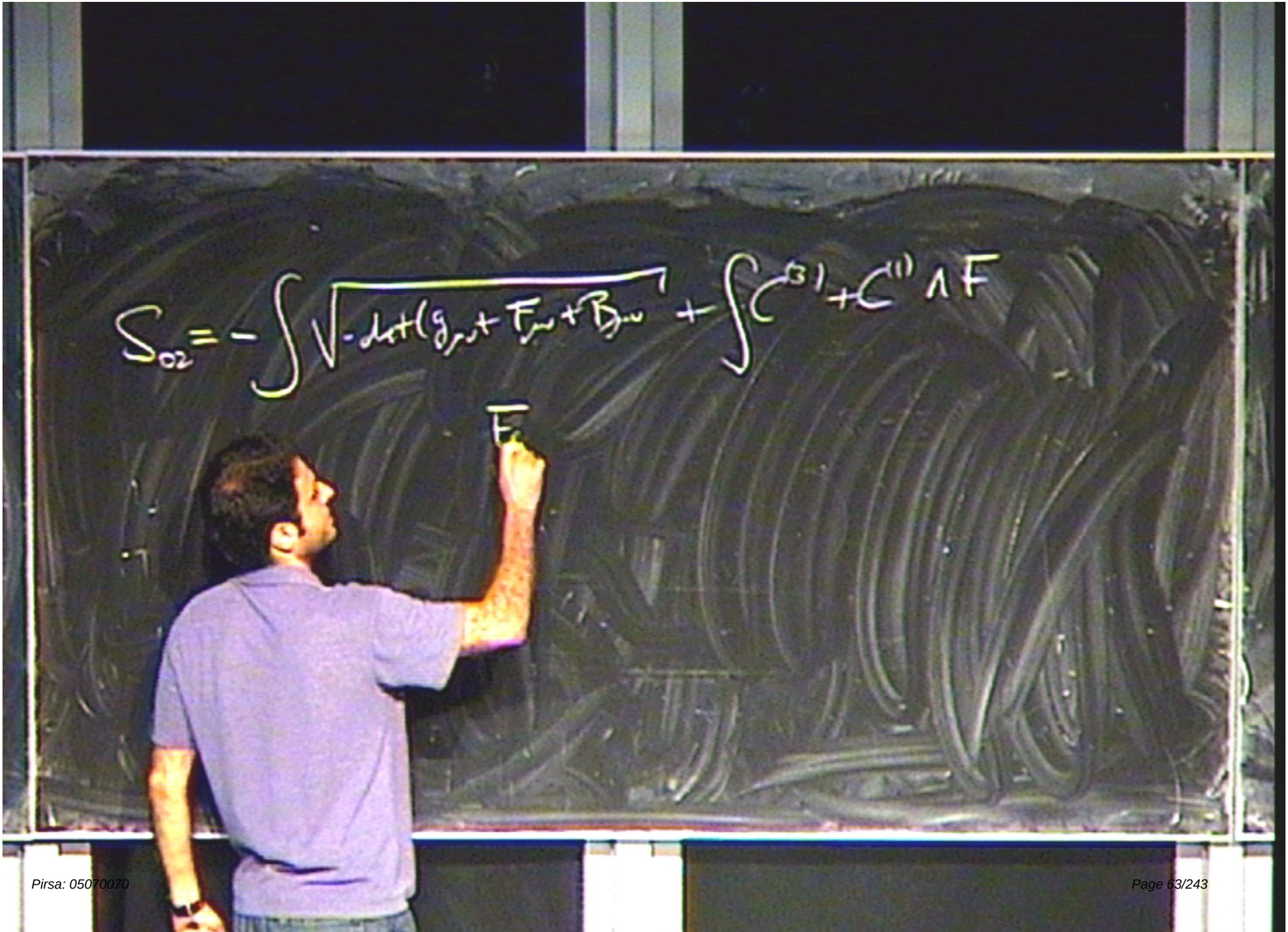
Sparticles




Sportules
F1
D0
J
1/4 Susy
D2/F1/D0



$$S_{D2} = -\int \sqrt{-\det(g_{\mu\nu} + F_{\mu\nu} + B_{\mu\nu})} + \int C^{(3)} + C^{(1)} \wedge F$$


$S_{D2} = -\int \sqrt{-\det(g_{\mu\nu} + F_{\mu\nu} + B_{\mu\nu})} + \int C^{(3)} + C^{(1)} \wedge F$
F

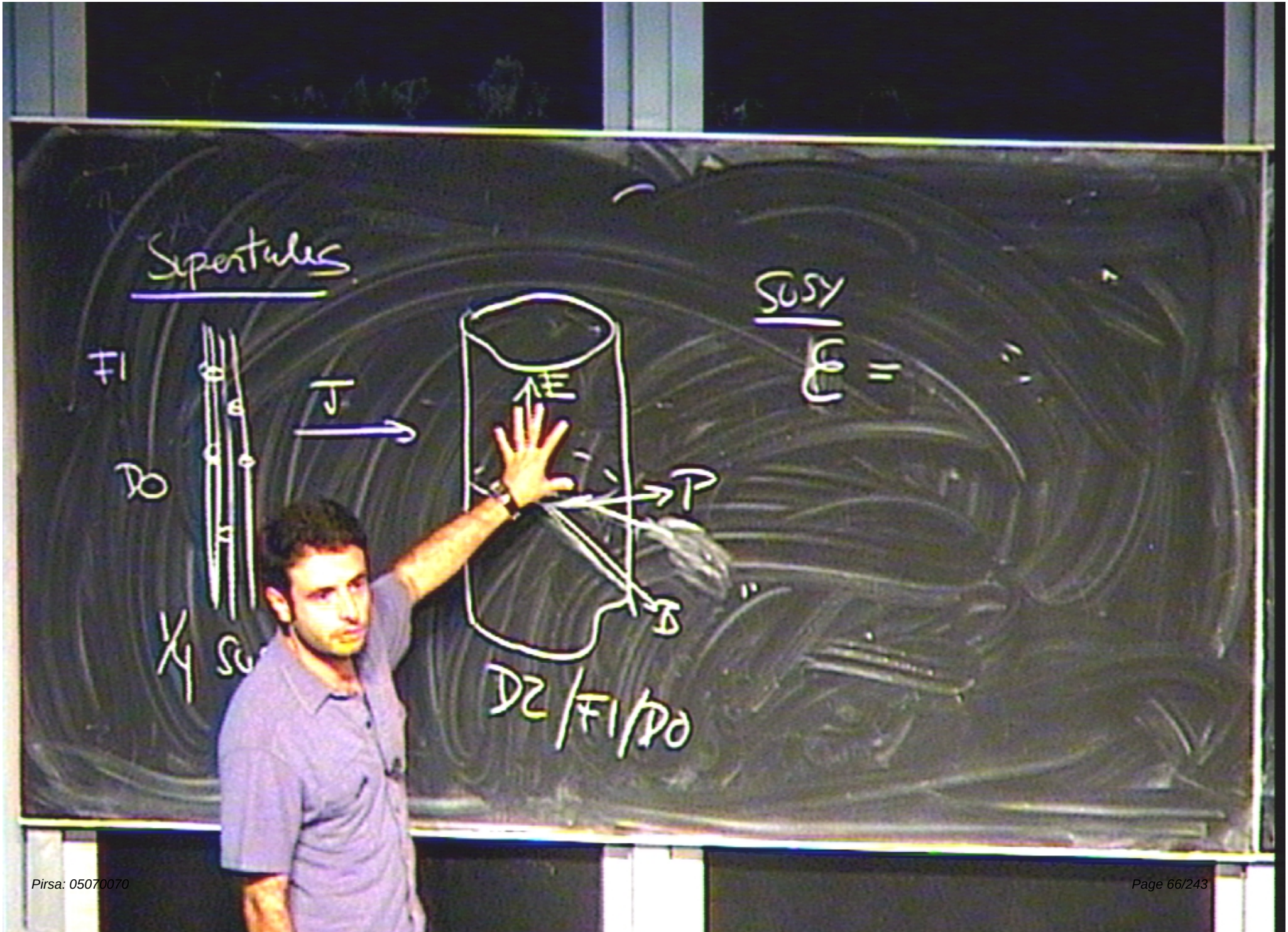
$$S_{D2} = -\int \sqrt{-\det(g_{\mu\nu} + F_{\mu\nu} + B_{\mu\nu})} + \int C^{(3)} + C^{(1)} \wedge F$$

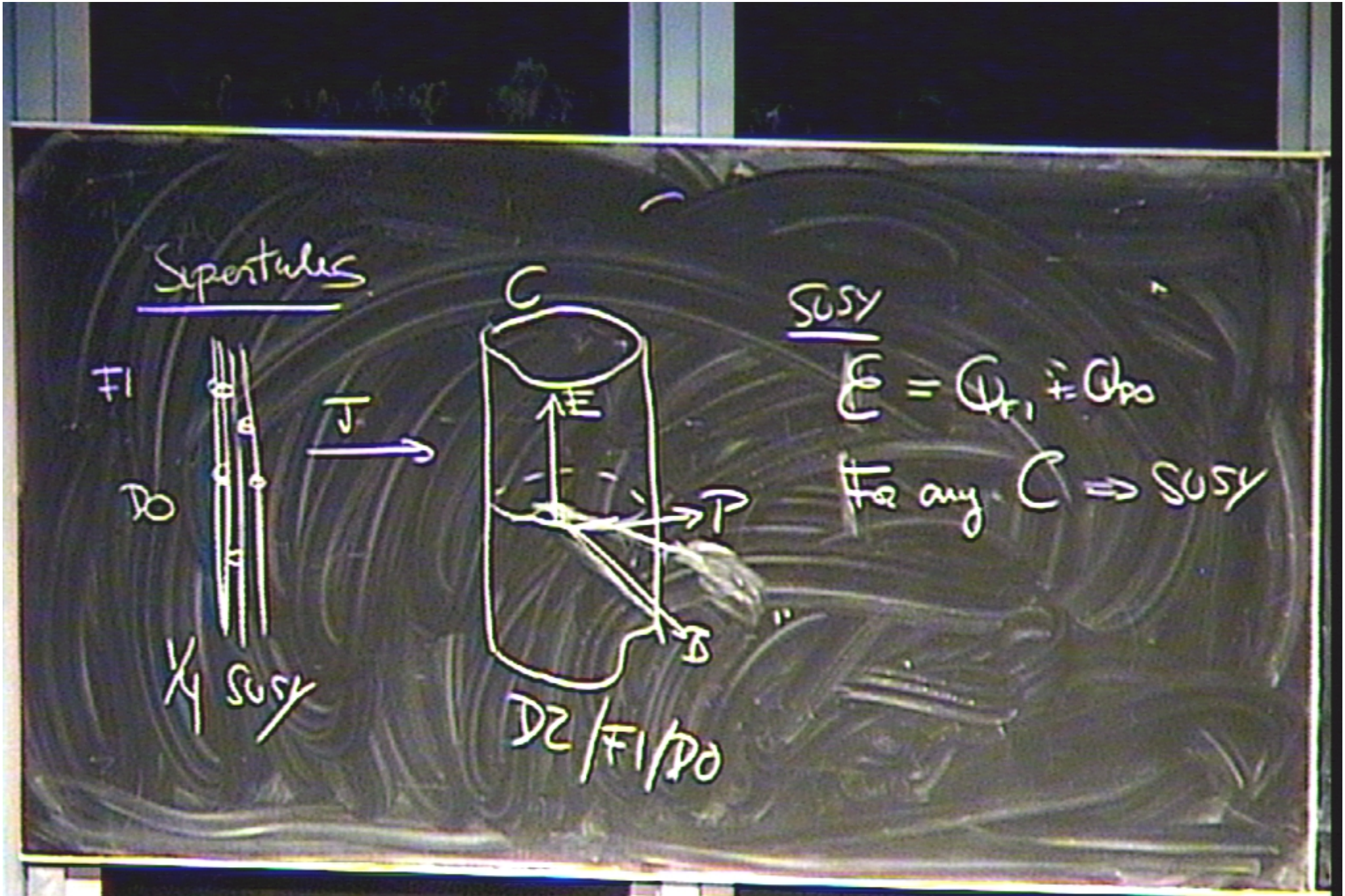
$$F_{0i} \rightarrow B_{0i}$$

$$S_{D2} = -\int \sqrt{-\det(g_{\mu\nu} + F_{\mu\nu} + B_{\mu\nu})} + \int C^{(3)} + C^{(1)} \wedge F$$

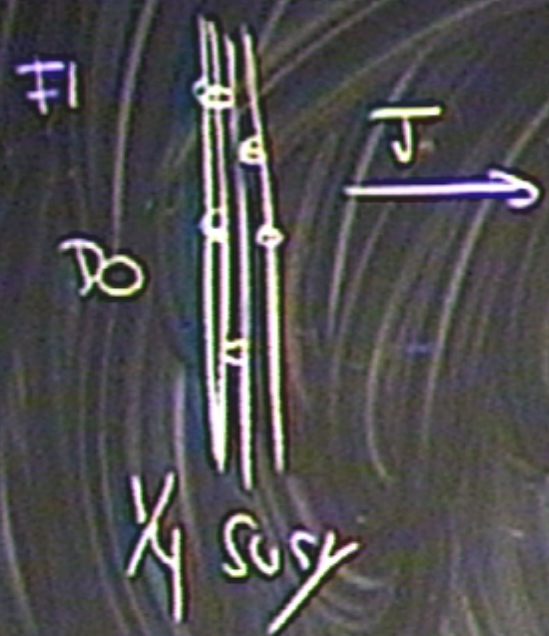
$$F_{0i} \rightarrow B_{0i}$$

$$C_t^{(1)} \; F_{12}$$


Supertubes
F1
D0
J
E
P
D
D2/F1/D0
SUSY


Supertubes
F1
D0
1/4 Susy
J
C
E
P
D
D2/F1/D0
Susy
$\mathcal{E} = Q_{F1} \pm Q_{D0}$
For any C ⇒ Susy

Supertubes



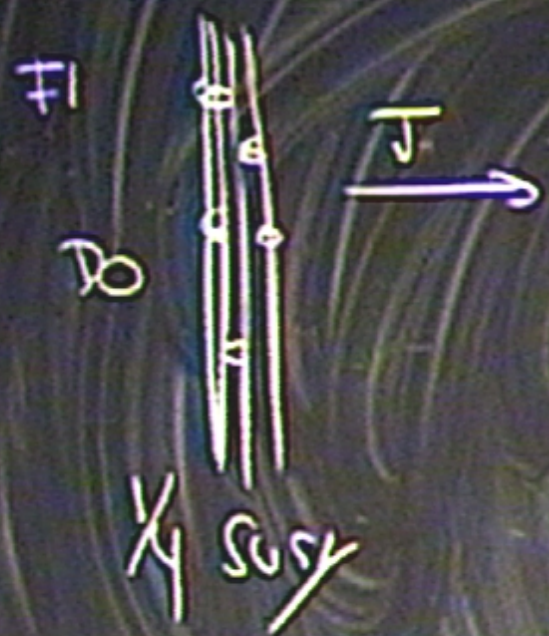


SUSY

$\mathcal{E} = \mathcal{C}_{F1} \pm \mathcal{C}_{D0}$

For any $C \Rightarrow$ SUSY

Supertubes



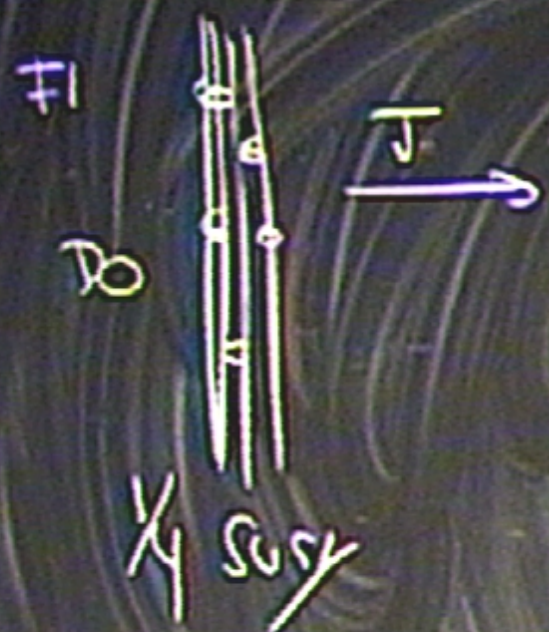


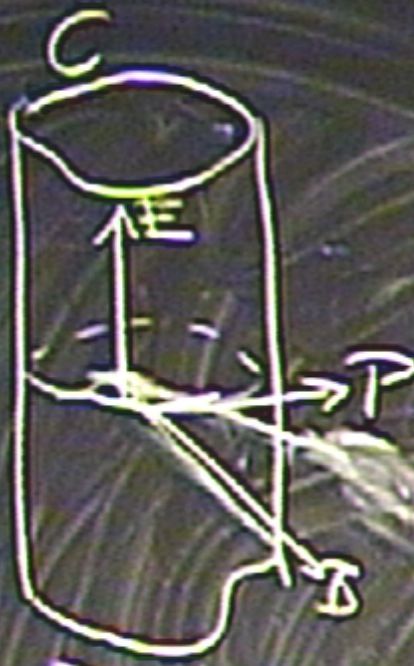
SUSY

$\xi = Q_{F1} \pm Q_{D0}$

For any $C \Rightarrow$ SUSY

Supertubes

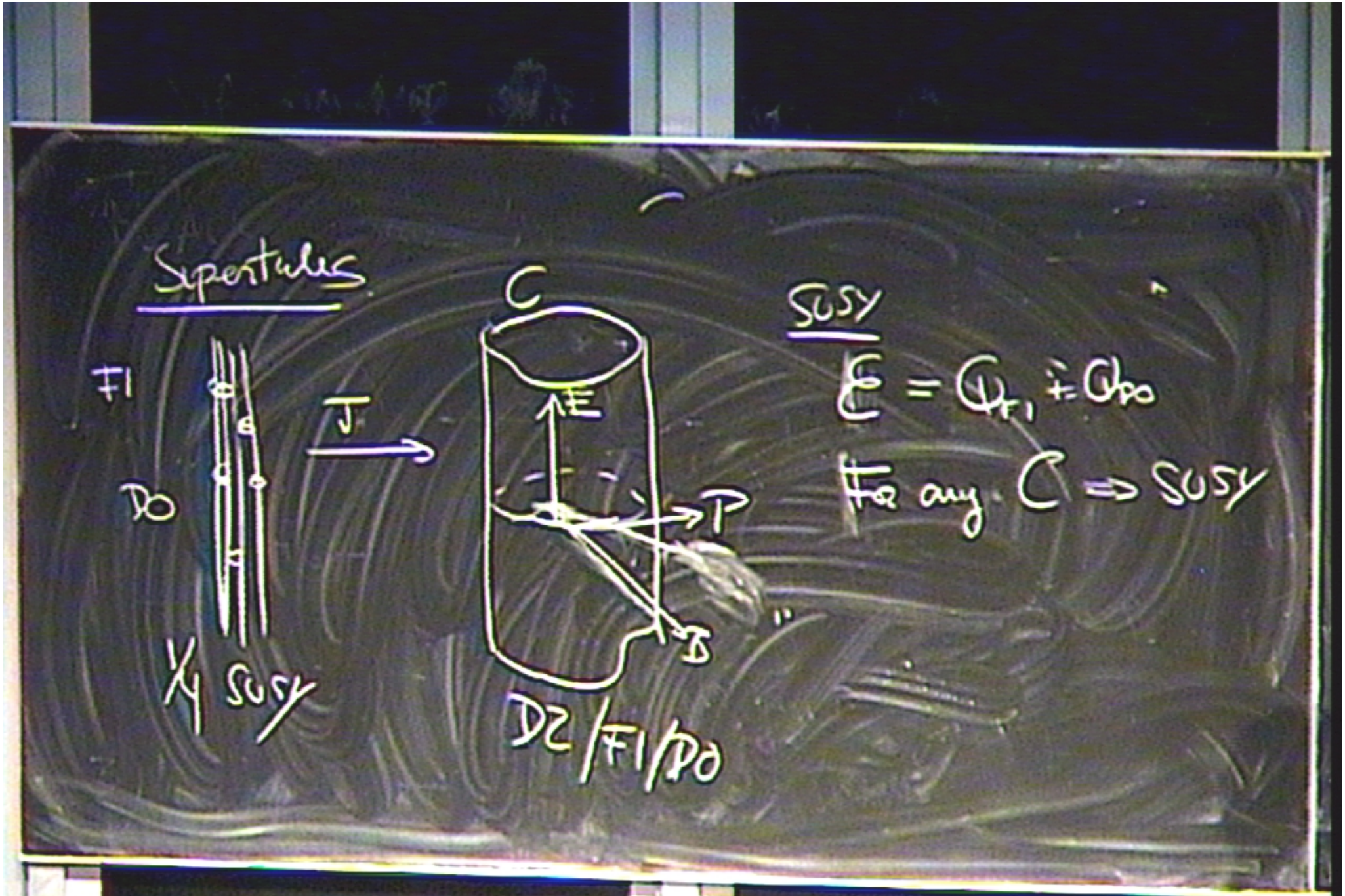


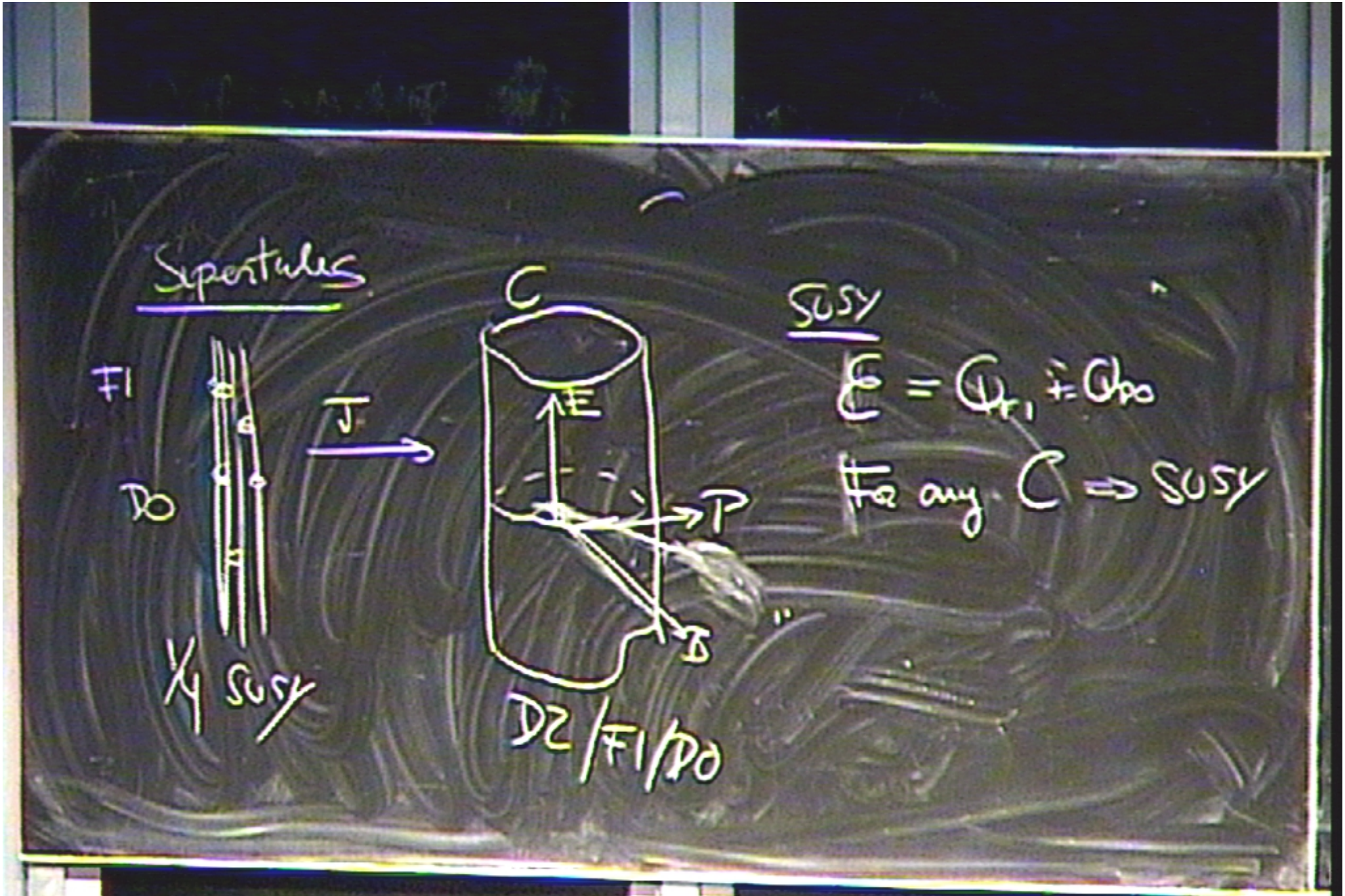


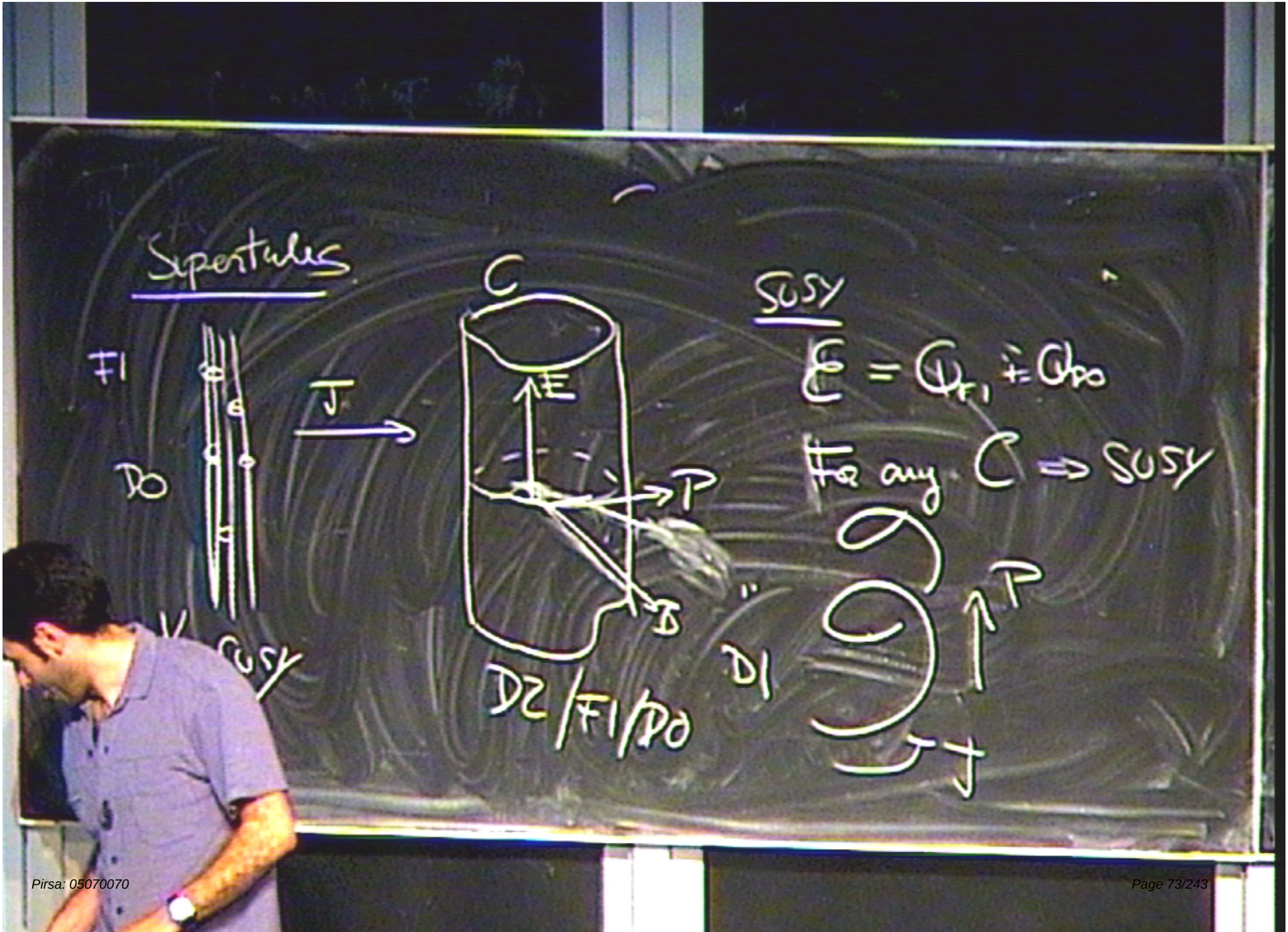
Susy

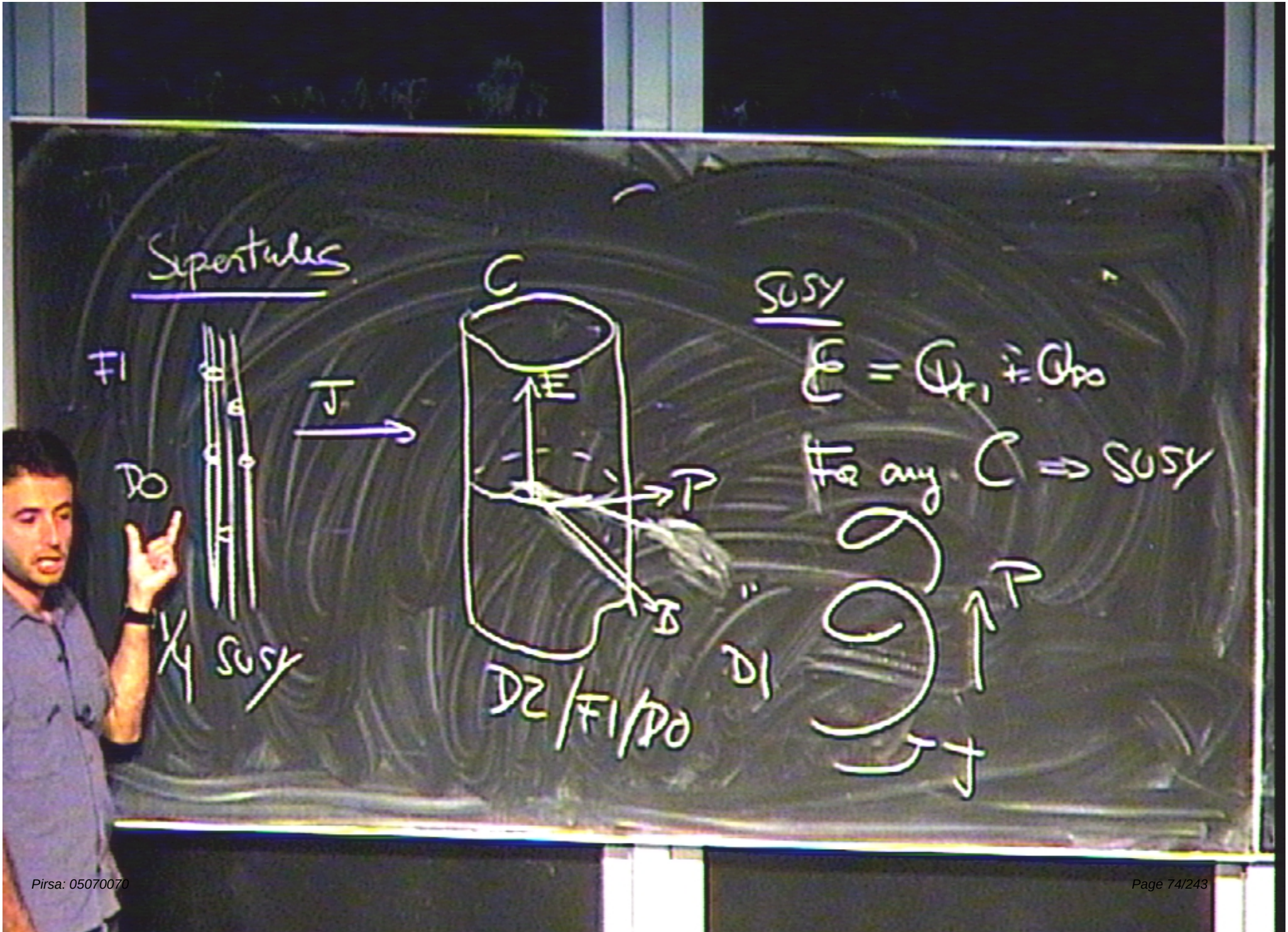
$\mathcal{E} = \Phi_{F1} + \Phi_{D0}$

For any $C \Rightarrow$ Susy

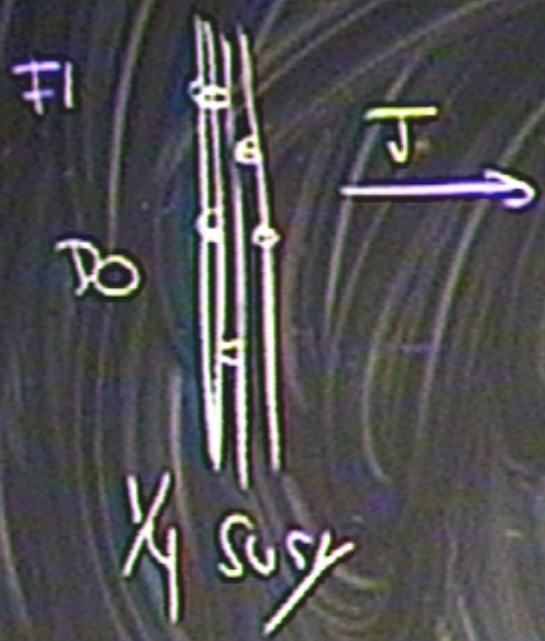

Supertubes
F1
D0
J
1/4 SUSY
C
E
P
D
D2/F1/D0
SUSY
$\mathcal{E} = Q_{F1} \pm Q_{D0}$
For any C ⇒ SUSY


Supertubes
F1
D0
J
1/4 SUSY
C
E
P
D
D2/F1/D0
SUSY
ε = ε_F1 + ε_D0
For any C ⇒ SUSY


Supertubes
F1
D0
J
C
E
P
D
D2/F1/D0
D1
SUSY
SUSY
For any C ⇒ SUSY
P
J


Spectrales
F1
D0
1/4 Susy
J
C
E
P
D
D2/F1/D0
D1
SUSY
ε = Q_F1 ± Q_D0
For any C ⇒ SUSY
P
J

Supertubes

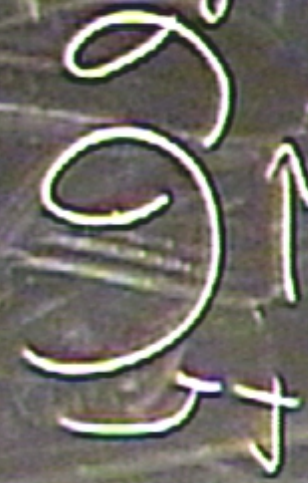




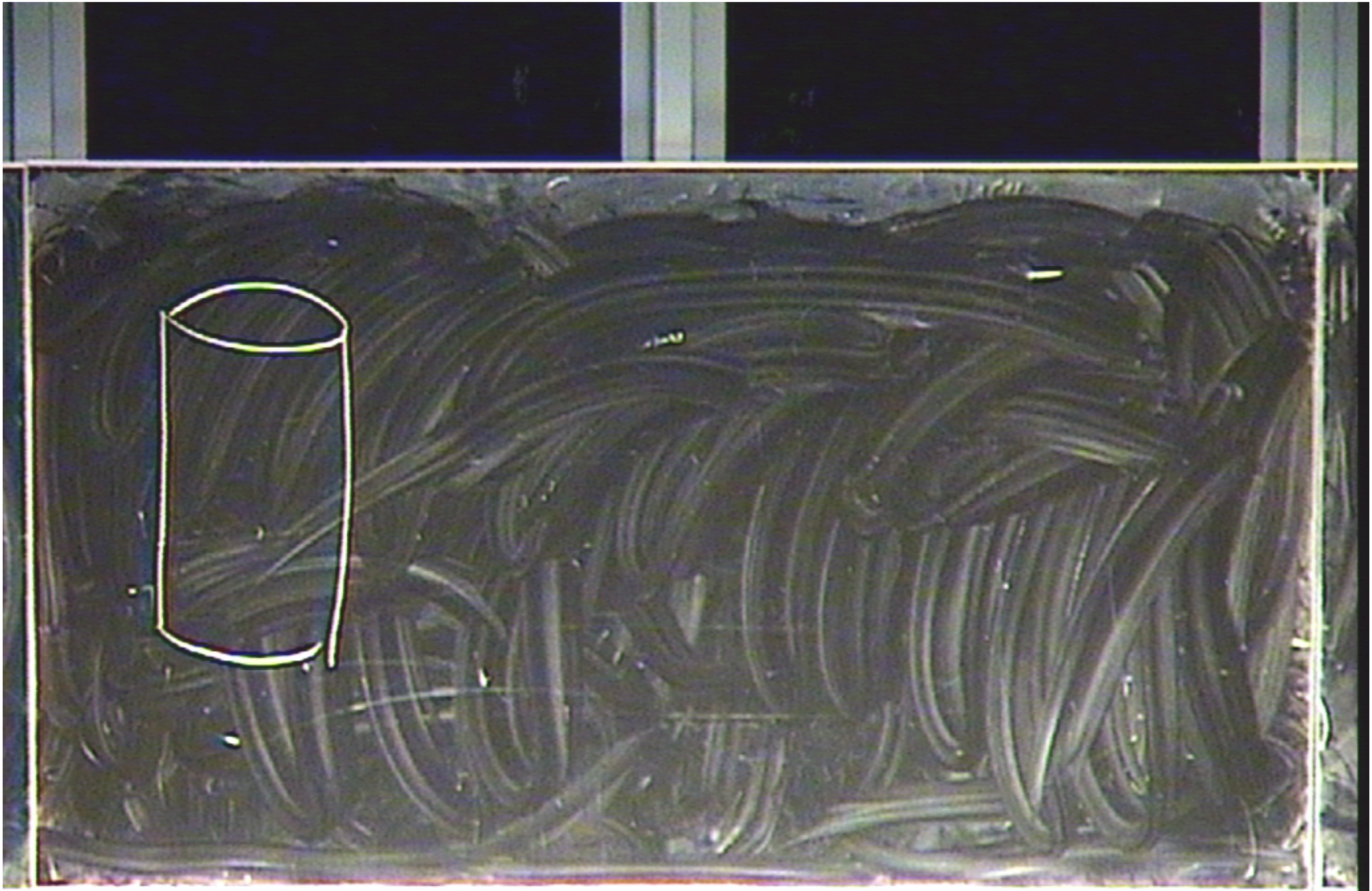
SUSY

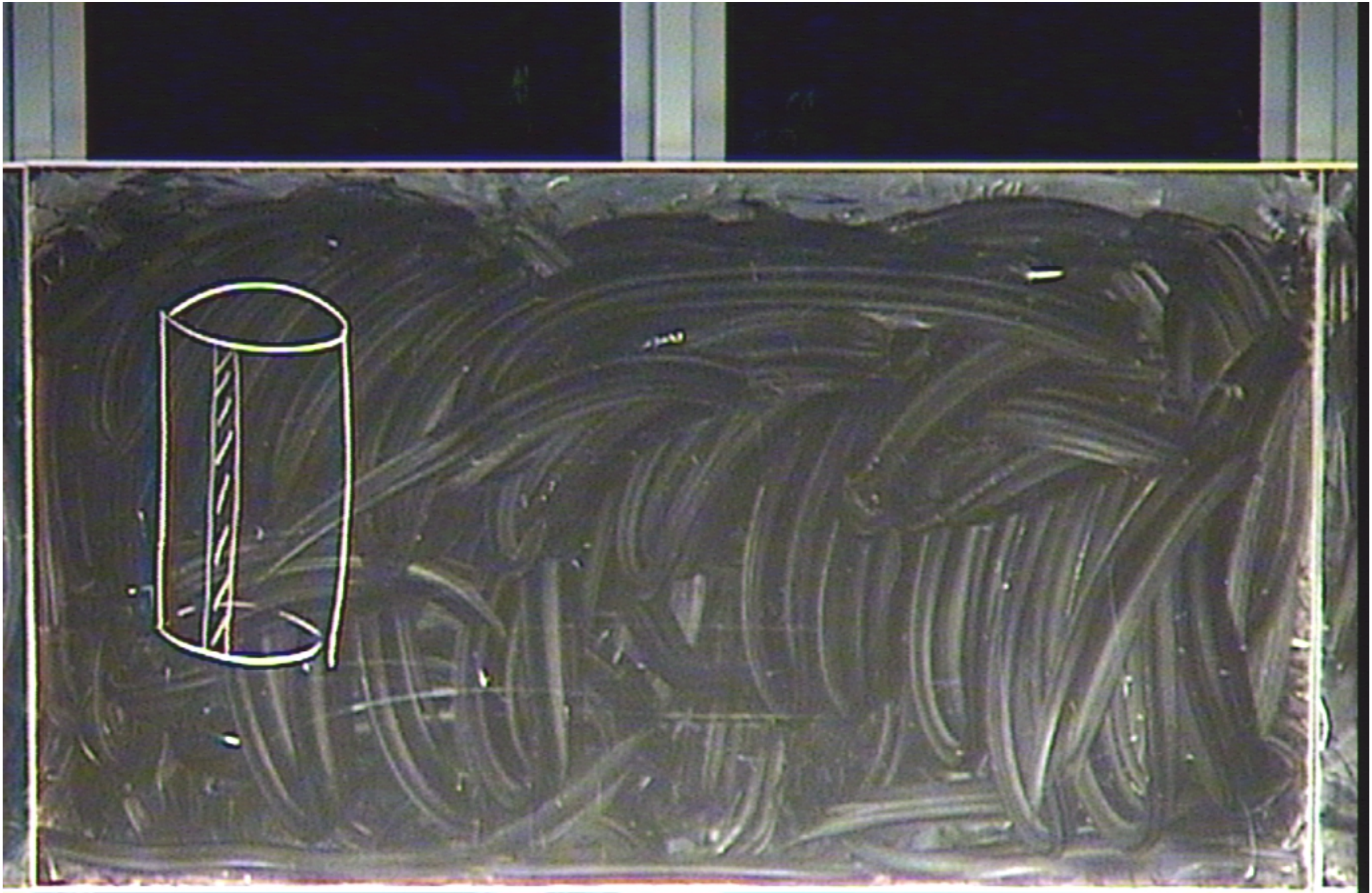
$\mathcal{E} = Q_{F1} \pm Q_{D0}$

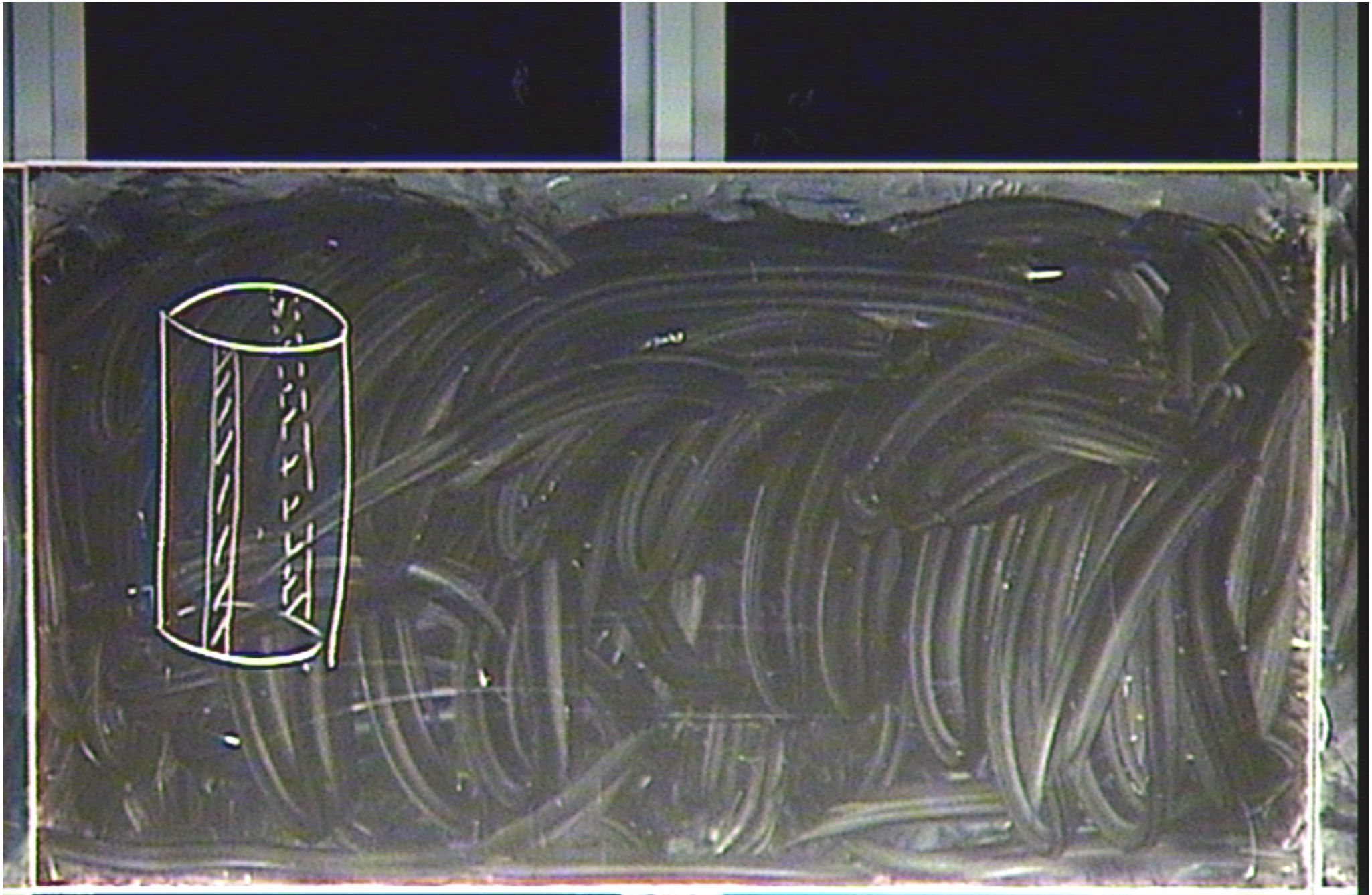
For any $C \Rightarrow$ SUSY

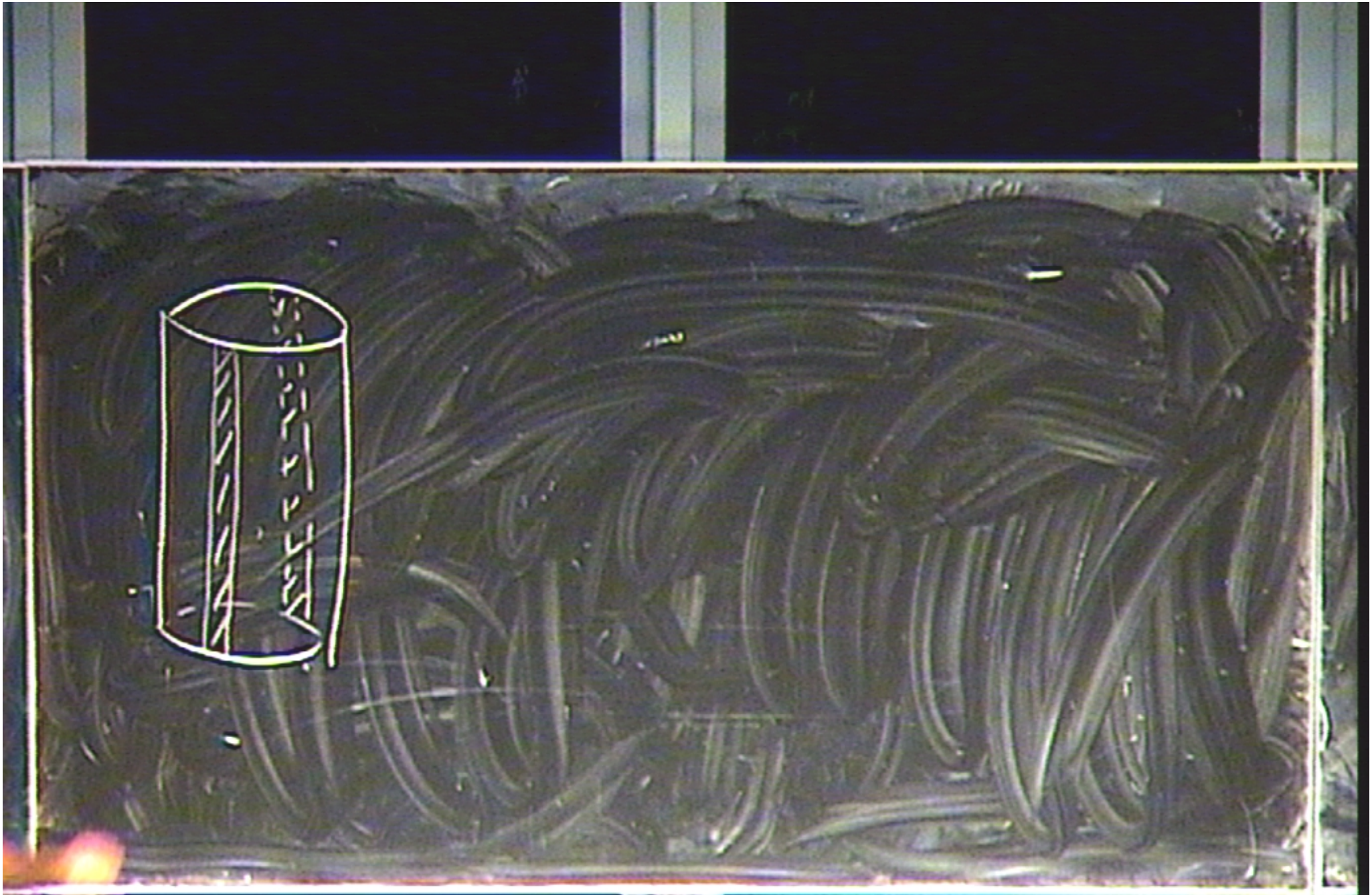


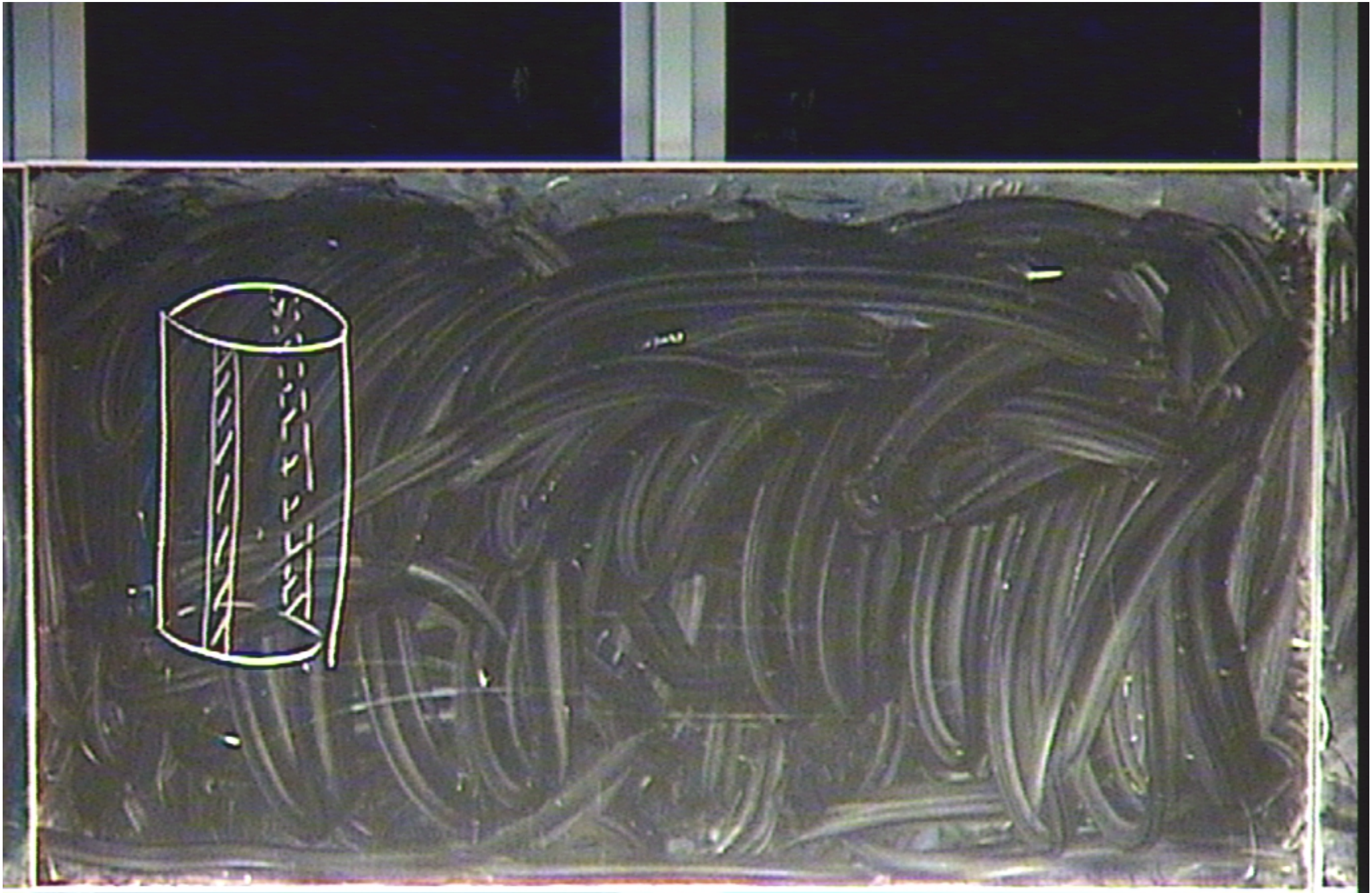


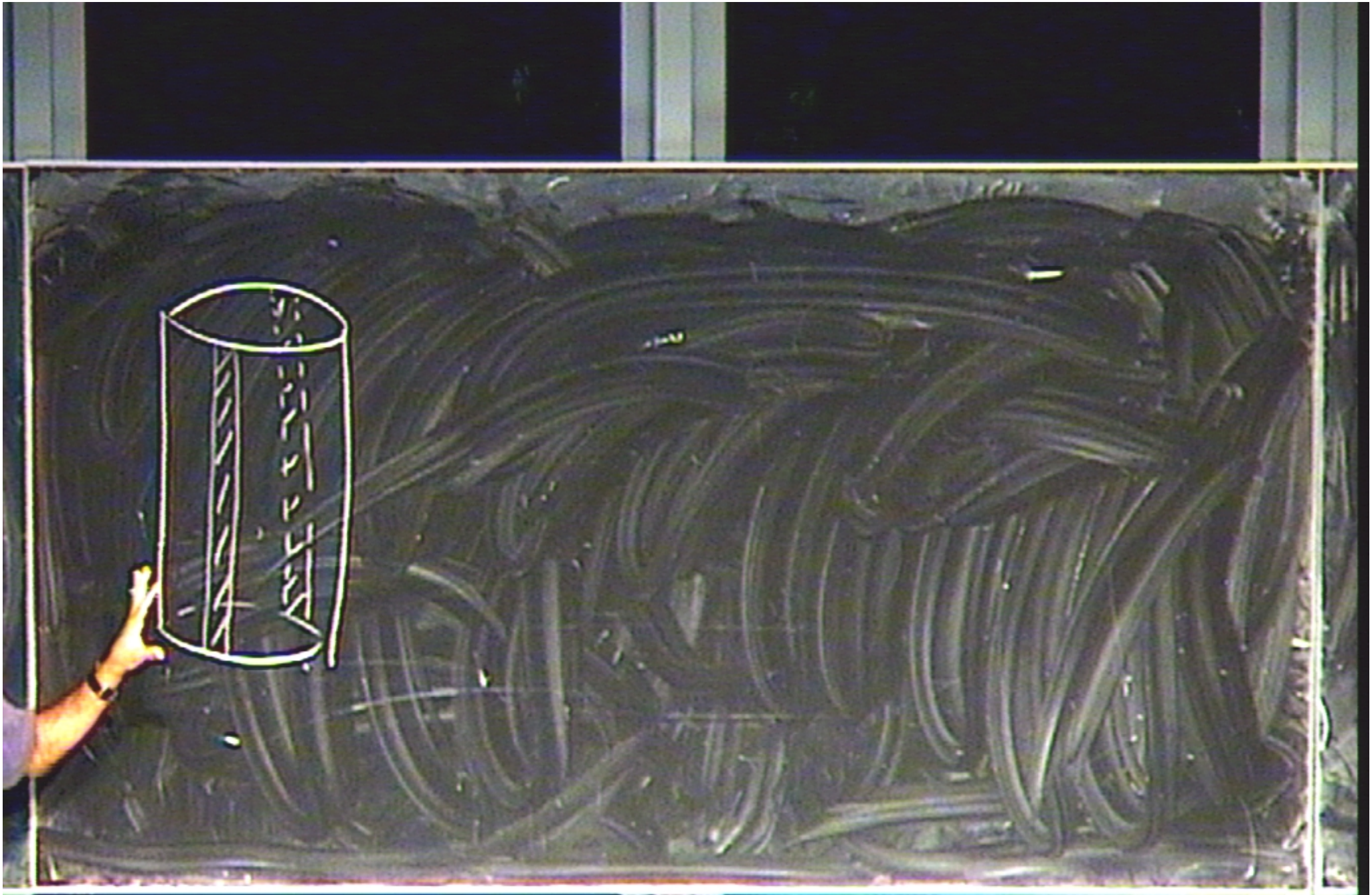


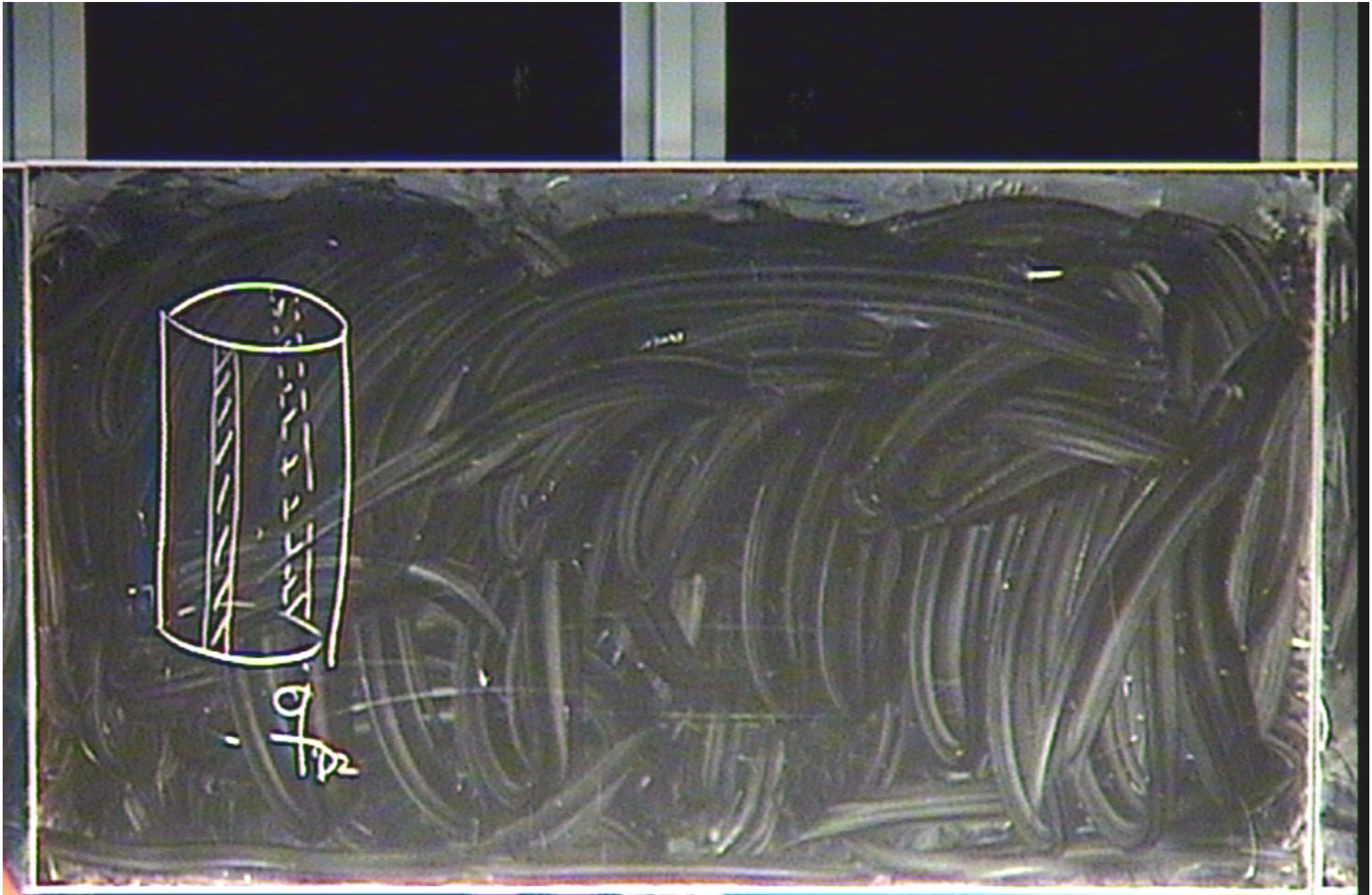


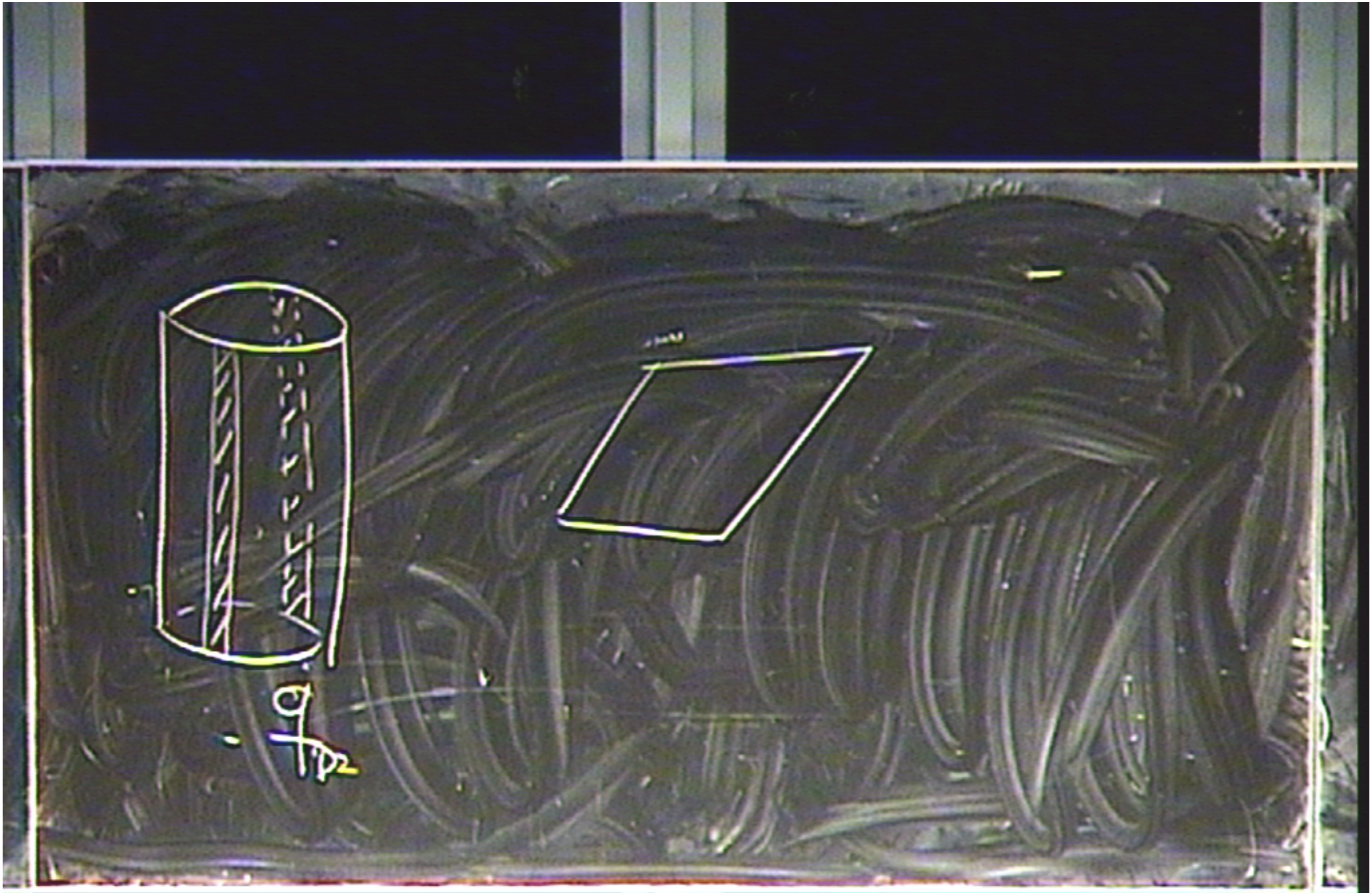






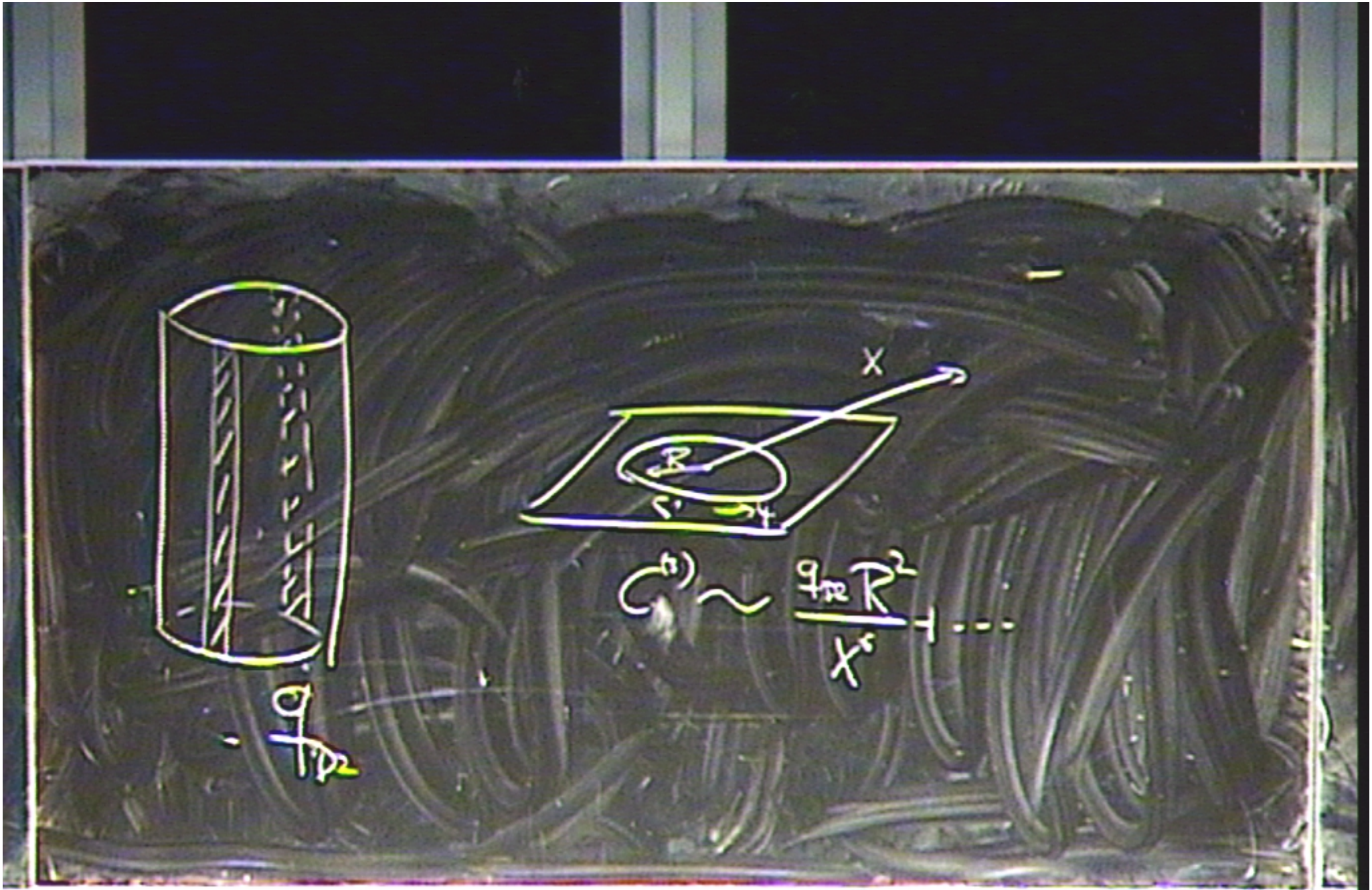


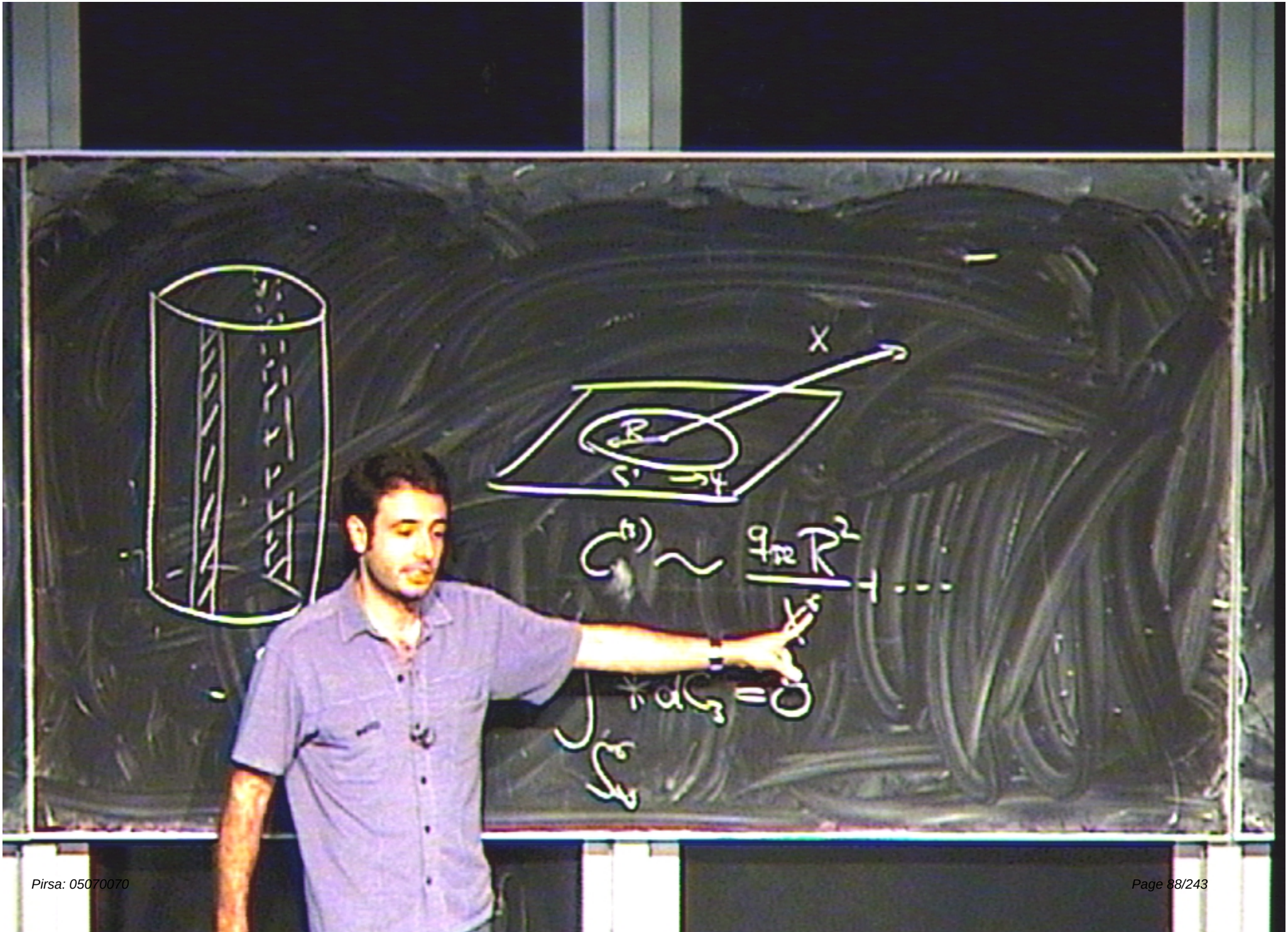


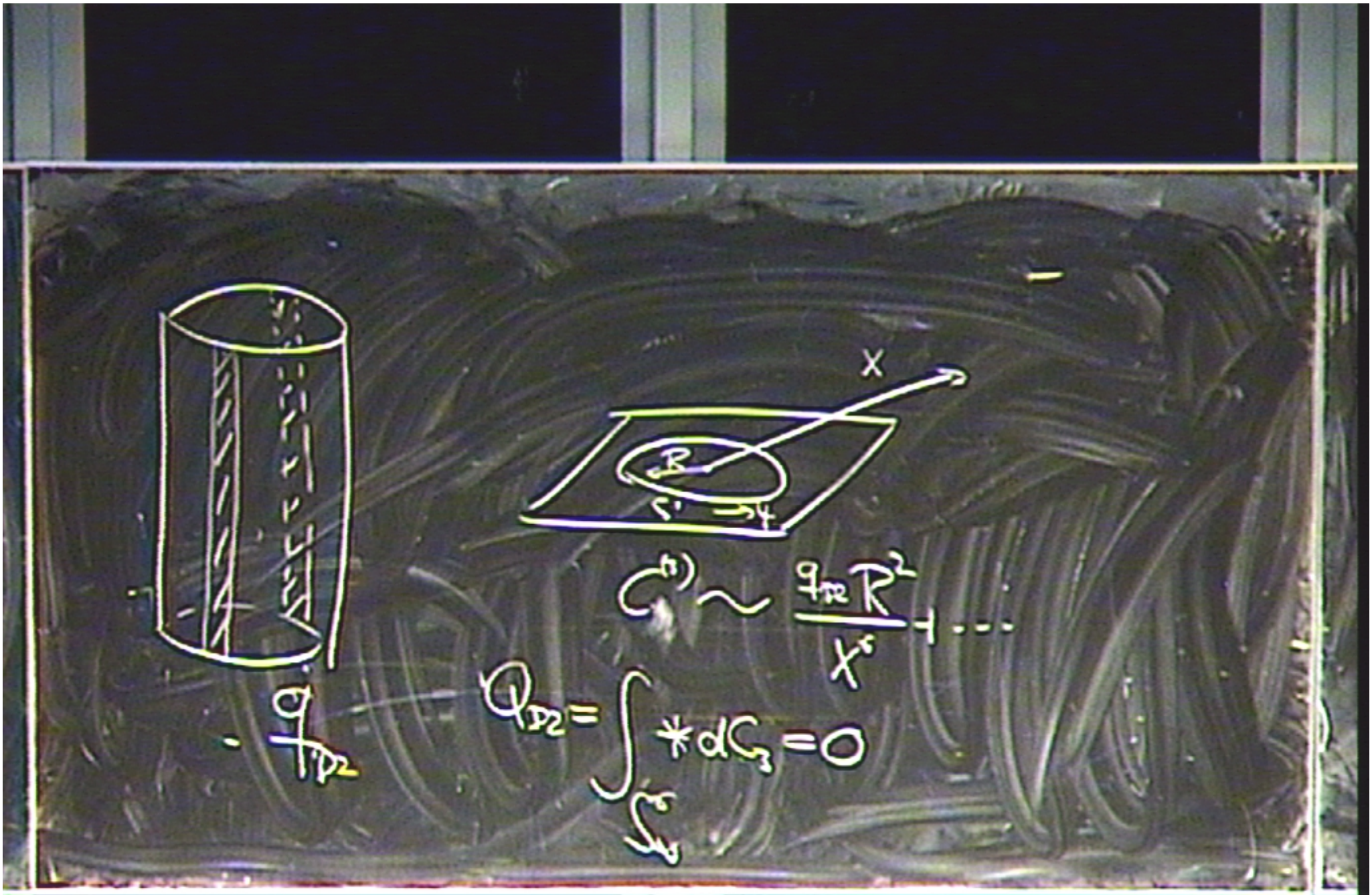


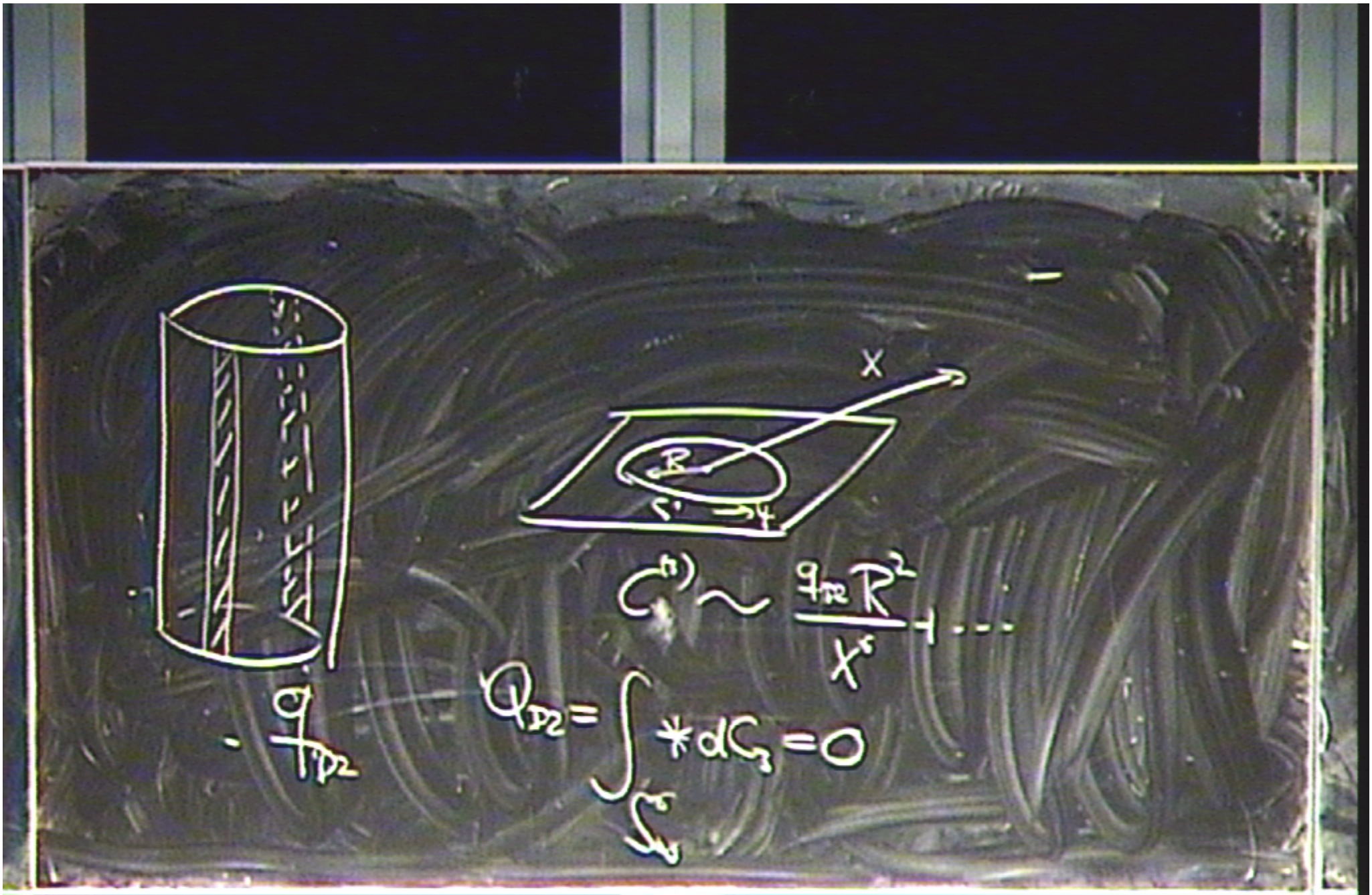

X

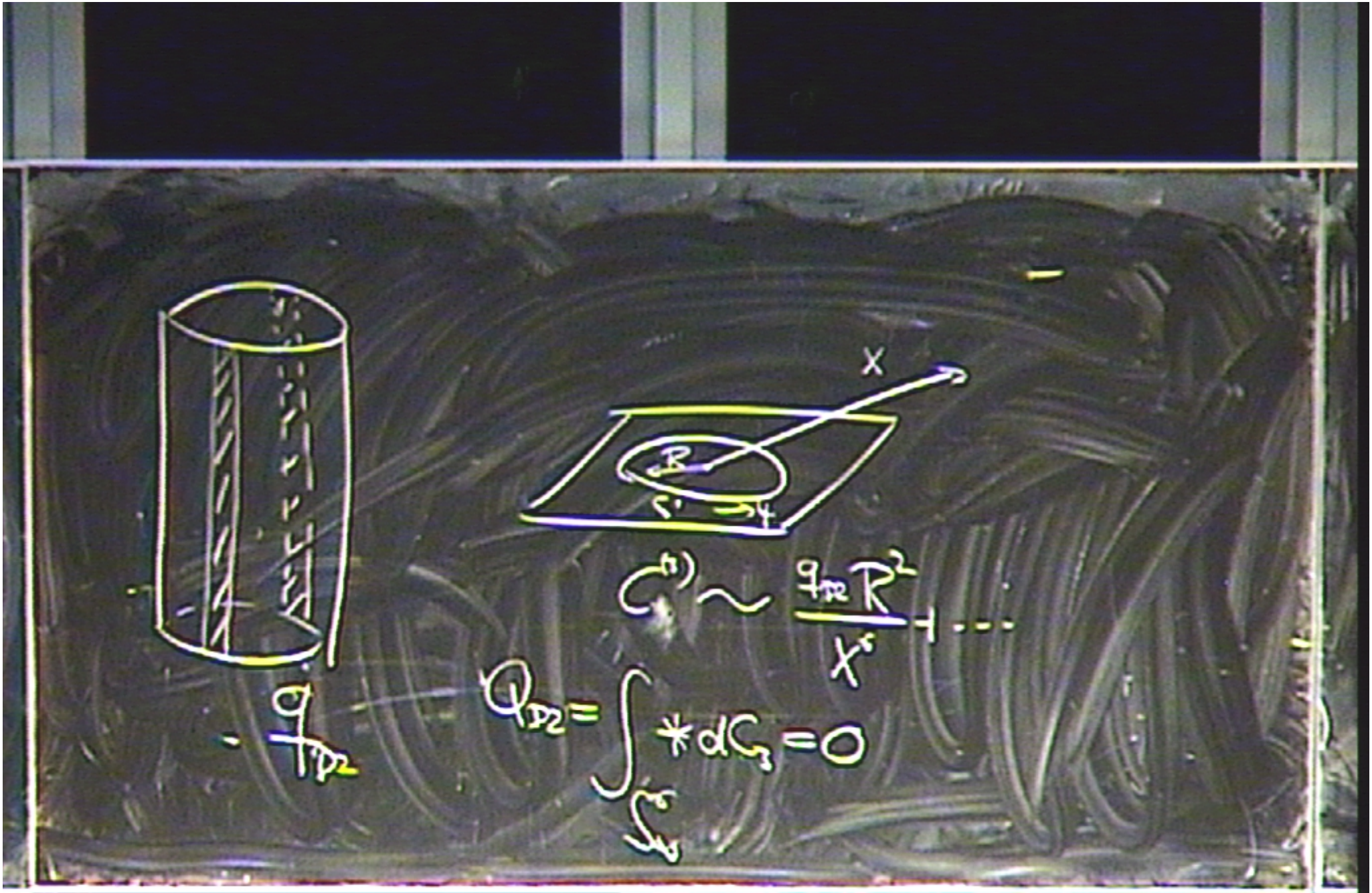

X

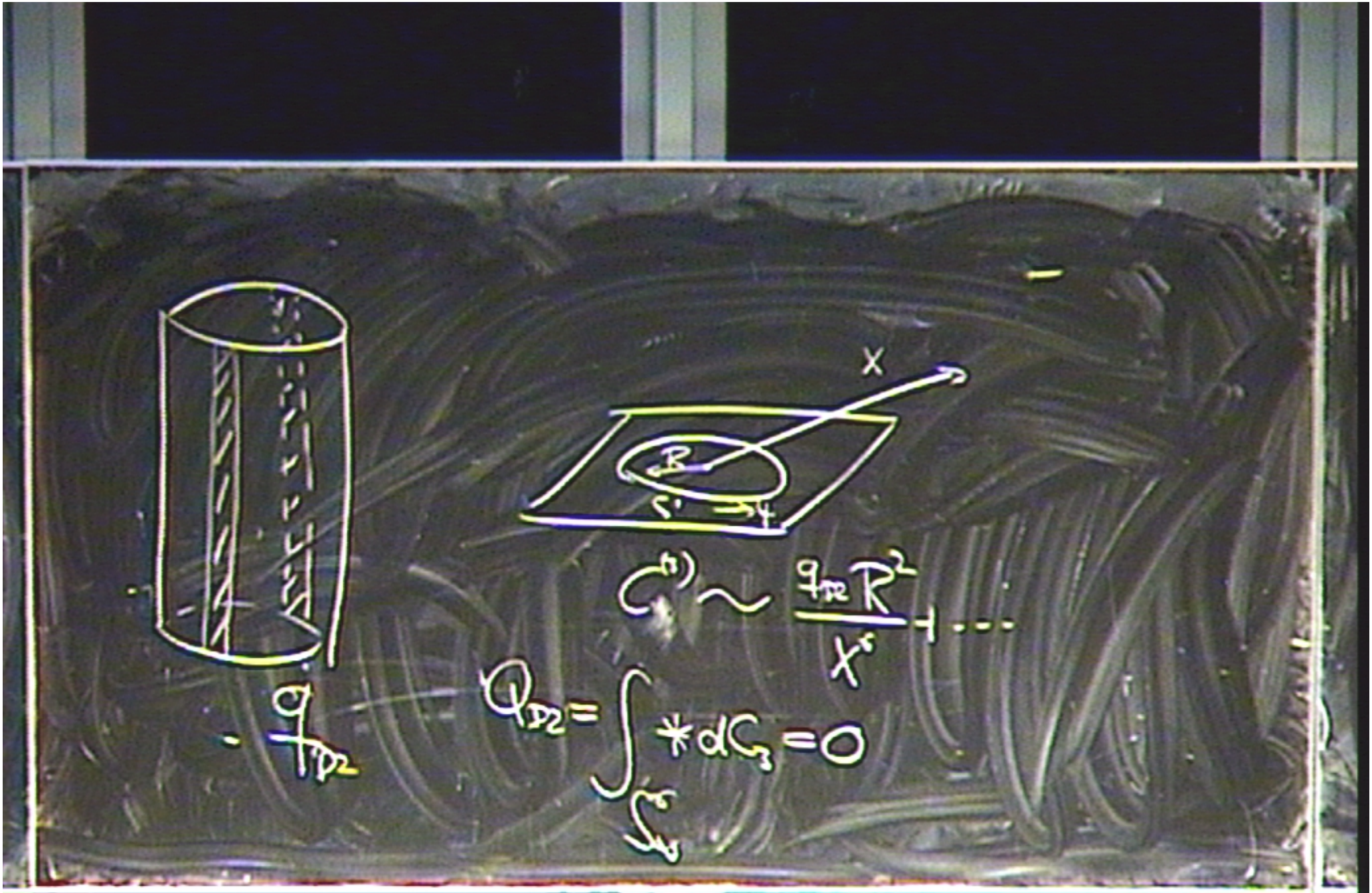

X
R
$C^{(1)} \sim \frac{q_{fr} R^2}{X^5} + \cdots$
q_{fr}

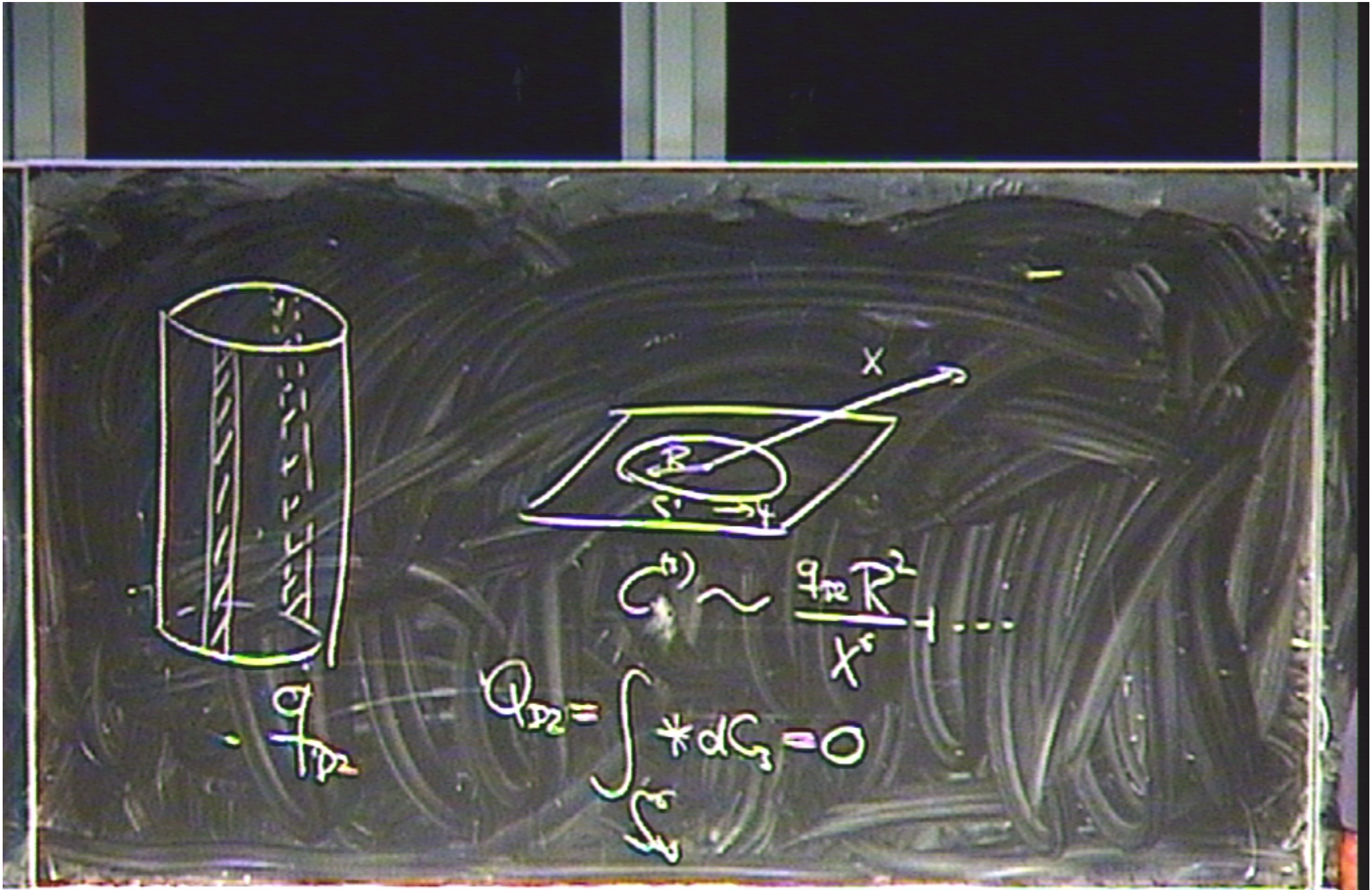

X
B
$C^{(1)} \sim \frac{q_{\pi} R^2}{r^4} + \cdots$
$*dC_3 = 0$

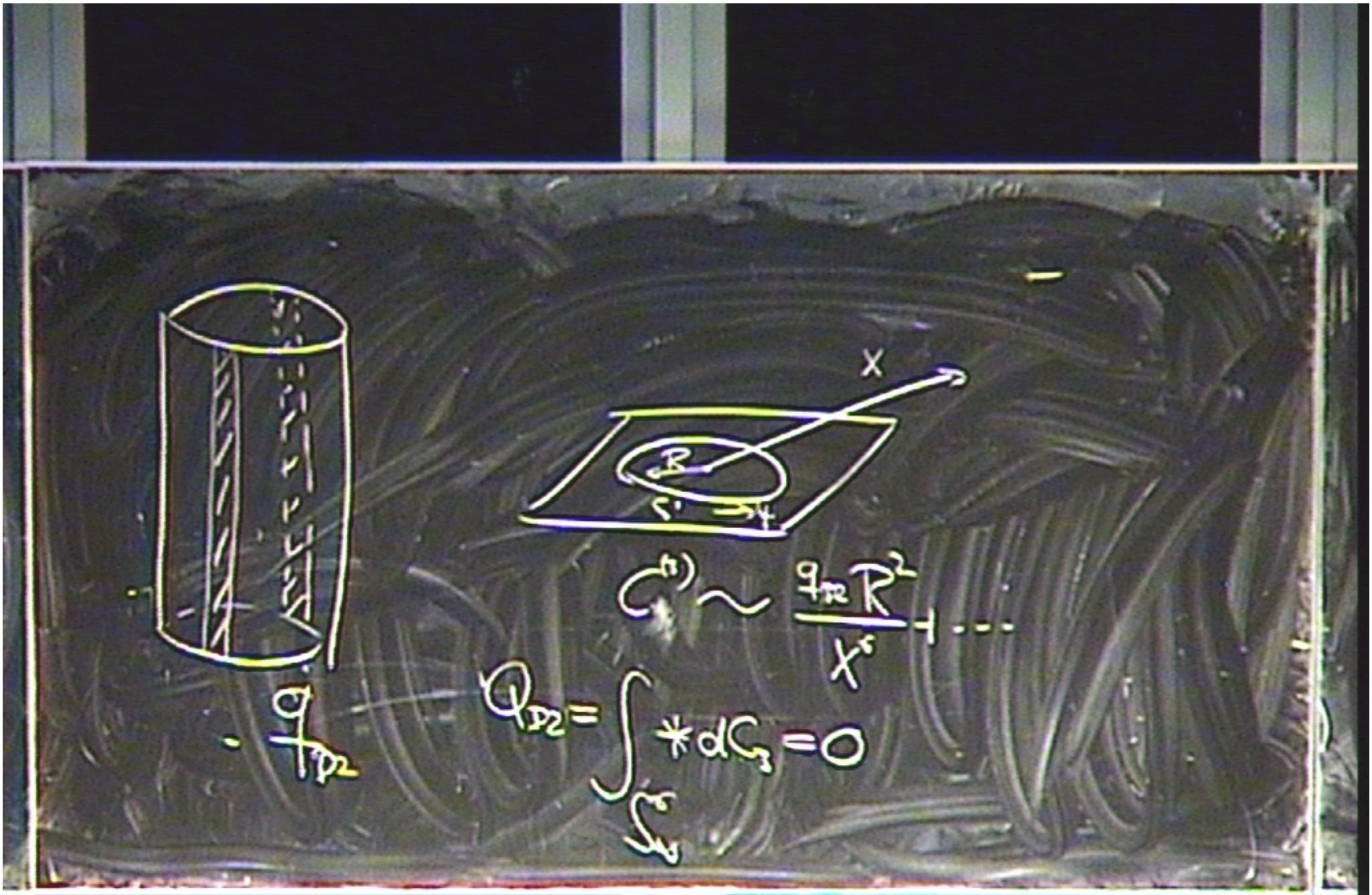

X
R
$C^{(1)} \sim \frac{q_{D2} R^2}{X^7} + \cdots$
$-q_{D2}$
$Q_{D2} = \int_{S^5} *dC_3 = 0$

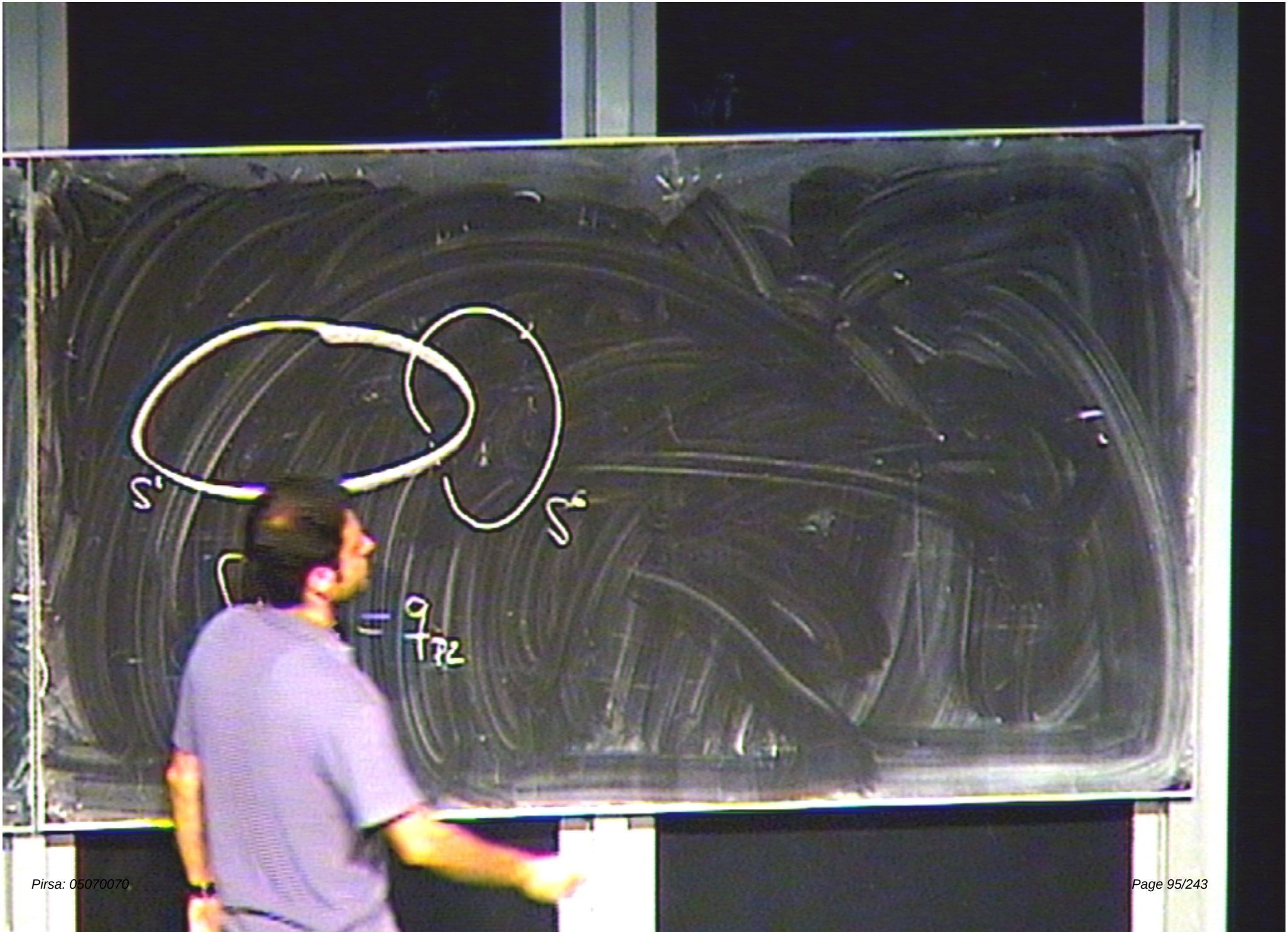

X
R
$C^{(1)} \sim \frac{q_{R^2} R^2}{X^4} + \cdots$
$-q_{R^2}$
$Q_{R^2} = \int_{S^5} *dC_5 = 0$

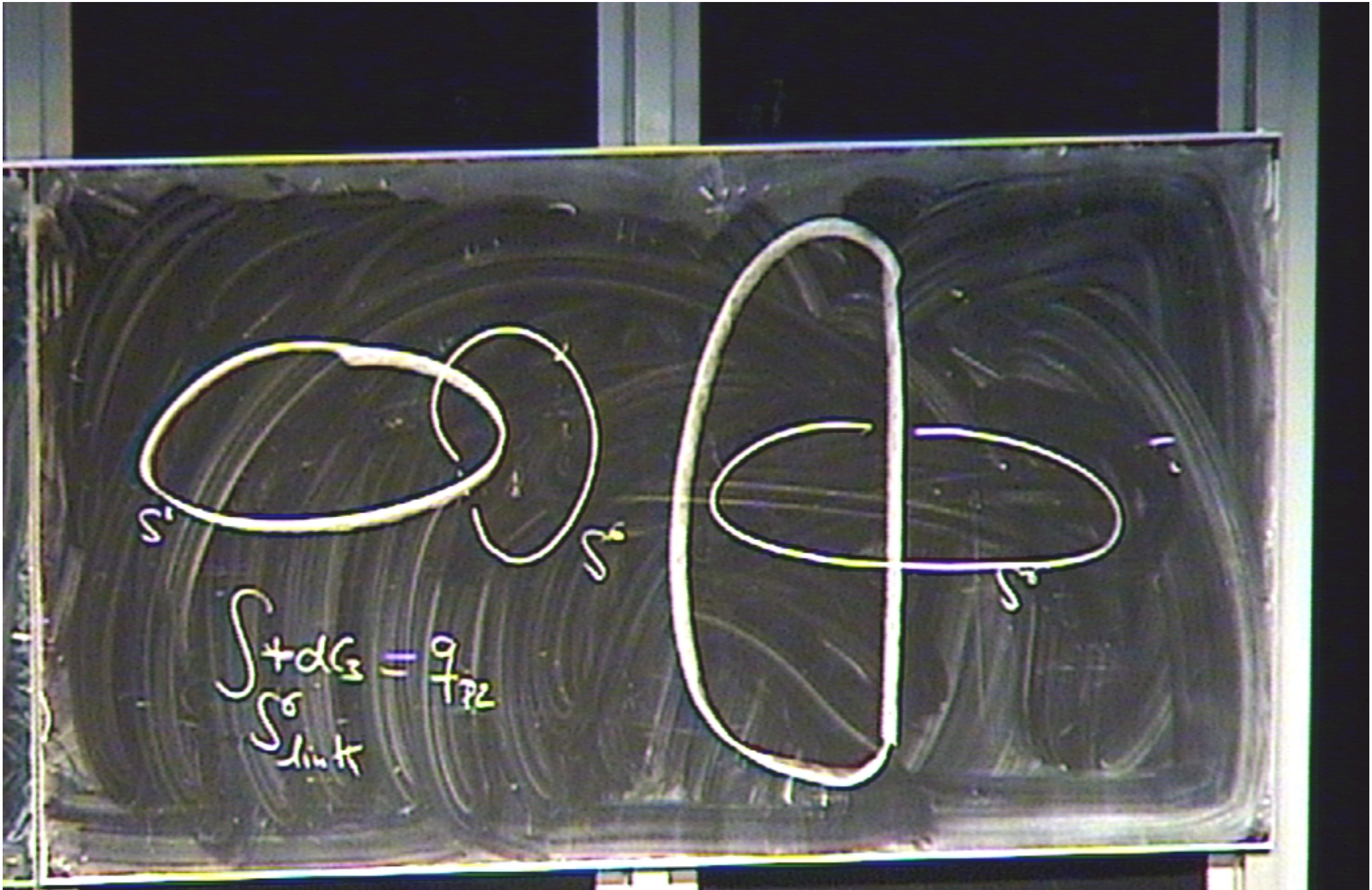

X
B
$C^{(1)} \sim \frac{q_{D2} R^2}{X^4} + \cdots$
q_{D2}
$Q_{D2} = \int_{S^5} *dC_3 = 0$

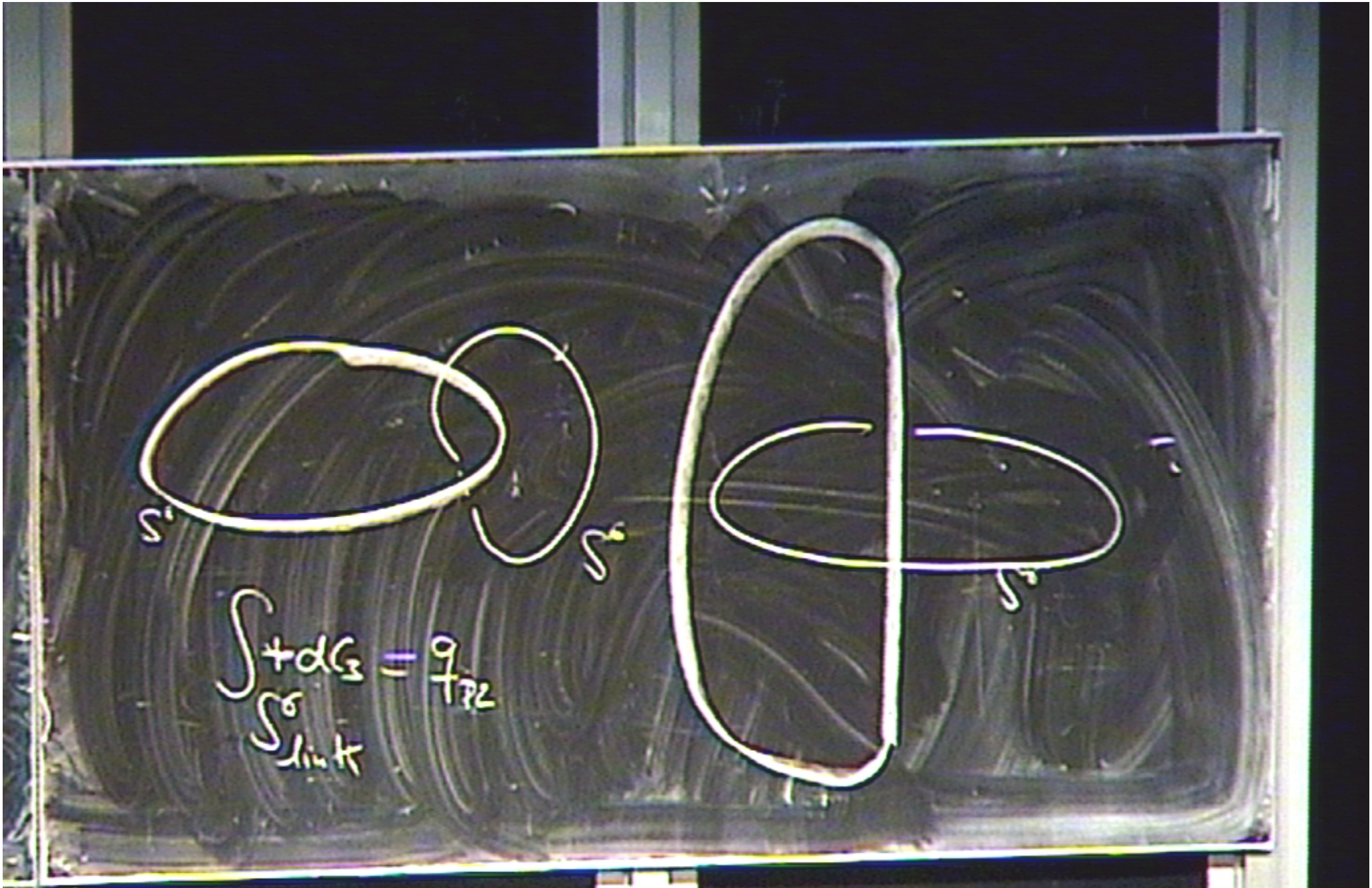

X
B
$C^{(1)} \sim \frac{q_{D2} R^2}{X^7} + \cdots$
$-q_{D2}$
$Q_{D2} = \int_{S^5} *dC_3 = 0$

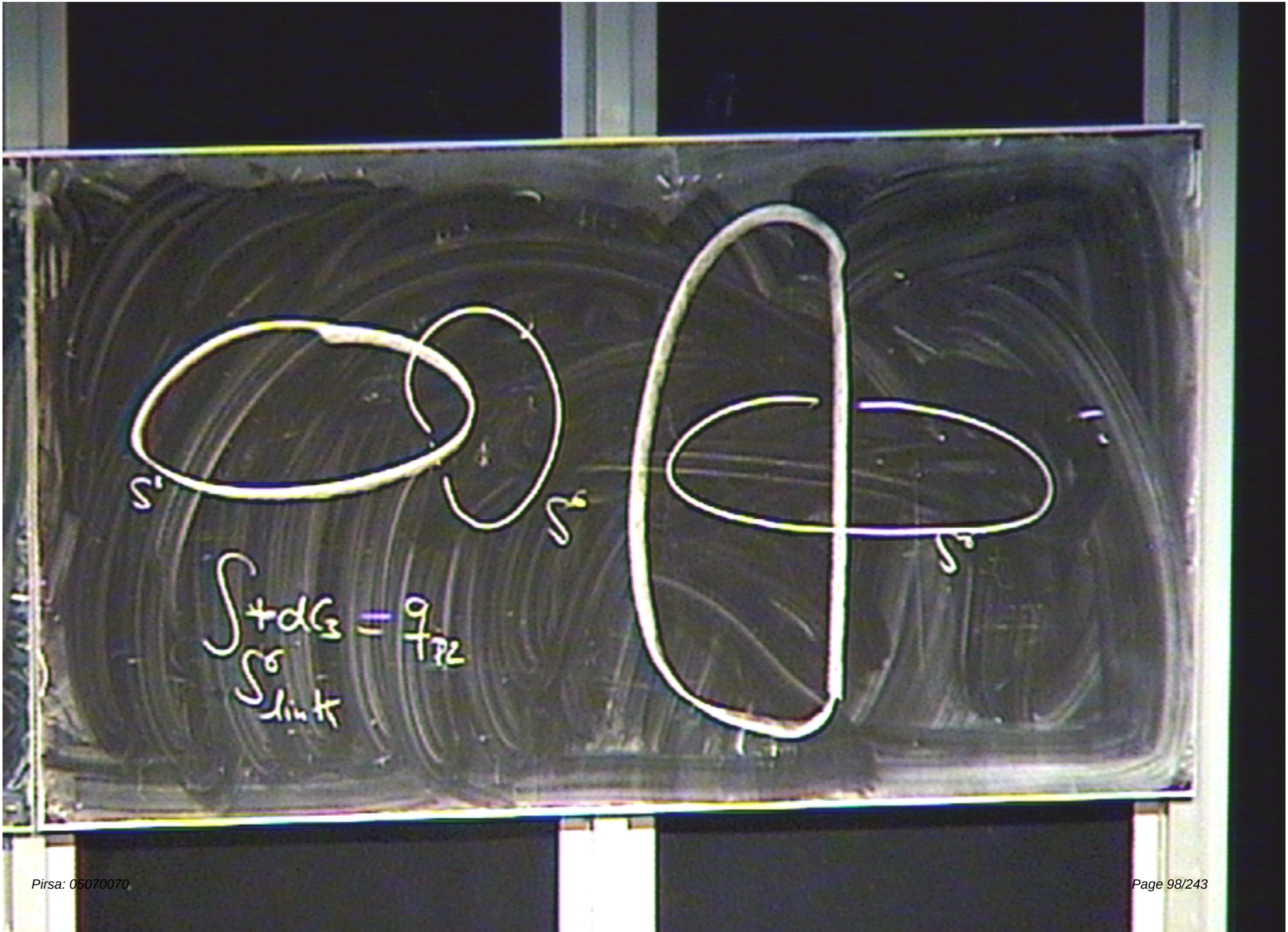

X
R
$C^{(1)} \sim \frac{q_{D2} R^2}{X^5} + \cdots$
q_{D2}
$Q_{D2} = \int_{S^5} *dC_3 = 0$

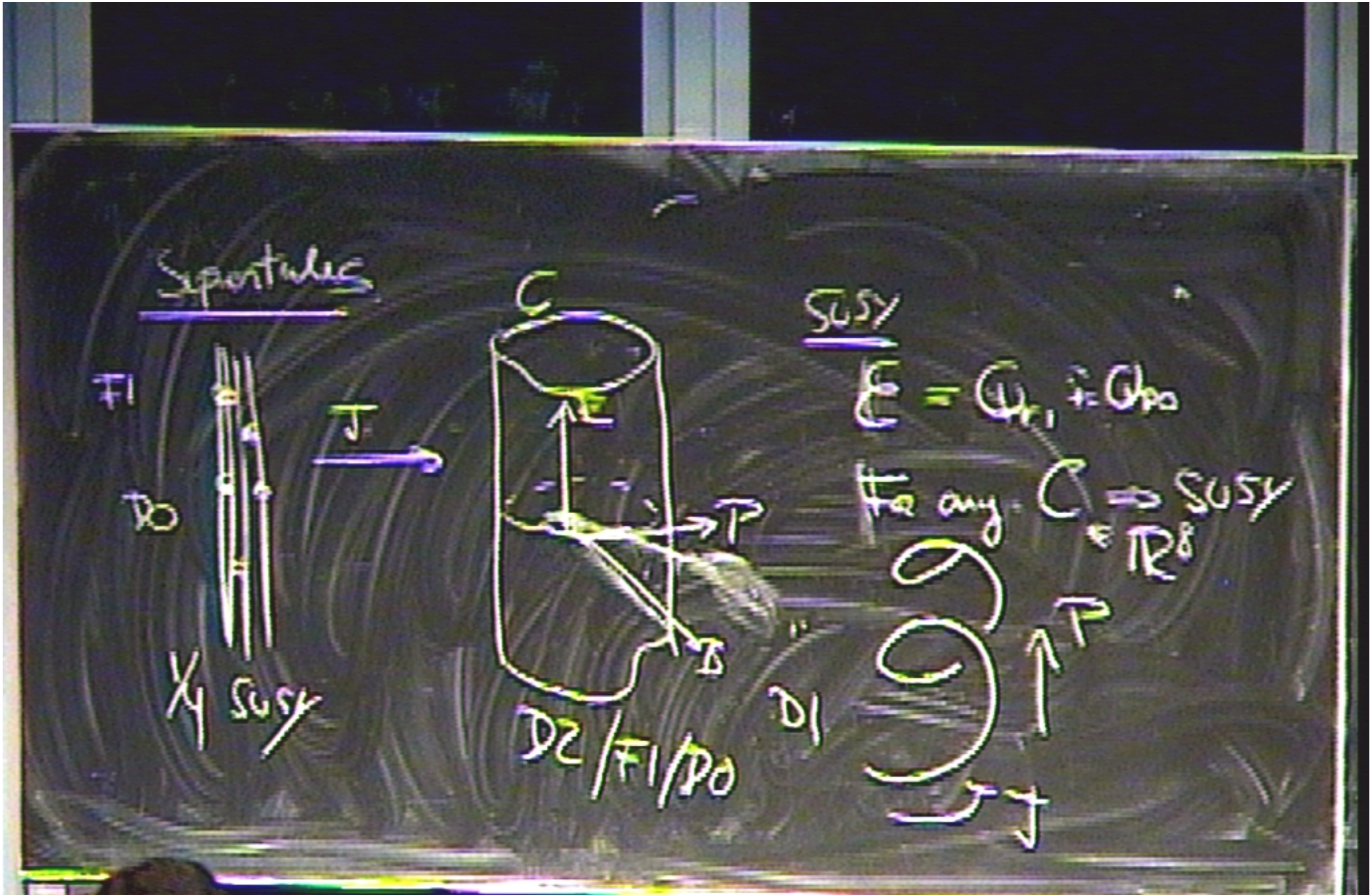

X
B
$C^{(1)} \sim \frac{q_{D2} R^2}{X^5} + \cdots$
q_{D2}
$Q_{D2} = \int_{S^5} *dC_3 = 0$

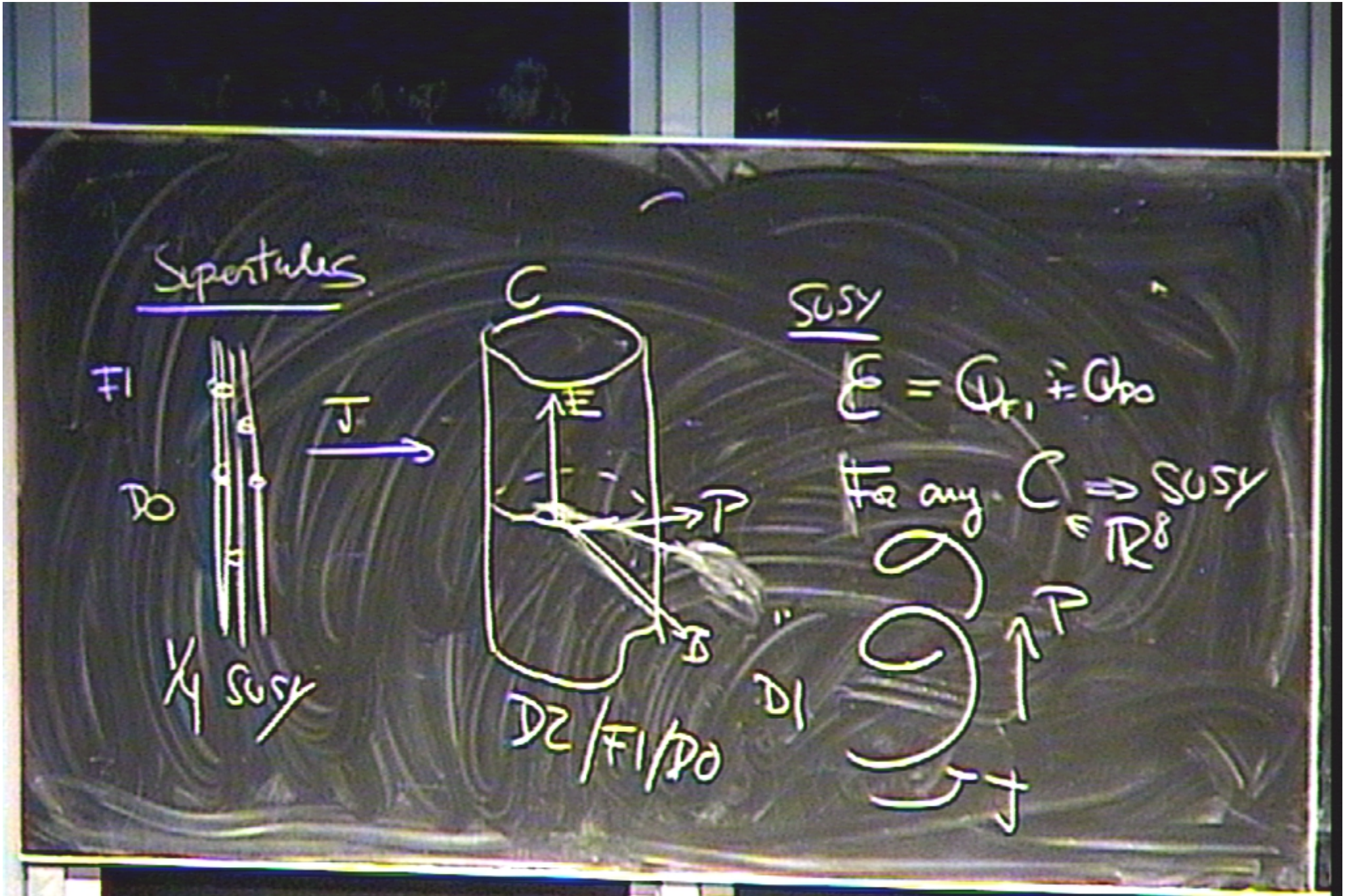

S^1
S^2
$= q_{12}$

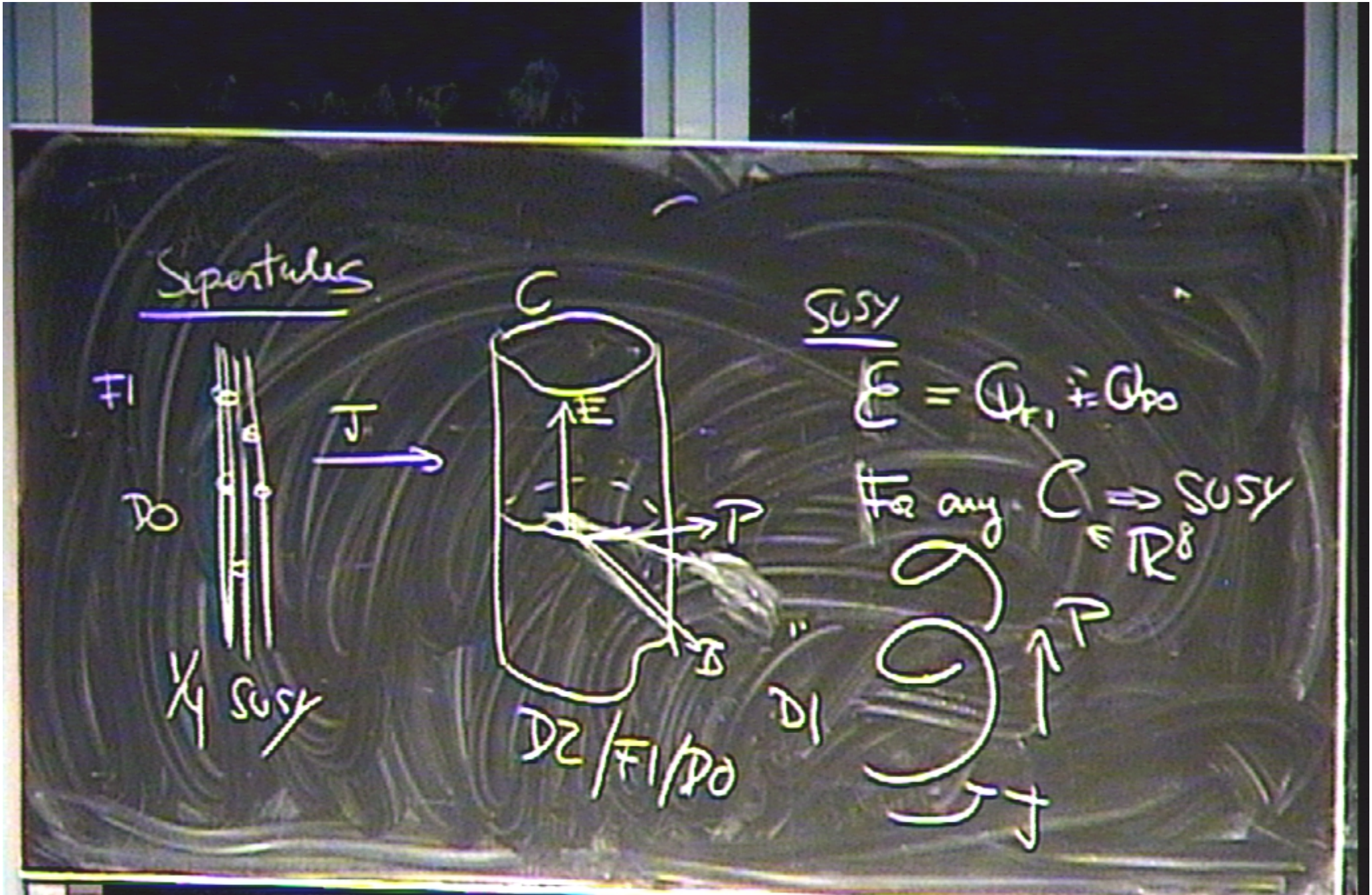

S^1
S^2
S^3
$\int_{link} \sigma^* dG_3 = q_{TP2}$

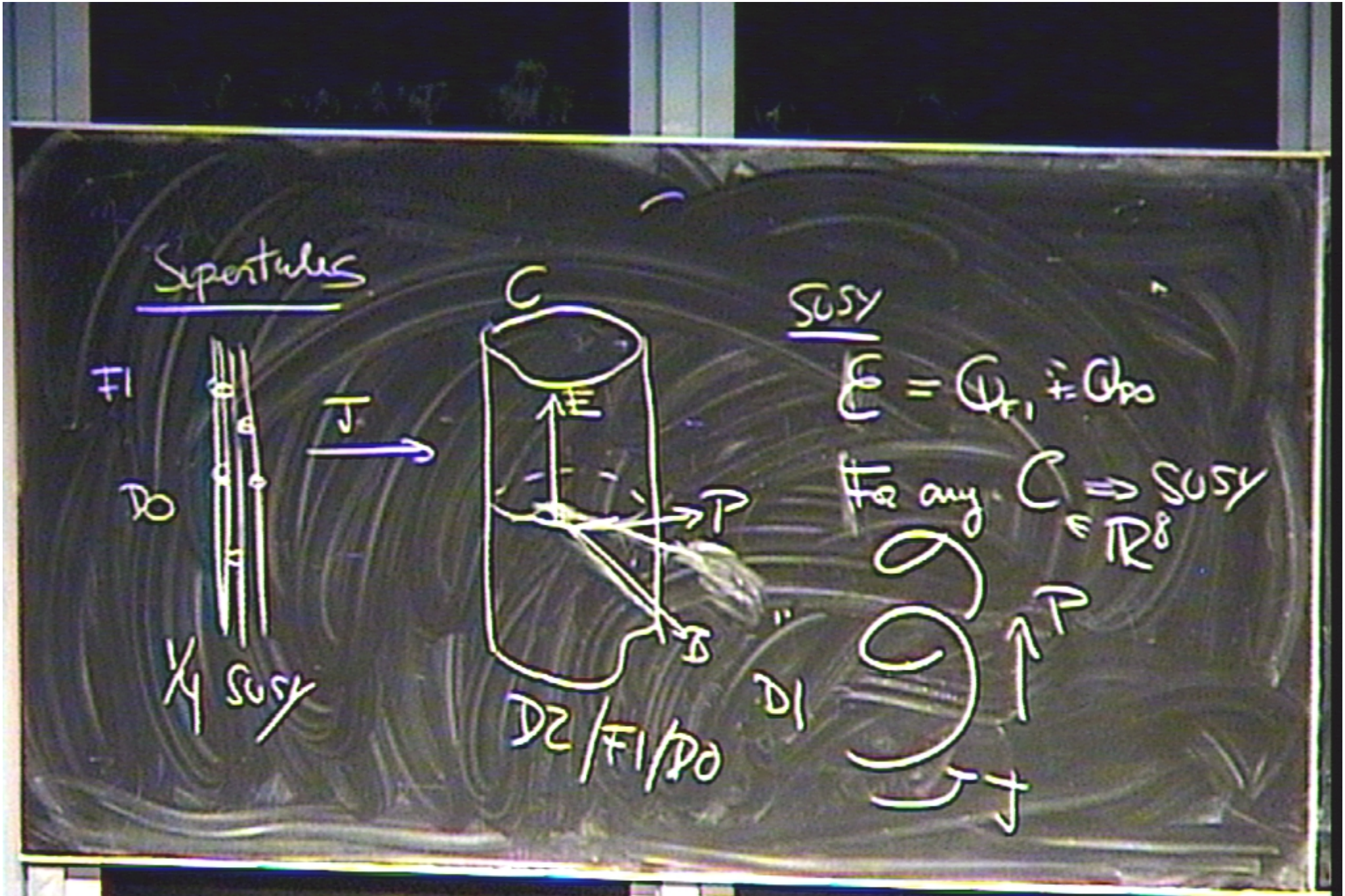

S^1
S^2
S^3
$\int_{S^2} *dG_3 = q_{TL}$

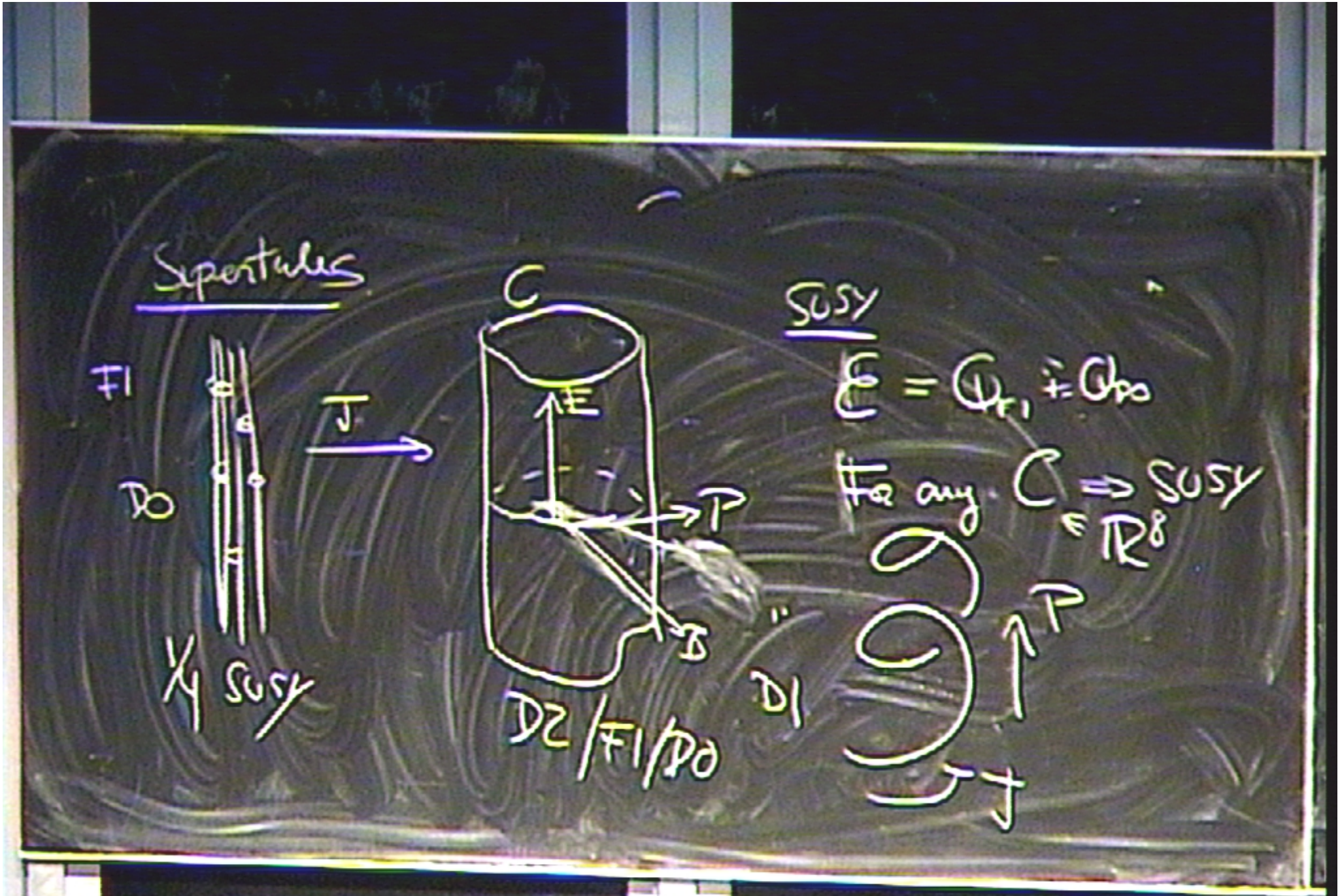

S¹
S²
S³
$\int_{\sigma} *dG_3 = q_{7_{32}}$
σ
S_{link}

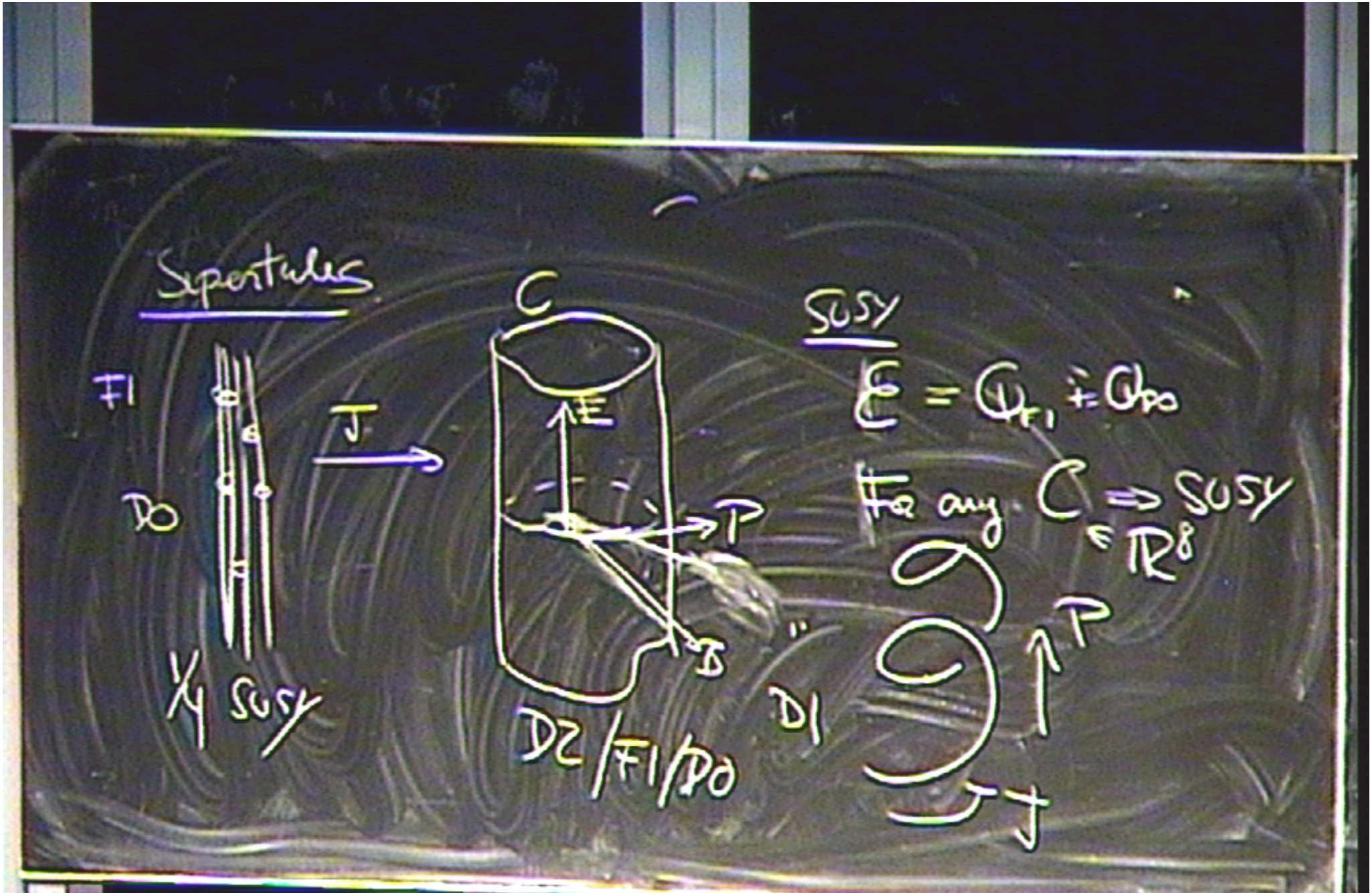

Spectrales
F1
D0
1/4 Susy
J
C
P
D2/F1/D0
D1
Susy
Susy
P
J

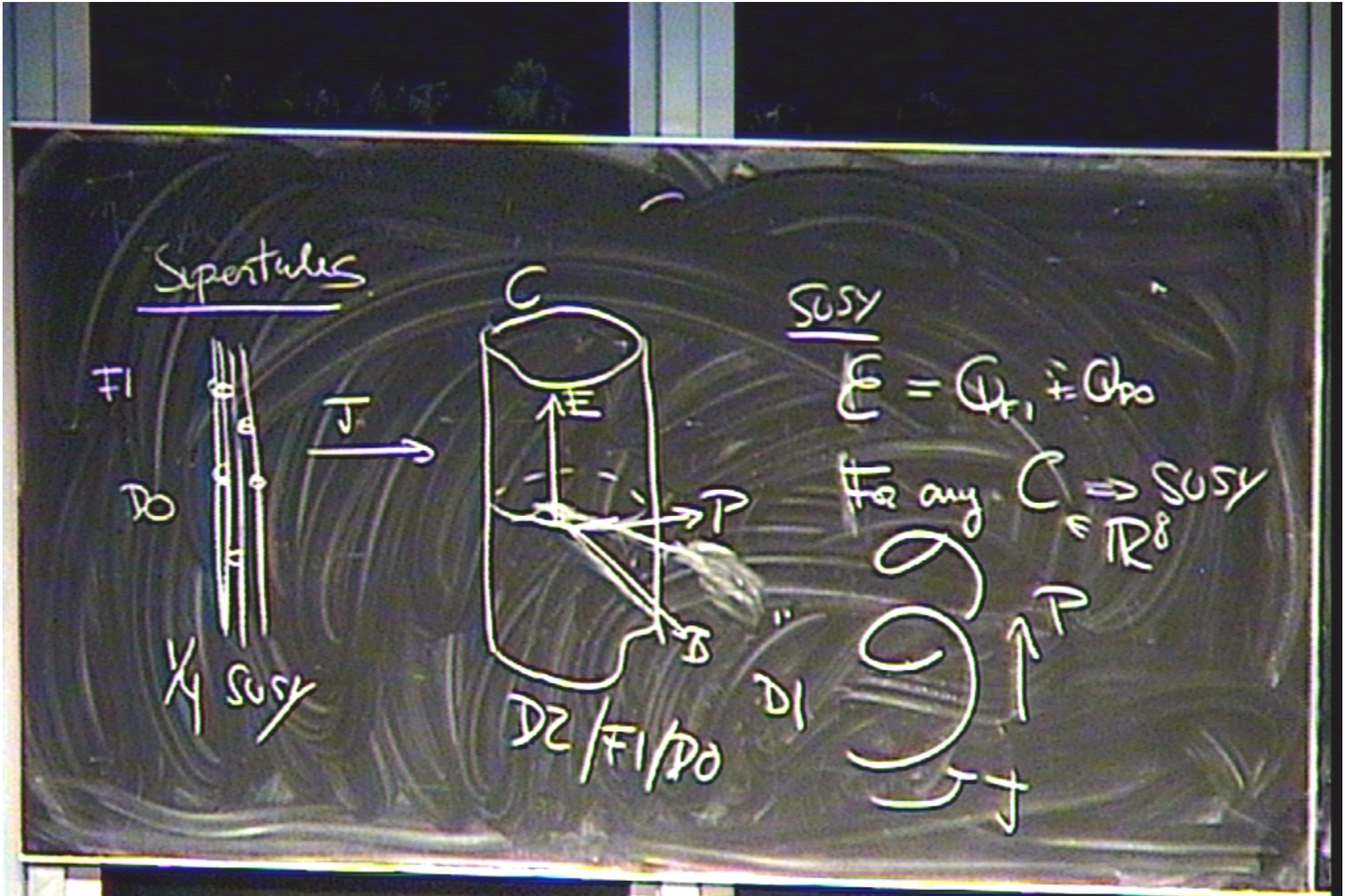

Supertubes
F1
D0
1/4 SUSY
J
C
E
P
D
D2/F1/D0
D1
SUSY
$\epsilon = Q_{F1} \pm Q_{D0}$
For any $C \Rightarrow$ SUSY
$\in \mathbb{R}^8$
P
J

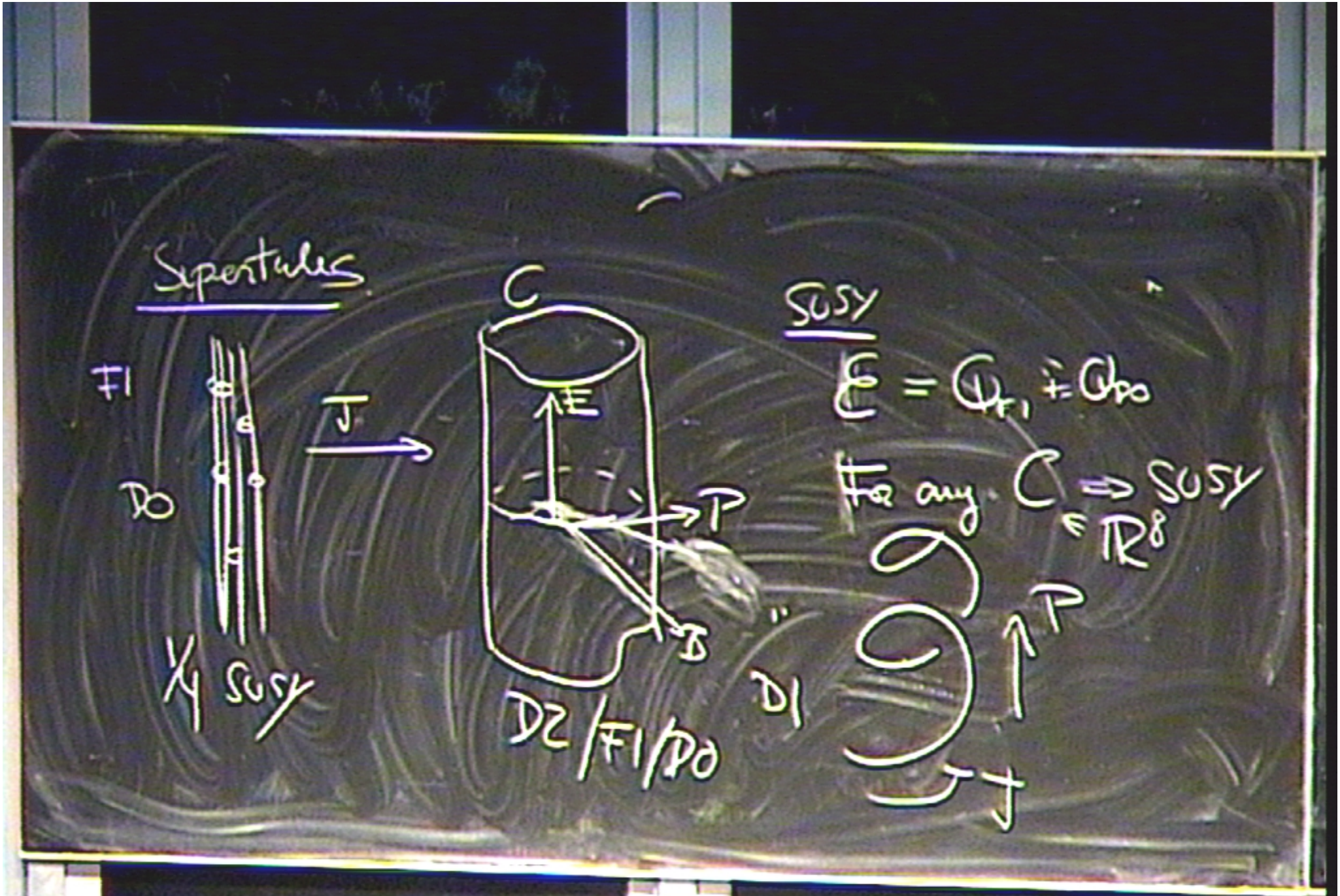

Supertubes
F1
D0
1/4 SUSY
J
C
E
P
D
D2/F1/D0
D1
SUSY
$\epsilon = \epsilon_{F1} + \epsilon_{D0}$
For any $C \Rightarrow$ SUSY
$\in R^8$
P
J


Supertubes
F1
D0
1/4 SUSY
J
C
E
P
B
D2/F1/D0
D1
SUSY
$\epsilon = \epsilon_{F1} + \epsilon_{D0}$
For any $C \in \mathbb{R}^8$
P
J

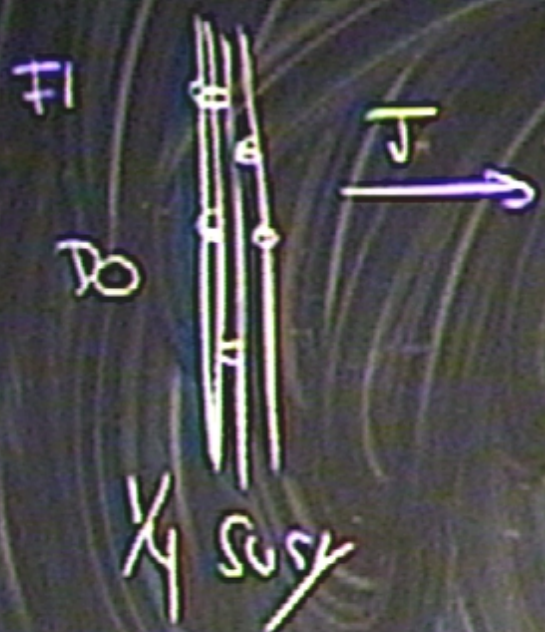

Supertubes
F1
D0
1/4 Susy
C
E
P
D2/F1/D0
D1
SUSY
For any C ⇒ SUSY
∈ R^8
P


Supertubes
F1
D0
1/4 SUSY
J
C
E
P
D2/F1/D0
D1
SUSY
$\epsilon = \epsilon_{F1} + \epsilon_{D0}$
For any $C \Rightarrow$ SUSY
$\in \mathbb{R}^8$
P
J


Supertubes
C
SUSY
ε = ε_F1 ± ε_D0
For any C ⇒ SUSY
∈ R^8
F1
D0
J
P
1/4 SUSY
D2/F1/D0
D1
P
J


Supertubes
F1
D0
1/4 Susy
J
C
E
P
D
D2/F1/D0
D1
SUSY
ε = Q_F1 ± Q_D0
For any C ∈ R^8 ⇒ SUSY
P
J

Supertubes



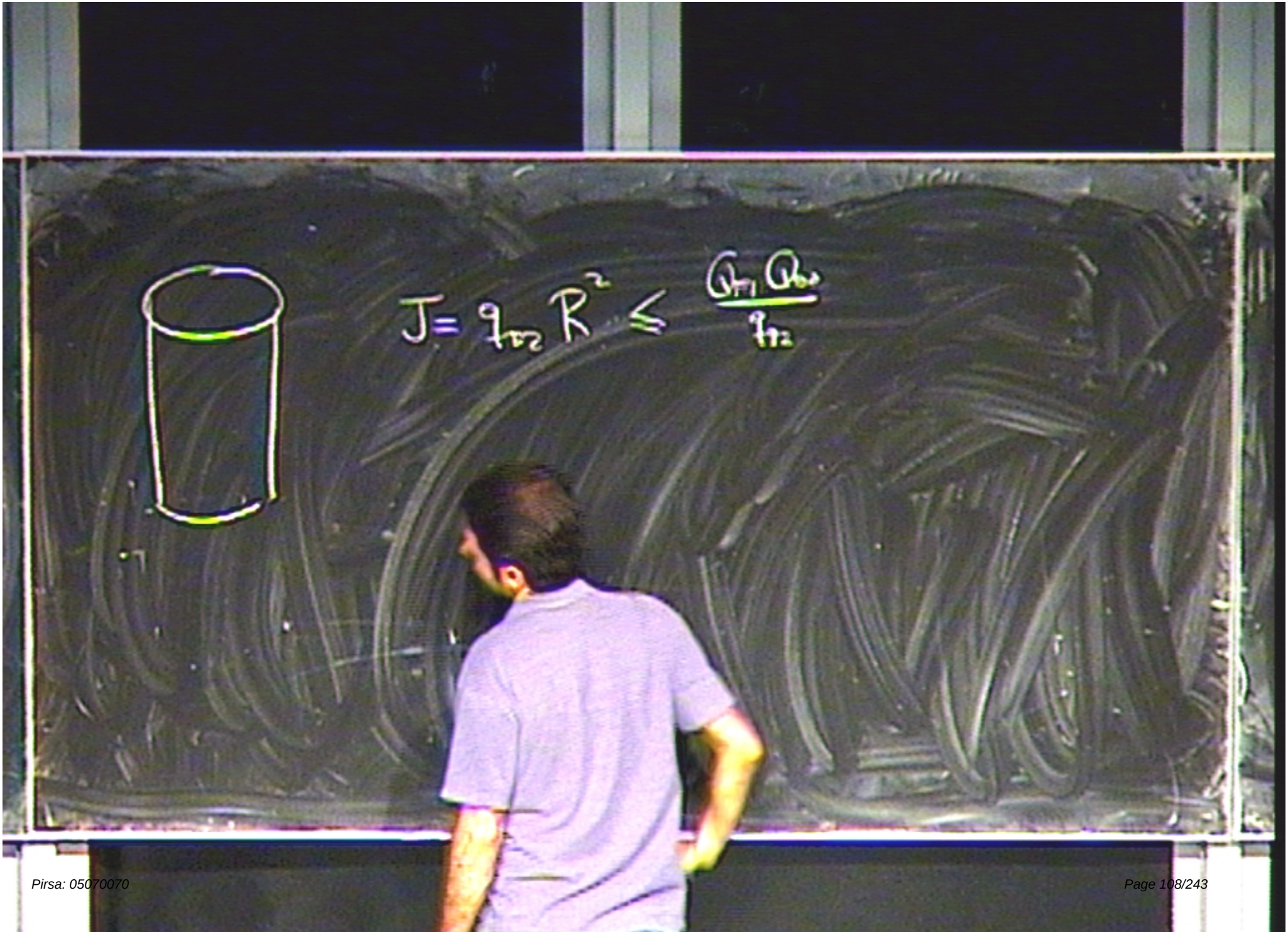


SUSY

$\mathcal{E} = Q_{F1} \pm Q_{D0}$

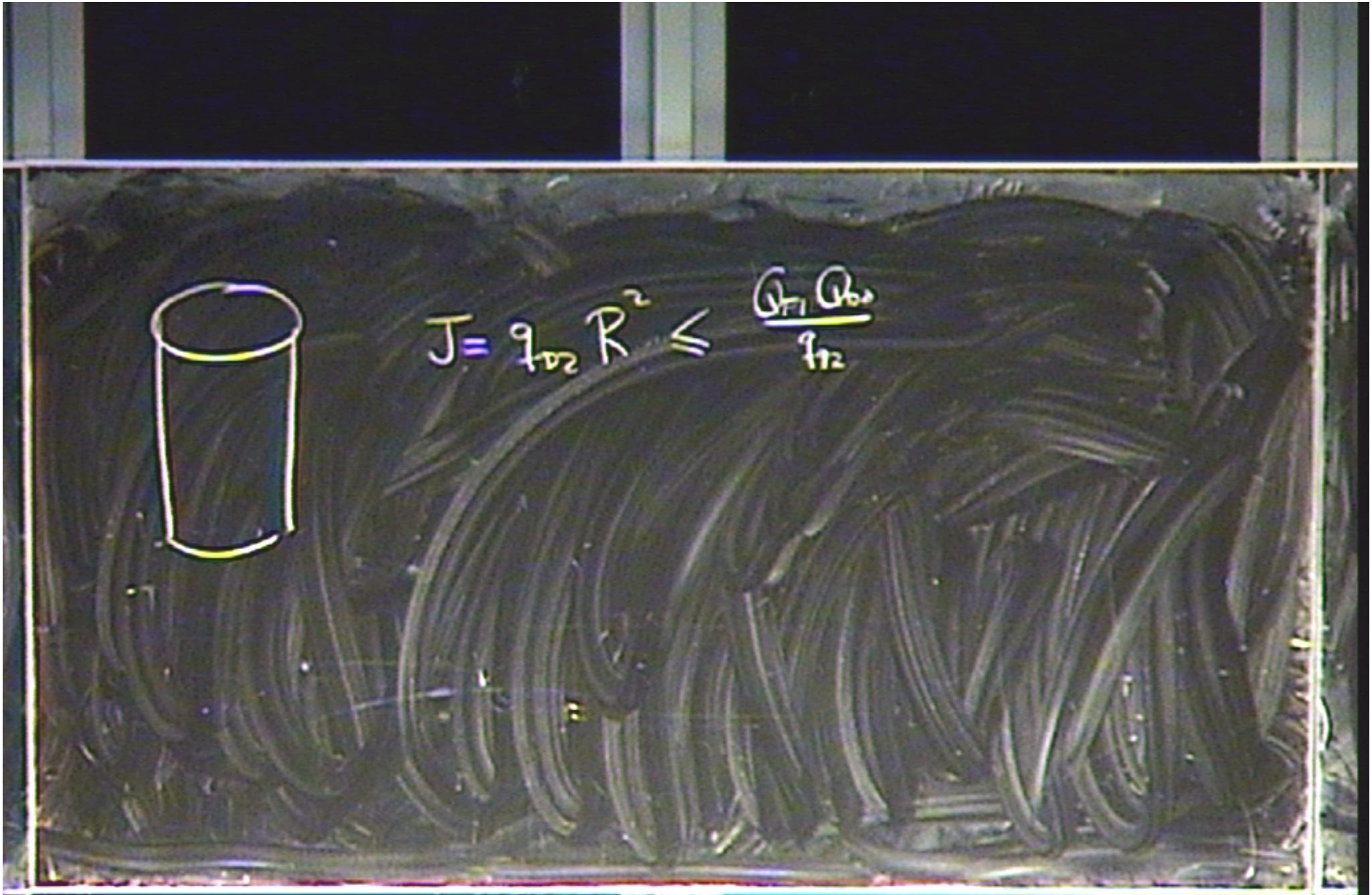
For any $C \in \mathbb{R}^8$ ⇒ SUSY




$J = q_{max} R^2 \leq \frac{Q_{in} Q_{bulk}}{q_{max}}$

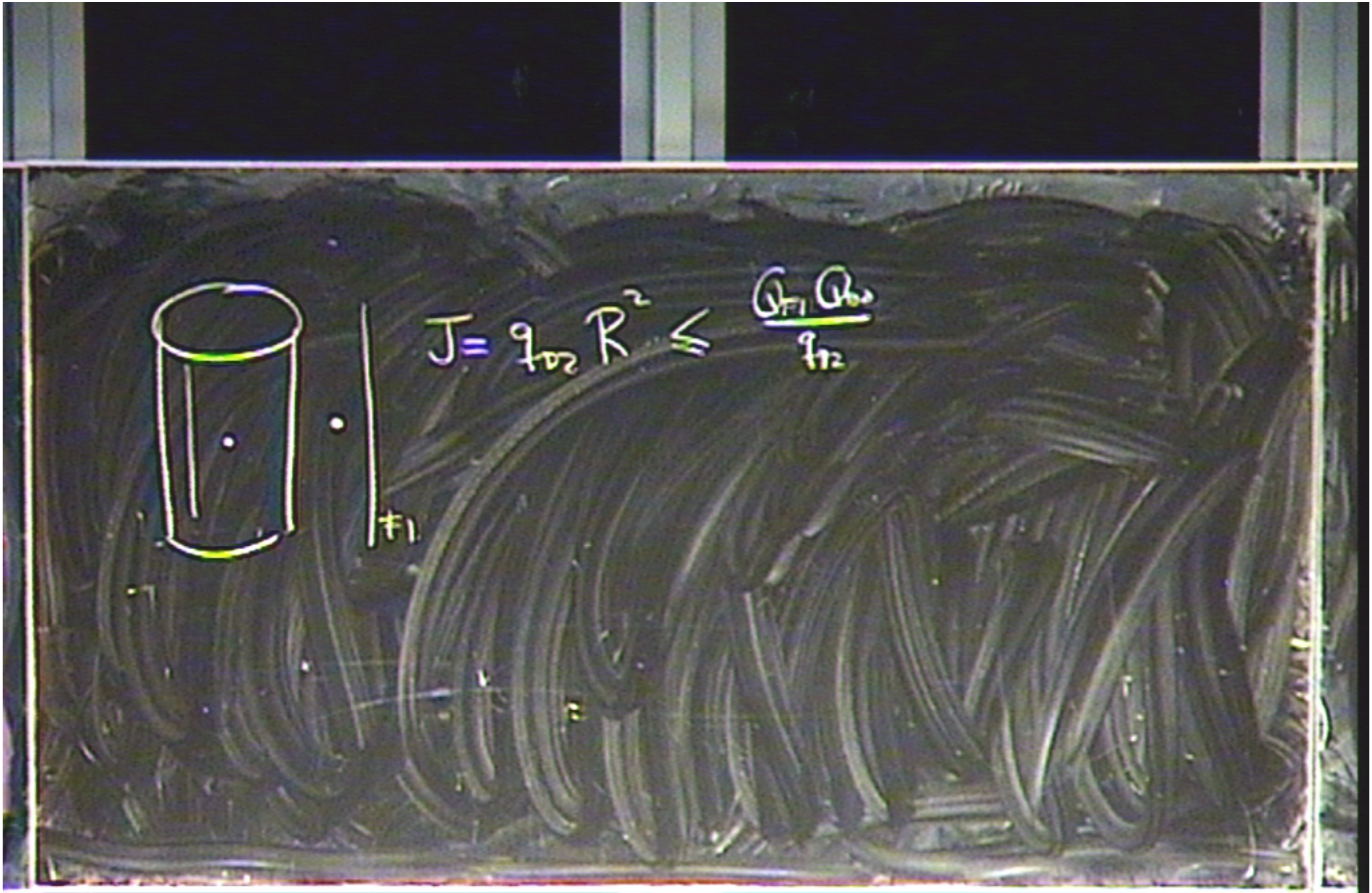


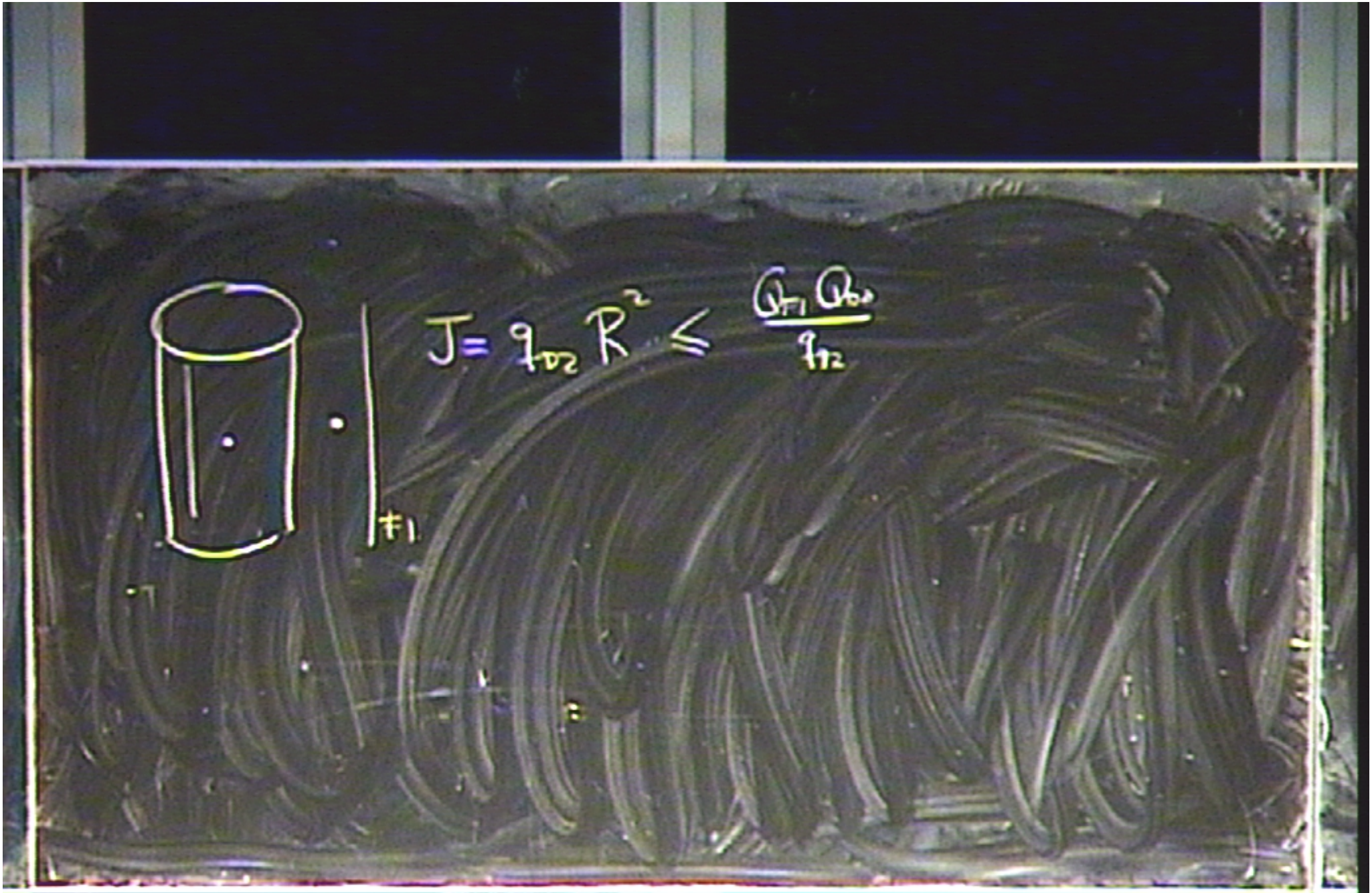
$$J = q_{D2} R^2 \leq \frac{Q_{F1} Q_{B2}}{q_{12}}$$


$J = q_{D2} R^2 \leq \frac{Q_{F1} Q_{b1}}{q_{12}}$



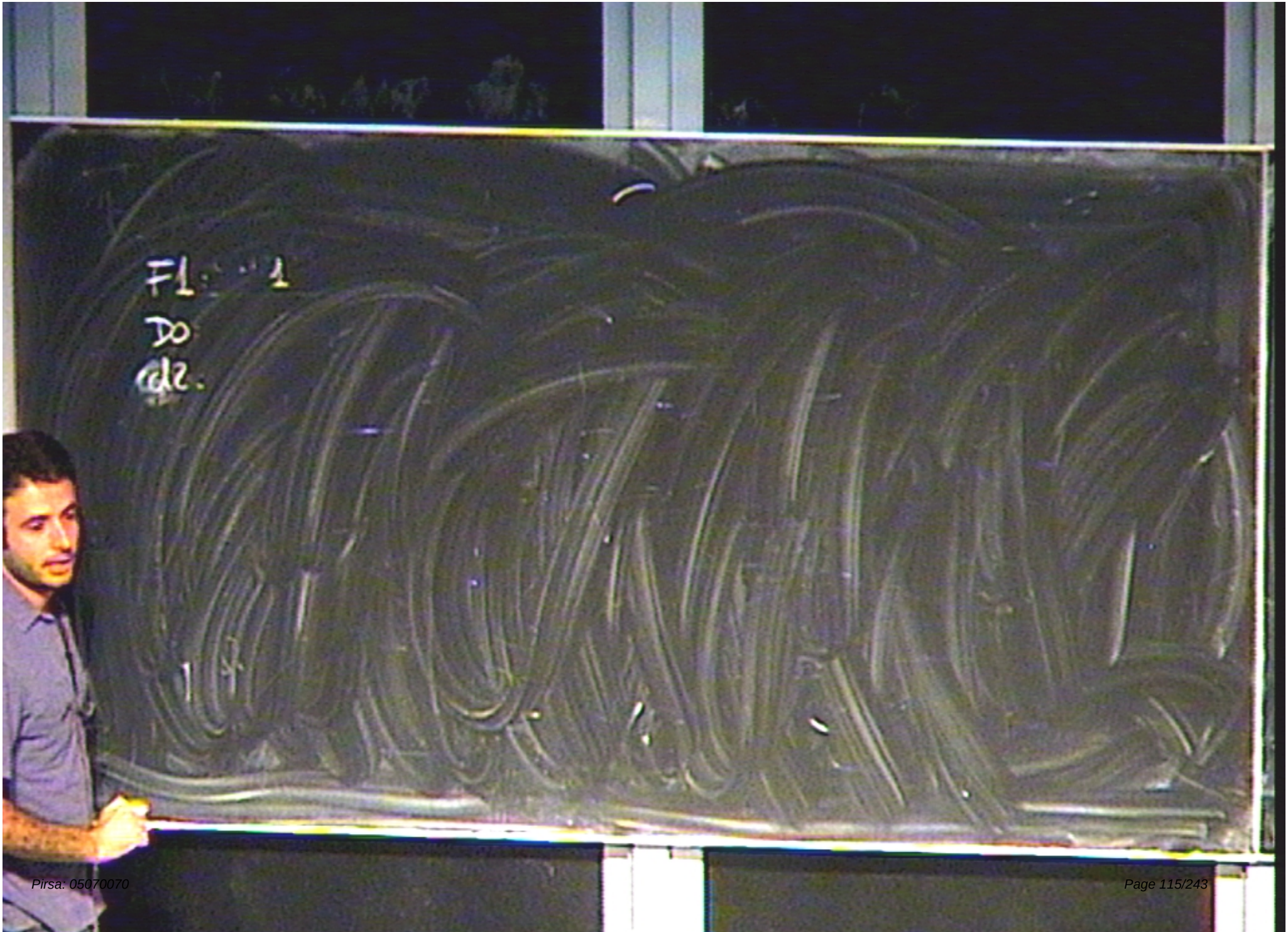
$$J = q_{D2} R^2 \leq \frac{Q_{F1} Q_{b2}}{q_{12}}$$

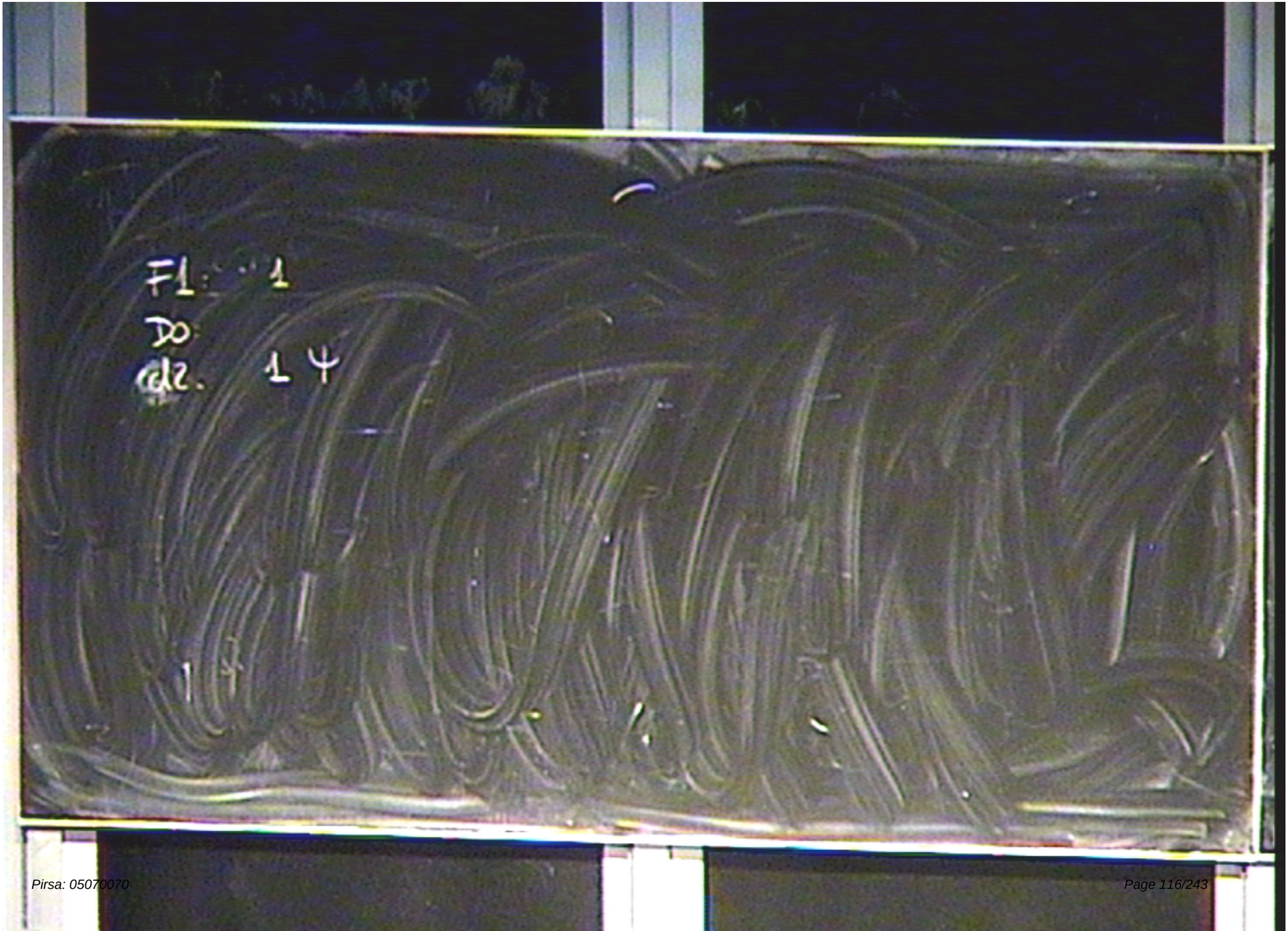

$J = q_{02} R^2 \leq \frac{Q_{F1} Q_{02}}{q_{12}}$
F1

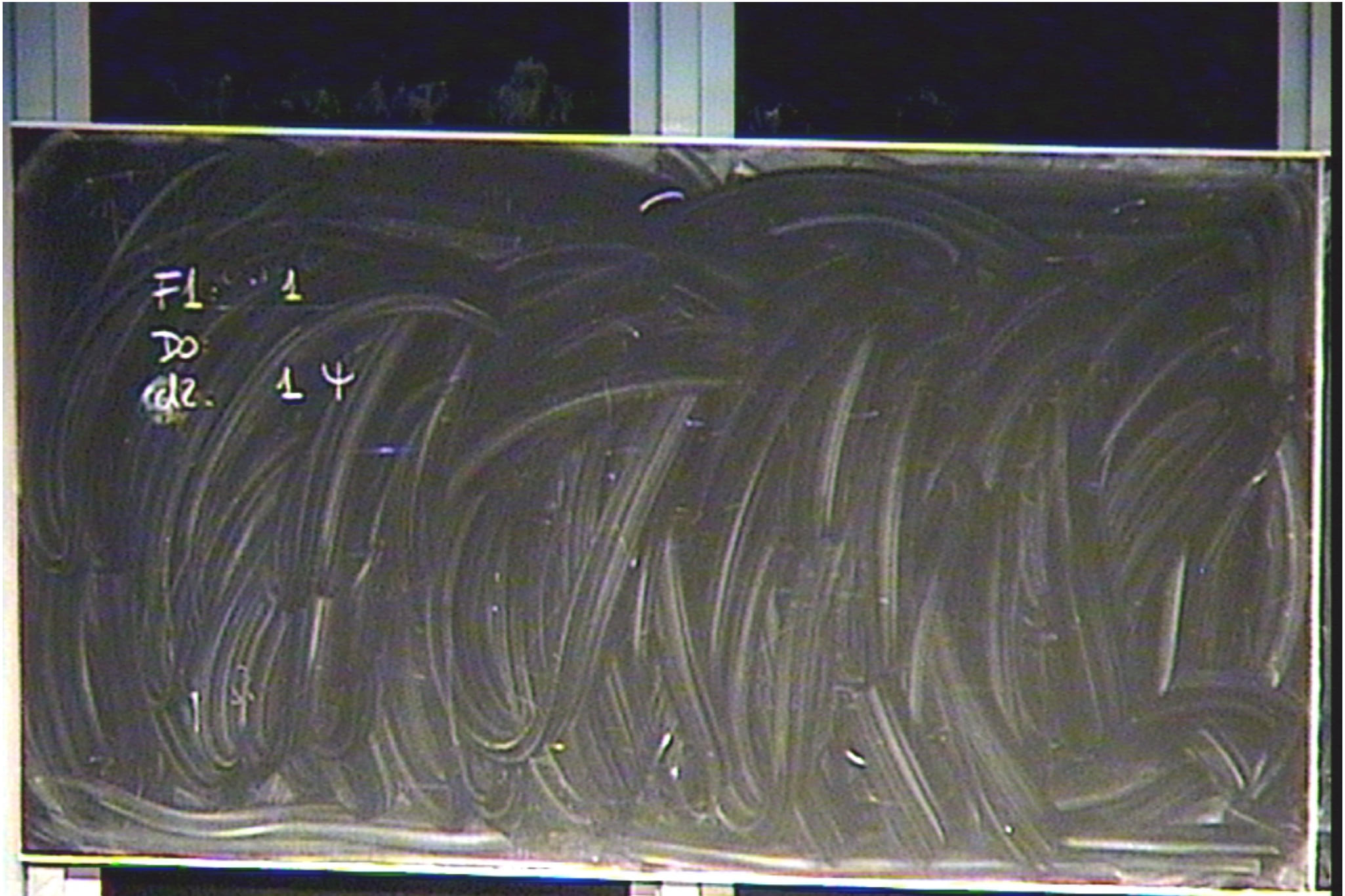

$J = q_{D2} R^2 \leq \frac{Q_{F1} Q_{b2}}{q_{12}}$
F_1

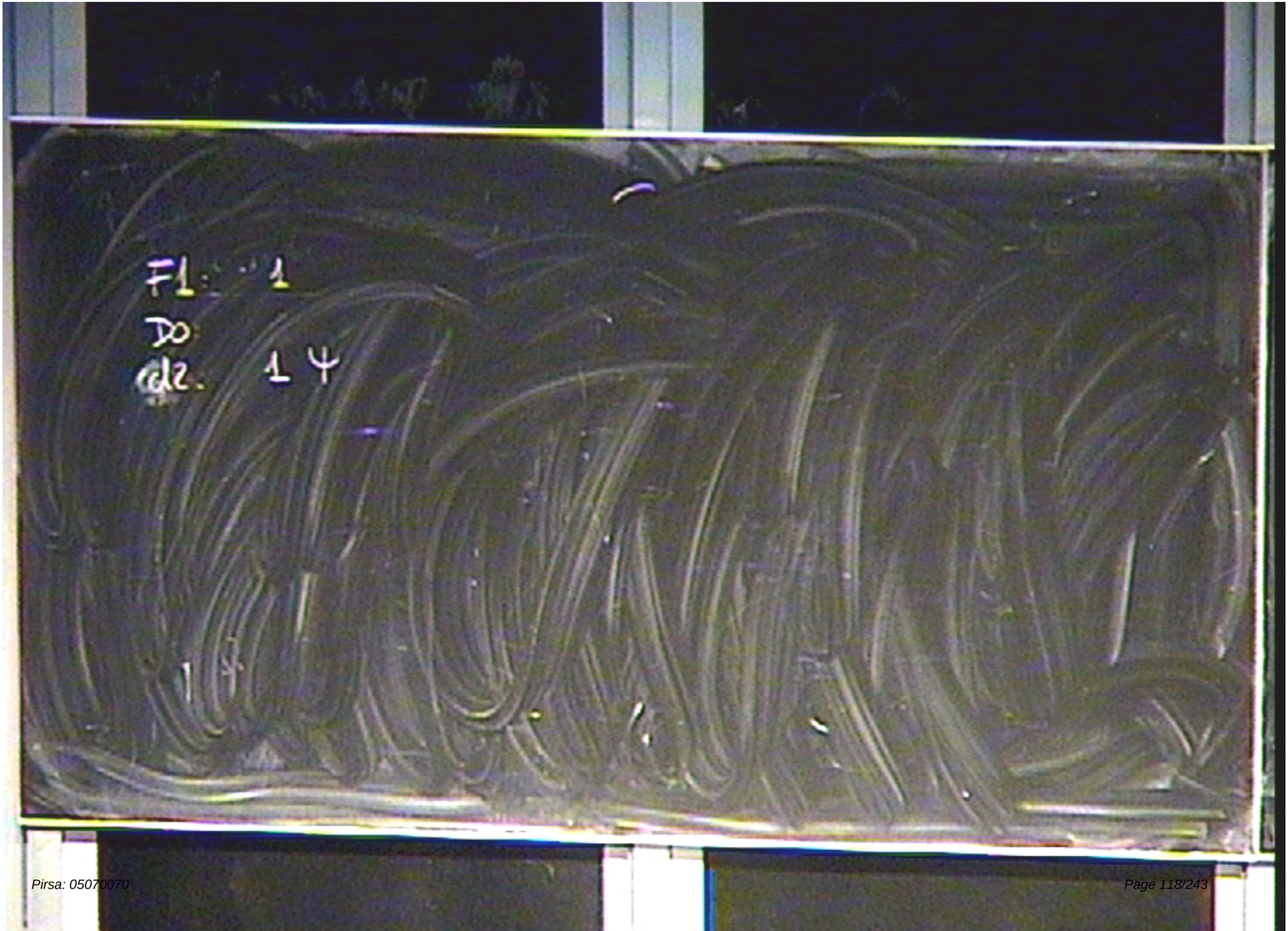


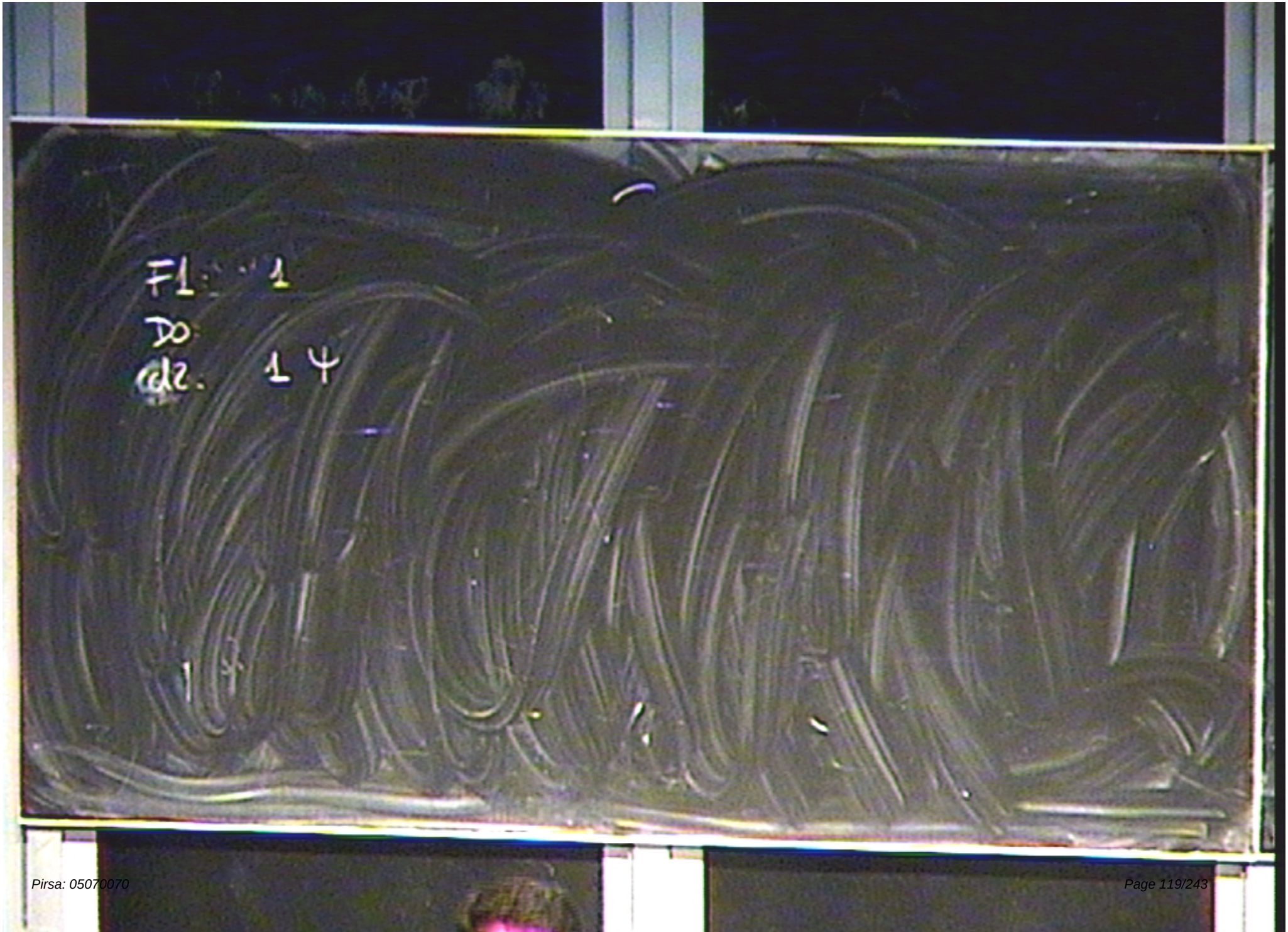
$$J = q_{D2} R^2 \leq \frac{Q_{F1} Q_{b2}}{q_{12}}$$

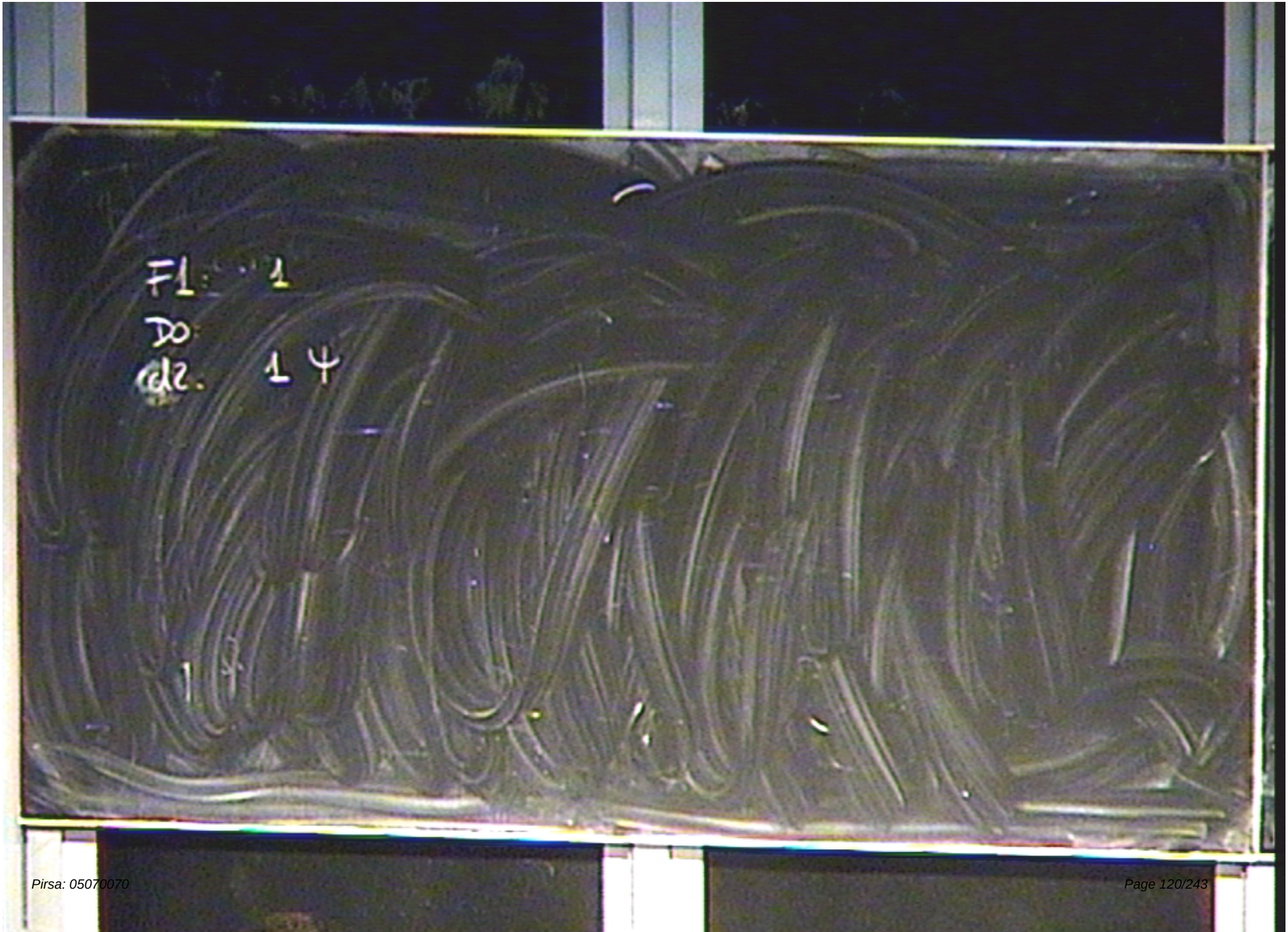

Fl
Do
dz.

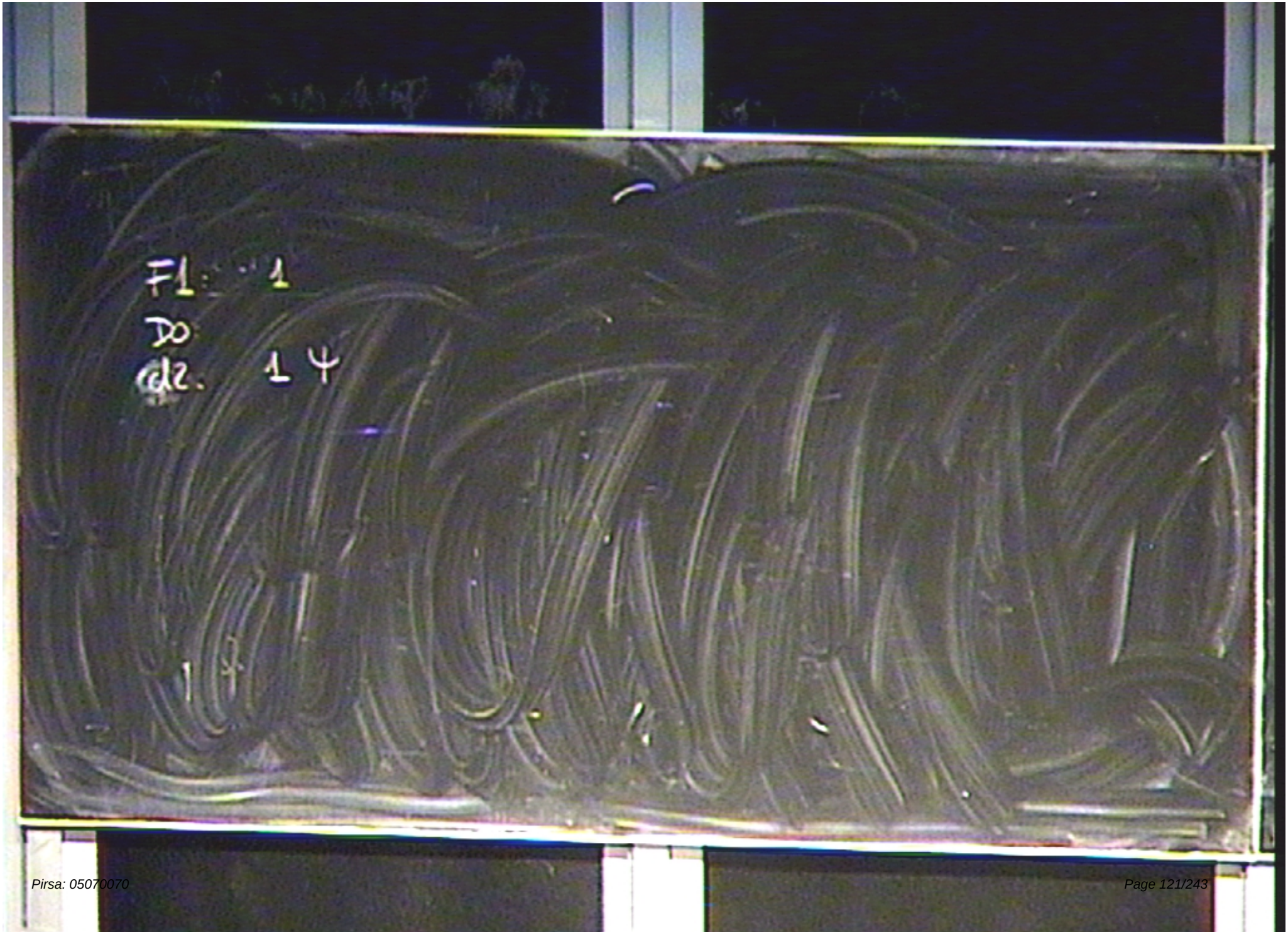

Fl: 1
Do
dz. 1 4

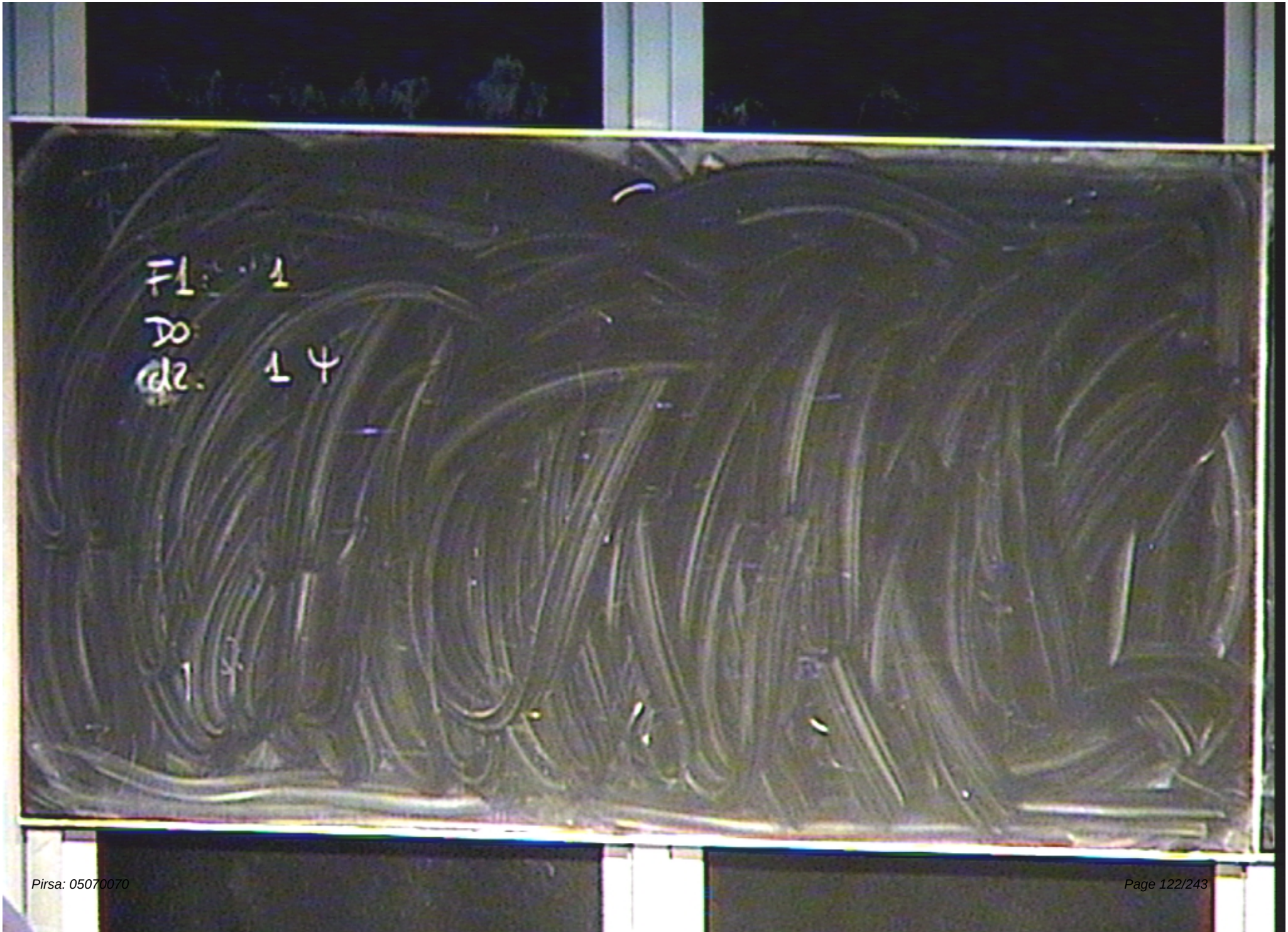

Fl: 1
Do
dz. 1 4

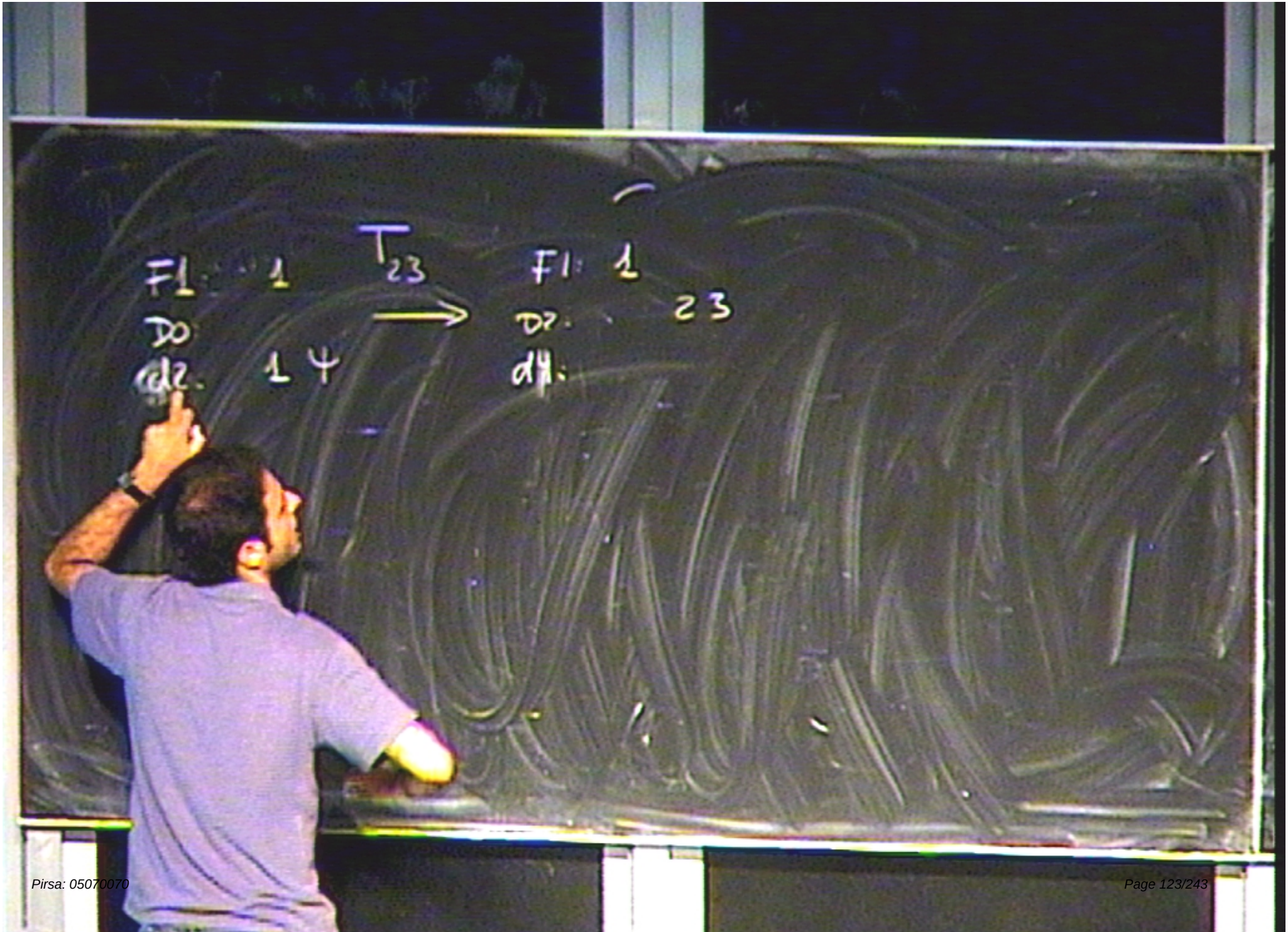

F1 : 1
Do
dz. 1 4

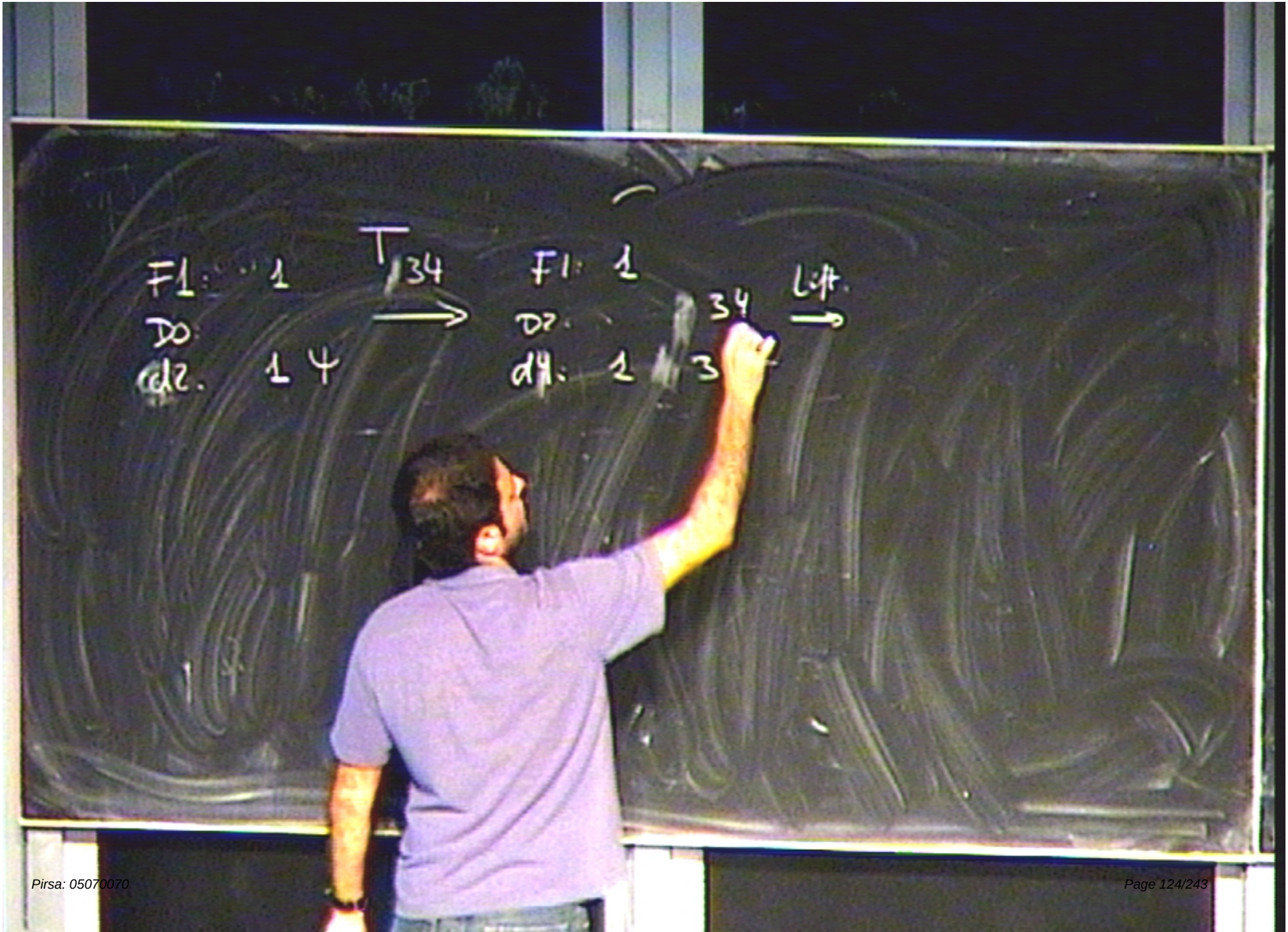

Fl: 1
Do
dz. 14

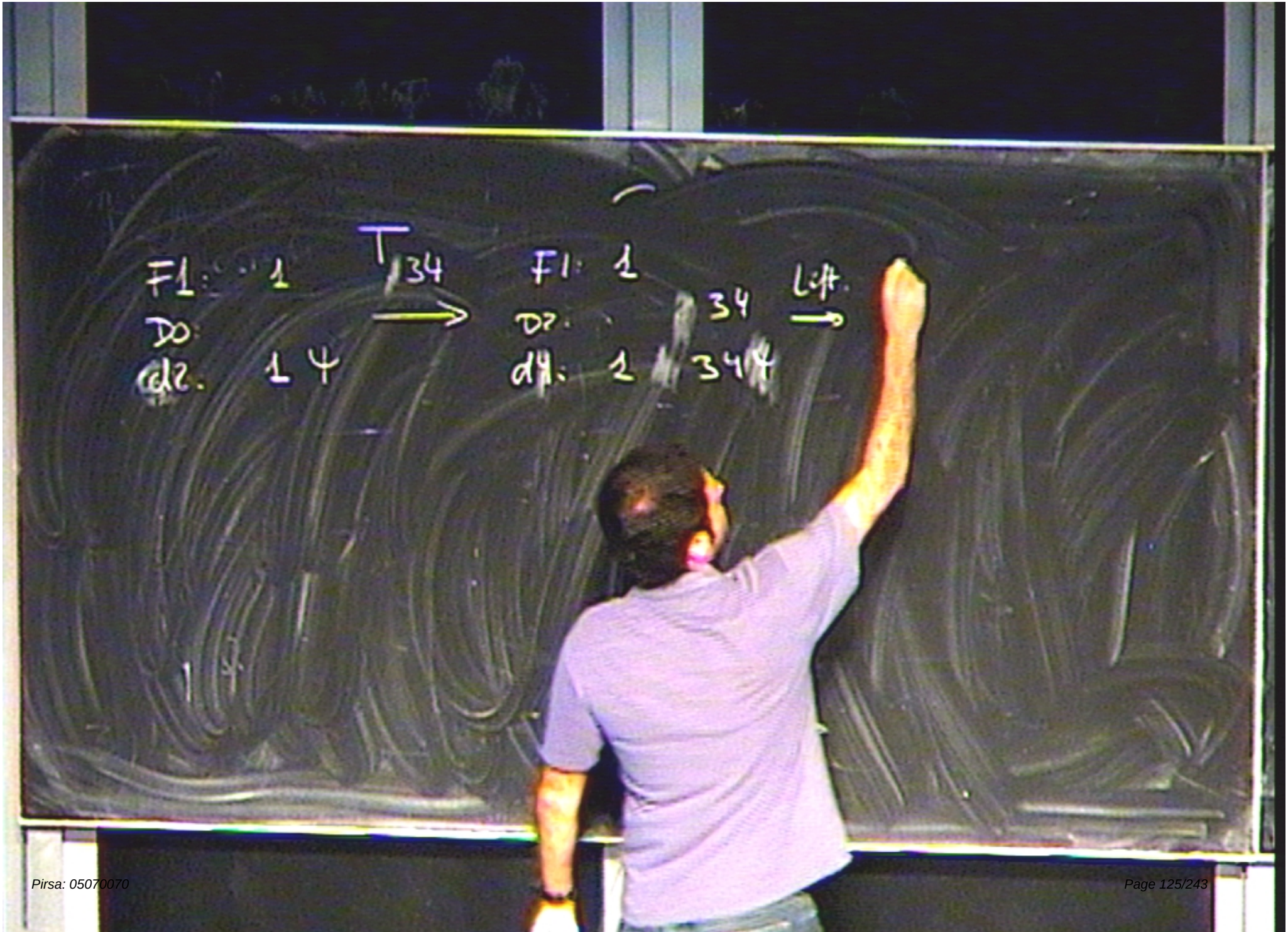

Fl:
Do
dz. 1 4

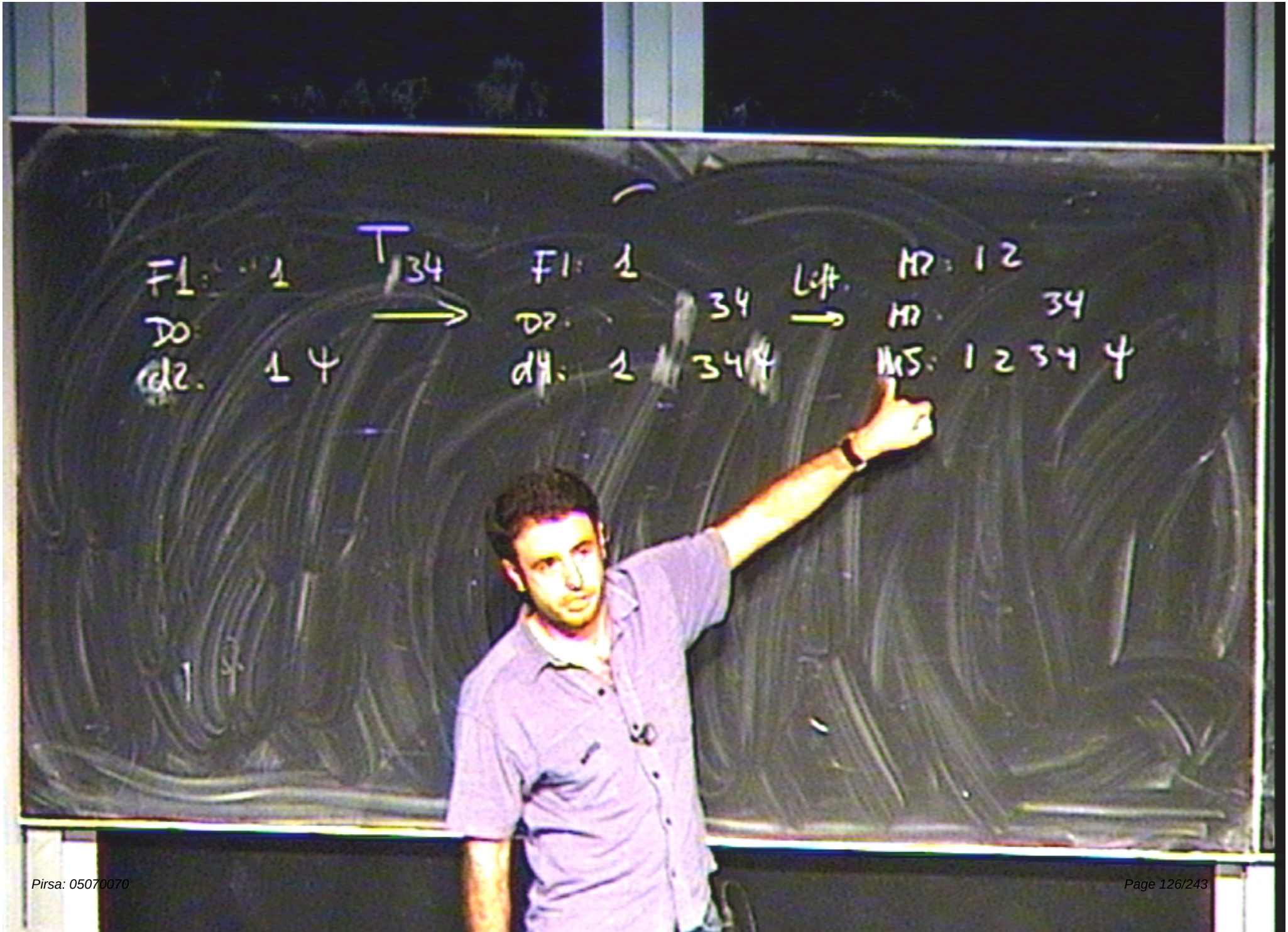

F1 : 1
Do
dz. 1 4
1 8

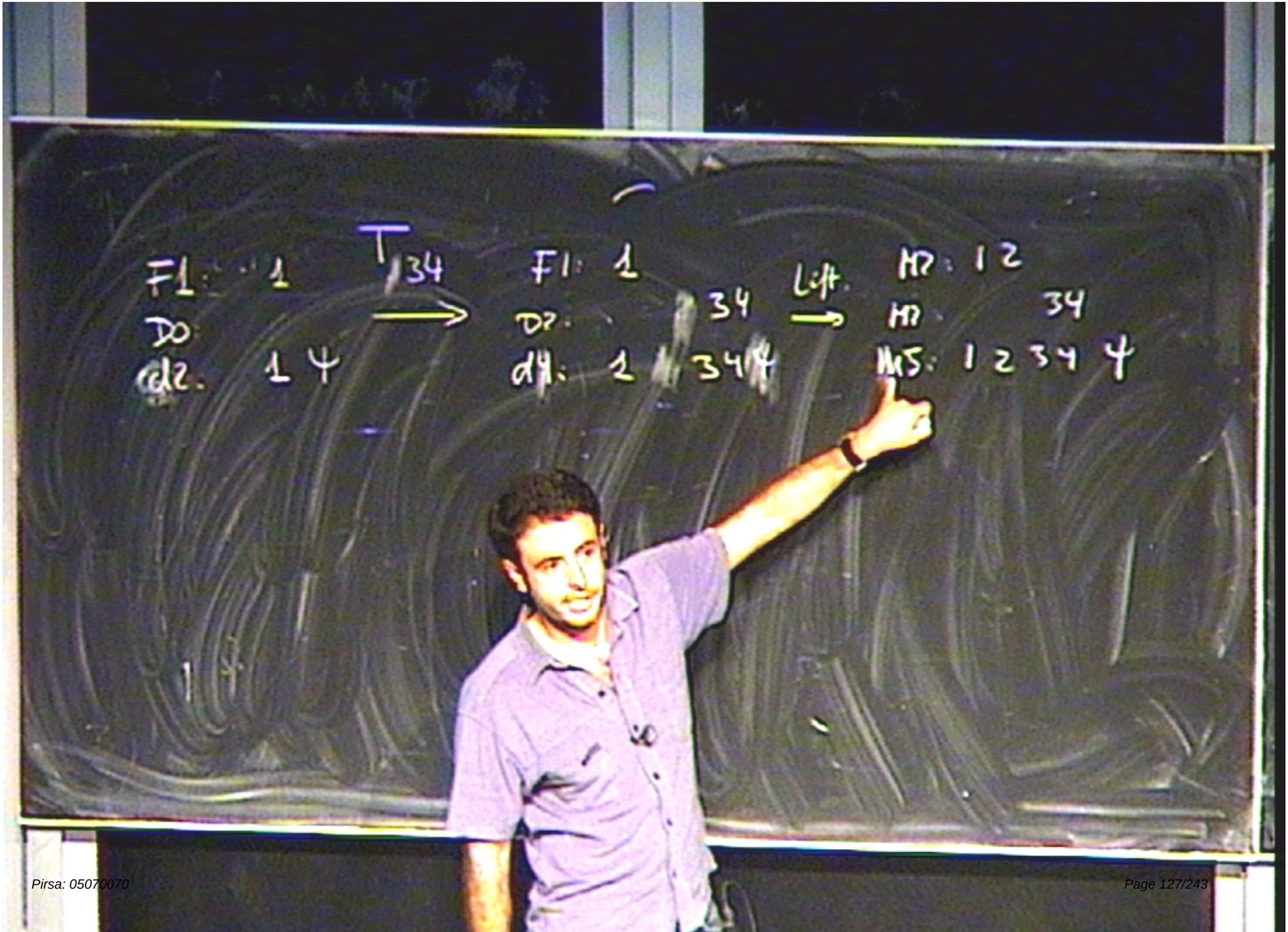

Fl: 1
Do
dz. 14

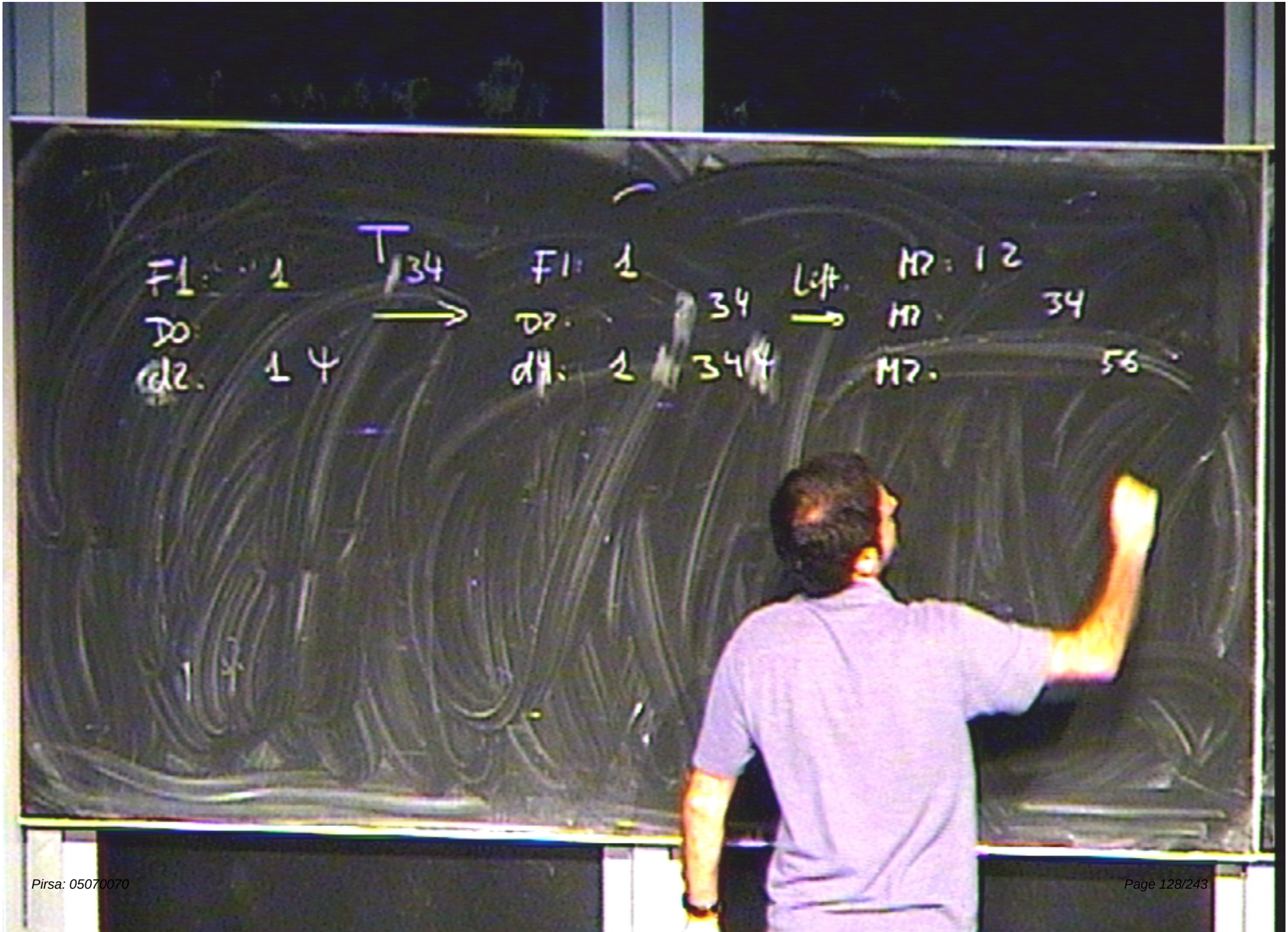

Fl: 1
T23
Fl: 1
D0
D2: 23
d2: 1 4
d4:

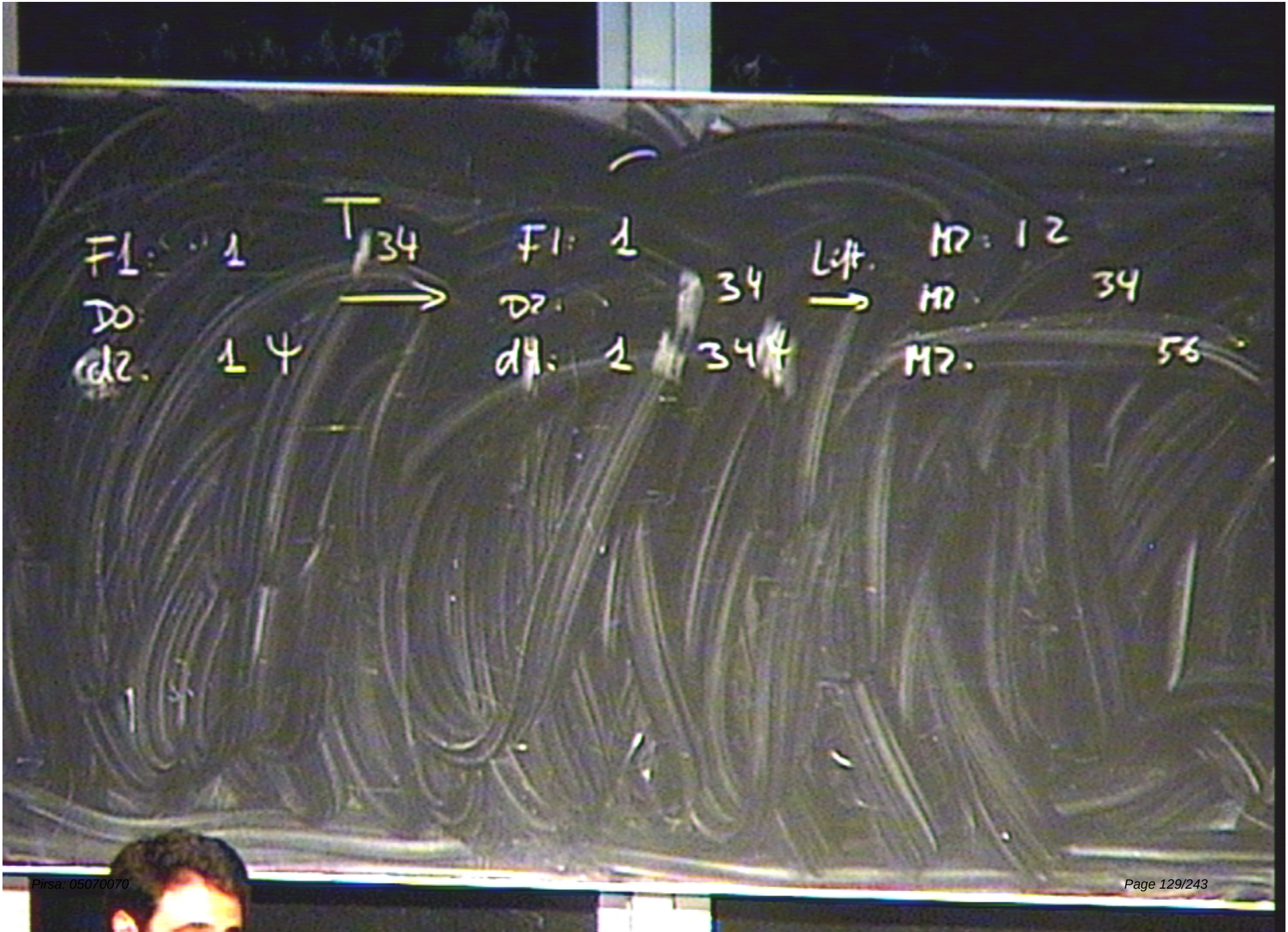

T34
Lift

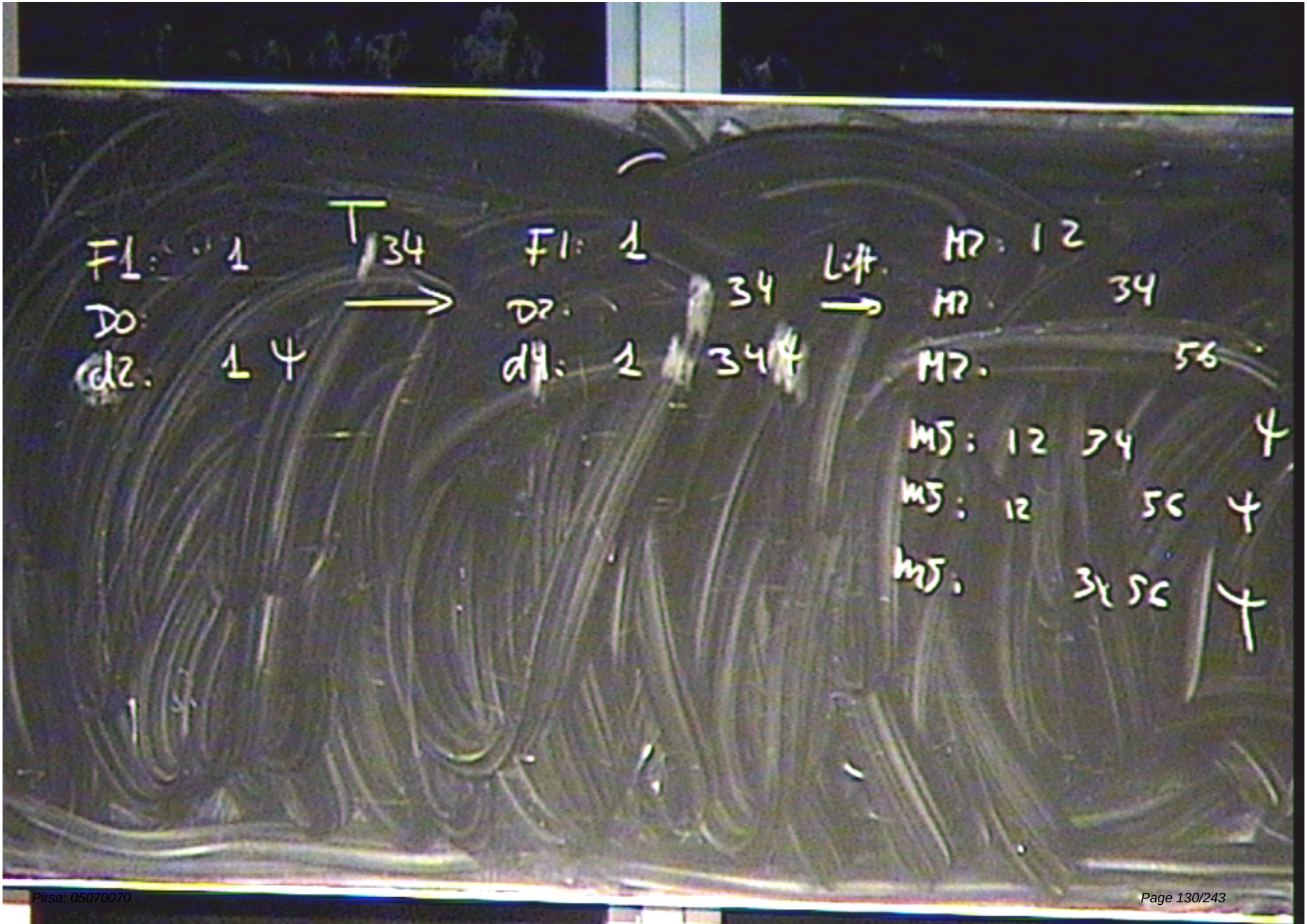

F1: 1
T34
F1: 1
Lift.
D0
D2. 34
d2. 1 4
d4: 1 34 4
1 4

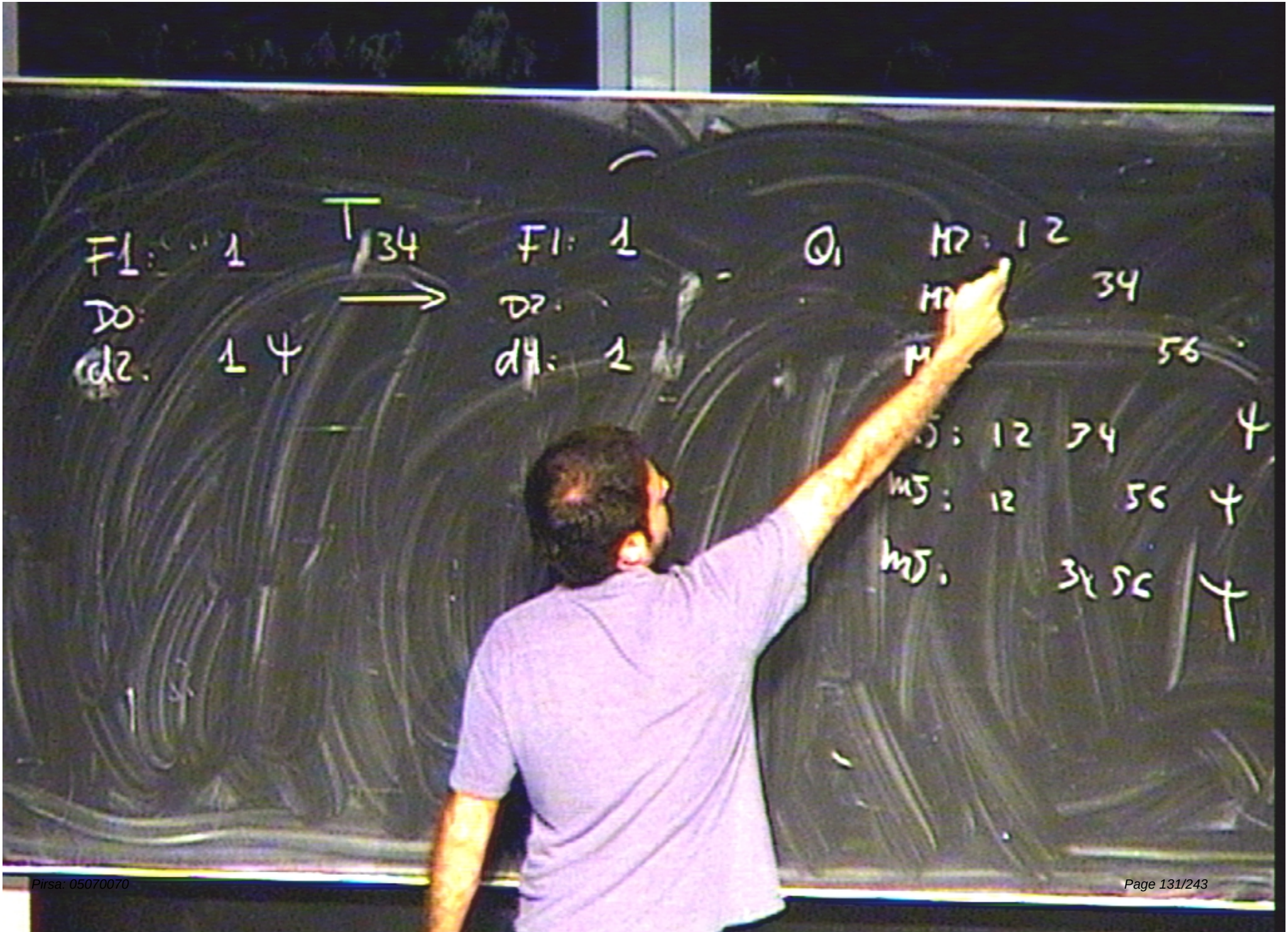

F1: 1
T34
F1: 1
Lift.
M2: 1 2
D0
D2.
34
M2.
34
d2. 1 4
d4: 1 34 4
M5: 1 2 3 4 4

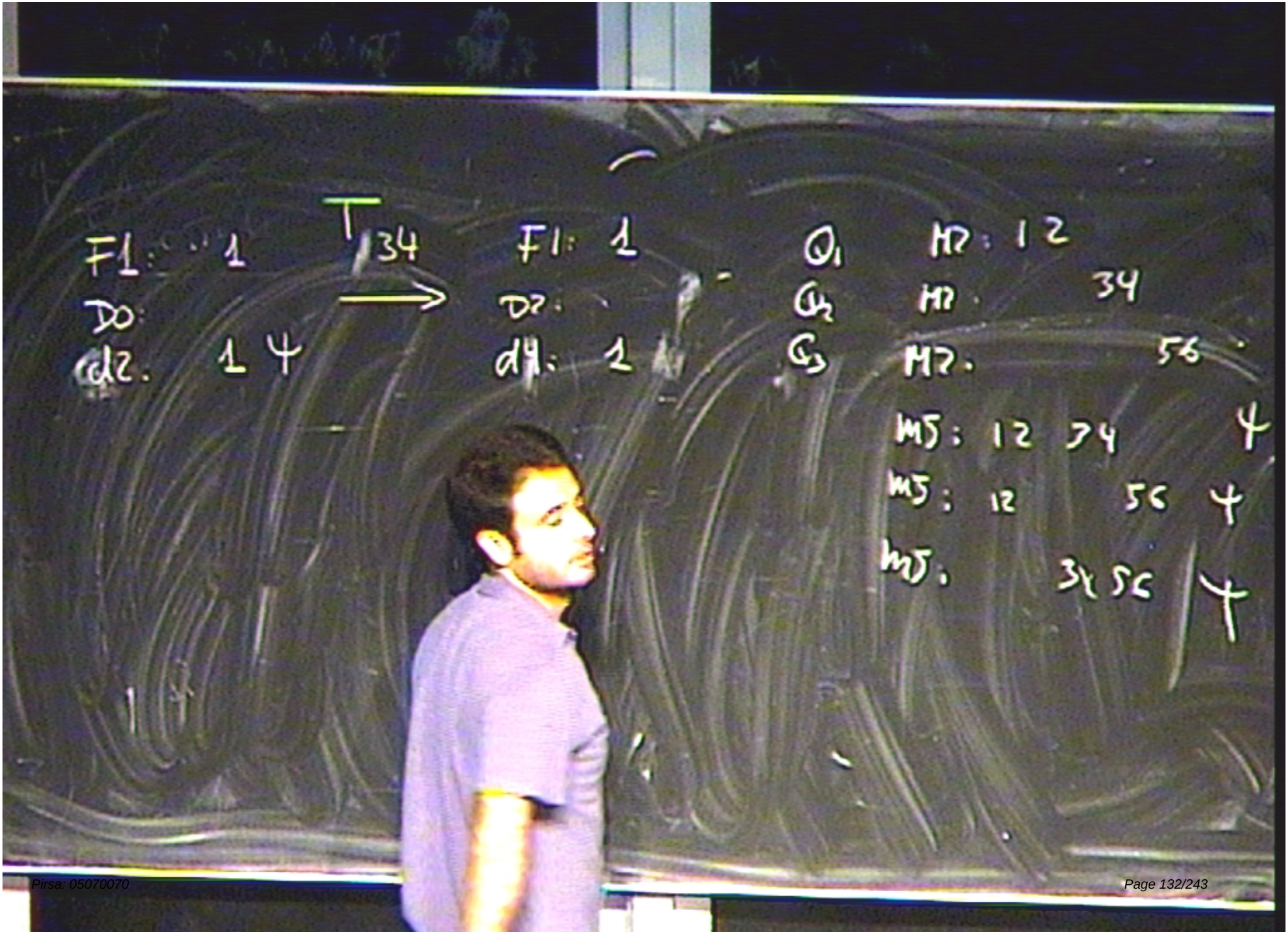

F1: 1
T34
F1: 1
Lift.
M2: 1 2
D0
D2. 34
M2. 34
d2. 1 4
d4: 1 34 4
M5: 1 2 34 4

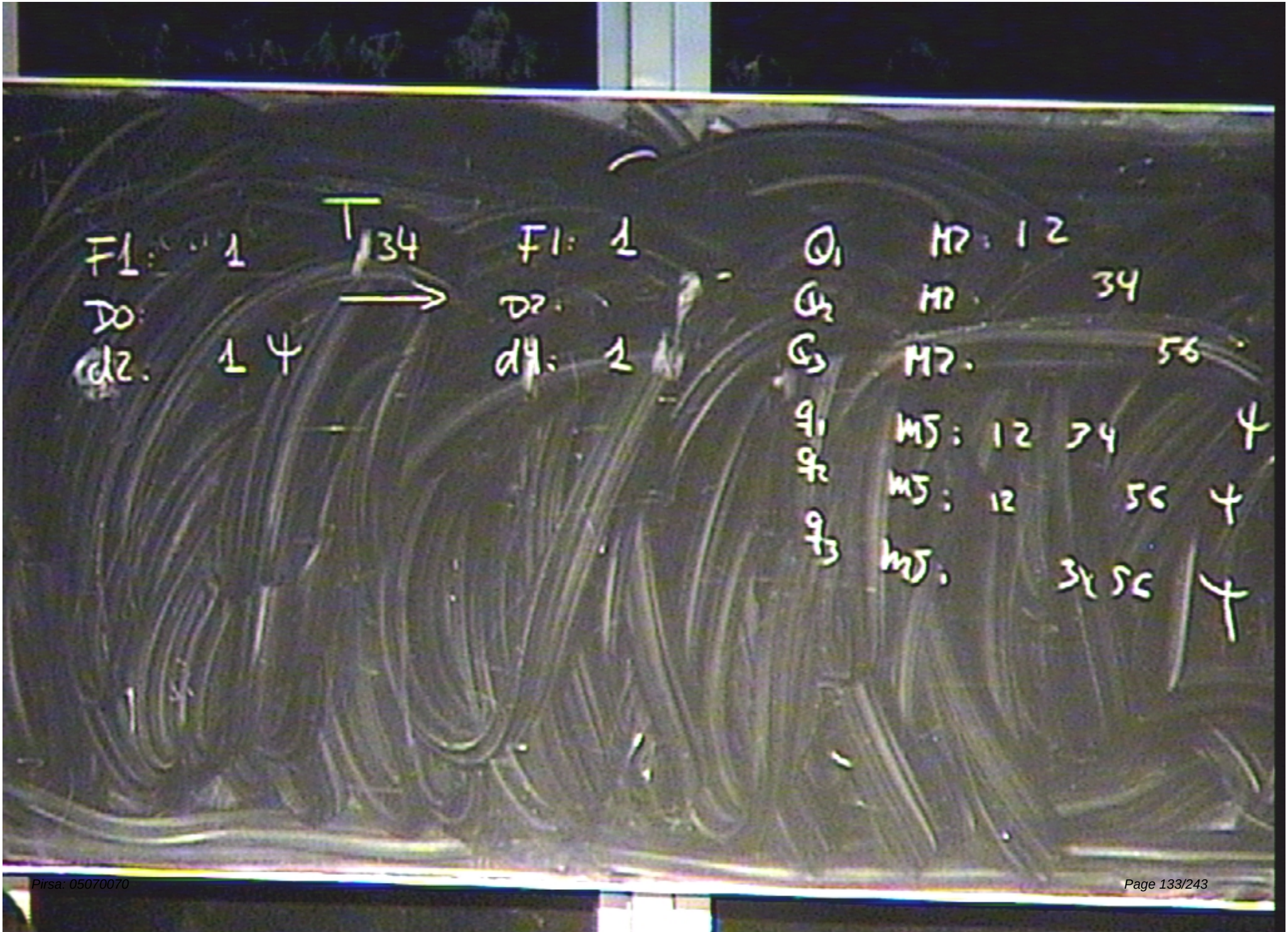

F1: 1
T34
F1: 1
Lift
M2: 12
D0
D2.
34
M2
34
d2. 14
d4: 2 134
M2.
56

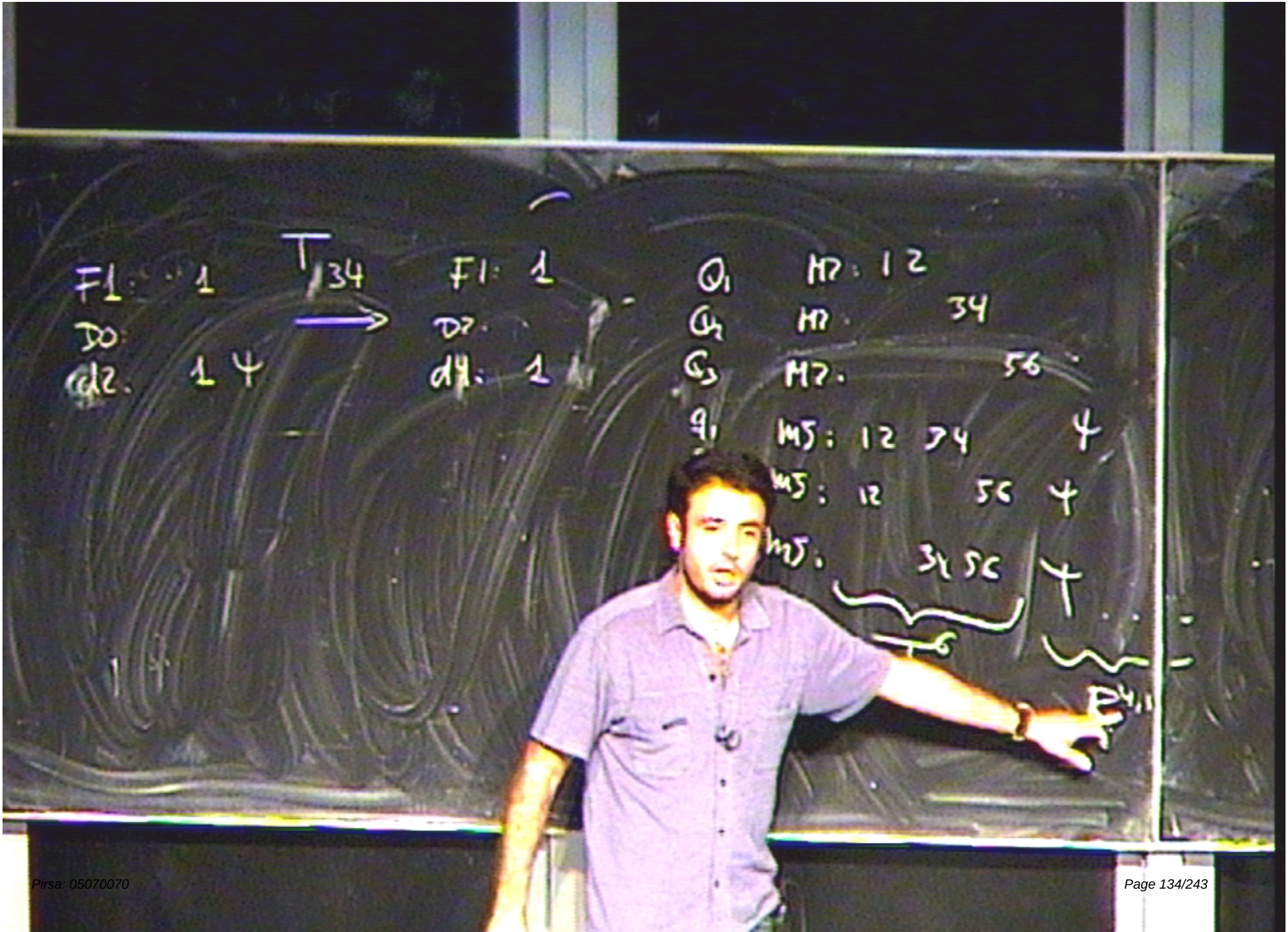

F1: 1
T 34
F1: 1
Left.
M2: 12
D0
D2: 34
M2 34
d2. 14
d4: 1 34
M2. 56

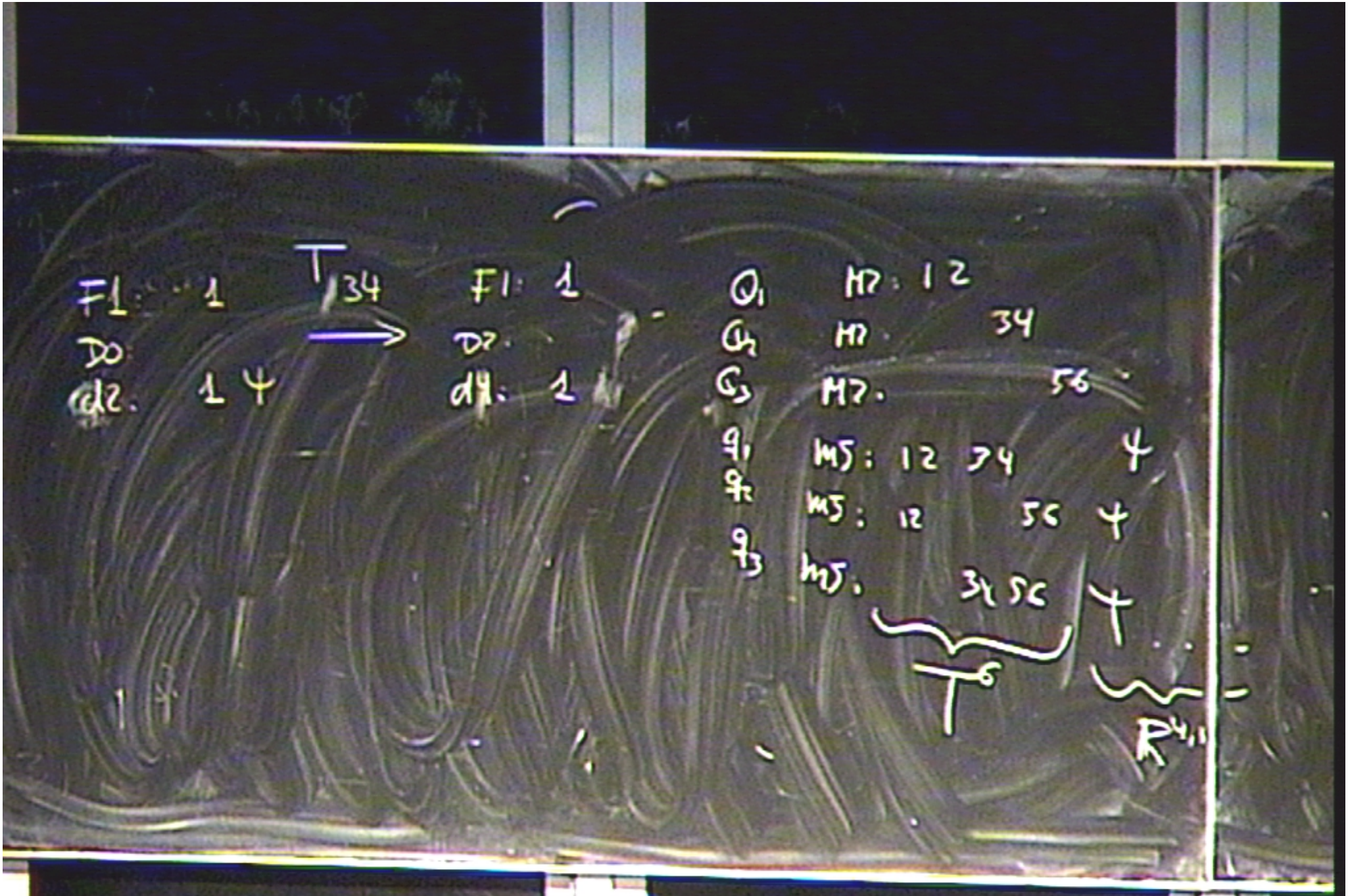

F1: 1
T 34
F1: 1
Lift
M2: 12
D0:
D2: 34
M2 34
d2. 14
d4: 1 34 4
M2. 56
M5: 12 34 4
M5: 12 56 4
M5: 34 56 4
1 4

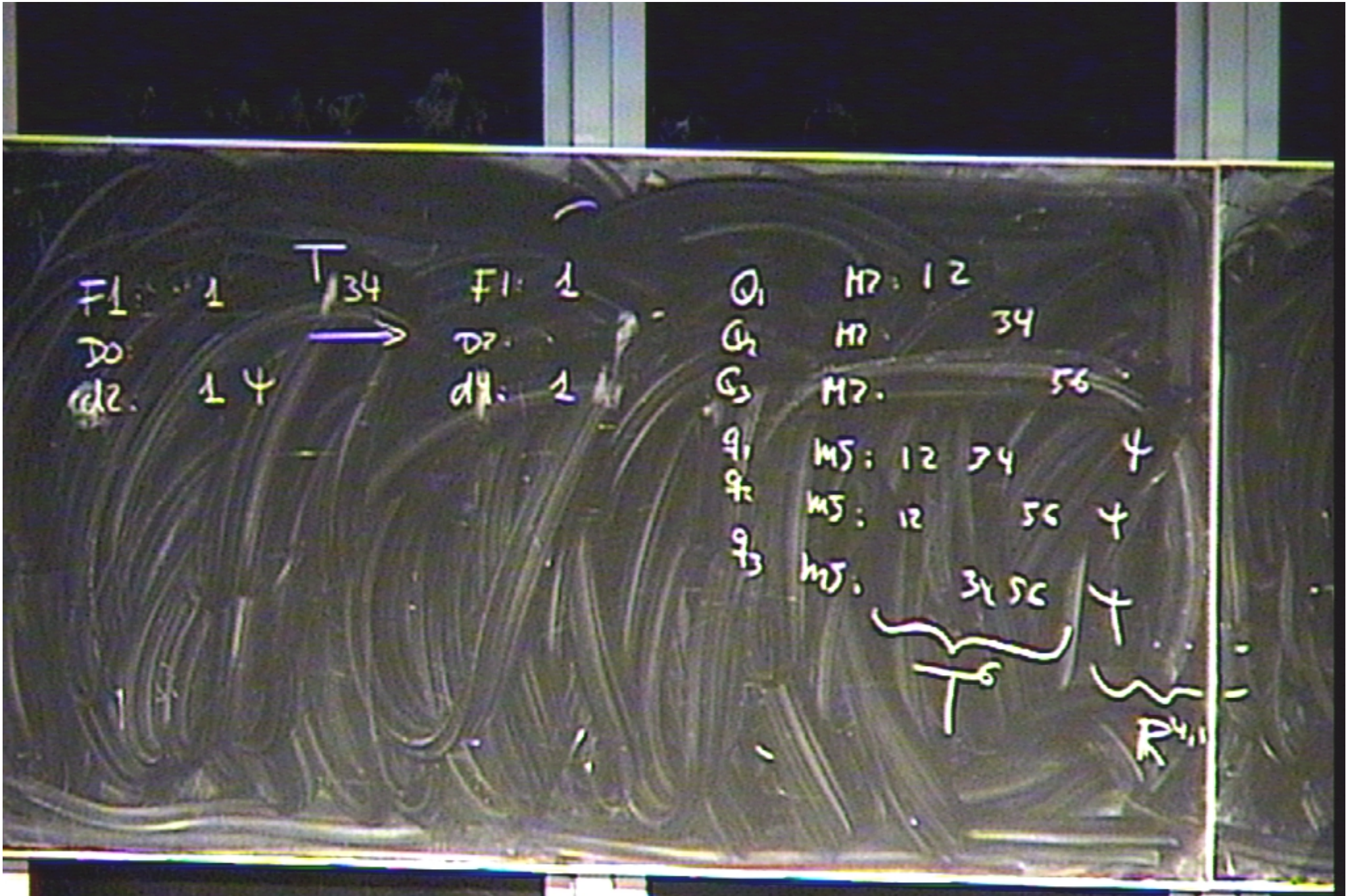

T
134
Q1

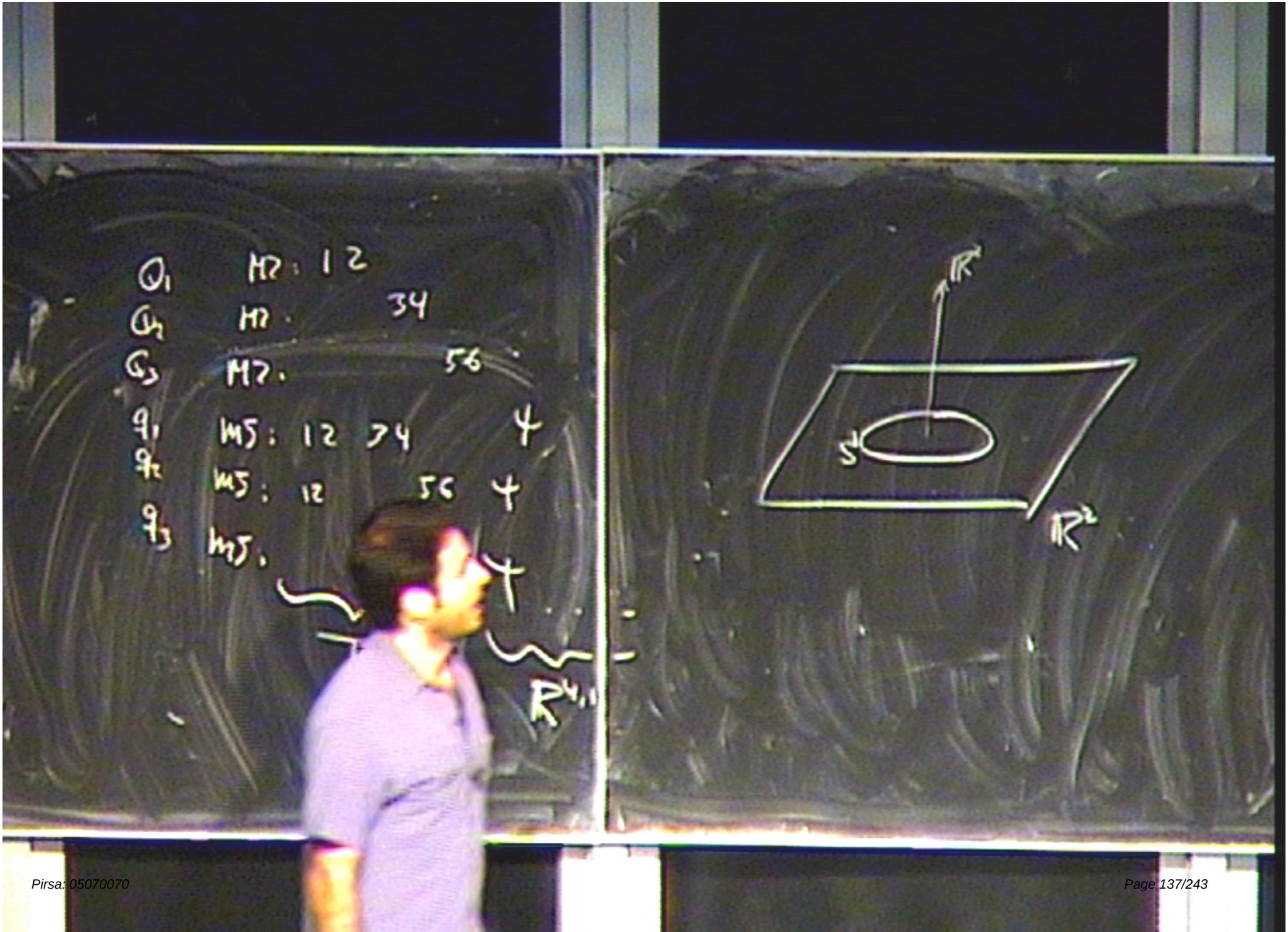

F1: 1
T 34
F1: 1
Q1 M2: 12
D0:
D2:
Q2 M2 34
d2. 14
d4: 2
Q3 M2. 56
M5: 12 34 4
M5: 12 56 4
M5: 34 56 4

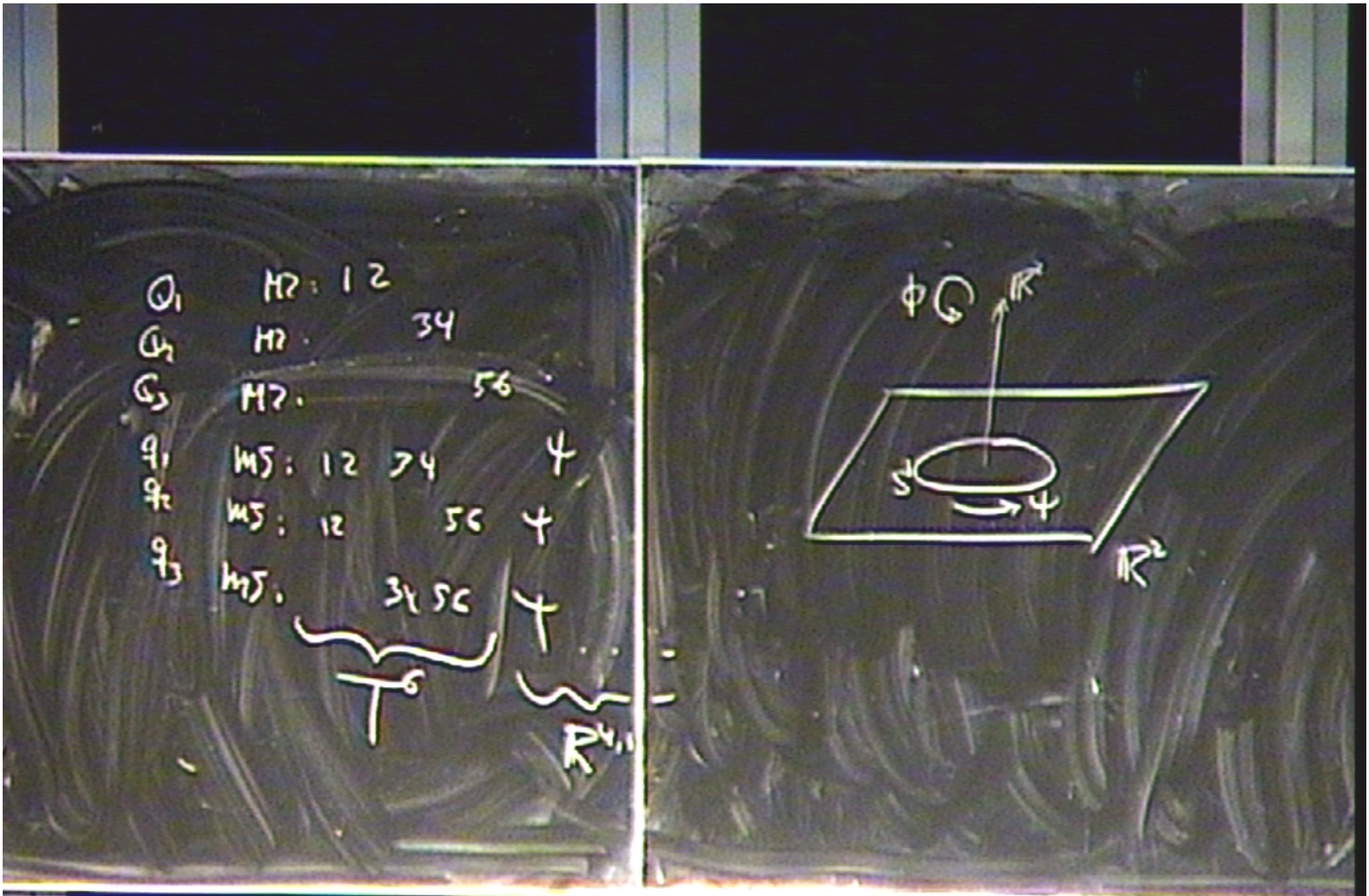

F1: 1
T134
F1: 1
D0:
D2:
d2. 1 4
d4: 2
Q1 M2: 1 2
Q2 M2. 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56 4
1 4

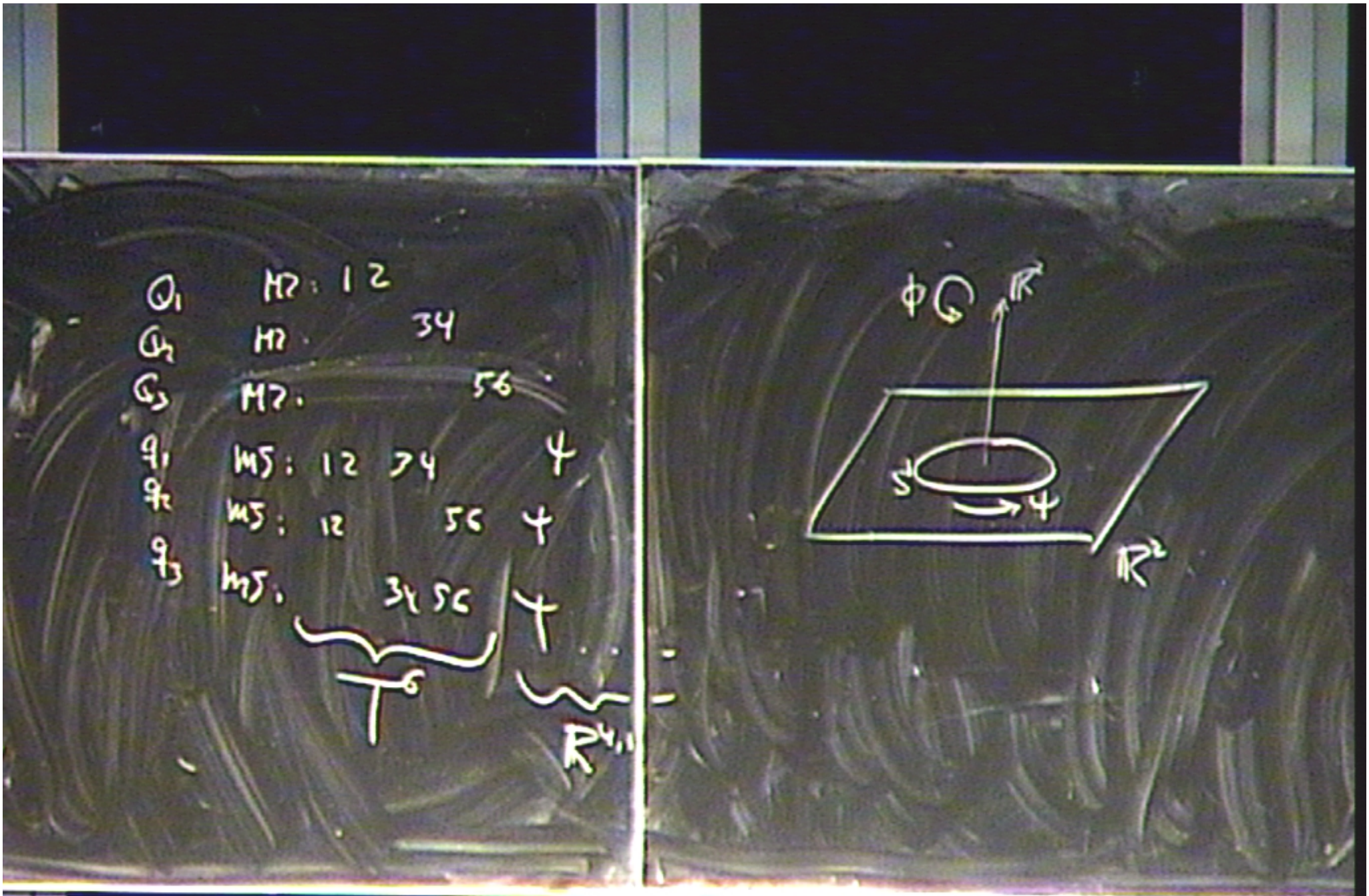

F1: 1
T34
F1: 1
D0:
D2.
d2. 1 4
d4: 1
Q1 M2: 12
Q4 M2. 34
Q3 M2. 56
q1 M5: 12 34 4
M5: 12 56 4
M5. 34 56

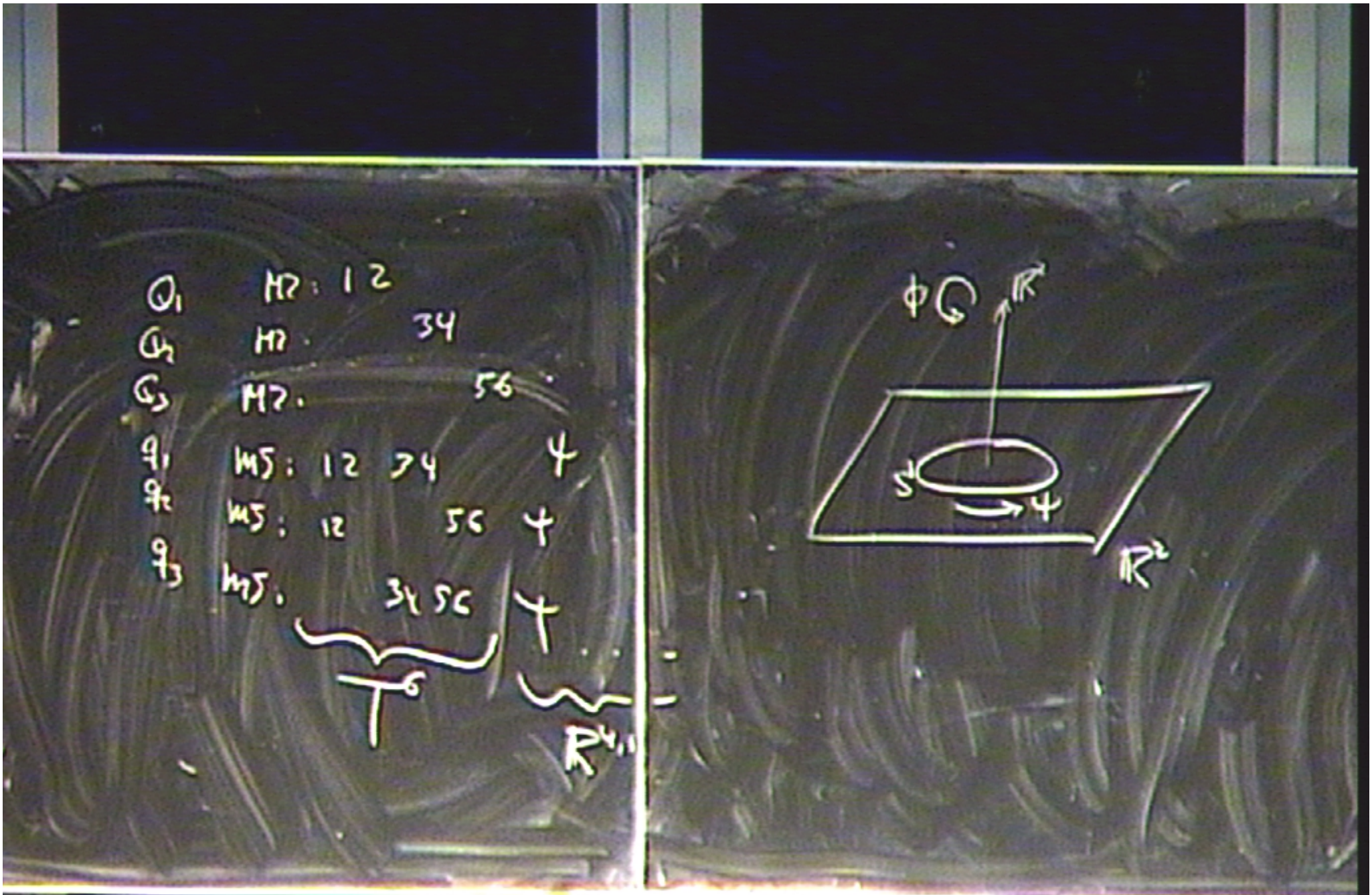

T34
Fl: 1
D0
d2. 1 ψ
Fl: 1
D2.
d4: 1
Q1 M2: 12
Q4 M2 34
Q3 M2. 56
q1 M5: 12 34 ψ
q2 M5: 12 56 ψ
q3 M5. 34 56 ψ
T6
R4,1

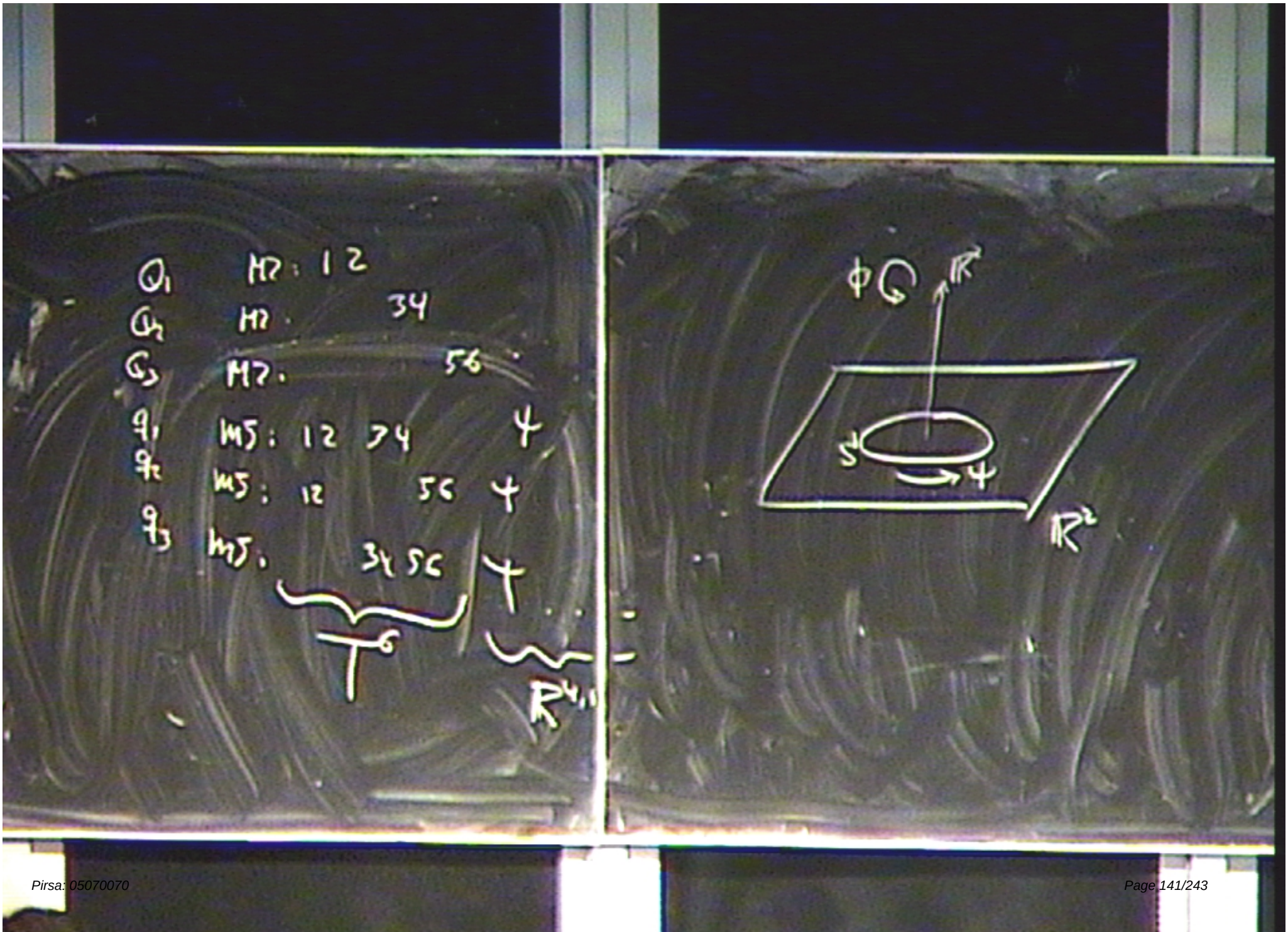

T34
F1: 1
D0:
d2. 1 4
F1: 1
D7:
d4: 1
O1 M7: 12
O4 M7 34
O3 M7. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56
T
R4,1

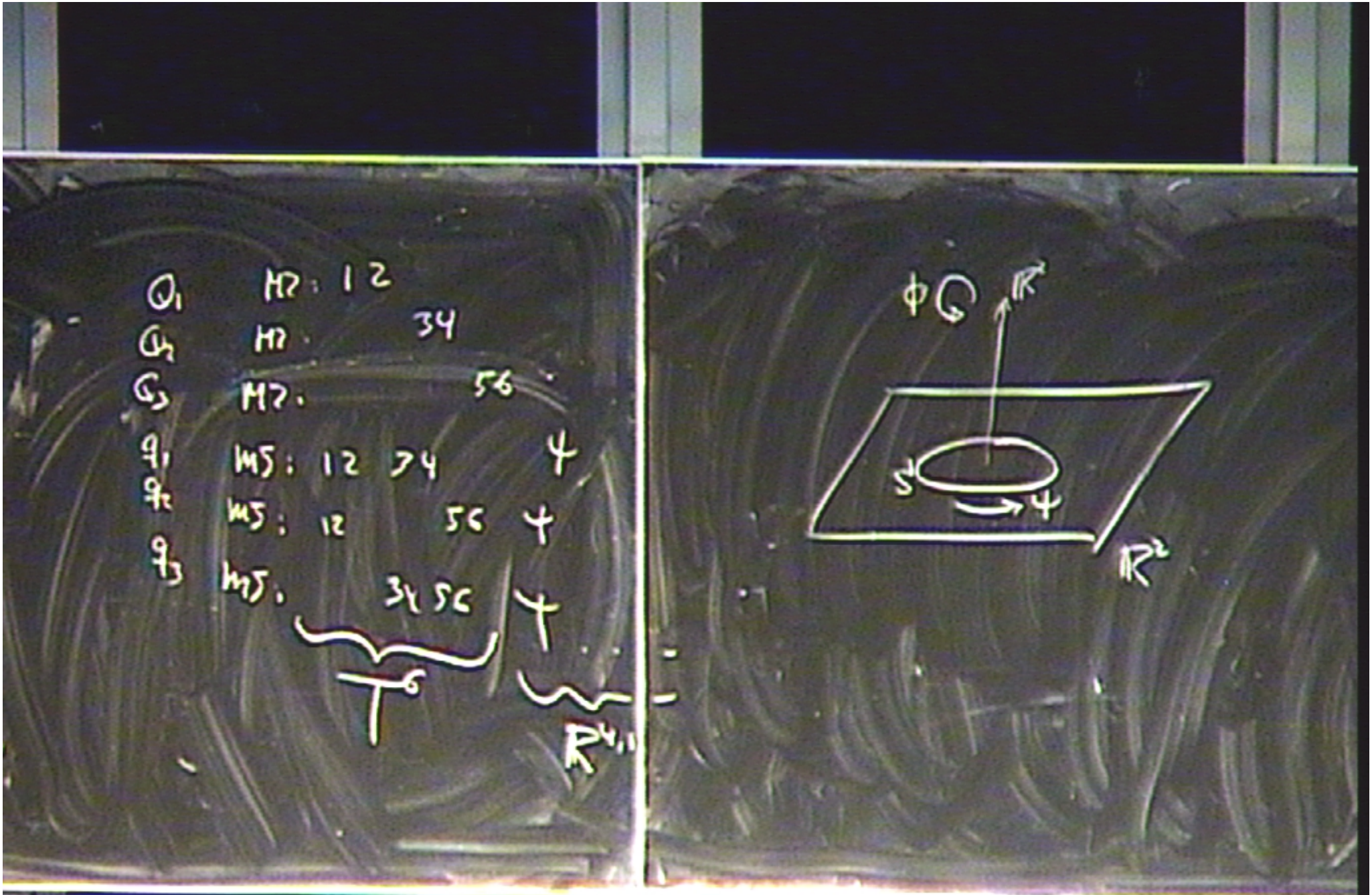

Q_1 M2: 12
G_1 M2: 34
G_2 M2: 56
q_1 M5: 12 34 4
q_2 M5: 12 56 4
q_3 M5: 4
$\mathbb{R}^{4,1}$
$\mathbb{R}$
S^1
$\mathbb{R}^2$

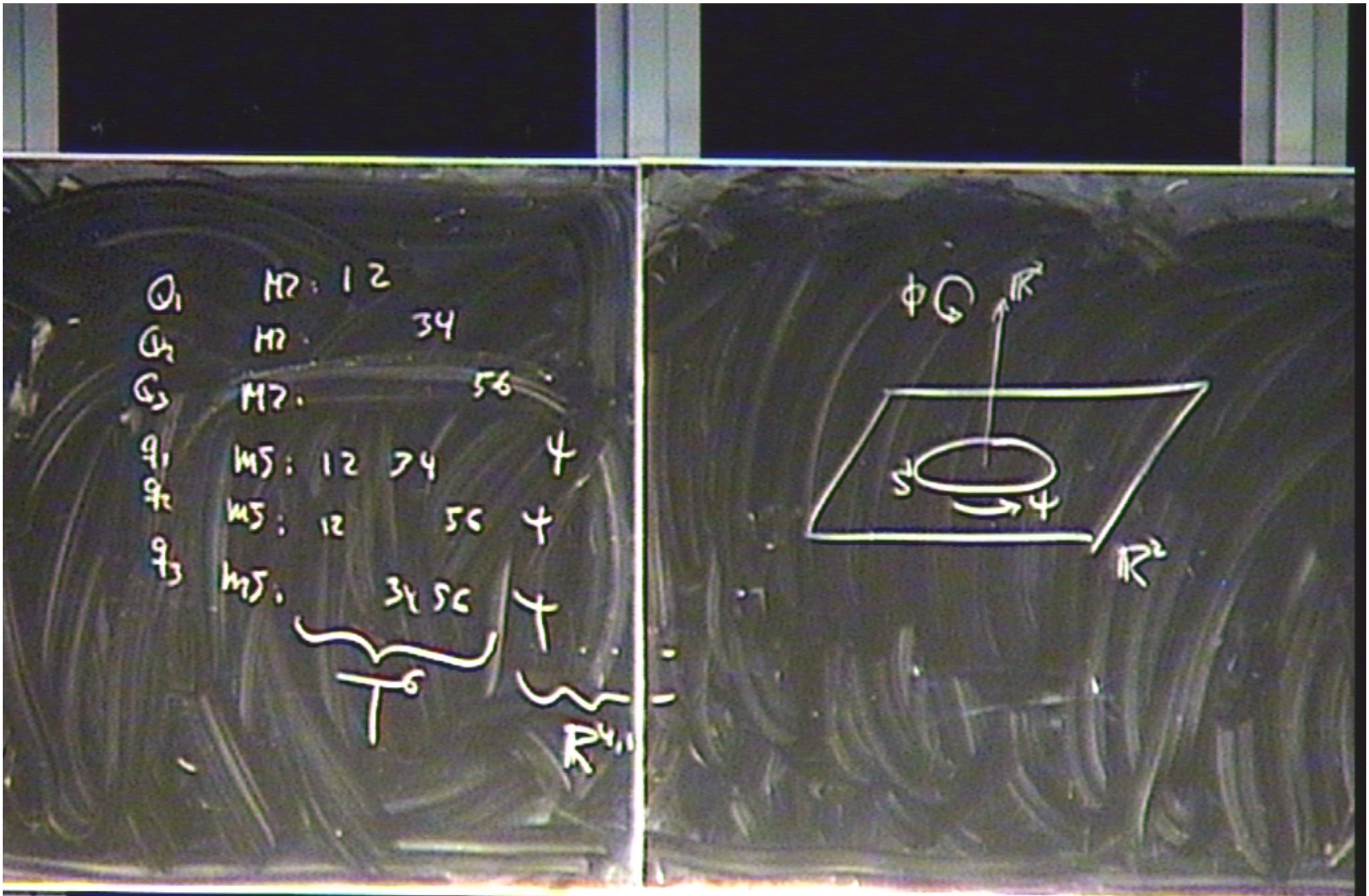

Q_1 M2: 12
G_1 M2: 34
G_2 M2: 56
q_1 M5: 12 34 4
q_2 M5: 12 56 4
q_3 M5: 34 56 4
T^6
$R^{4,1}$
ϕG
$\mathbb{R}$
S^1
4
R^2

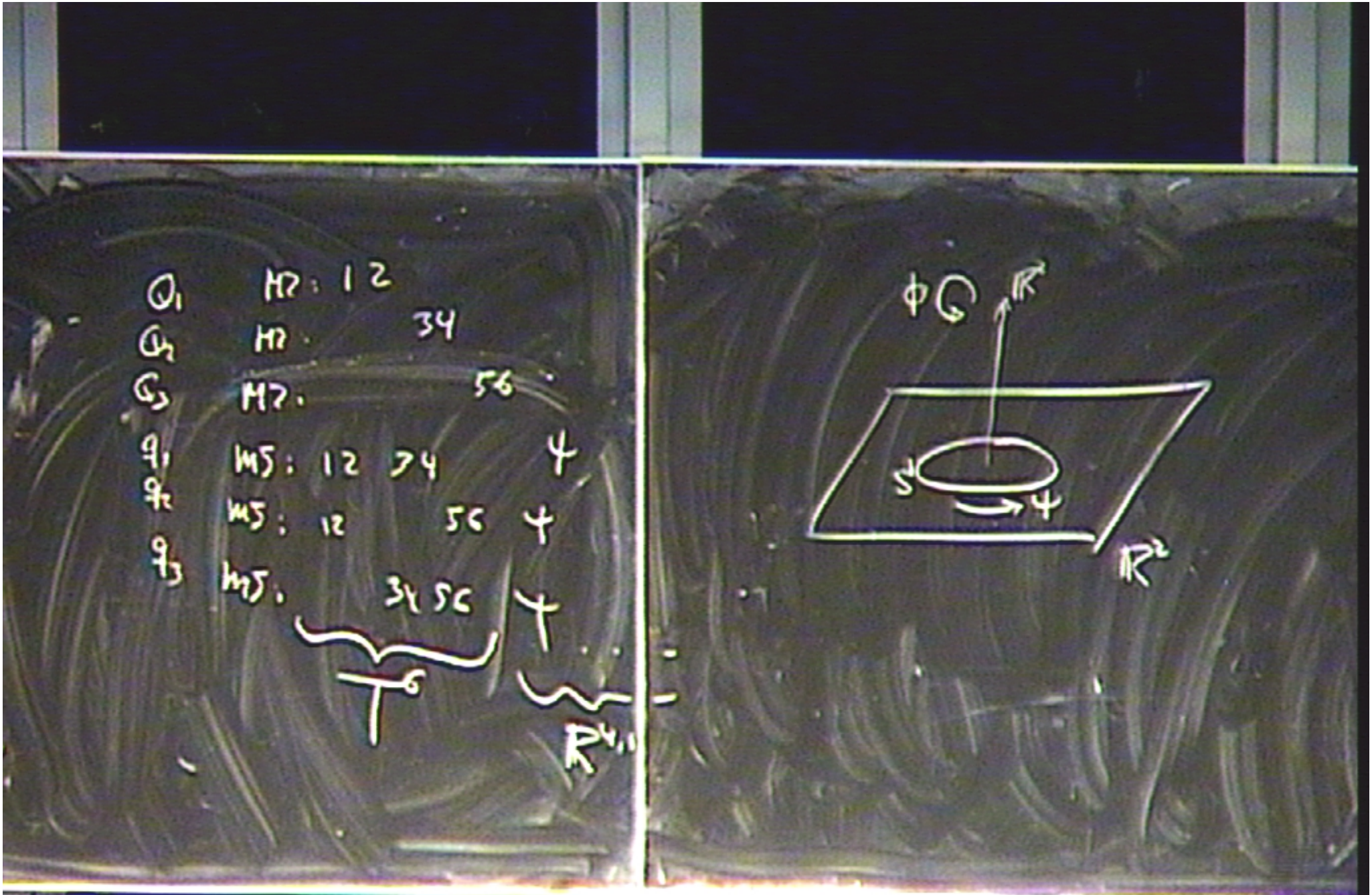

Q_1 M2: 12
G_2 M2: 34
G_3 M2: 56
q_1 M5: 12 34 4
q_2 M5: 12 56 4
q_3 M5: 34 56 4
T6
$R^{4,1}$
ϕG
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

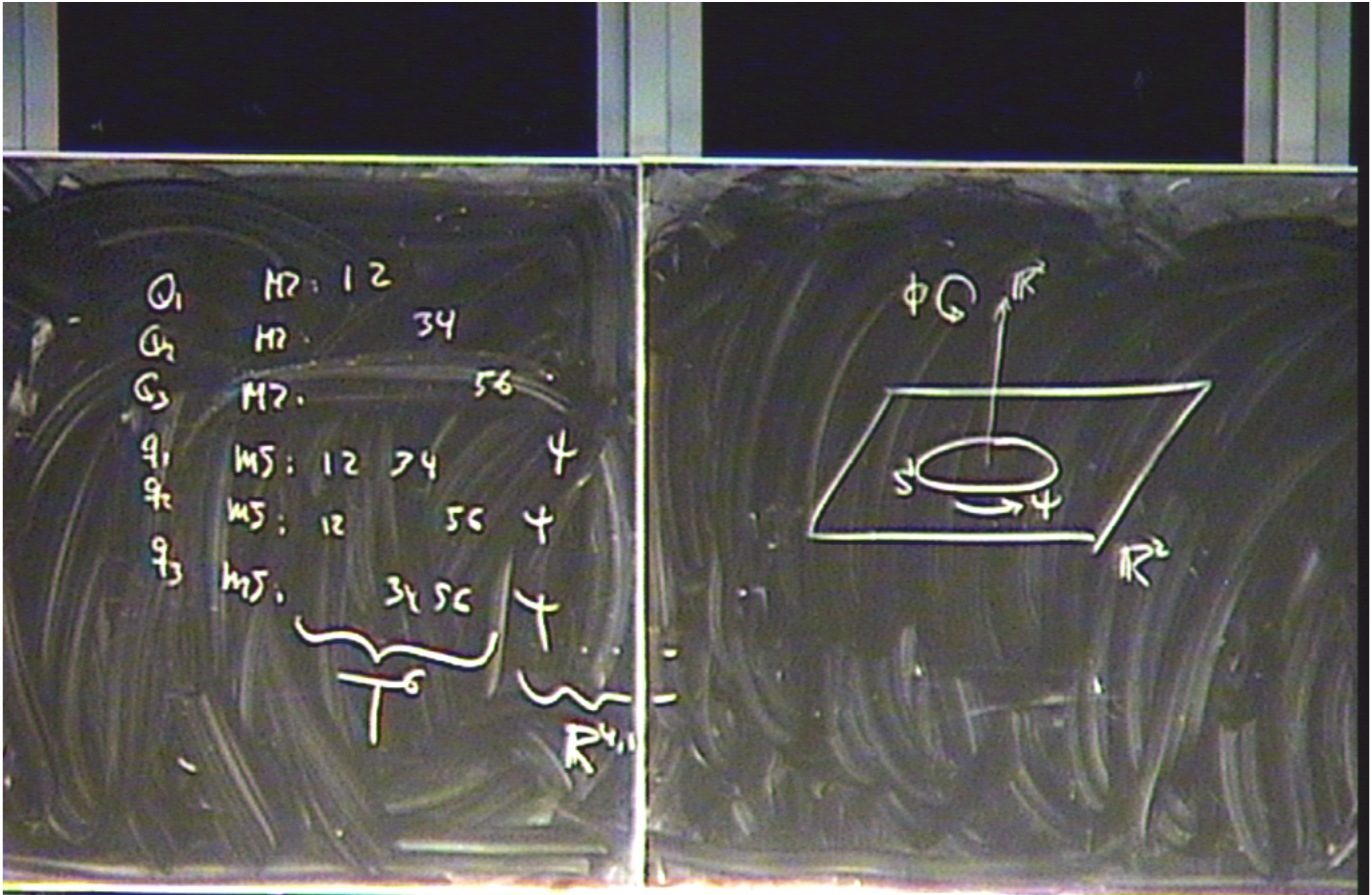

Q_1 M2 : 12
G_2 M2 . 34
G_3 M2 . 56
q_1 M5 : 12 34 4
q_2 M5 : 12 56 4
q_3 M5 . 34 56 4
T6
$\mathbb{R}^{4,1}$
ϕG
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

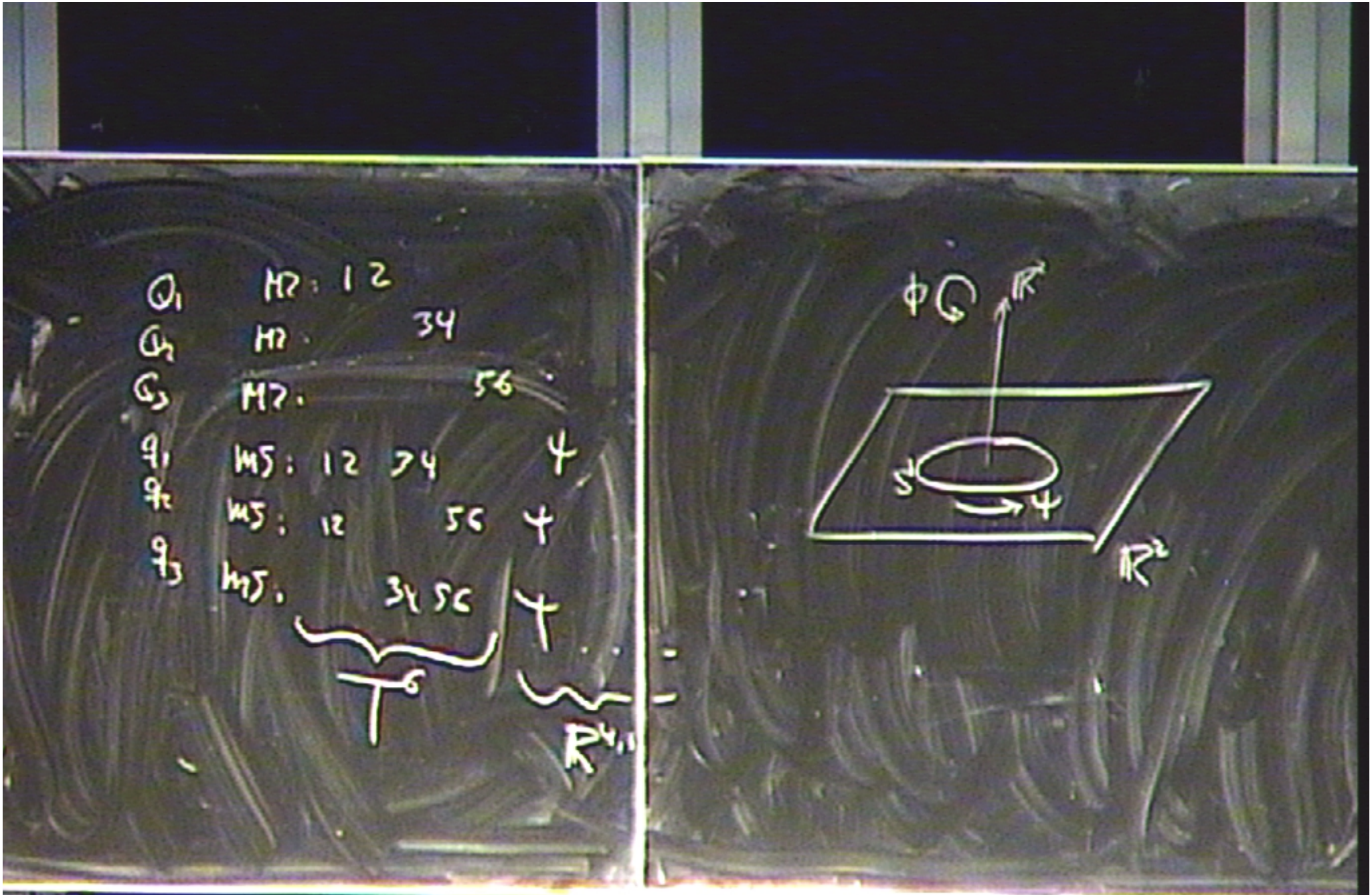

Q_1 M2 : 12
Q_2 M2 . 34
Q_3 M2 . 56
q_1 M5 : 12 34 4
q_2 M5 : 12 56 4
q_3 M5 . 34 56 4
T6
$\mathbb{R}^{4,1}$
ϕG
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

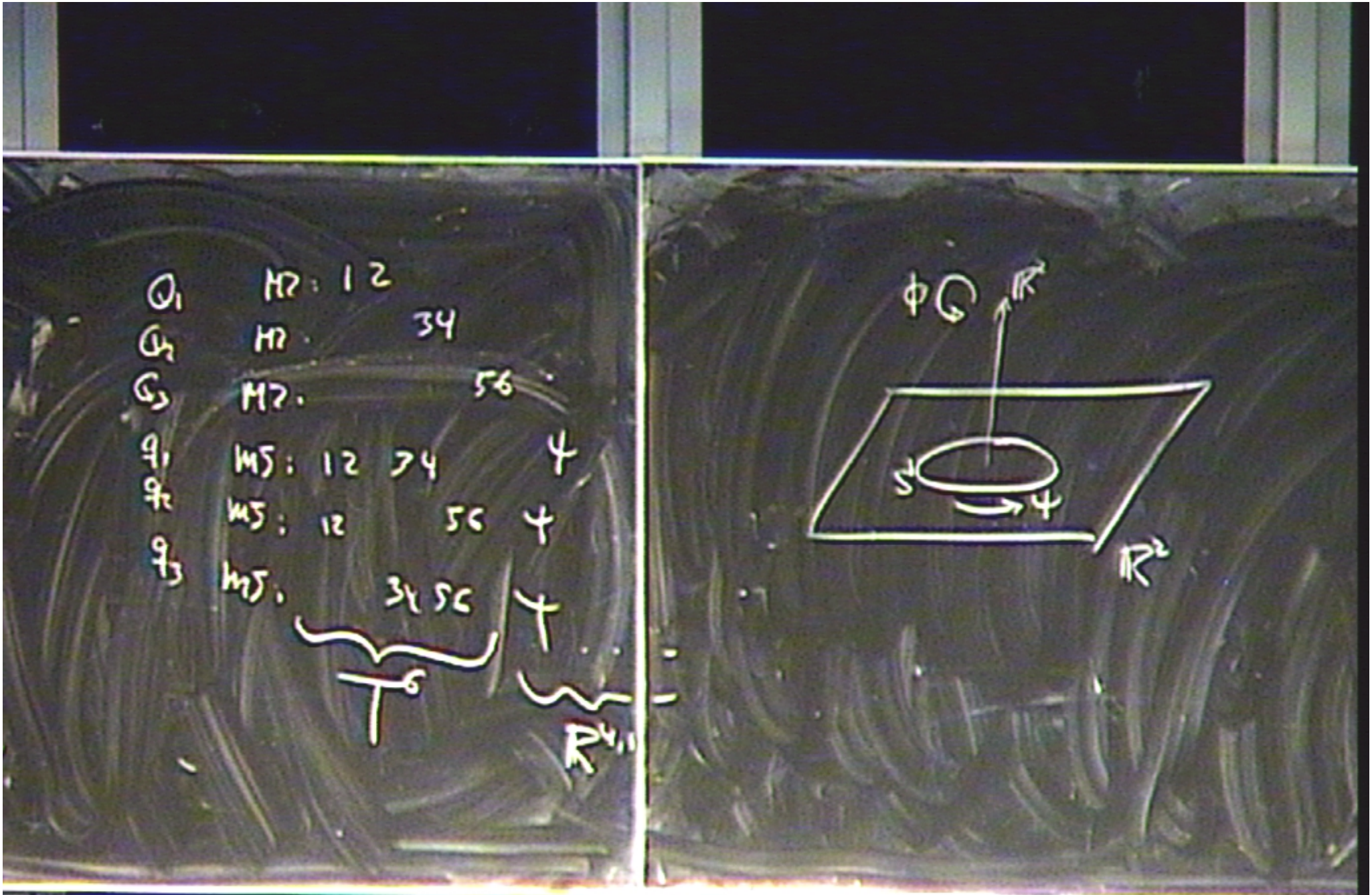

Q_1 NN: 12
Q_2 NN: 34
Q_3 NN: 56
q_1 MM: 12 34 4
q_2 MM: 12 56 4
q_3 MM: 34 56 4
T^6
$\mathbb{R}^{4,1}$
ϕ_Q
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

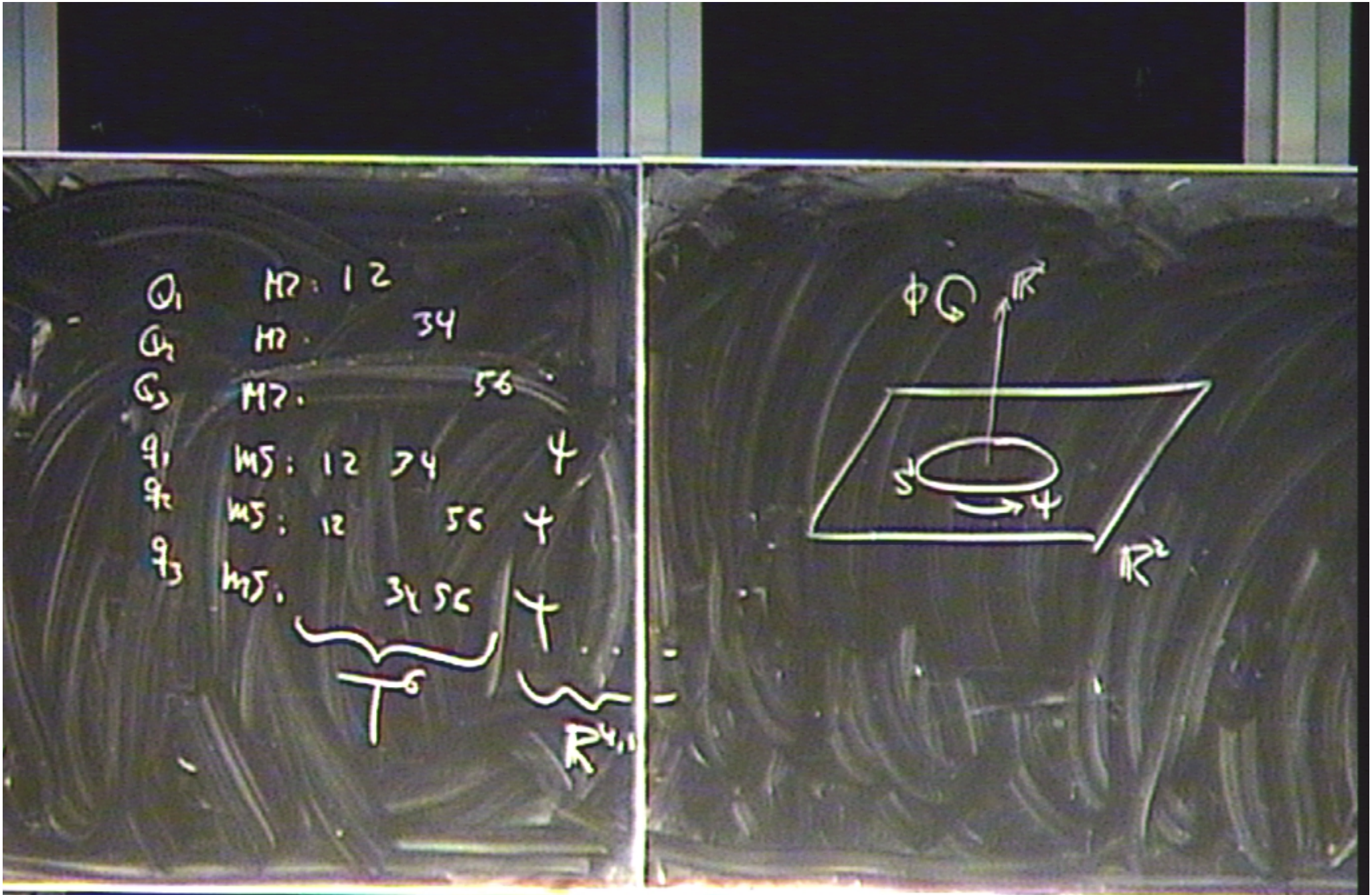

Q_1 M2 : 12
G_2 M2 . 34
G_3 M2 . 56
q_1 M5 : 12 34 4
q_2 M5 : 12 56 4
q_3 M5 . 34 56 4
T^6
$\mathbb{R}^{4,1}$
ϕ_G
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

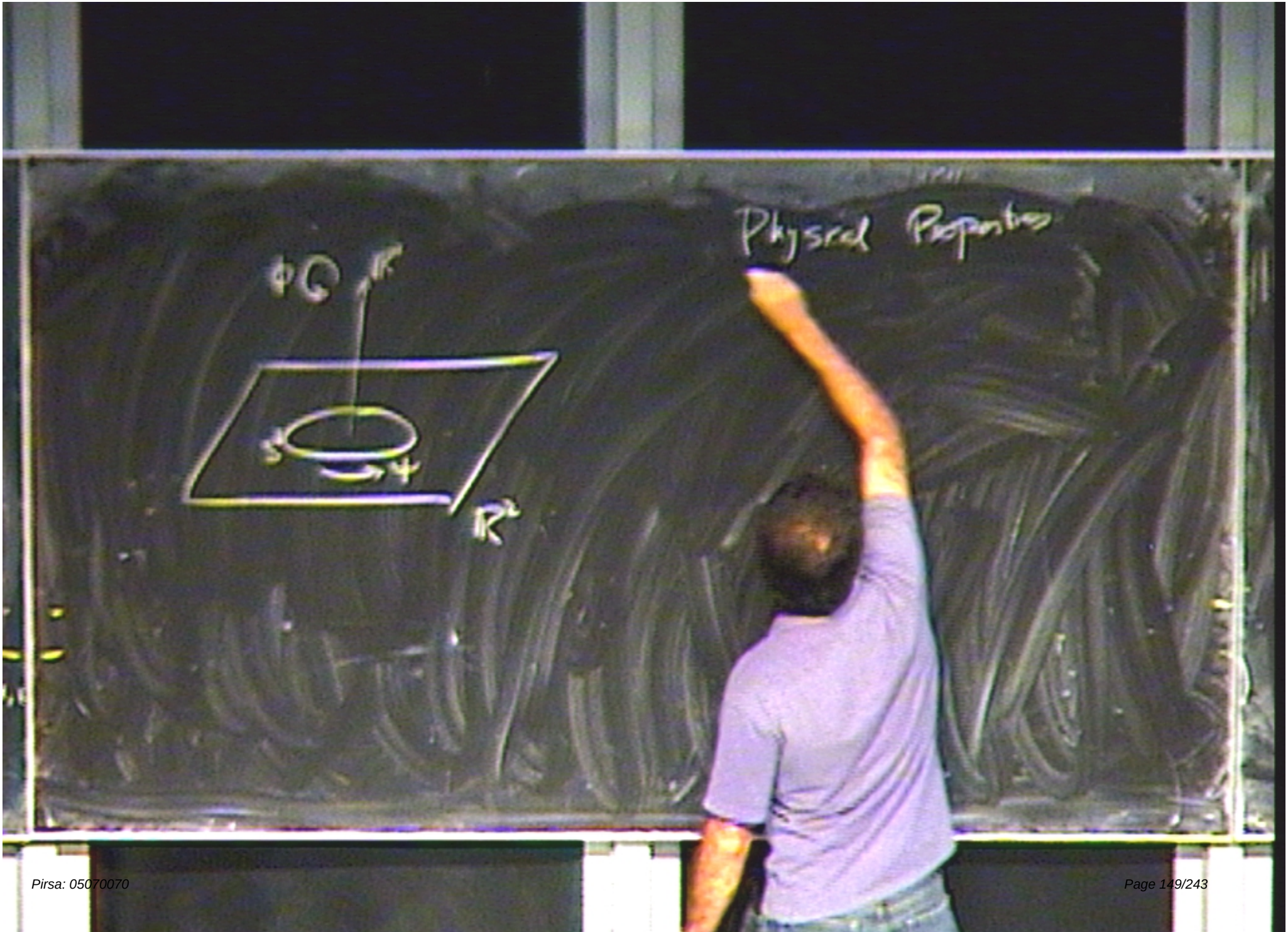

Q_1 M2: 12
G_2 M2: 34
G_3 M2: 56
q_1 M5: 12 34 ψ
q_2 M5: 12 56 ψ
q_3 M5: 34 56 ψ
T^6
$R^{4,1}$
ϕG
$\mathbb{R}$
S^1
ψ
$\mathbb{R}^2$

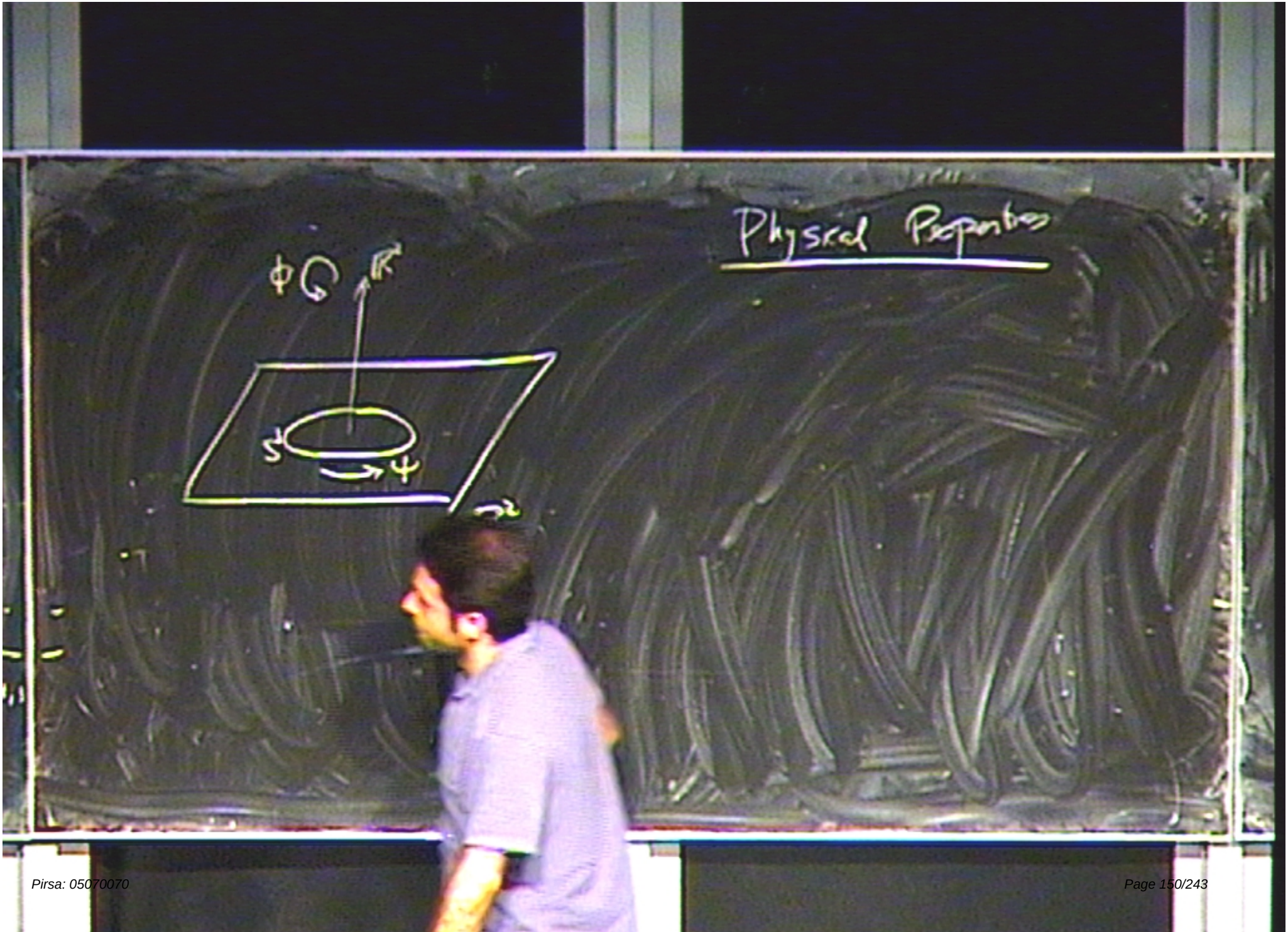

Q_1 M2: 12
G_2 M2: 34
G_3 M2: 56
q_1 M5: 12 34 ψ
q_2 M5: 12 56 ψ
q_3 M5: 34 56 ψ
T^6
$\mathbb{R}^{4,1}$
ϕG
$\mathbb{R}$
S^1
ψ
$\mathbb{R}^2$


Q_1 M2: 12
Q_2 M2: 34
Q_3 M2: 56
q_1 M5: 12 34 4
q_2 M5: 12 56 4
q_3 M5: 34 56 4
T^6
$\mathbb{R}^{4,1}$
ϕG
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

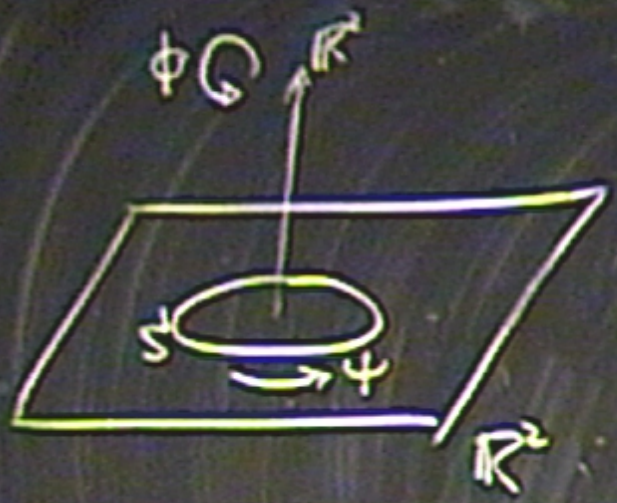

Q_1 M2: 12
G_2 M2: 34
G_3 M2: 56
q_1 M5: 12 34 4
q_2 M5: 12 56 4
q_3 M5: 34 56 4
T^6
$\mathbb{R}^{4,1}$
ϕG
$\mathbb{R}$
S^1
4
$\mathbb{R}^2$

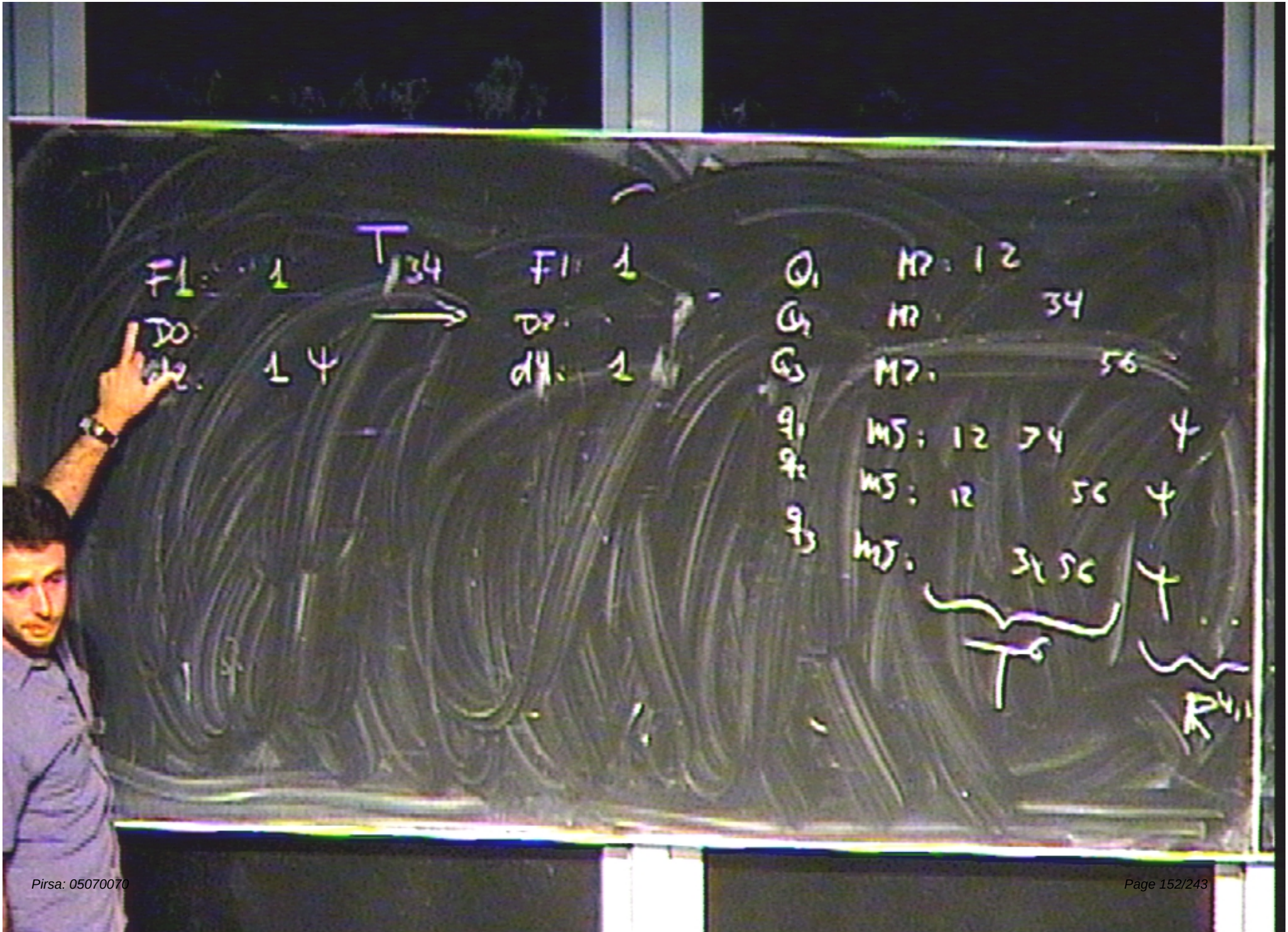

Q_1 M2: 12
G_2 M2: 34
G_3 M2: 56
q_1 M5: 12 34 ψ
q_2 M5: 12 56 ψ
q_3 M5: 34 56 ψ
T^6
$\mathbb{R}^{4,1}$
ϕG
$\mathbb{R}$
S^1
ψ
$\mathbb{R}^2$

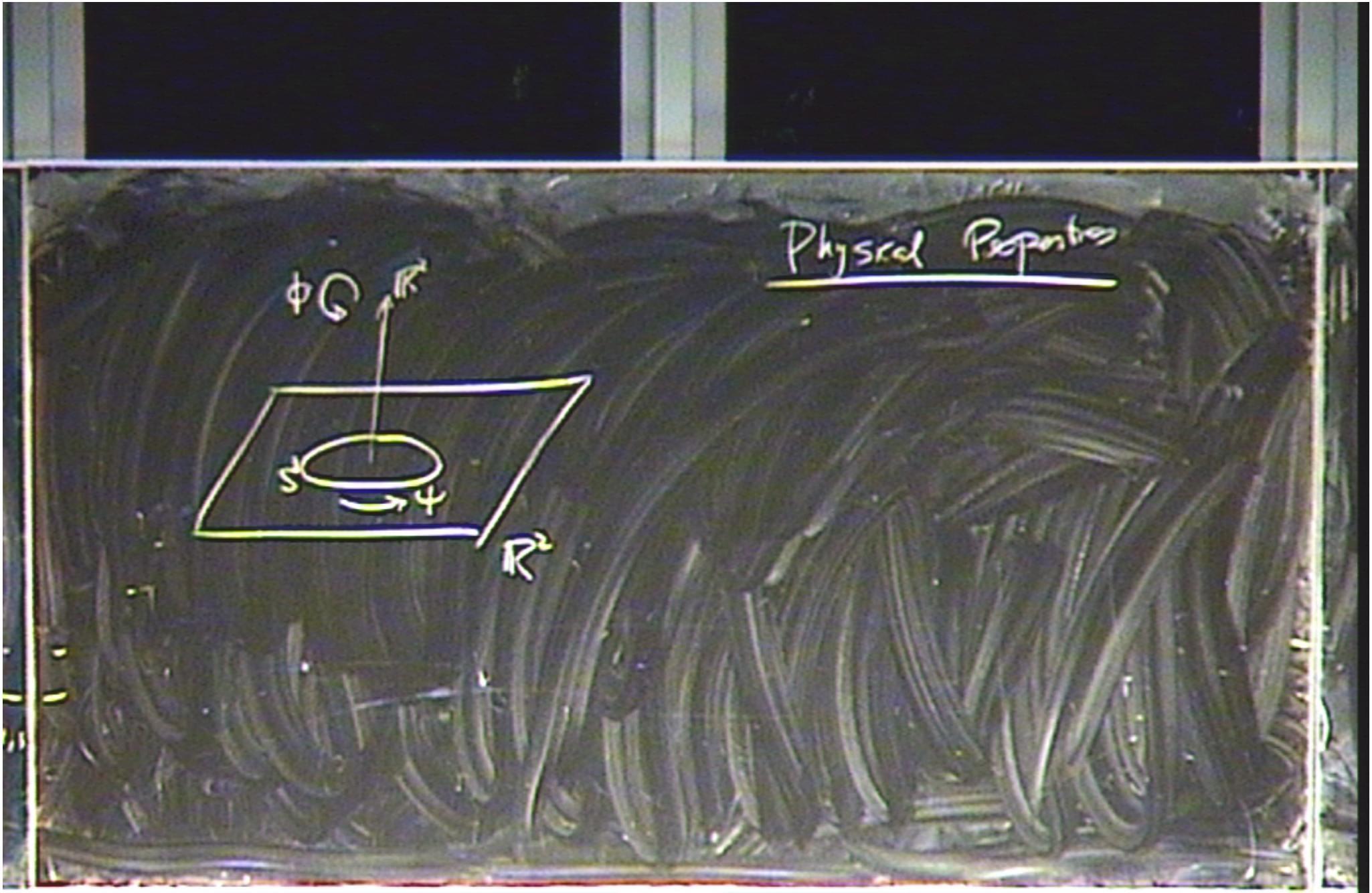

Physical Properties
$\mathbb{R}^2$

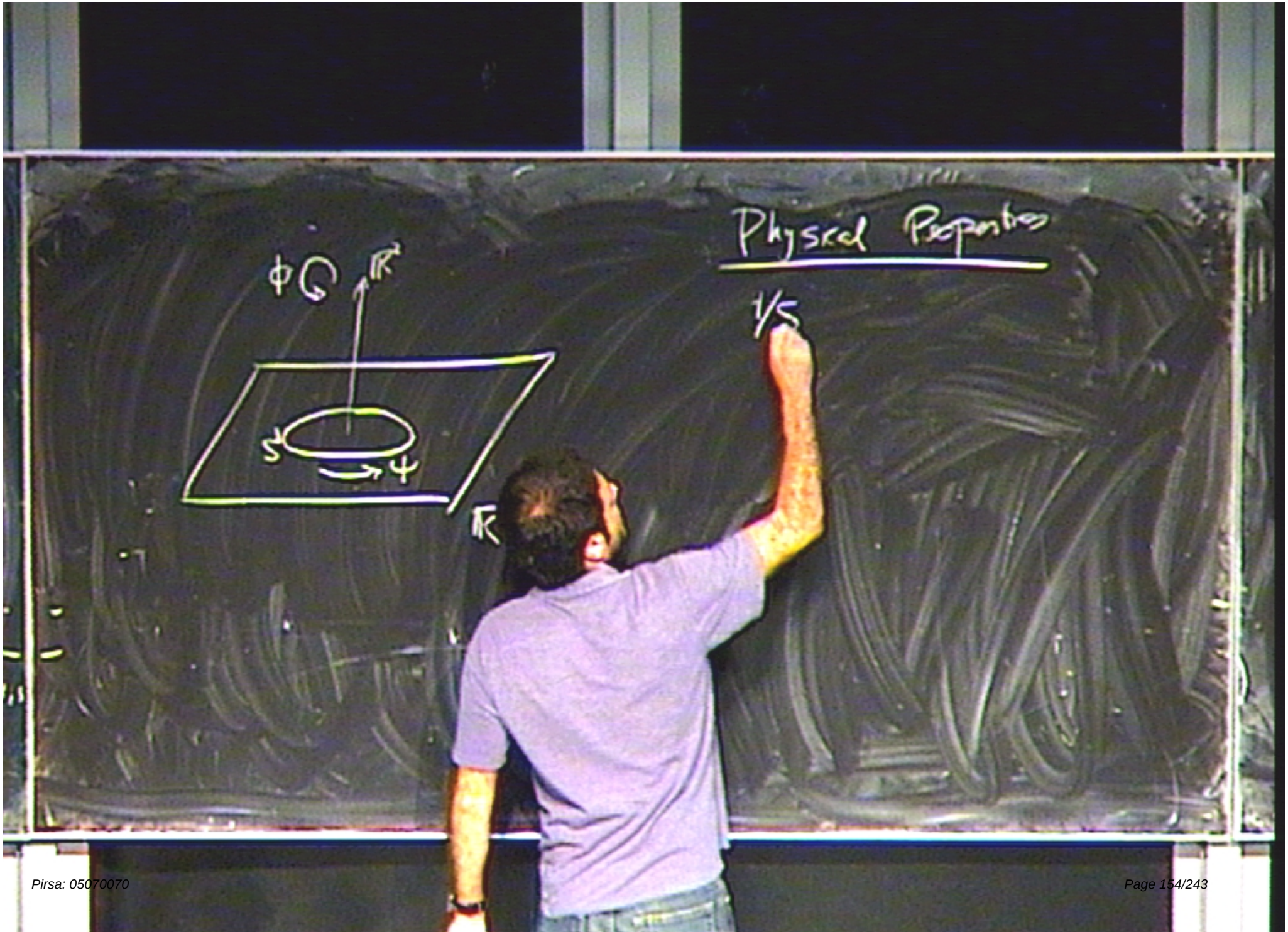

Physical Properties

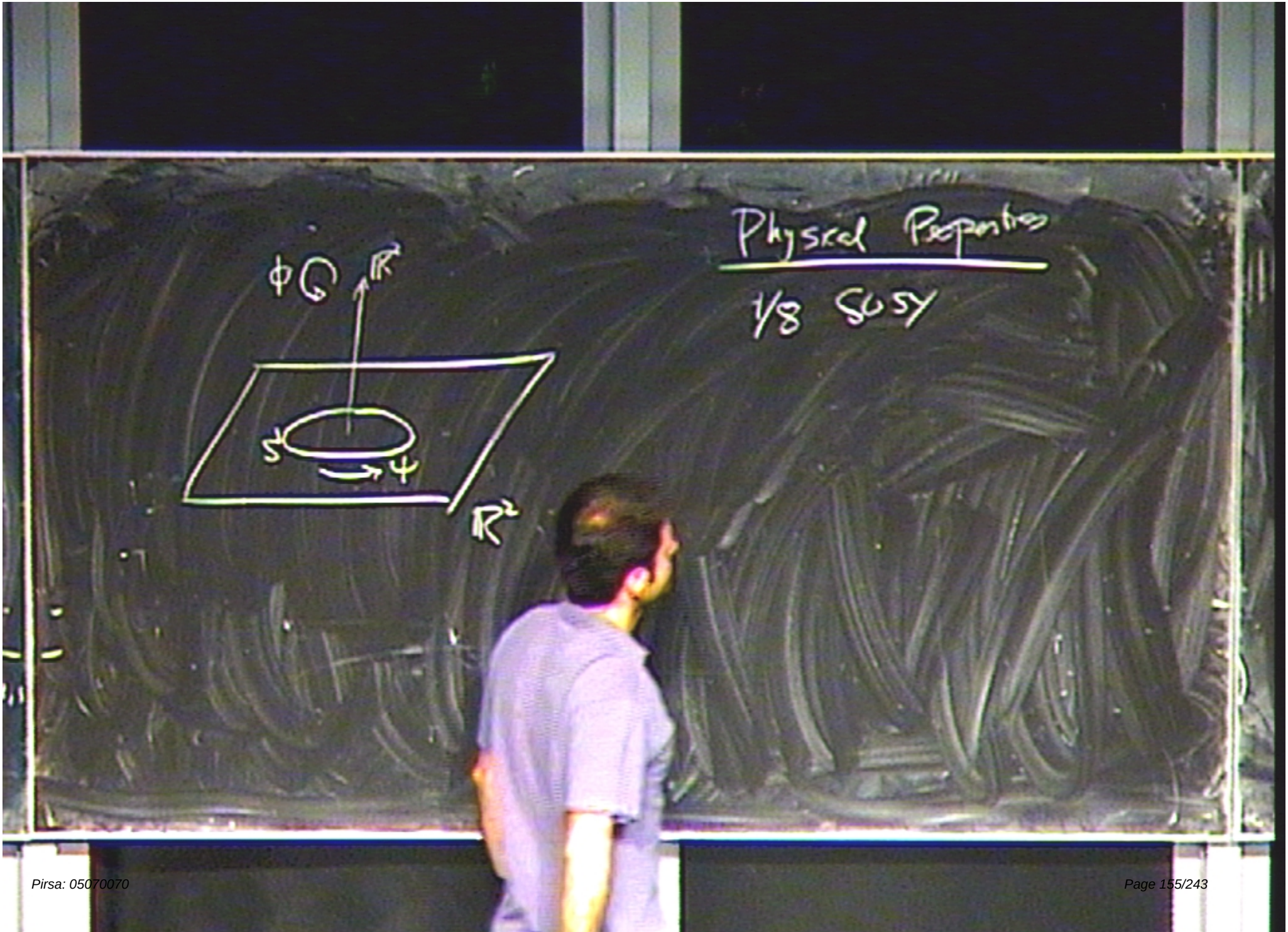
Physical Properties

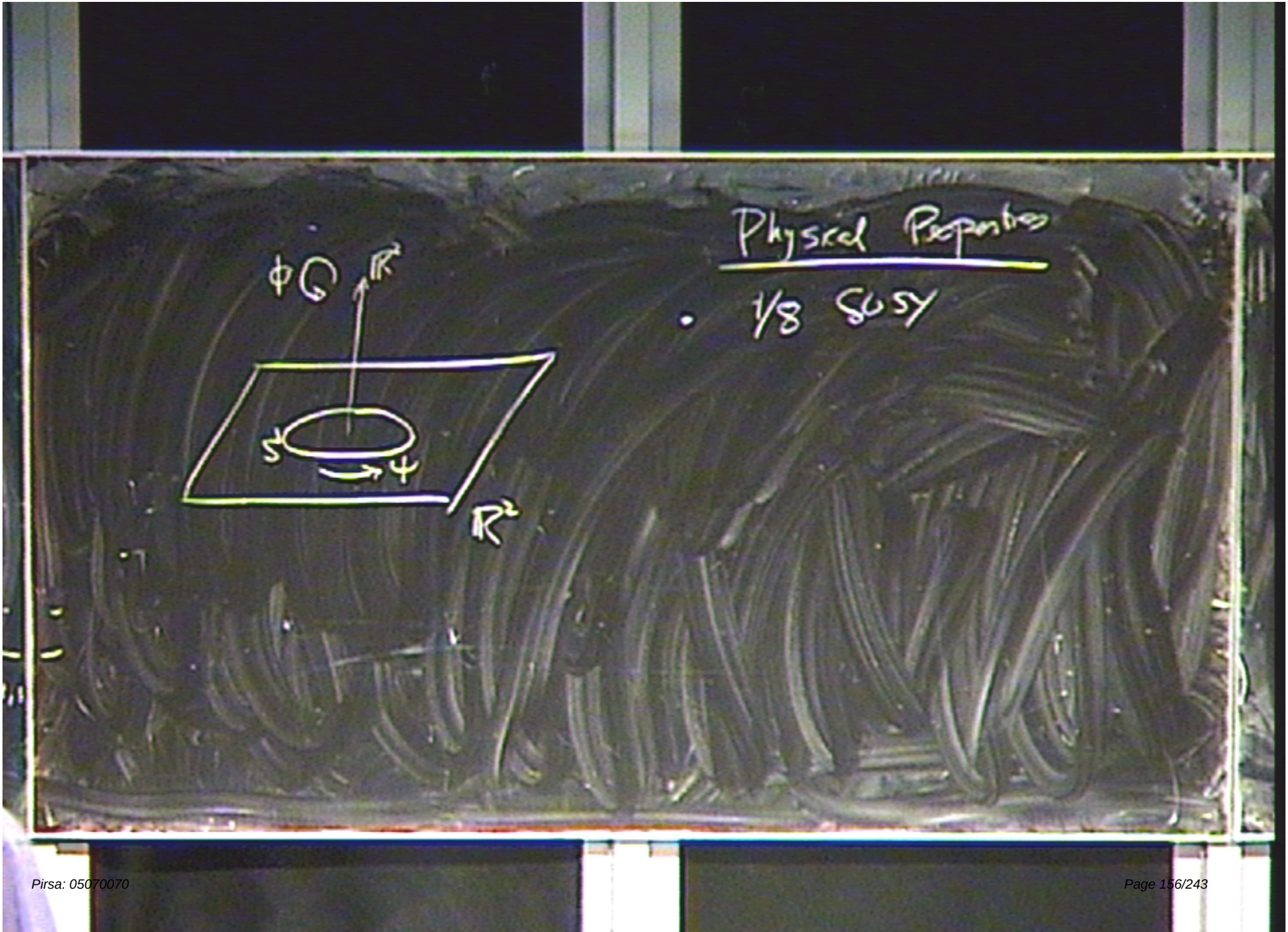


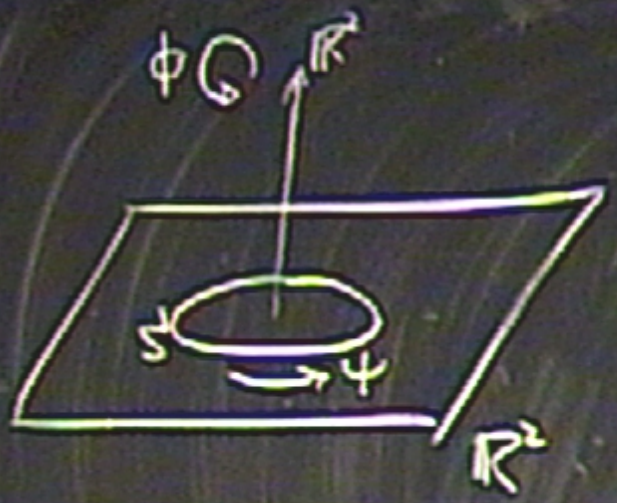

T34
Pirsa: 05070070
Page 152/243


Physical Properties
ϕ
$\mathbb{R}$
S
$\mathbb{R}^2$


Physical Properties
1/S

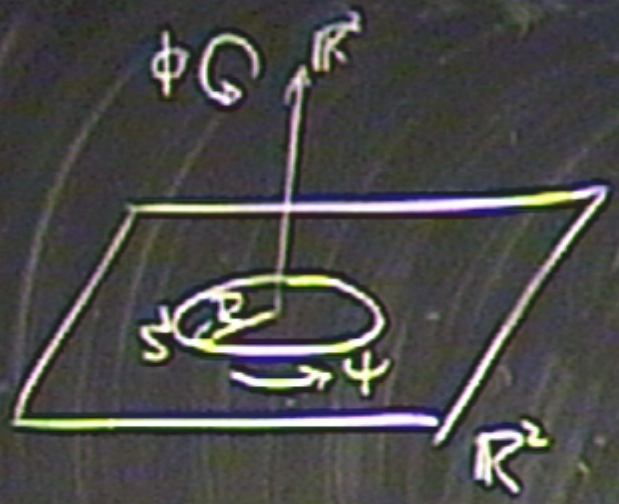

Physical Properties
1/8 SUSY
ϕQ
$\mathbb{R}$
S
ψ
$\mathbb{R}^2$


Physical Properties
1/8 SUSY
ϕ_Q
$\mathbb{R}$
S
$\mathbb{R}^2$



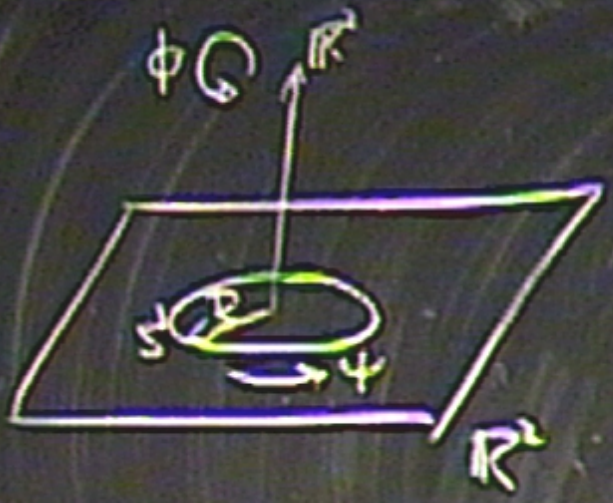
Physical Properties

- 1/8 SUSY
- 5D stationary and AF.



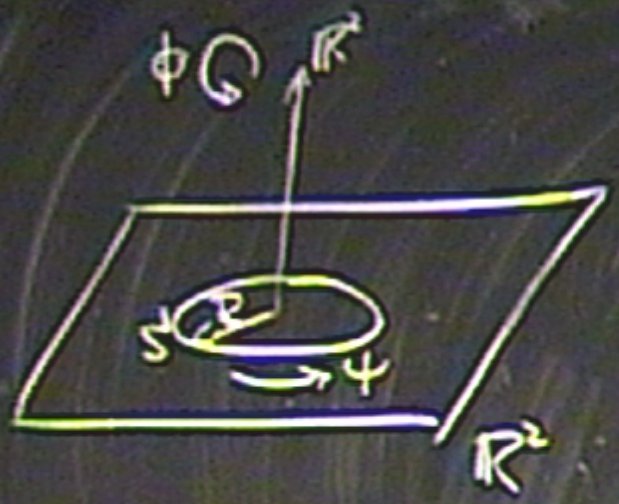
Physical Properties

- 1/8 SUSY
- 5D stationary and AF.



Physical Properties

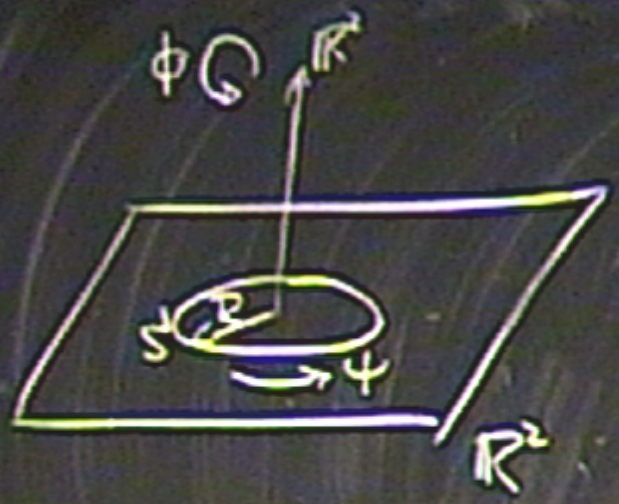
- 1/8 SUSY
- 5D stationary and AF.
- Parameters:



Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

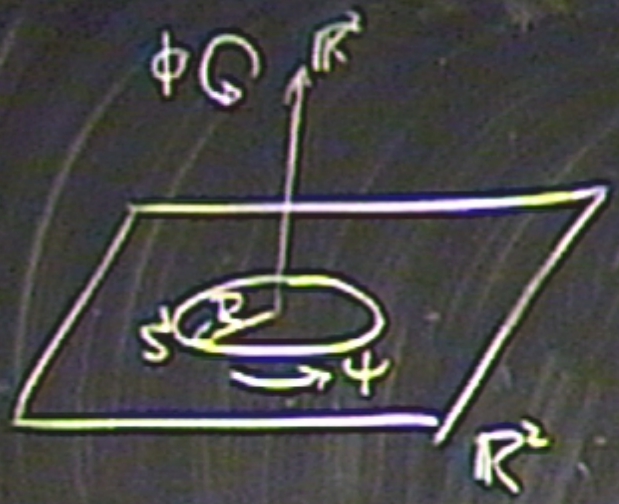
$$Q_i, q_i, R \qquad i = 1,2,3$$



Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

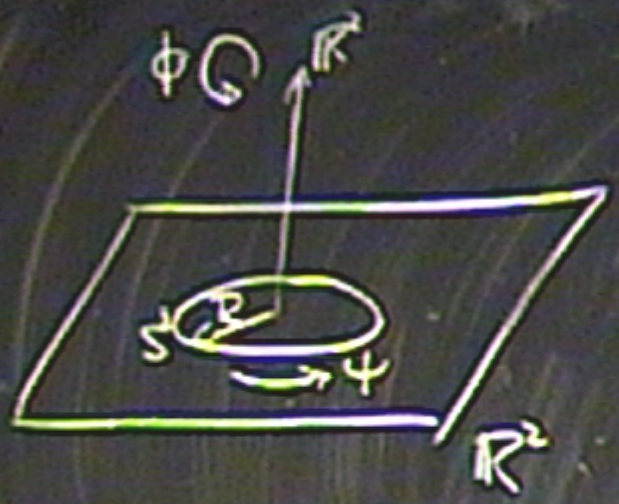
$$Q_i, q_i, R \qquad i = 1,2,3$$



Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

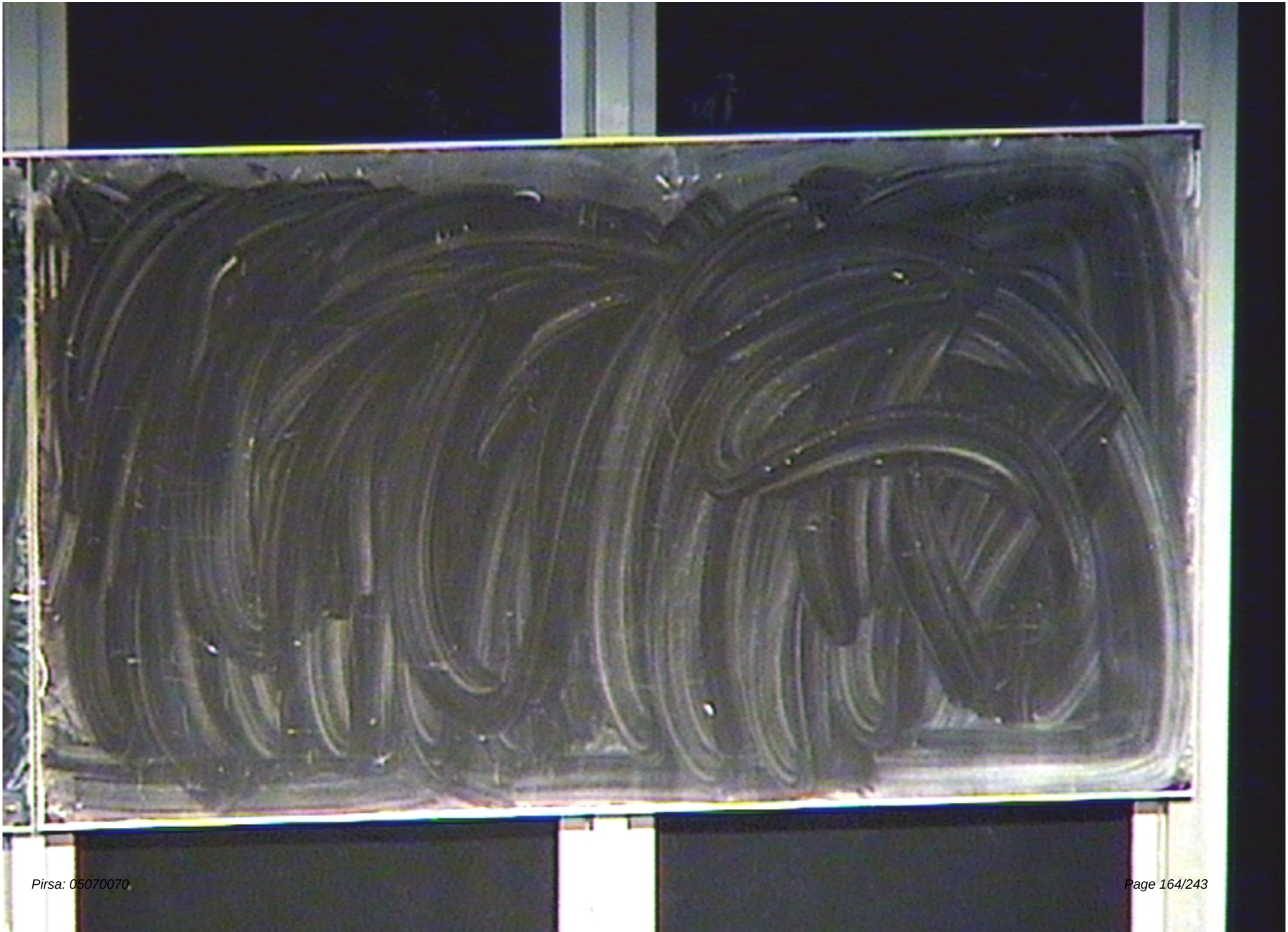
$$Q_i, \phi_i, R \qquad i=1,2,3$$

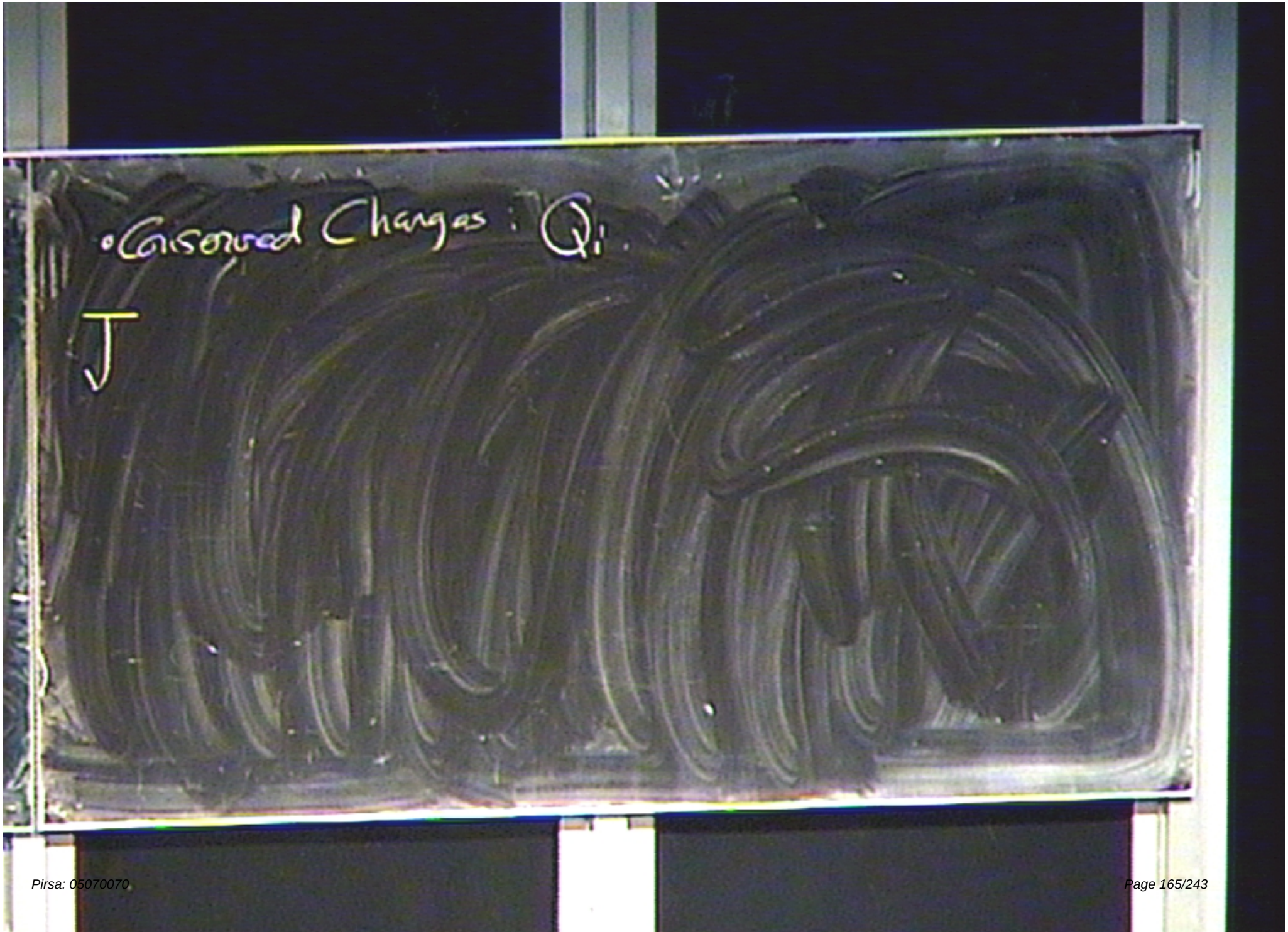


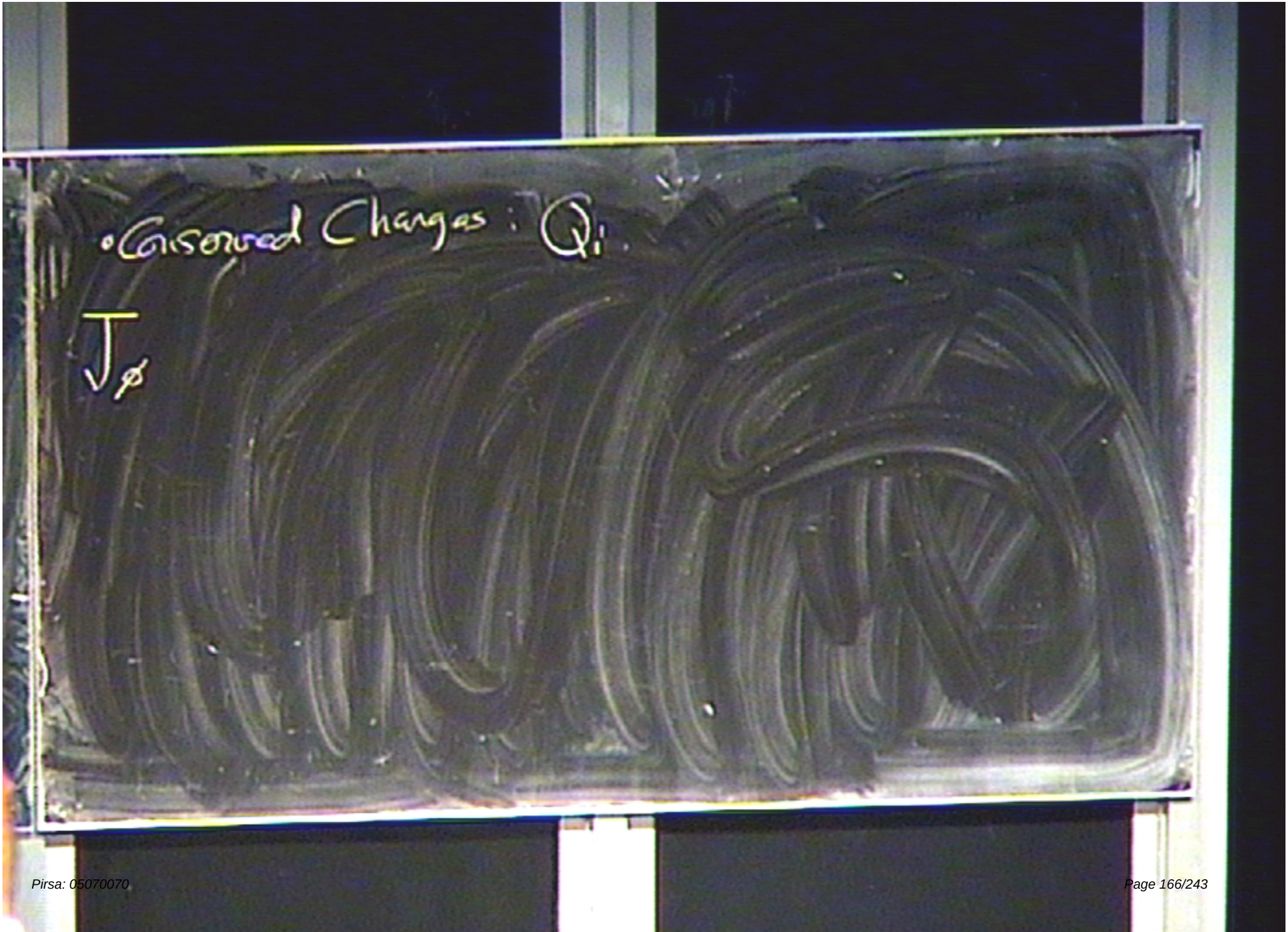
Physical Properties

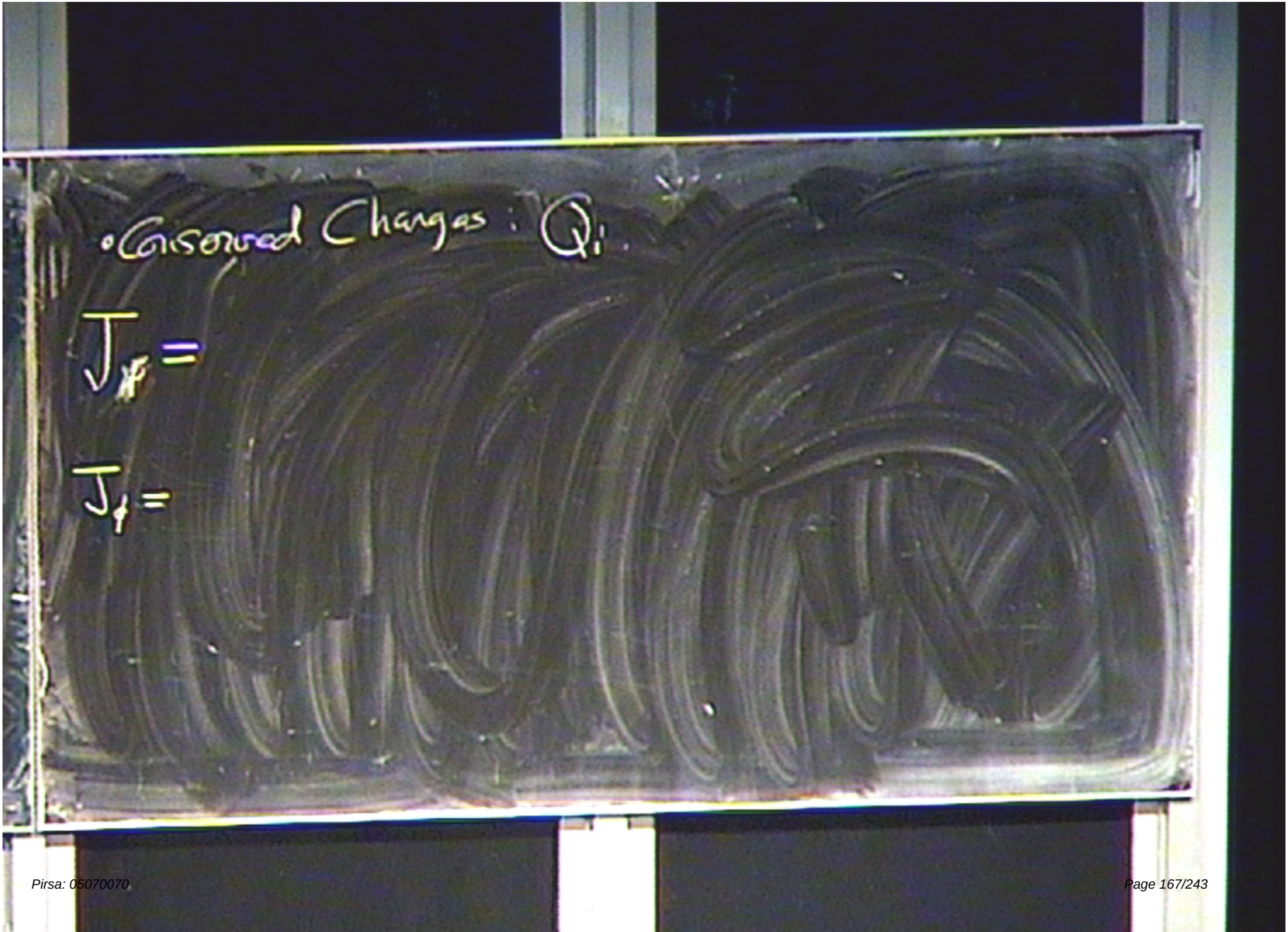
- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

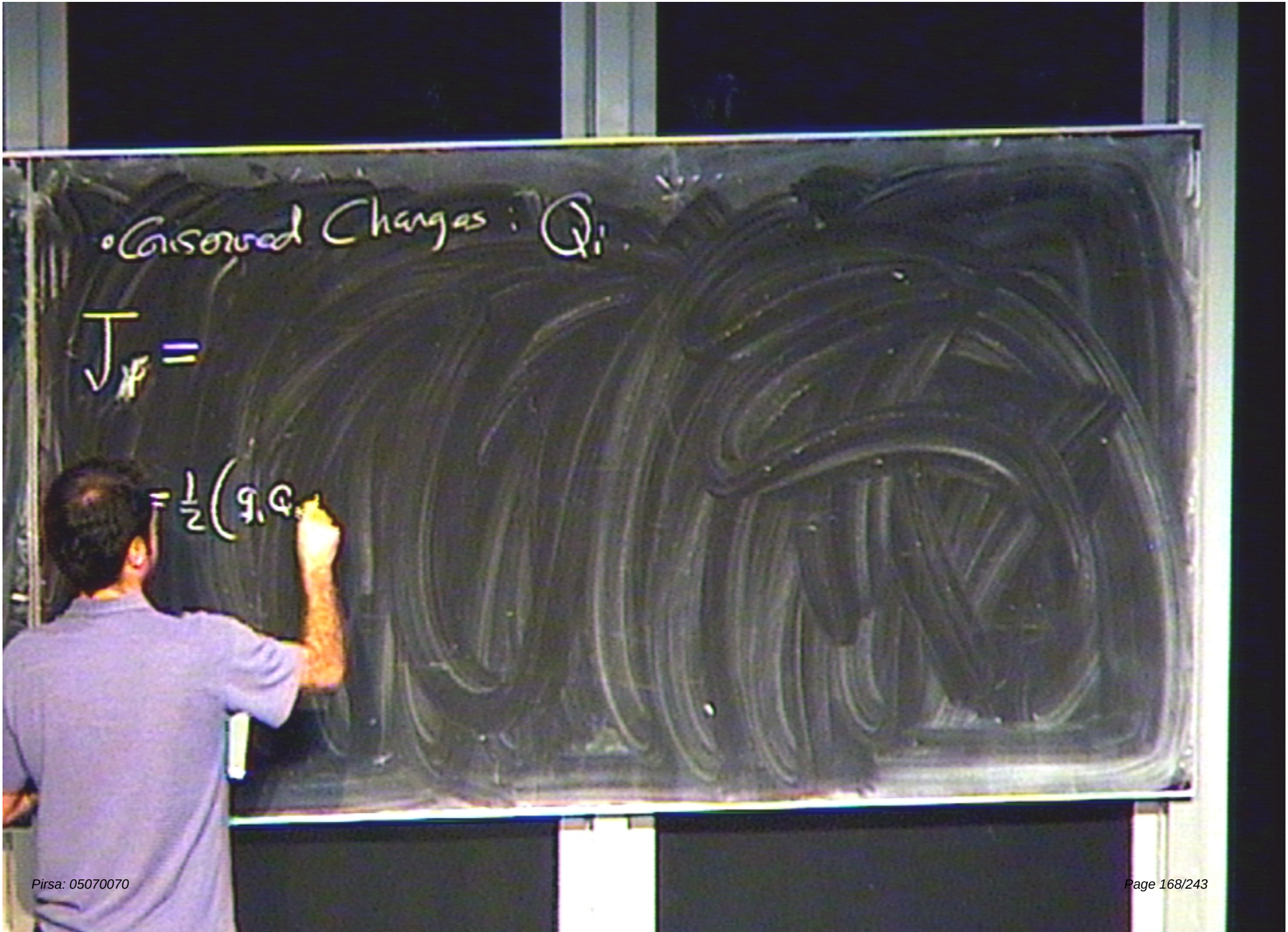
$$Q_i, \phi_i, R \qquad i = 1,2,3$$




• Conserved Charges : Q_i.
J


• Conserved Charges : Q_i.
J_ϕ


• Conserved Charges : Q_i.
$J_\mu =$
$J_\mu =$


• Conserved Charges : Q_i.
$J_{ij} =$
$= \frac{1}{2}(q_i Q_j$

• Conserved Charges : Q_i.

$$J_{\#} = \#^2(q_1+q_2+q_3) + J_{\#}$$

$$J_f = \frac{1}{2}\left(q_1 Q_1 + q_2 Q_2 + q_3 Q_3 - q_1 q_2 q_3\right)$$

• Conserved Charges: Q_i.

$$J_{\#} = \#^2(q_1+q_2+q_3) + J_{\#}$$

$$J_i = \frac{1}{2}\left(q_1 Q_1 + q_2 Q_2 + q_3 Q_3 - q_1 q_2 q_3\right)$$

• Conserved Charges : Q_i.

$$J_{\#} = k^2(q_1+q_2+q_3) + J_{\#}$$

$$J_i = \frac{1}{2}\left(q_1 Q_{1i} + q_2 Q_{2i} + q_3 Q_{3i} - q_1 z_2 z_3\right)$$

• Conserved Charges : Q_i.

$$J_{ff} = R^2(q_1+q_2+q_3) + J_f$$

$$J_i = \frac{1}{2}\left(q_1 Q_1 + q_2 Q_2 + q_3 Q_3 - q_1 q_2 q_3\right)$$

• Conserved Charges : Q_i.

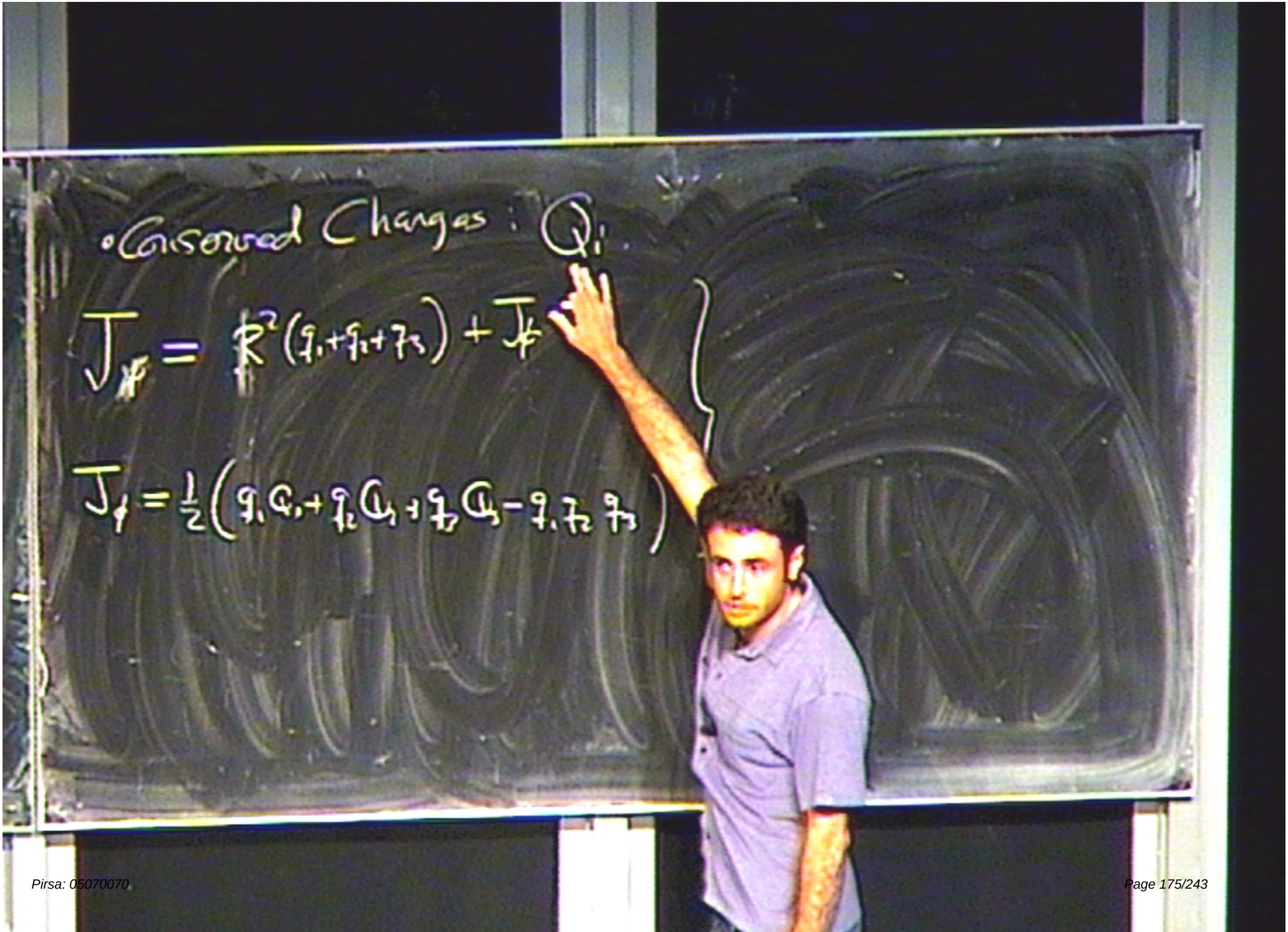
$$J_{ff} = k^2(q_1+q_2+q_3) + J_f$$

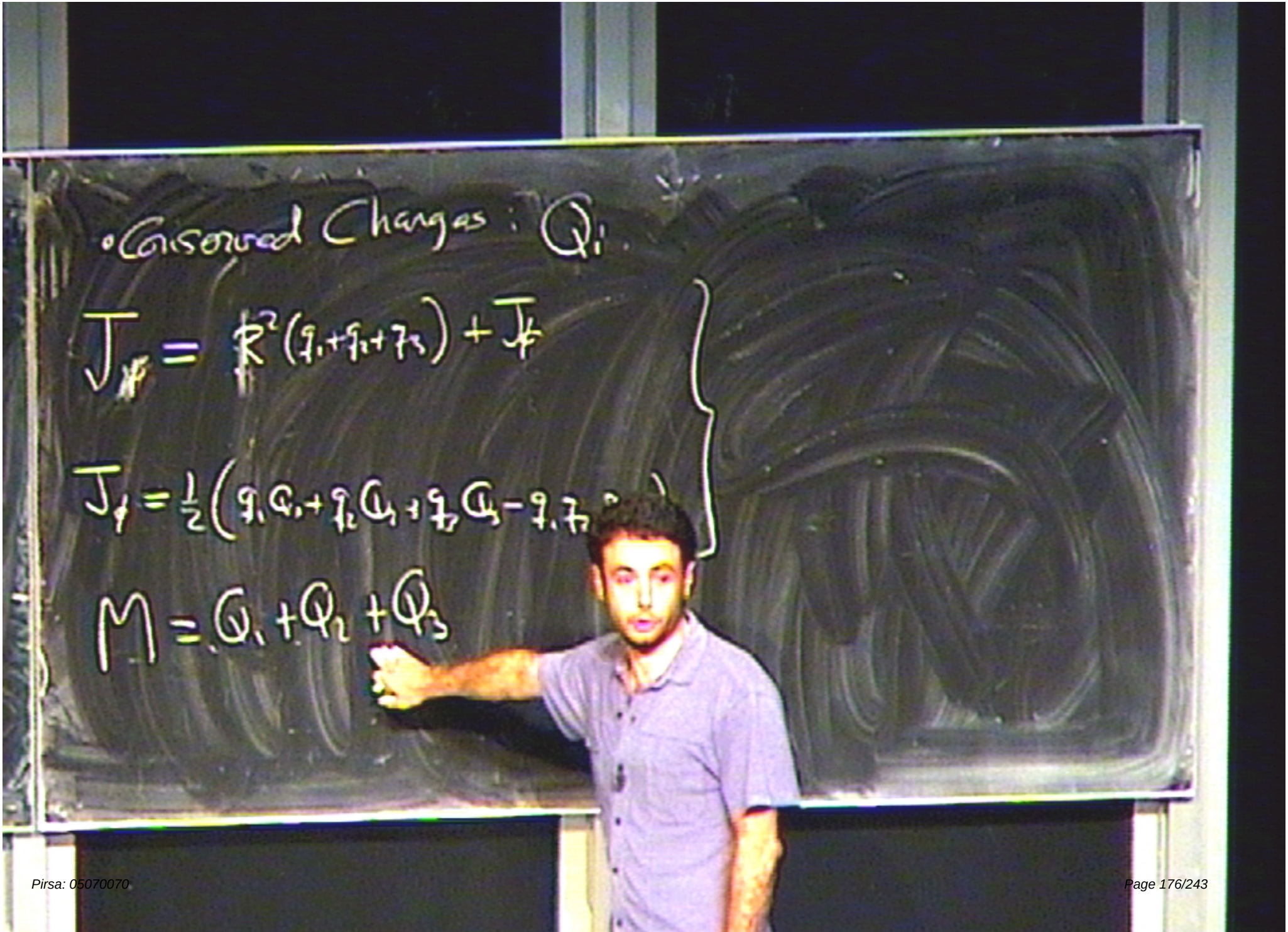
$$J_f = \frac{1}{2}\left(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3\right)$$

• Conserved Charges : Q_i.

$$J_{ff} = R^2(q_1+q_2+q_3) + J_f$$

$$J_f = \frac{1}{2}\left(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3\right)$$


• Conserved Charges : Q_i
$J_H = R^2(q_1+q_2+q_3) + J_f$
$J_f = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$


• Conserved Charges : Q_i
$J_{\#} = \#^2(q_1+q_2+q_3) + J_{\#}$
$J_f = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2$
$M = Q_1 + Q_2 + Q_3$

• Conserved Charges: Q_i.

$$J_{\#} = R^2(q_1+q_2+q_3) + J_{\#}$$

$$J_f = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$$

$\Rightarrow$ 5 conserved charges.

$$M = Q_1 + Q_2 + Q_3$$

• Conserved Charges: Q_i.

$$J_{\#} = R^2(q_1+q_2+q_3) + J_{\#}$$

$$J_i = \frac{1}{2}(q_1 Q_1 + q_2 Q_2 + q_3 Q_3 - q_1 q_2 q_3)$$

$\Rightarrow$ 5 conserved charges.

$$M = Q_1 + Q_2 + Q_3$$

• Conserved Charges: Q_i.

$$J_{ij} = \tilde{R}^2 (q_{1i} + q_{2i} + q_{3i}) + \tilde{J}_{ij}$$

$$\tilde{J}_{ij} = \frac{1}{2}\left(q_{1i}Q_{1j} + q_{2i}Q_{2j} + q_{3i}Q_{3j} - q_{1i}q_{2j}q_{3k}\right)$$

$\Rightarrow$ 5 conserved charges.

$$M = Q_1 + Q_2 + Q_3$$

• Conserved Charges: Q_i.

$$J_R = R^2(q_1+q_2+q_3) + J_f$$

$$J_f = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$$

$$M = Q_1 + Q_2 + Q_3$$

$\Rightarrow$ 5 conserved charges.

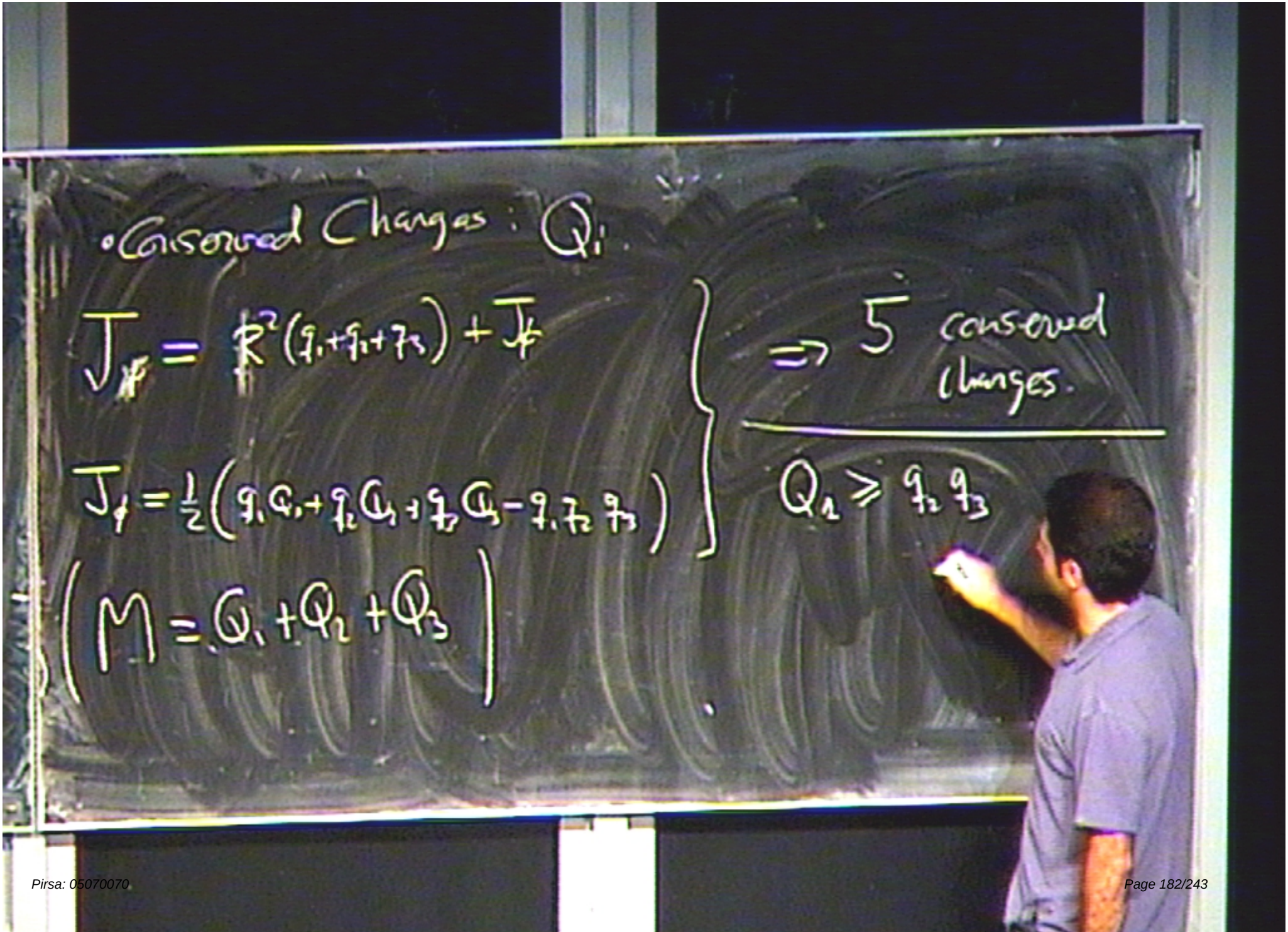
• Conserved Charges: Q_i.

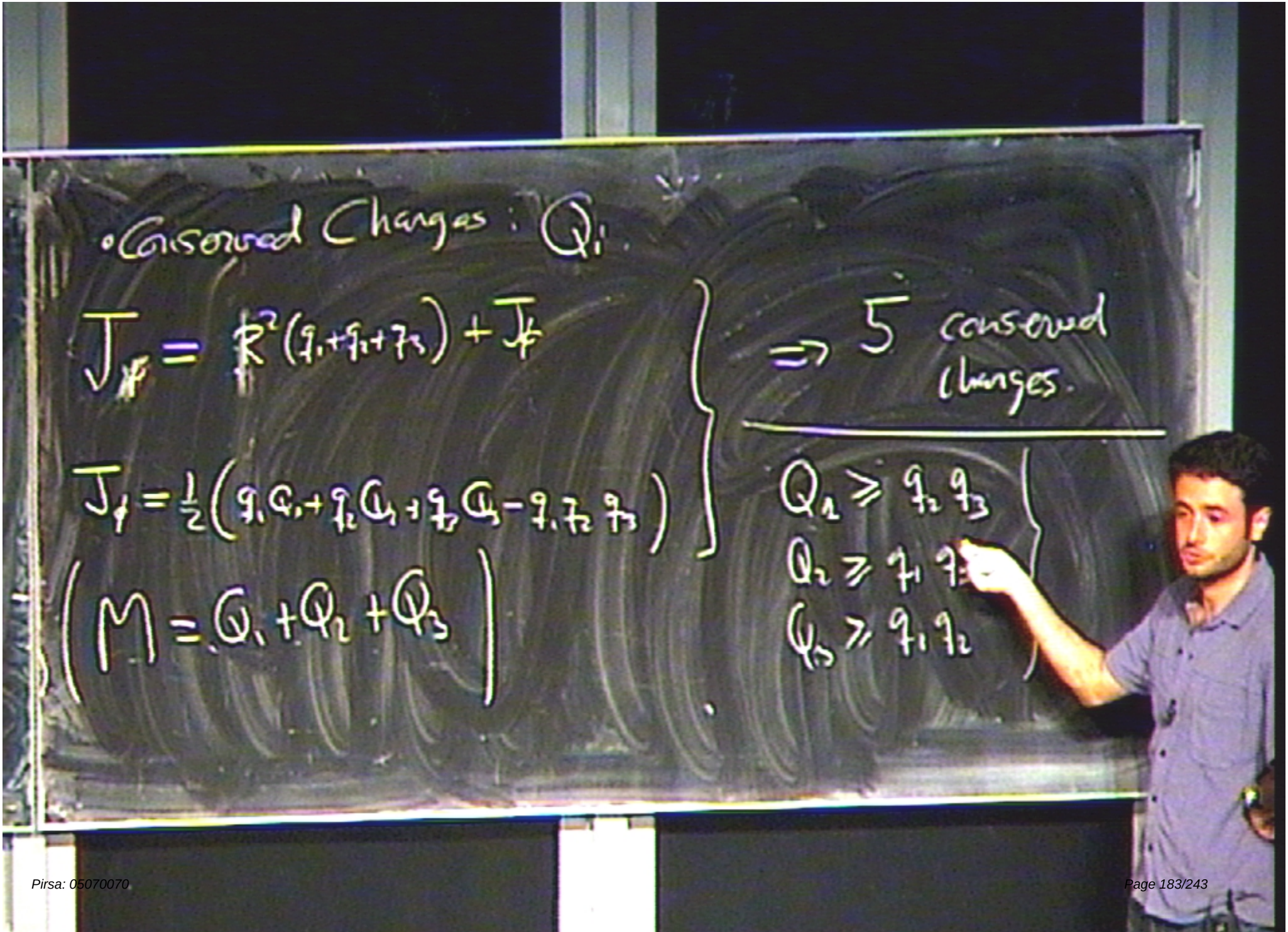
$$J_{\#} = \#^2(q_1+q_2+q_3) + J_{\#}$$

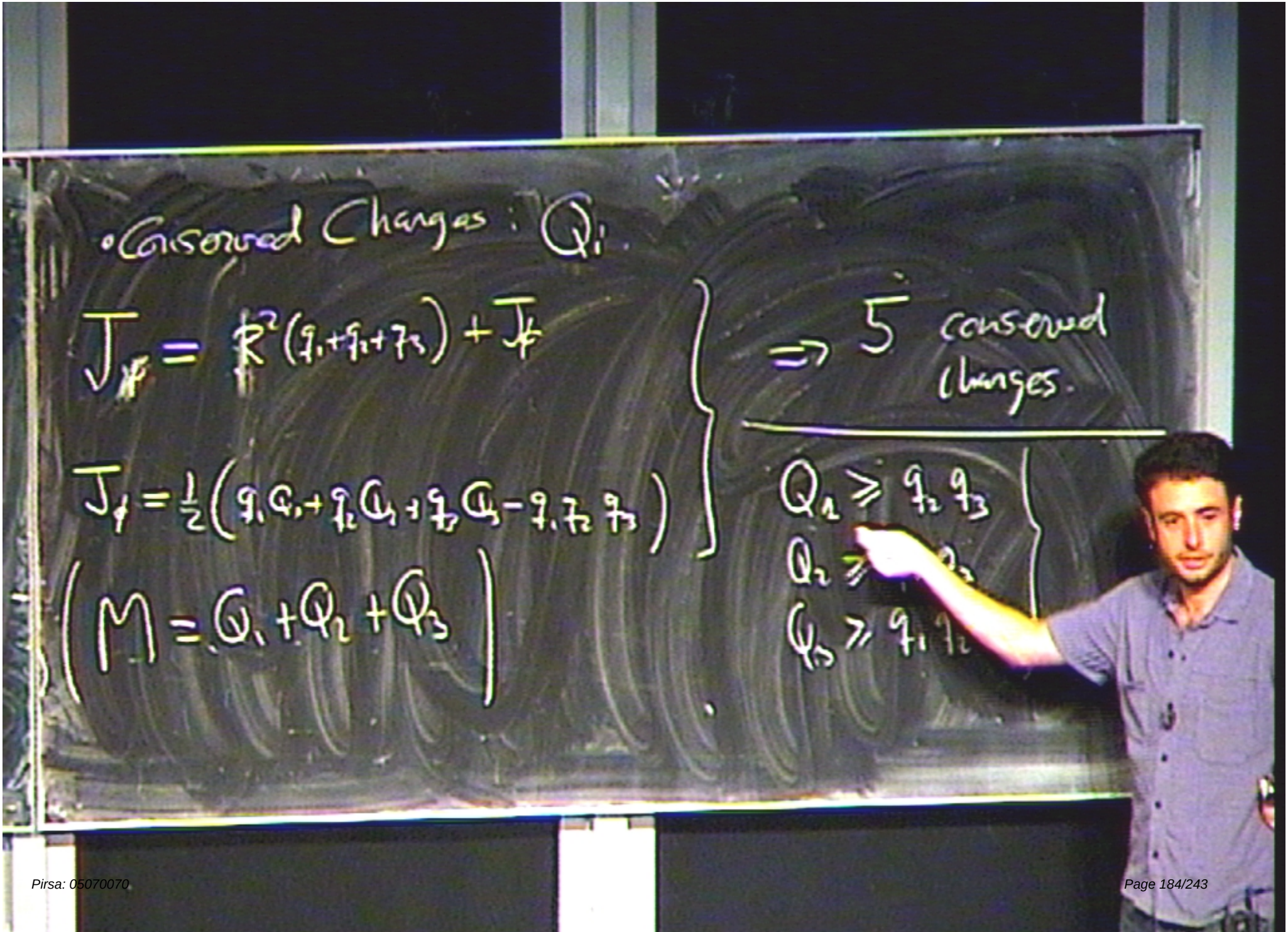
$$J_I = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$$

$$\Rightarrow 5 \text{ conserved charges.}$$

$$M = Q_1 + Q_2 + Q_3$$


• Conserved Charges: Q_i.
$J_R = R^2(q_1+q_2+q_3) + J_F$
$J_F = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$
$\Rightarrow$ 5 conserved charges.
$Q_i \geq q_j q_k$
$M = Q_1 + Q_2 + Q_3$


• Conserved Charges : Q_i
$J_{ij} = \epsilon^{ijk}(q_1+q_2+q_3) + J_{ij}$
$J_{ij} = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$
$M = Q_1 + Q_2 + Q_3$
$\Rightarrow$ 5 conserved charges.
$Q_1 \geq q_2 q_3$
$Q_2 \geq q_1 q_3$
$Q_3 \geq q_1 q_2$


• Conserved Charges: Q_i
$J_R = R^2(q_1+q_2+q_3) + J_F$
$J_F = \frac{1}{2}(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3)$
$M = Q_1 + Q_2 + Q_3$
$\Rightarrow$ 5 conserved charges.
$Q_1 \geq q_2q_3$
$Q_2 \geq$
$Q_3 \geq q_1q_2$

• Conserved Charges: Q_i.

$$J_{ij} = R^2(q_i + q_j + q_k) + J_{ij}$$

$$J_{ij} = \frac{1}{2}(q_i Q_i + q_j Q_j + q_k Q_k - q_i q_j q_k)$$

$$M = Q_1 + Q_2 + Q_3$$

$\Rightarrow$ 5 conserved charges.

$$Q_1 \geq q_2 q_3$$
$$Q_2 \geq q_1 q_3$$
$$Q_3 \geq q_1 q_2$$

• Conserved Charges: Q_i.

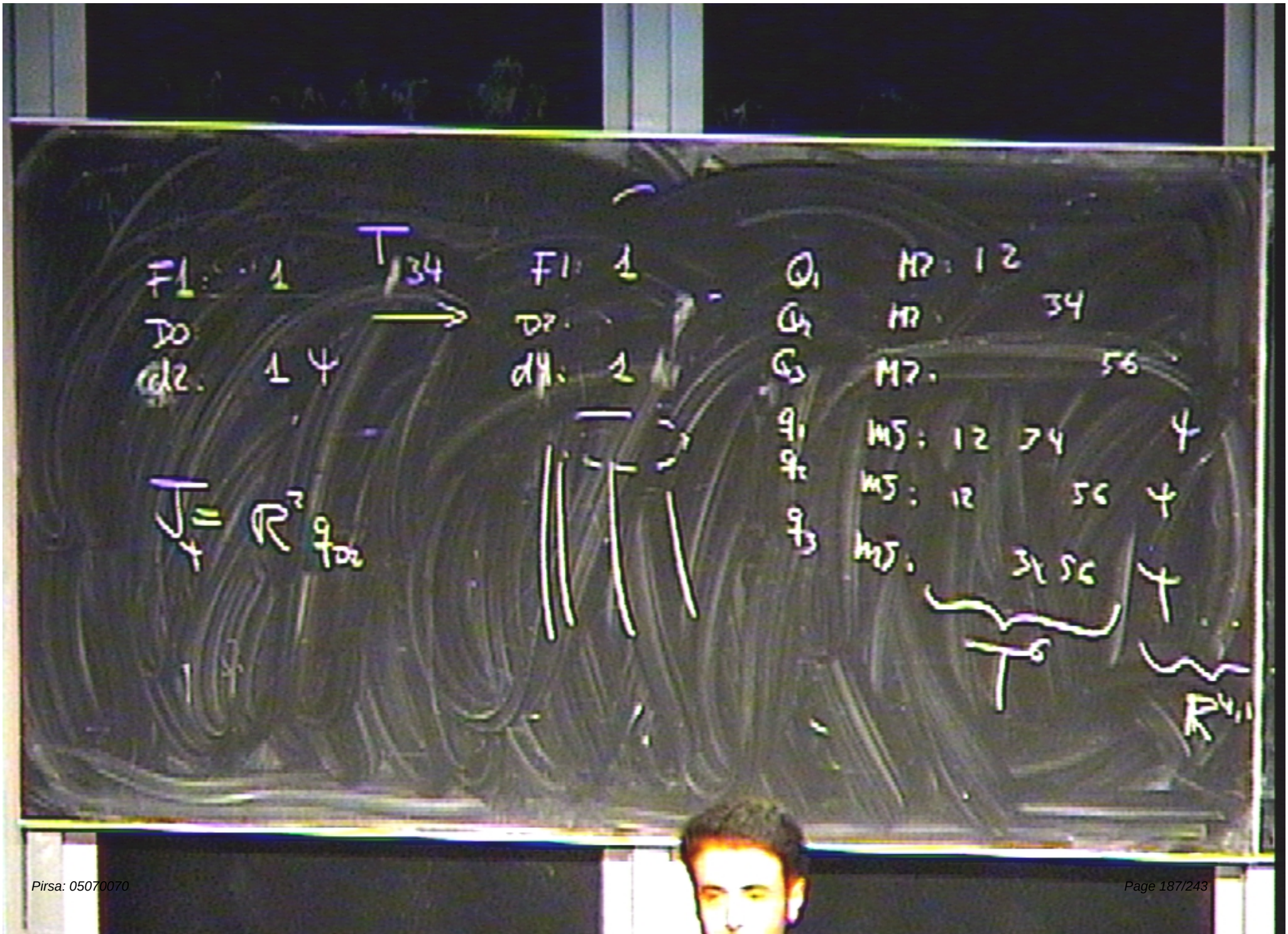
$$J_{\#} = R^2(q_1+q_2+q_3) + J_{\#}$$

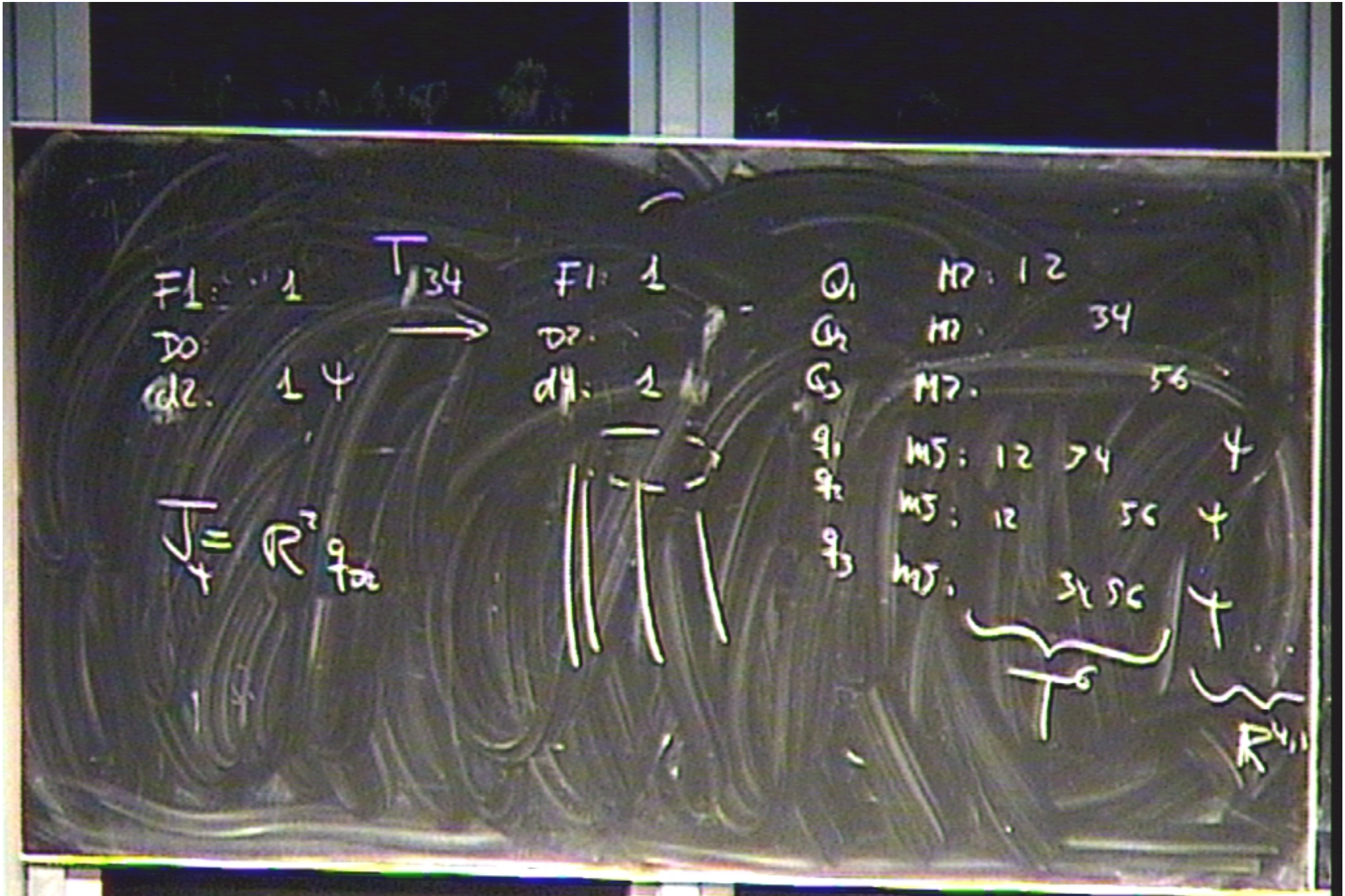
$$J_{\#} = \frac{1}{2}\left(q_1Q_1 + q_2Q_2 + q_3Q_3 - q_1q_2q_3\right)$$

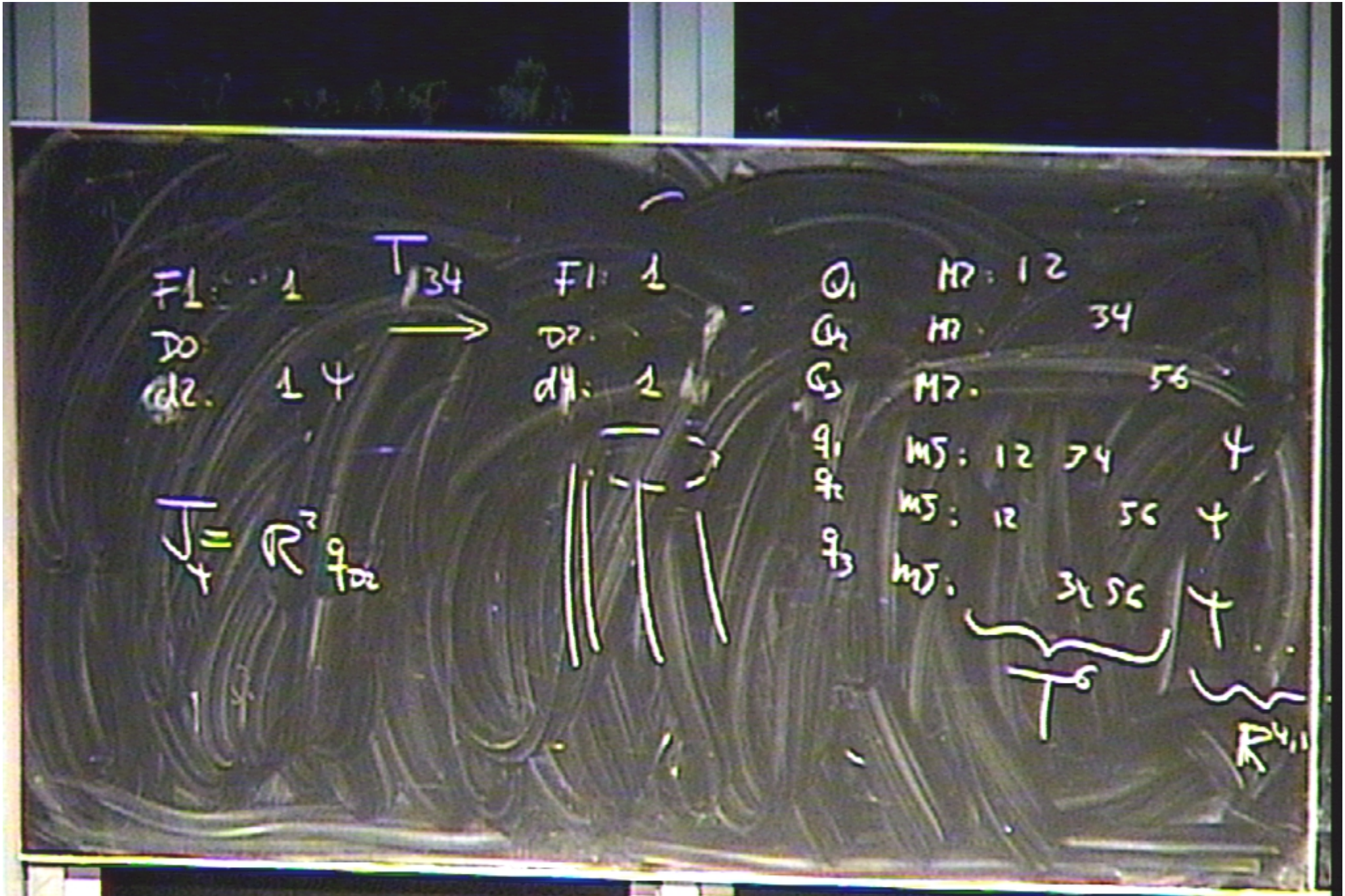
$$M = Q_1 + Q_2 + Q_3$$

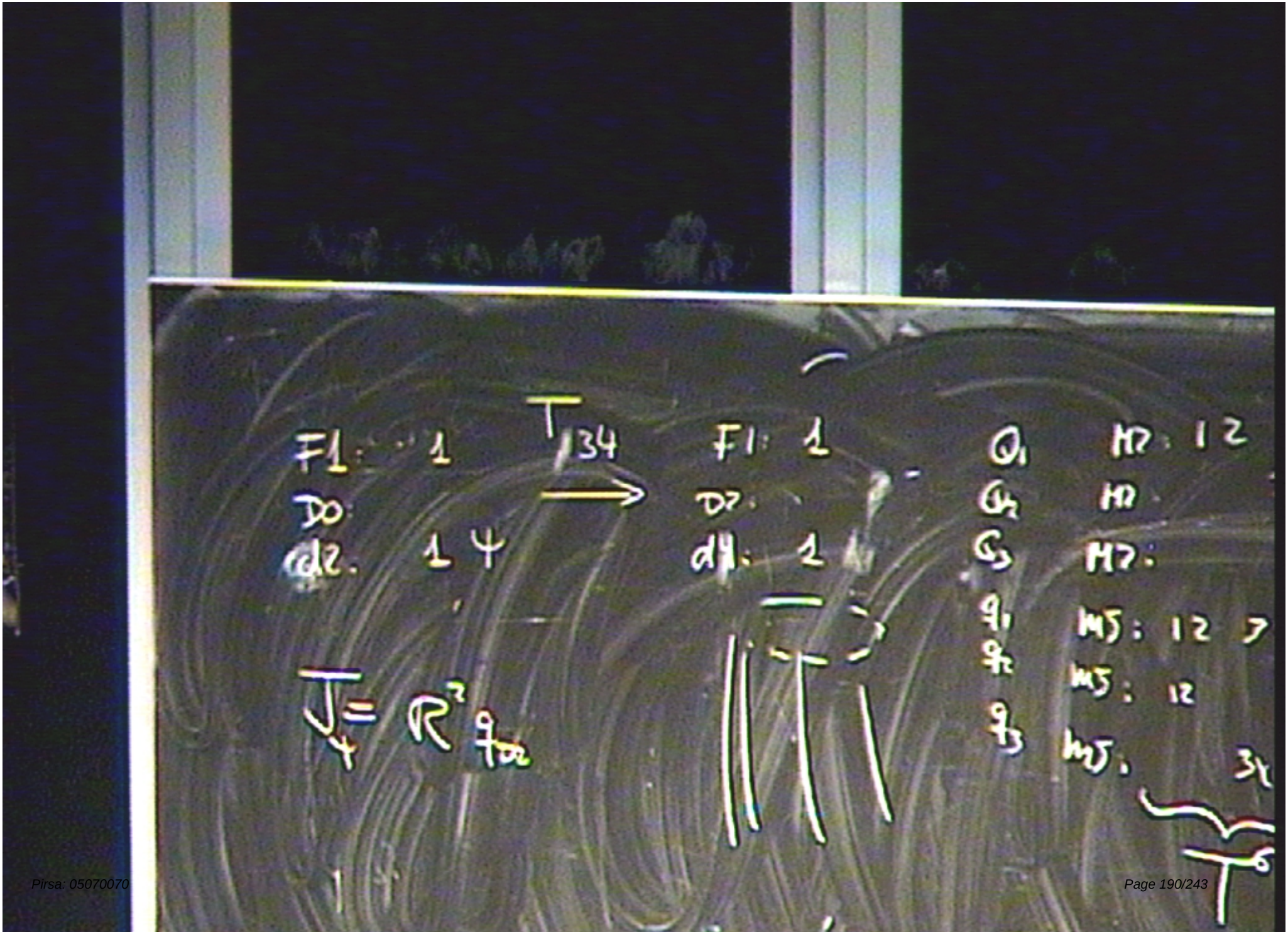
$\Rightarrow$ 5 conserved charges.

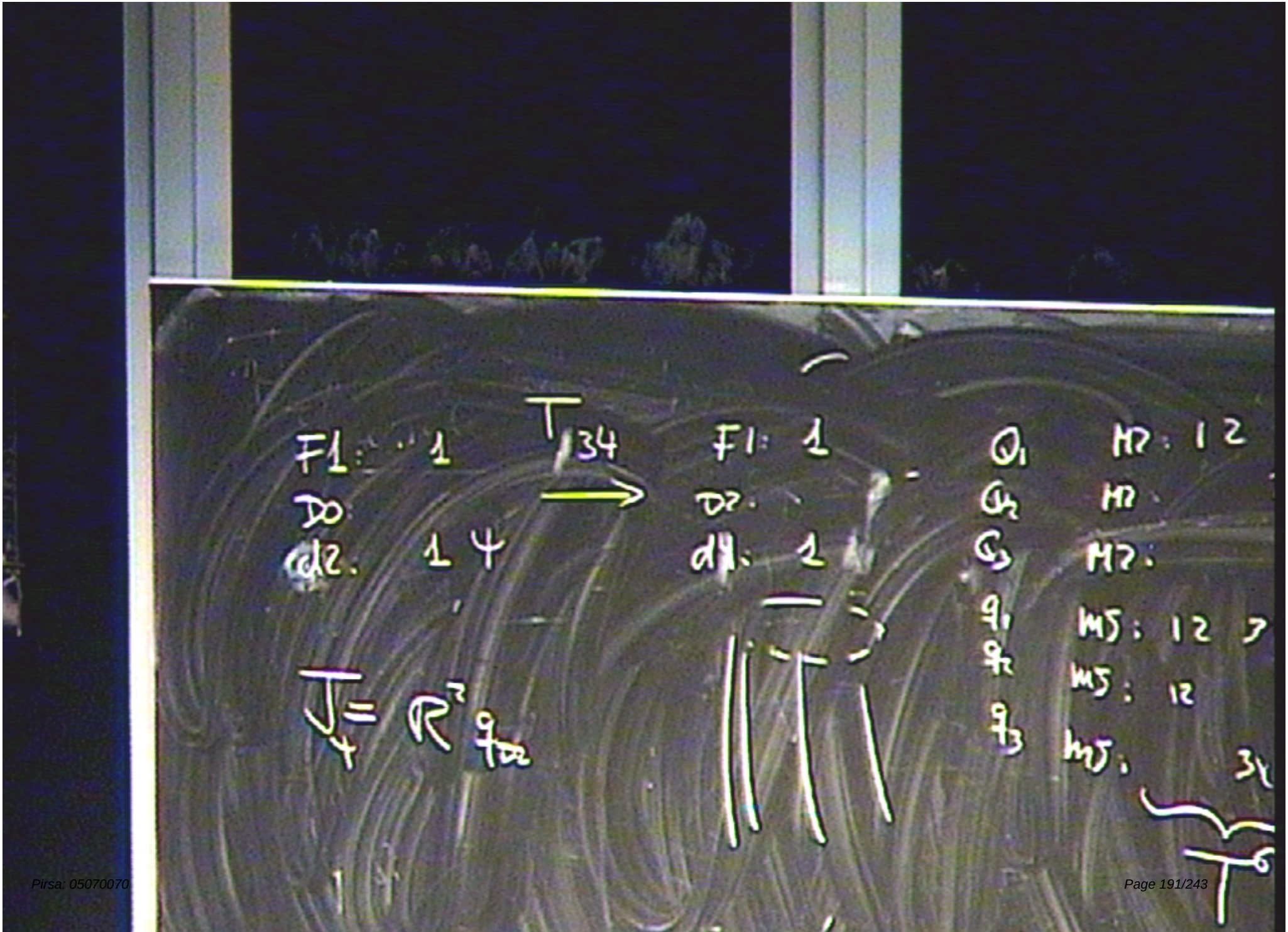
$$Q_1 \geq q_2q_3$$
$$Q_2 \geq q_1q_3$$
$$Q_3 \geq q_1q_2$$

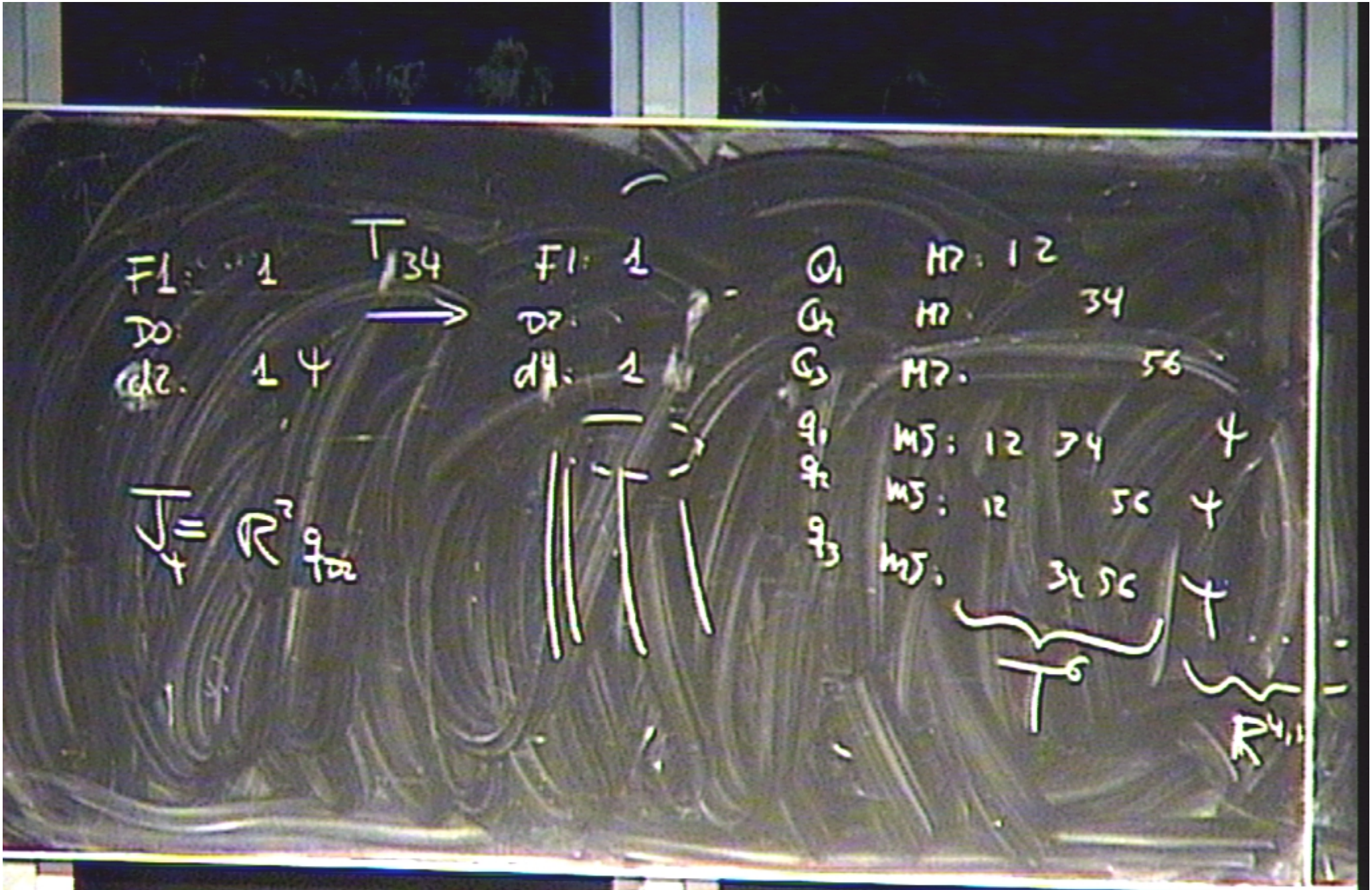

T34
R4,1


F1: 1
D0
d2. 1 4
T 34
F1: 1
D2.
d4: 1
Q1 M2: 1 2
Q2 M3 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5: 34 56
R4,1

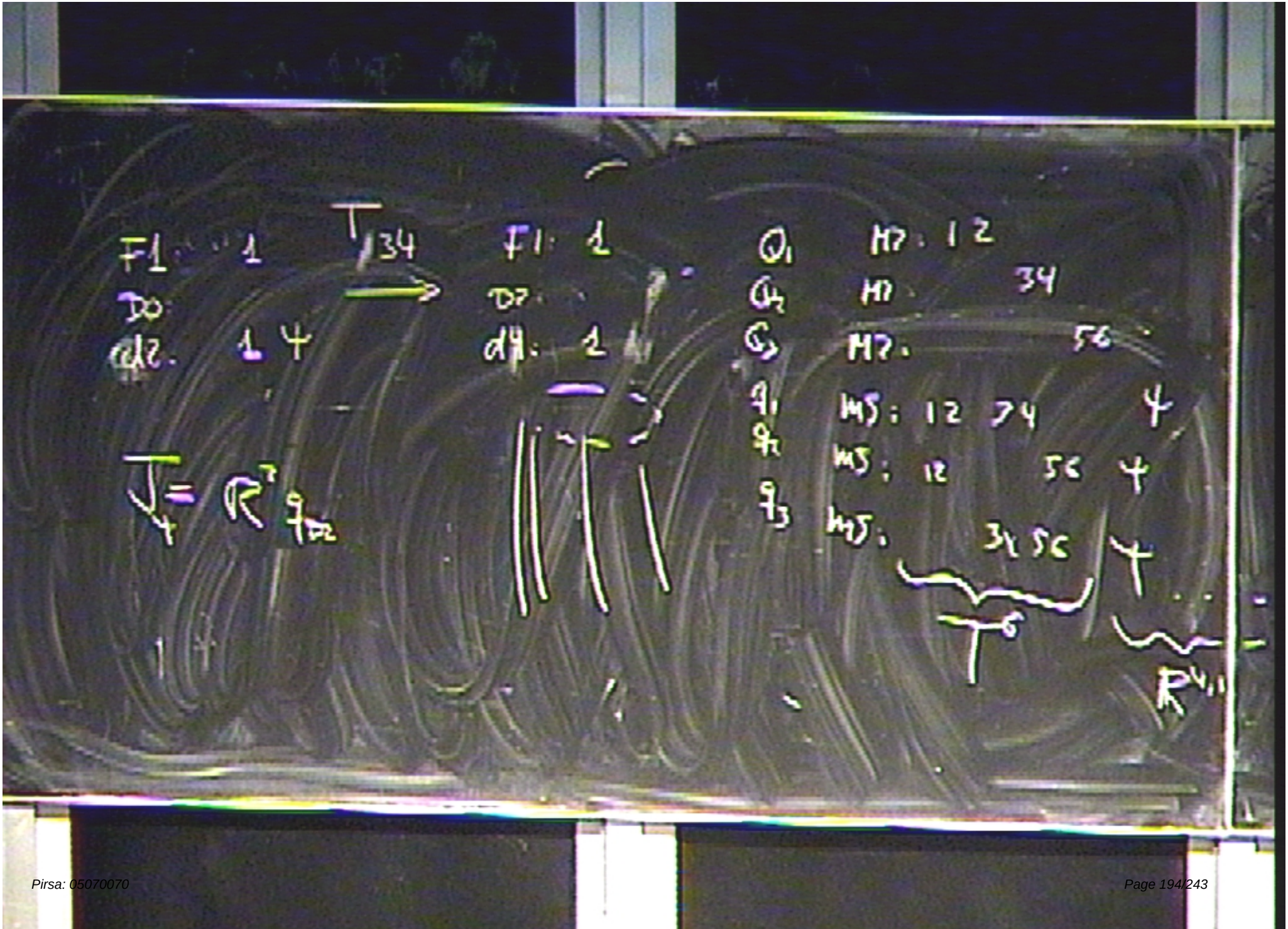

Fl: 1
Do
dz. 1 4
T 34
Fl: 1
Dz.
dy: 1
Q1 M2: 12
G4 M2 34
G3 M2. 56
q1 M3: 12 34 4
q2 M3: 12 56 4
q3 M3. 34 56
R4,1

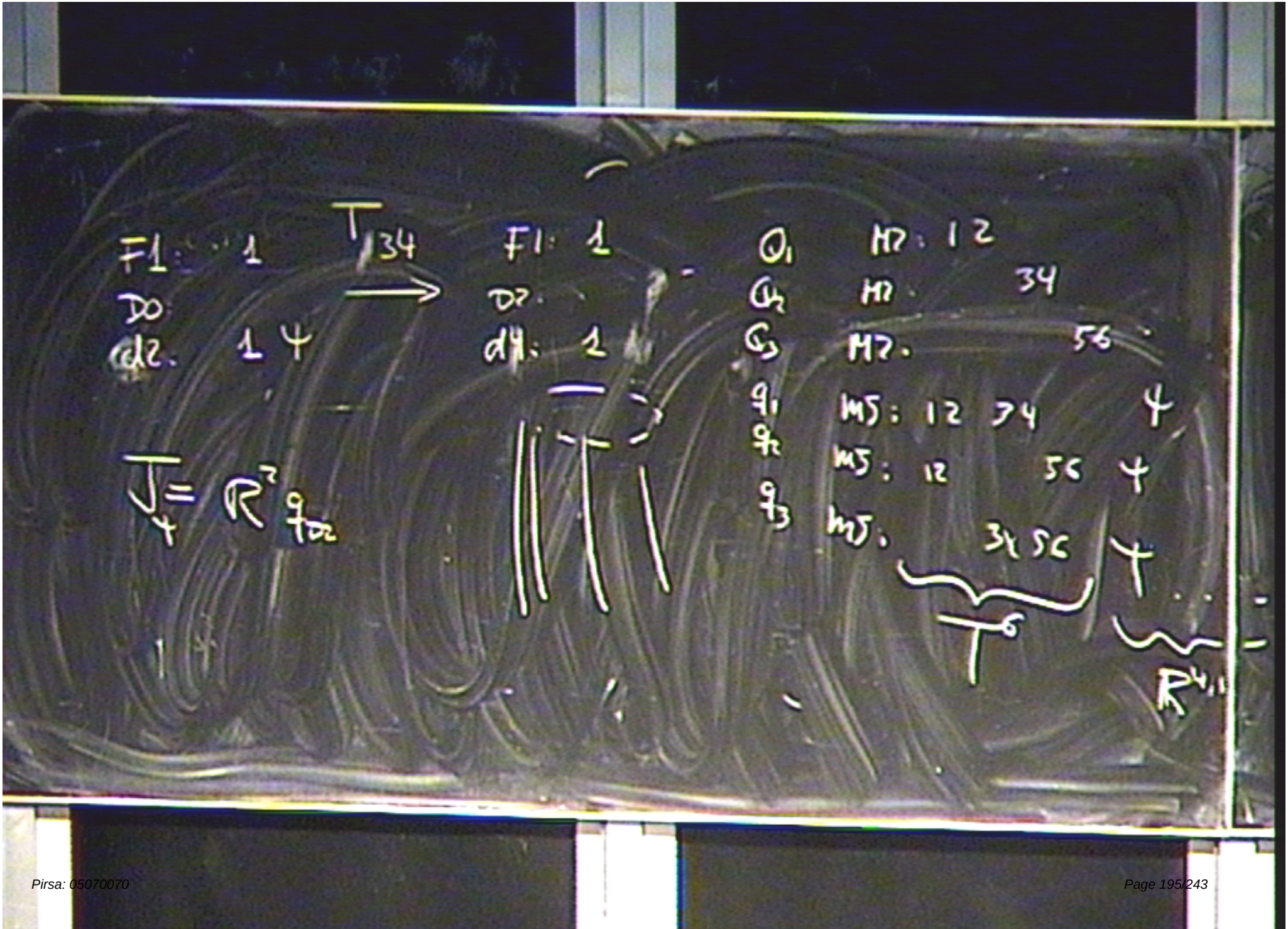

Fl: 1
Do:
dz. 1 4
T134
Fl: 1
D2:
d4: 2
Q1 M2: 12
Q2 M2
Q3 M2:
q1 M5: 12 7
q2 M5: 12
q3 M5.
3(

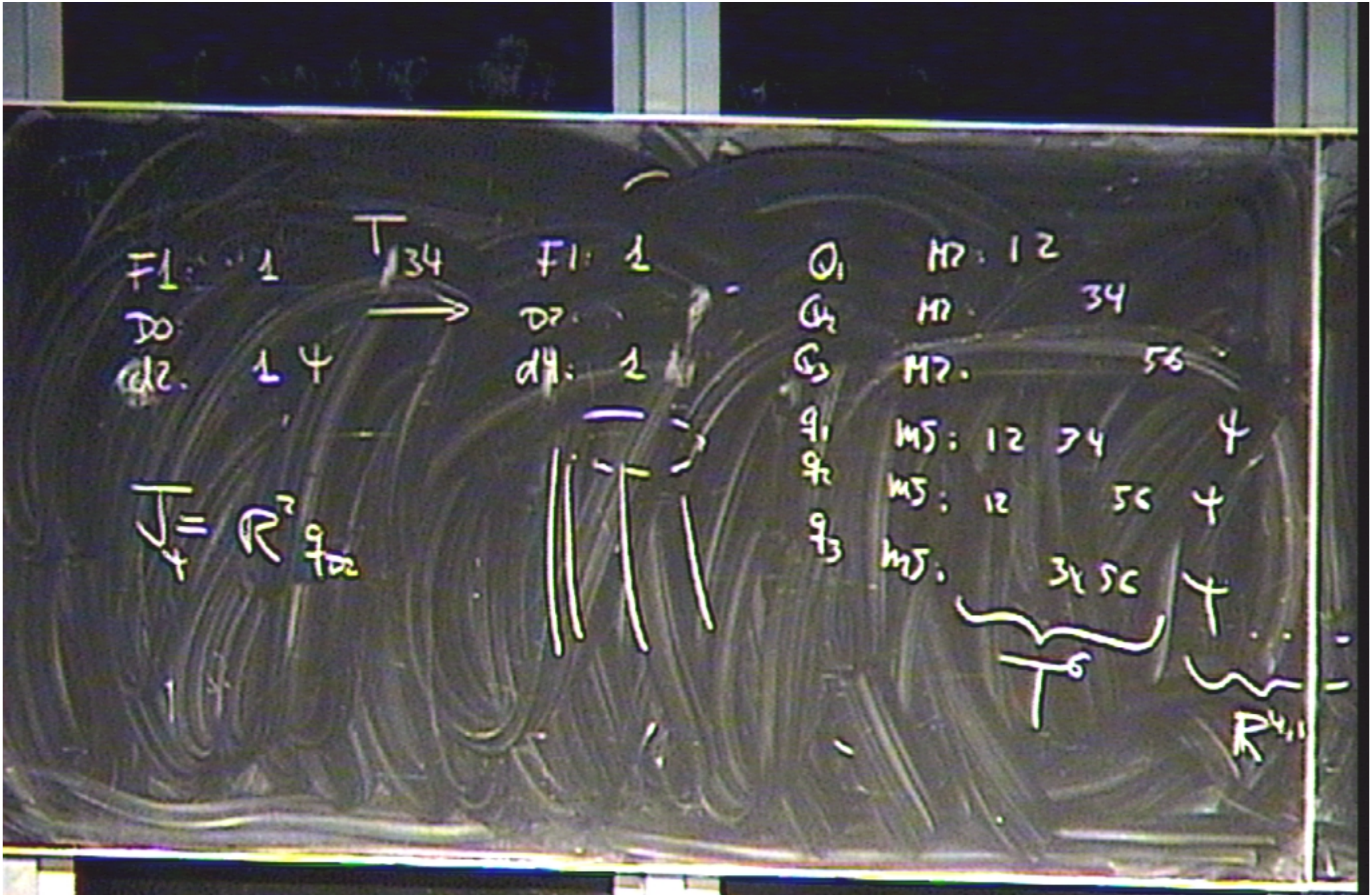

F1: 1
Do
dz. 1 4
T34
F1: 1
Dz.
d4: 2
Q1 M2: 12
G4 M2
G3 M2:
q1 M5: 12 3
q4 M5: 12
q3 M5:
3(

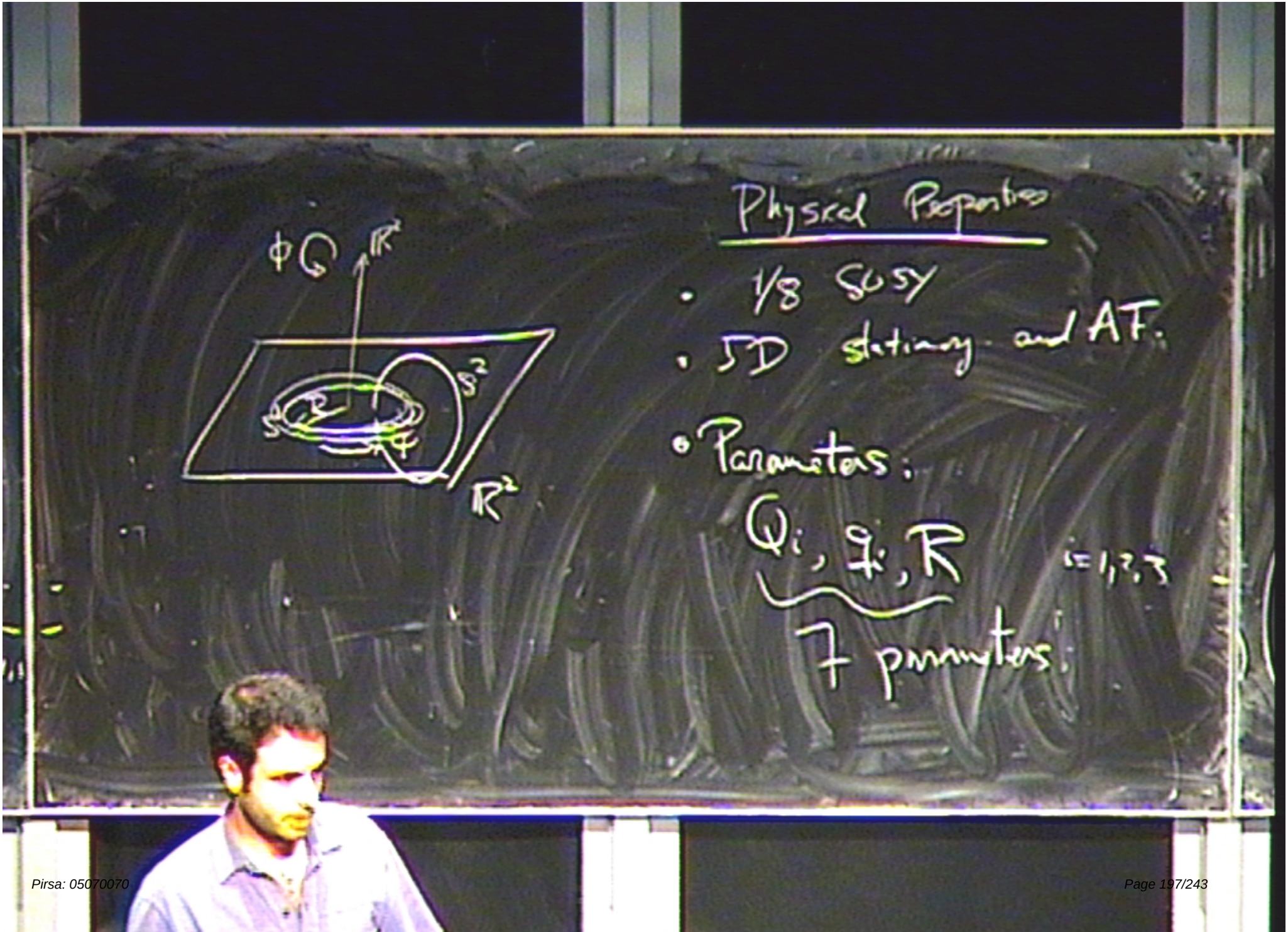

T134
Fl: 1
Do:
d2. 1 4
Fl: 1
D2:
d4: 1
O1 M2: 12
O2 M2: 34
O3 M2: 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5: 34 56 4

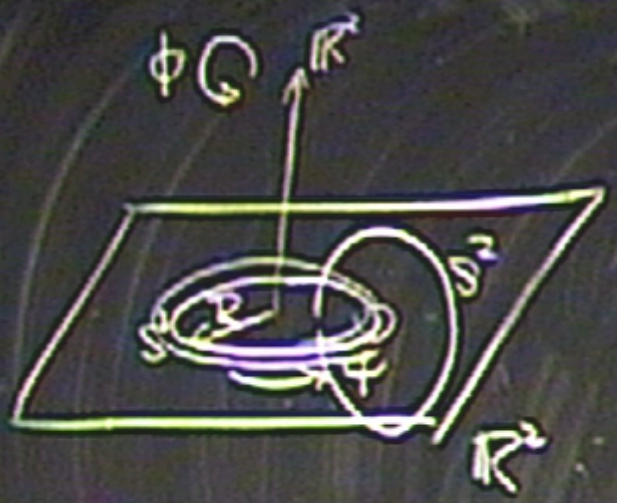



T134
$\overline{J}_4 = R^7 q_{12}$
$R^{4,11}$


Fl: 1
T134
Fl: 1
Q1 M7: 12
M7: 34
M7: 56
M5: 12 34
M5: 12 56
M5: 34 56
R4,1


Fl: 1
Do
dl2. 1 4
T134
Fl: 1
D2
d4: 2
Q1 M2: 12
Q2 M2 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56
R4,1

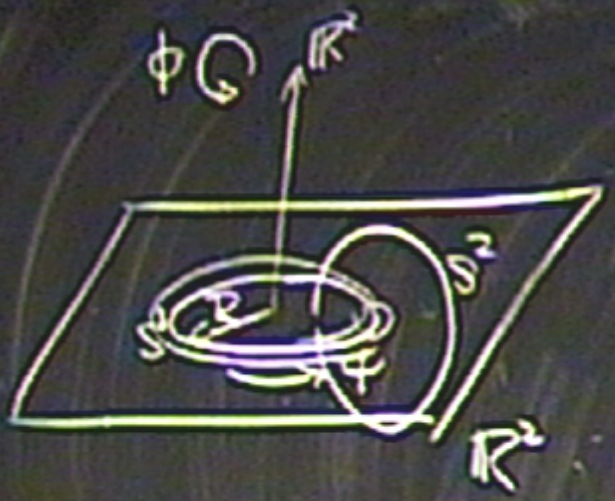

Physical Properties
• 1/8 SUSY
• 5D stationary and AF.
• Parameters:
Q_i, q_i, R $i=1,2,3$
7 parameters!
ϕ_Q
$\mathbb{R}$
S^2
S^2
$\mathbb{R}^2$



Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

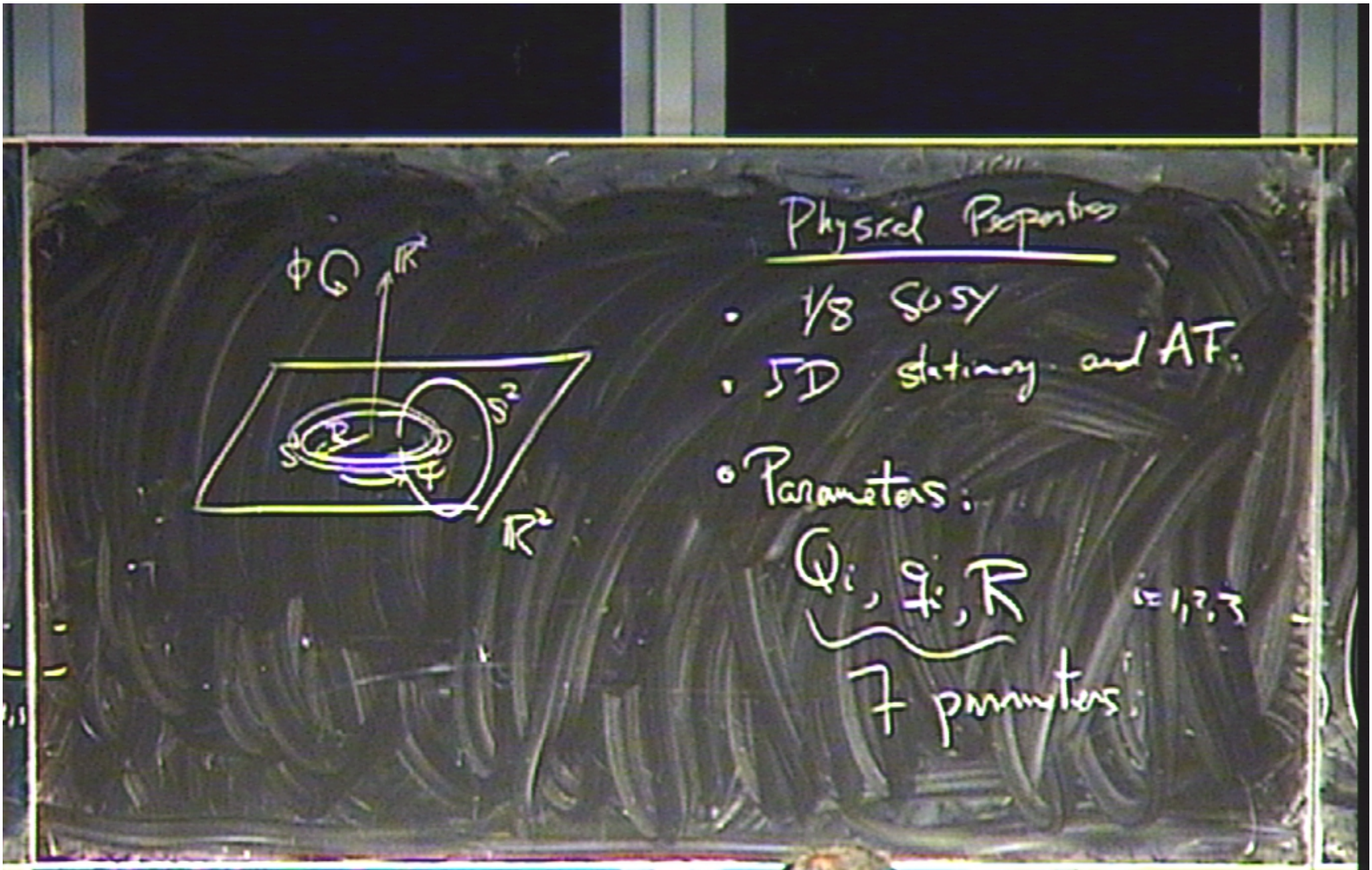
$$\underbrace{Q_i, q_i, R}_{7 \text{ parameters}} \quad i=1,2,3$$



Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

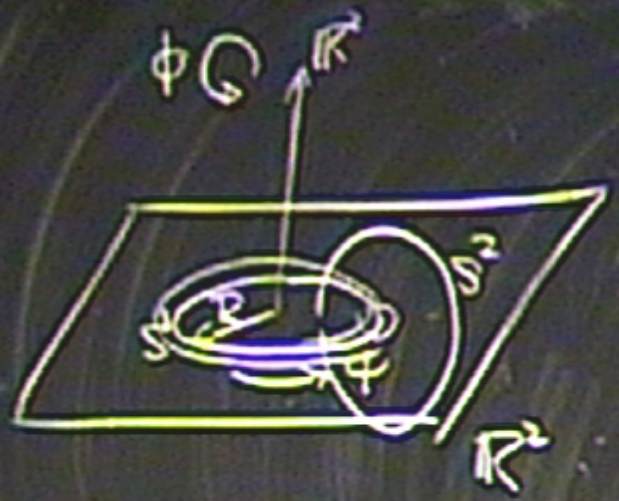
$$\underbrace{Q_i, q_i, R}_{7 \text{ parameters}} \quad i=1,2,3$$

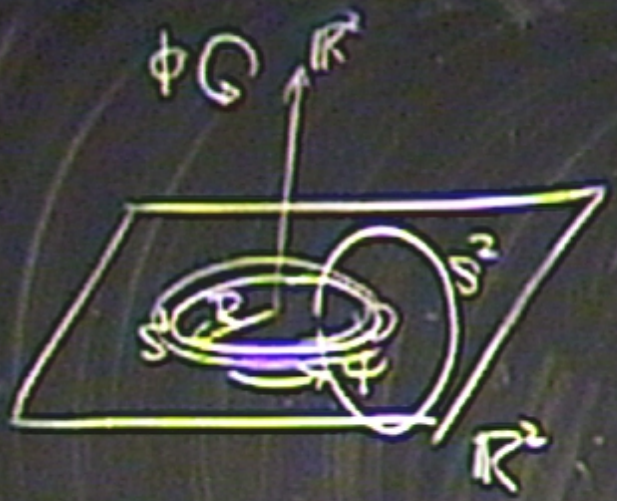

Physical Properties
ϕ_Q
$\mathbb{R}$
S^2
S^2
$\mathbb{R}^2$
• 1/8 SUSY
• 5D stationary and AF.
• Parameters:
Q_i, q_i, R $i=1,2,3$
7 parameters.

Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

$$\underbrace{Q_i, q_i, R}_{7 \text{ parameters}} \quad i=1,2,3$$

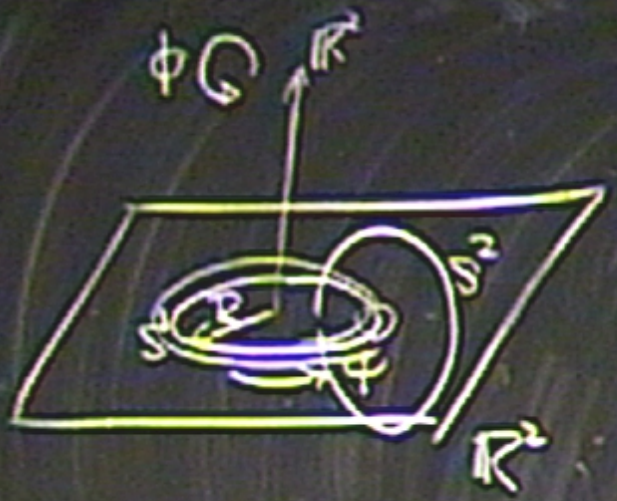




Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

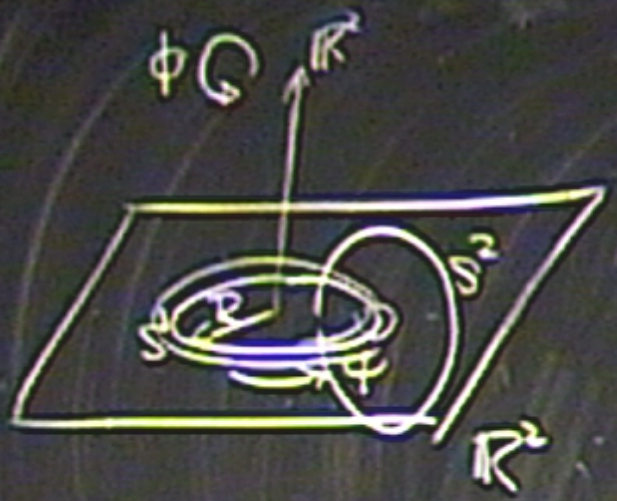
$$\underbrace{Q_i, q_i, R}_{7 \text{ parameters}} \quad i=1,2,3$$



Physical Properties

- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

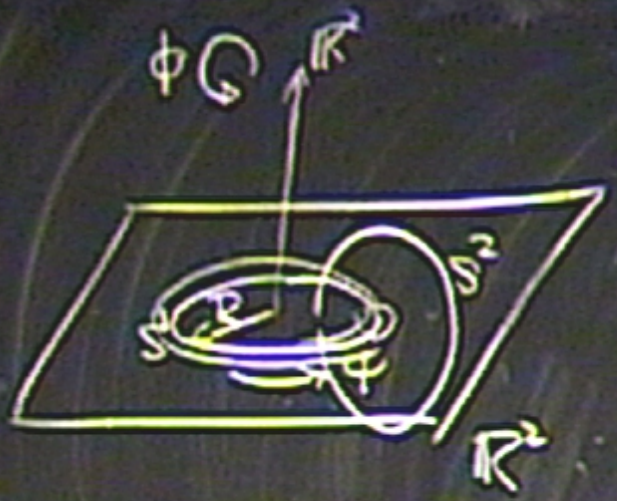
$$\underbrace{Q_i, q_i, R}_{7 \text{ parameters}} \quad i=1,2,3$$

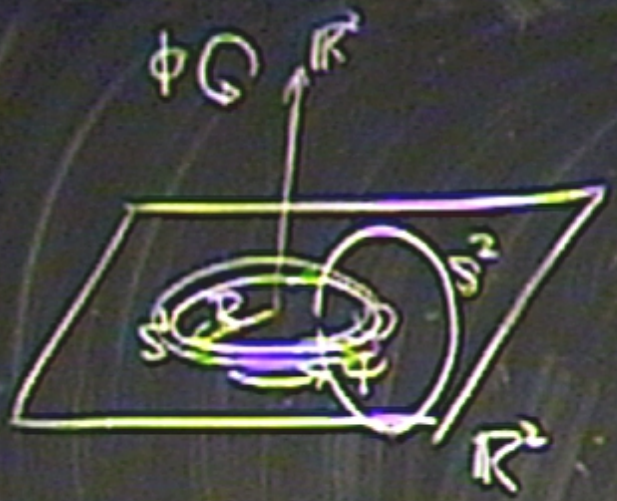


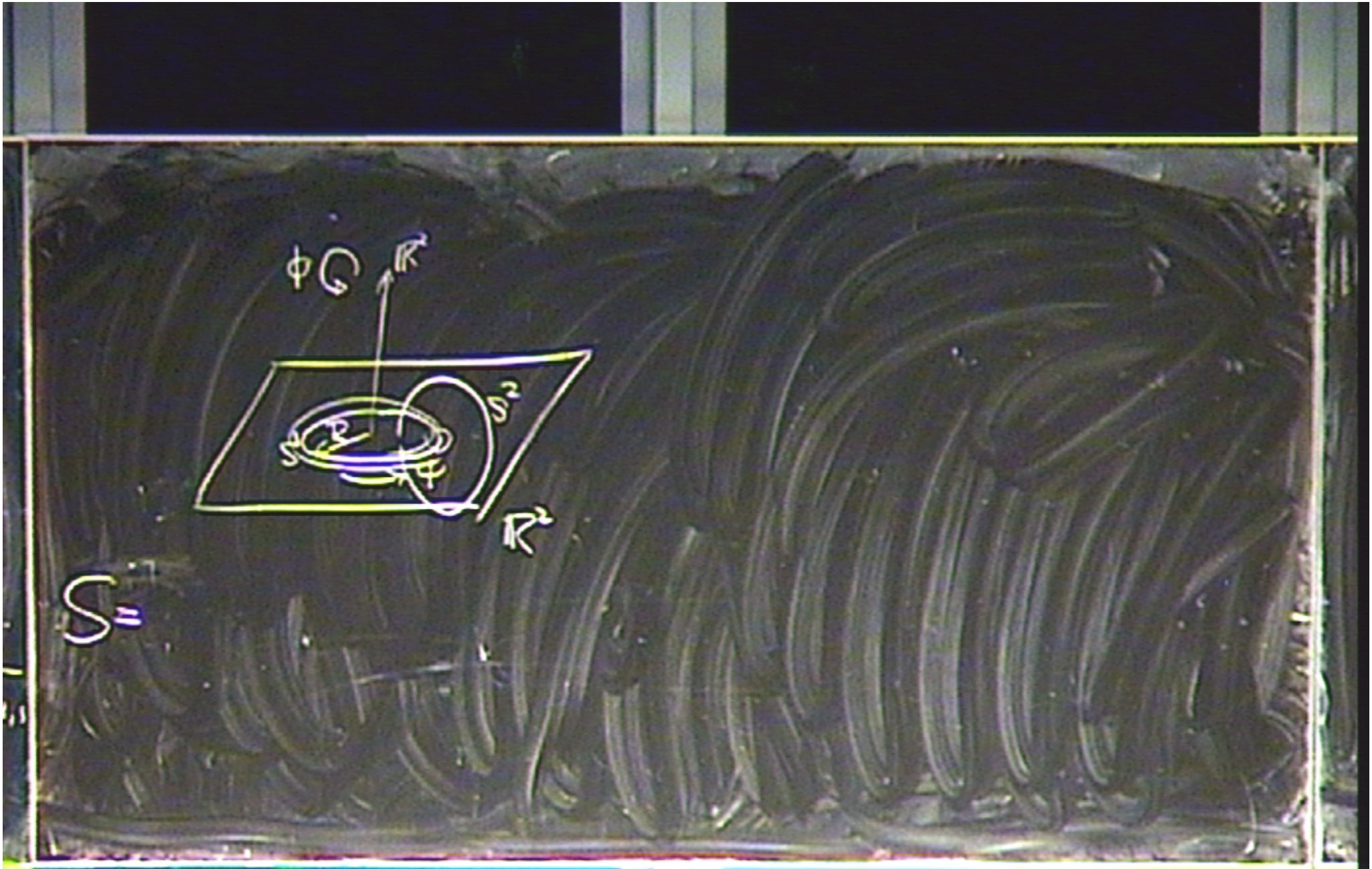
Physical Properties

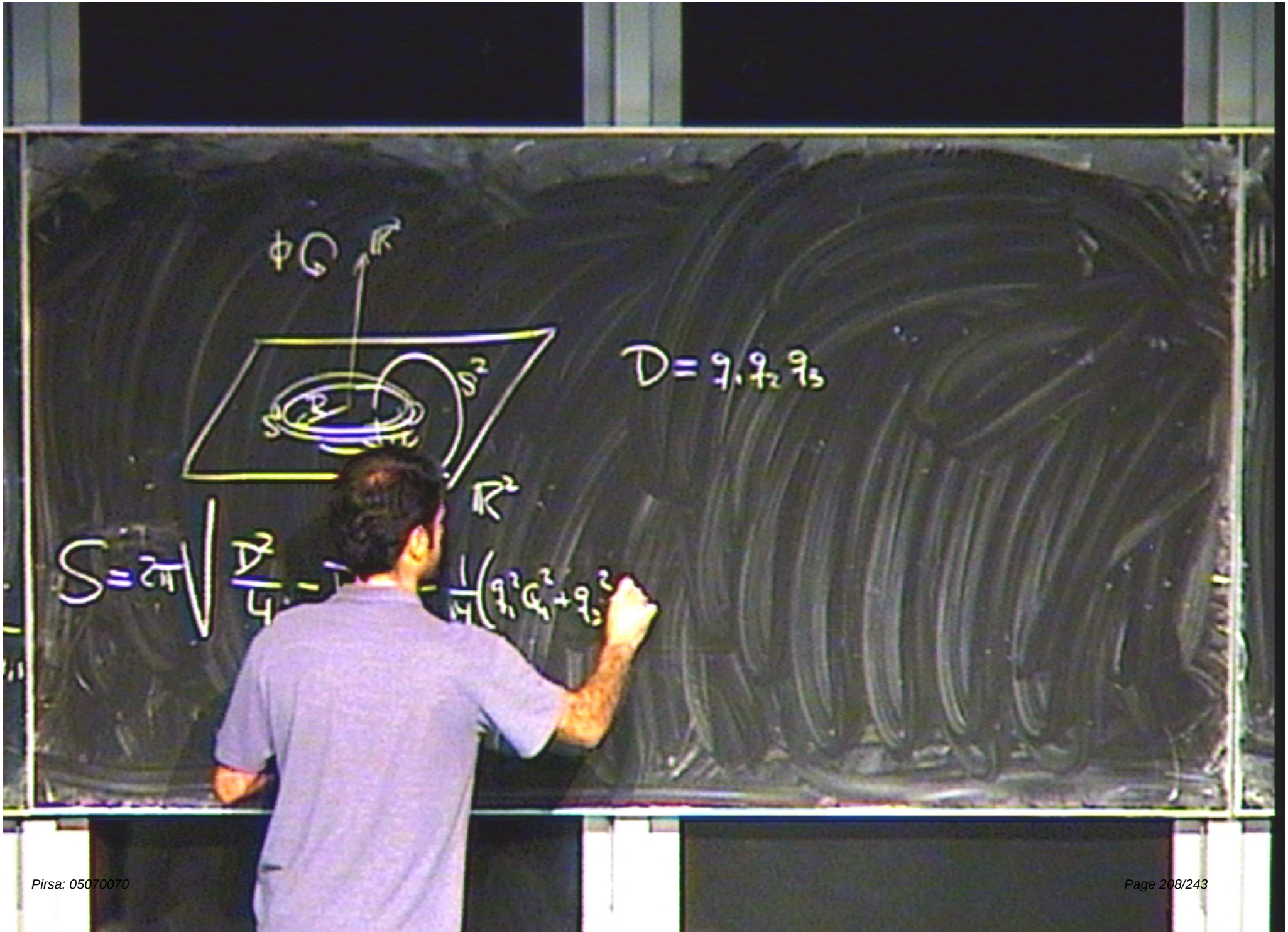
- 1/8 SUSY
- 5D stationary and AF.
- Parameters:

$$\underbrace{Q_i, q_i, R}_{7 \text{ parameters}} \quad i=1,2,3$$


ϕ_G
$\mathbb{R}$
S^2
$\mathbb{R}^3$


ϕ_Q
$\mathbb{R}$
S^2
$\mathbb{R}^3$


ϕ_G
$\mathbb{R}$
S^2
$\mathbb{R}^3$
$S =$


ϕ_G
S^2
R^2
$D = q_1 q_2 q_3$
$S = \frac{D^2}{4\pi} - \frac{1}{4\pi}(q_1^2 G_1^2 + q_2^2$



$$D = q_1 q_2 q_3$$

$$S = \pi R^2 \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$$D = q_1 q_2 q_3$$

$$S = \pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 a_1^2 + q_2^2 a_2^2 + q_3^2 a_3^2\right) + \frac{D}{2}\left(\frac{a_1 a_2}{q_3} + \frac{a_2 a_3}{q_1} + \frac{a_1 a_3}{q_2}\right)}$$



$$D = q_1 q_2 q_3$$

$$S = \pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$$D = q_1 q_2 q_3$$

$$S = \pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 G_1^2 + q_2^2 G_2^2 + q_3^2 G_3^2\right) + \frac{D}{2}\left(\frac{G_1 G_2}{q_3} + \frac{G_2 G_3}{q_1} + \frac{G_1 G_3}{q_2}\right)}$$



$$D = q_1 q_2 q_3$$

$$S = \pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 G_1^2 + q_2^2 G_2^2 + q_3^2 G_3^2\right) + \frac{D}{2}\left(\frac{G_2 G_3}{q_1} + \frac{G_1 G_3}{q_2} + \frac{G_1 G_2}{q_3}\right)}$$



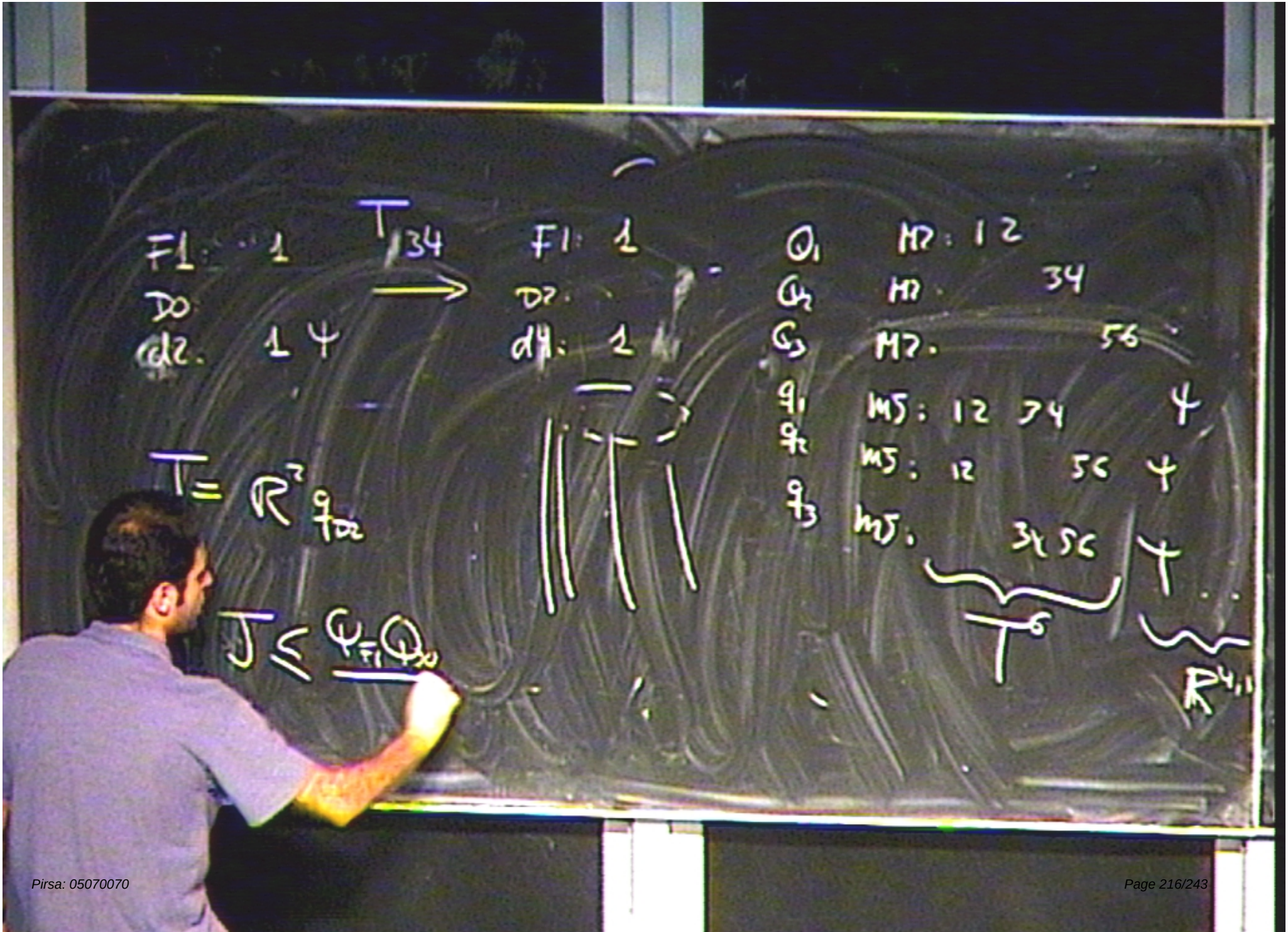
$$D = q_1 q_2 q_3$$

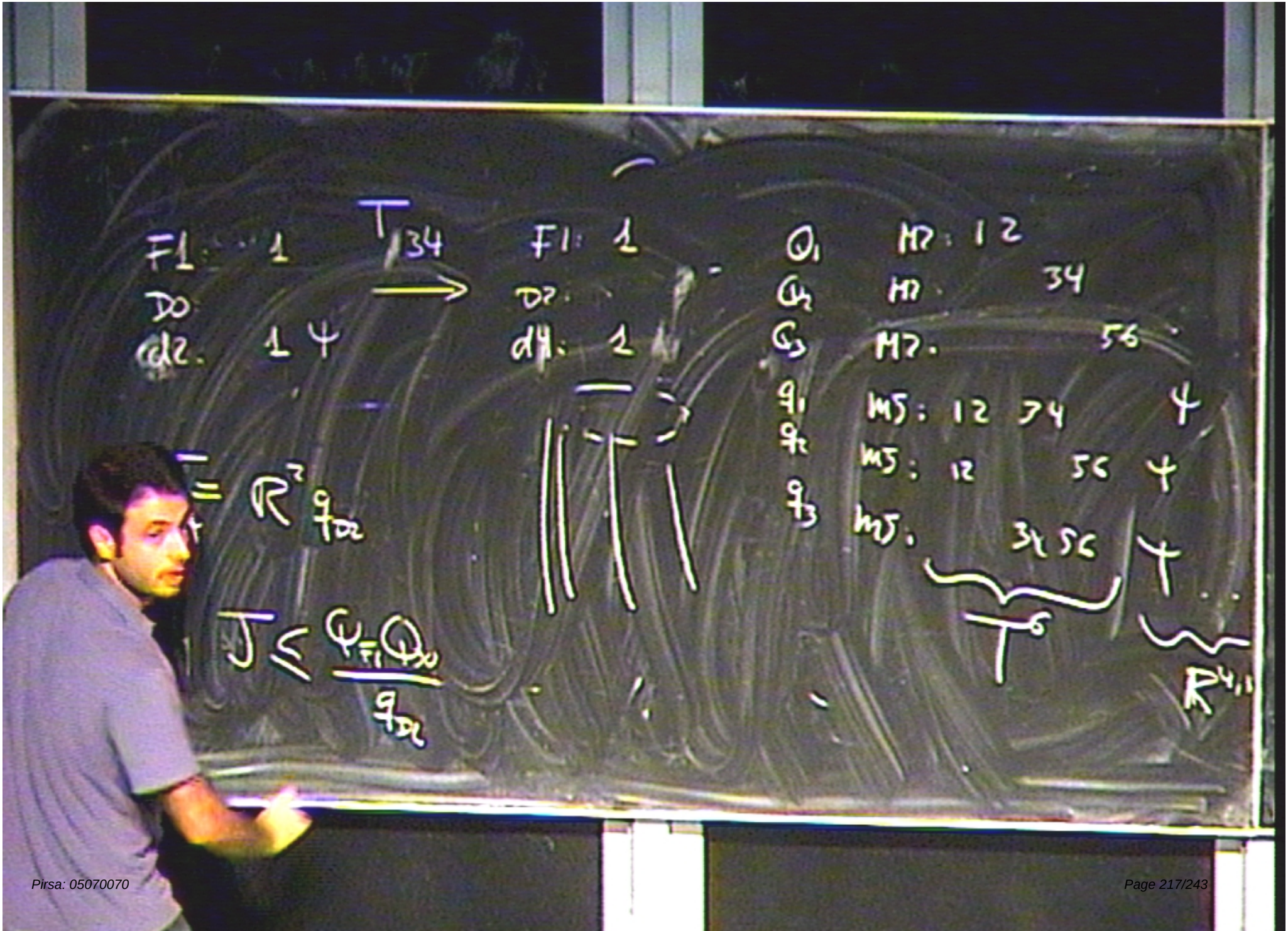
$$S = \pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$

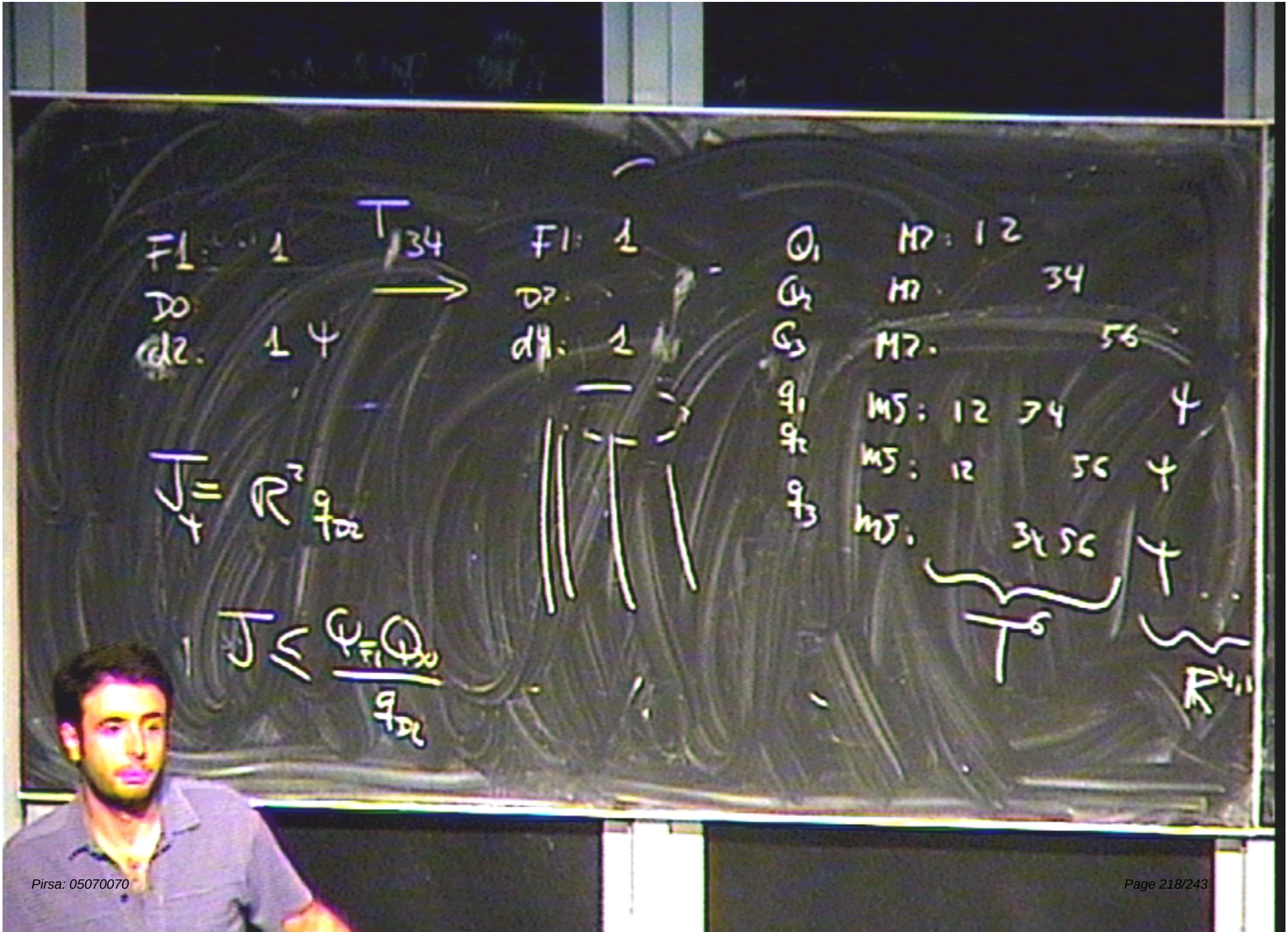


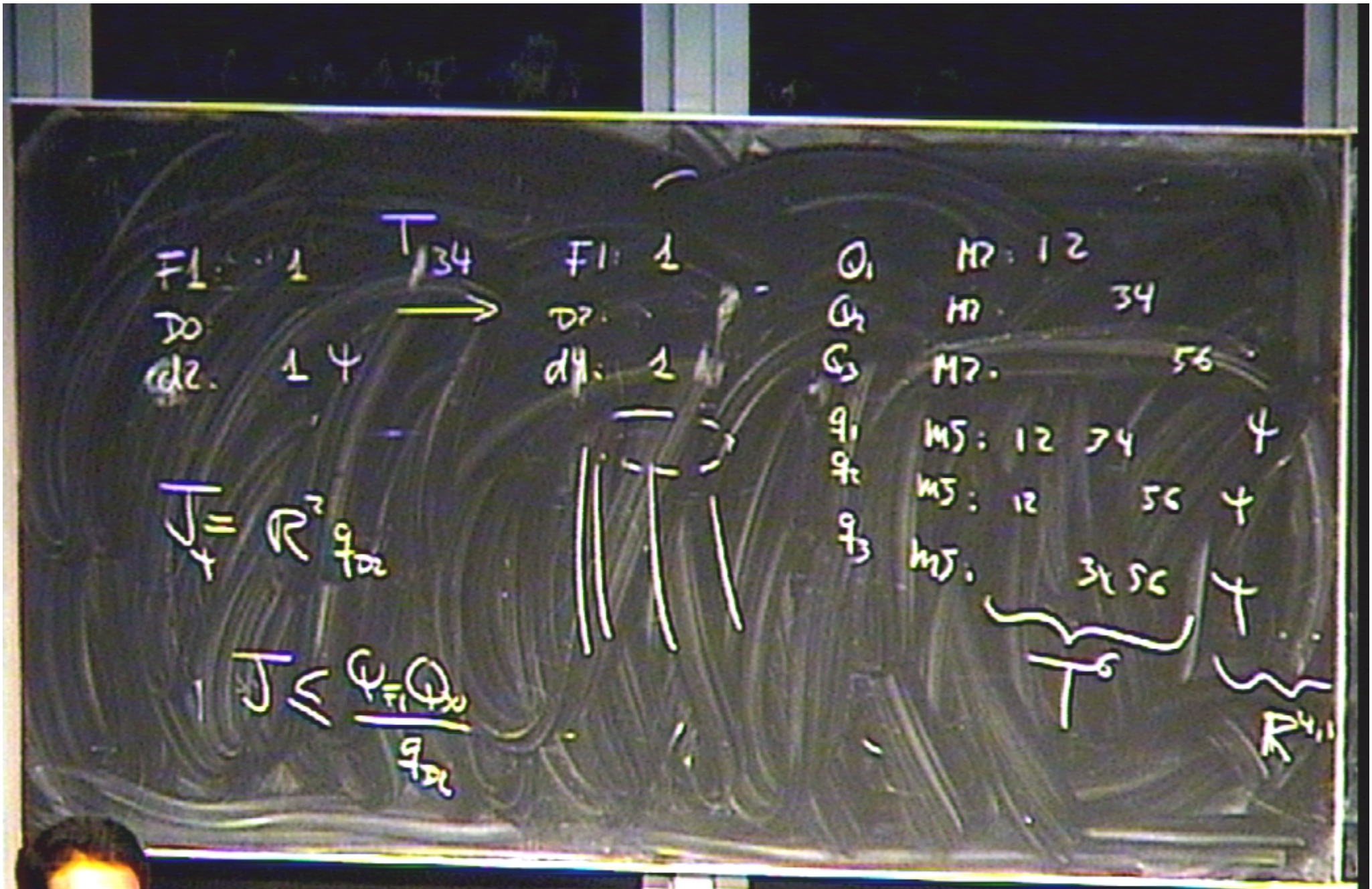
$$D = q_1 q_2 q_3$$

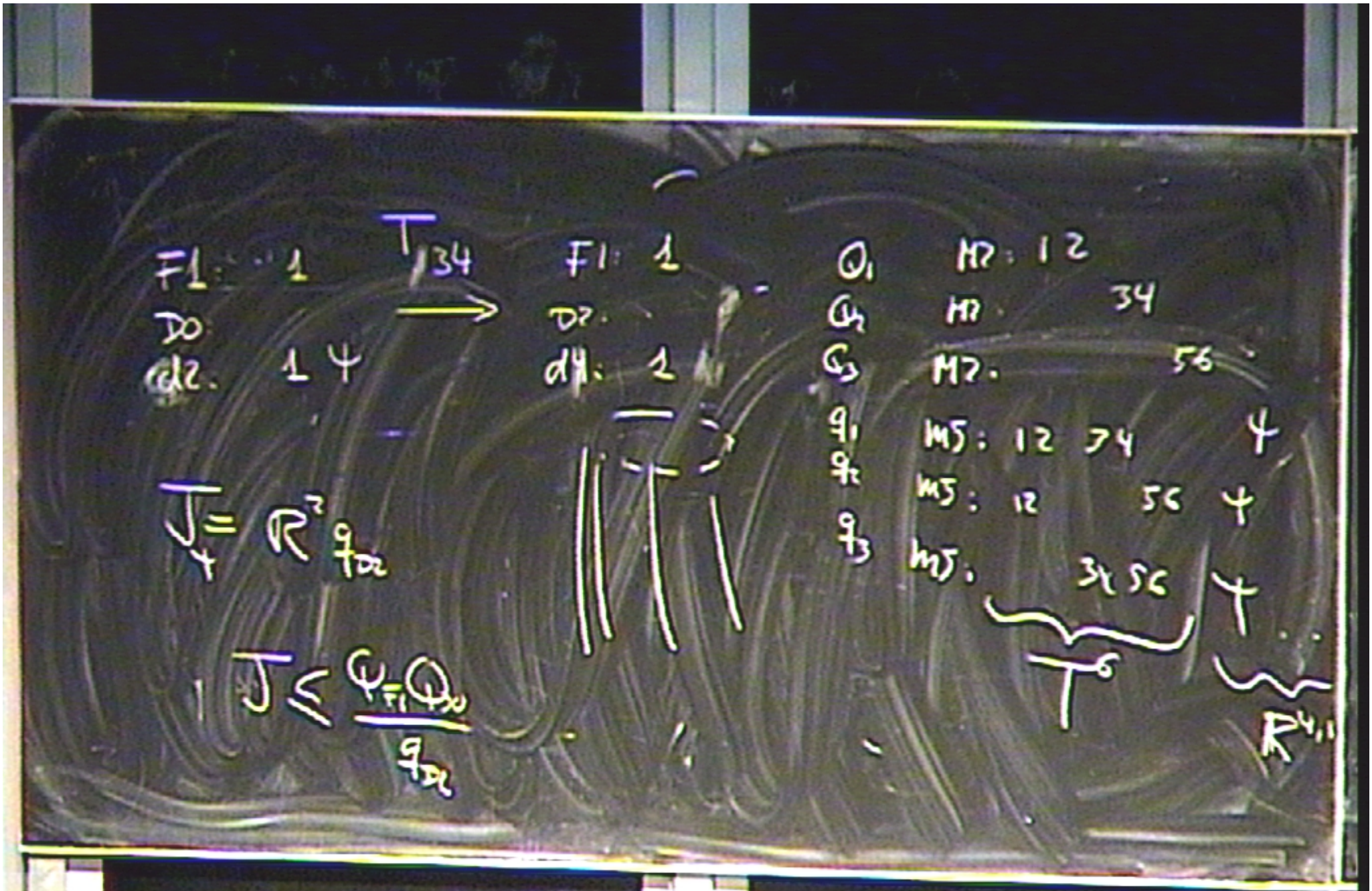
$$S = \text{const} \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$

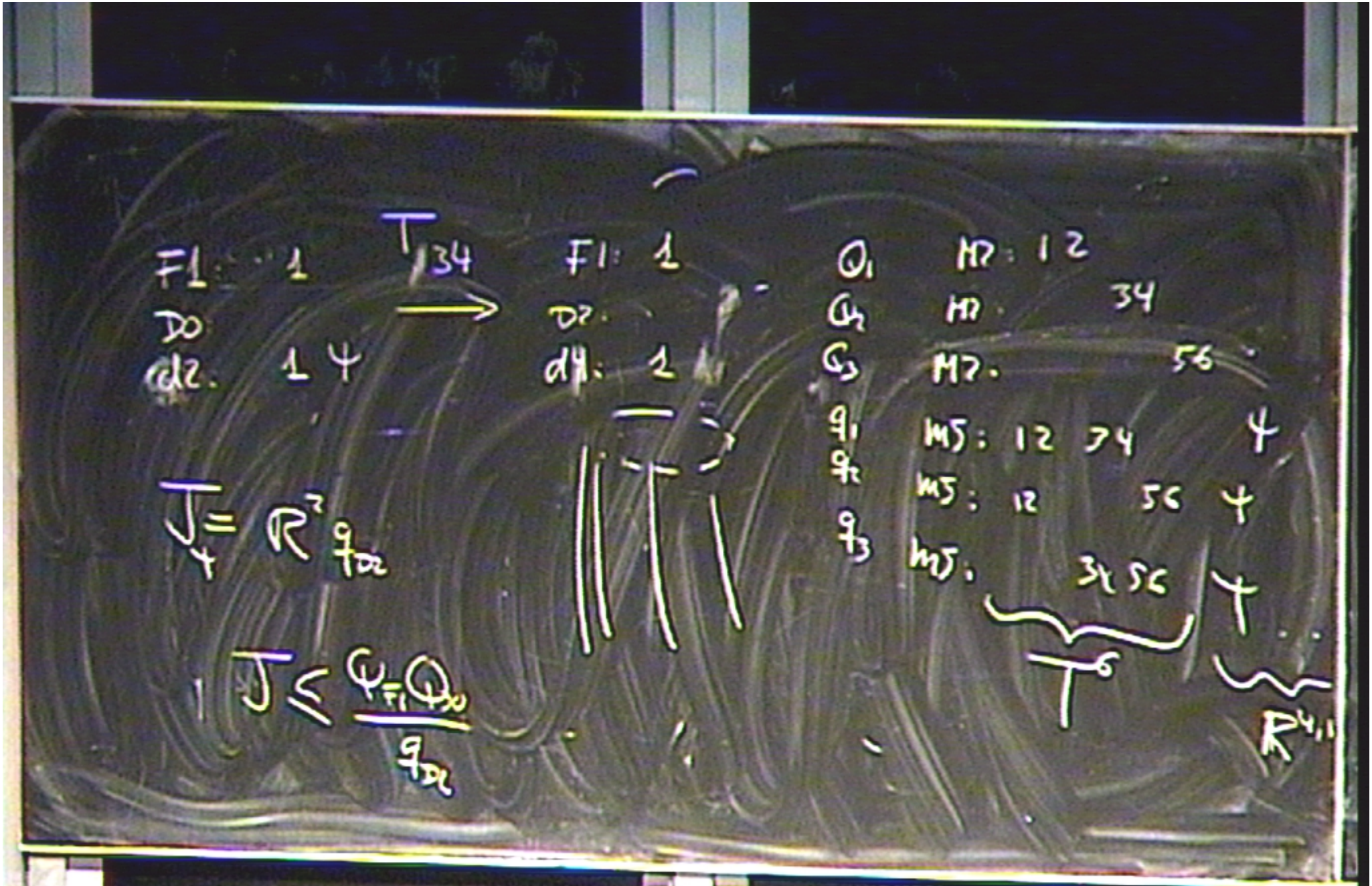

F1: 1
D0
dz. 1 ψ
T34
F1: 1
D2.
dy: 1
Q1 M2: 12
Q2 M2. 34
Q3 M2. 56
q1 M5: 12 34 ψ
q2 M5: 12 56 ψ
q3 M5. 3,4,5,6 ψ
T= R² q₁q₂
J ≤ Ψ=1 Q=0
T⁶
R⁴,¹

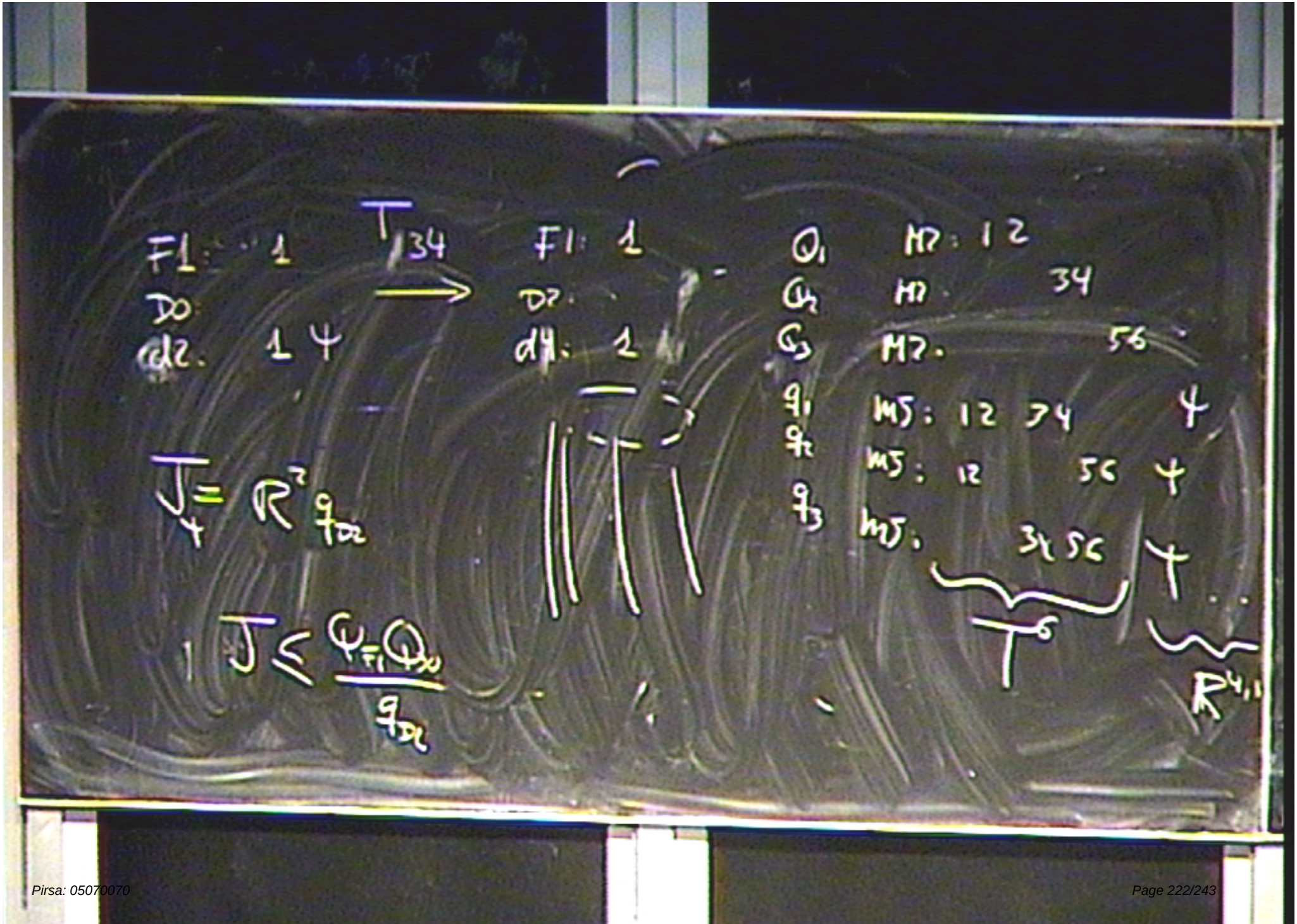

Fl: 1
D0
d2. 1 4
T34
Fl: 1
D2:
d4: 2
Q1 M2: 1 2
Q4 M2 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56
T6
R4,1

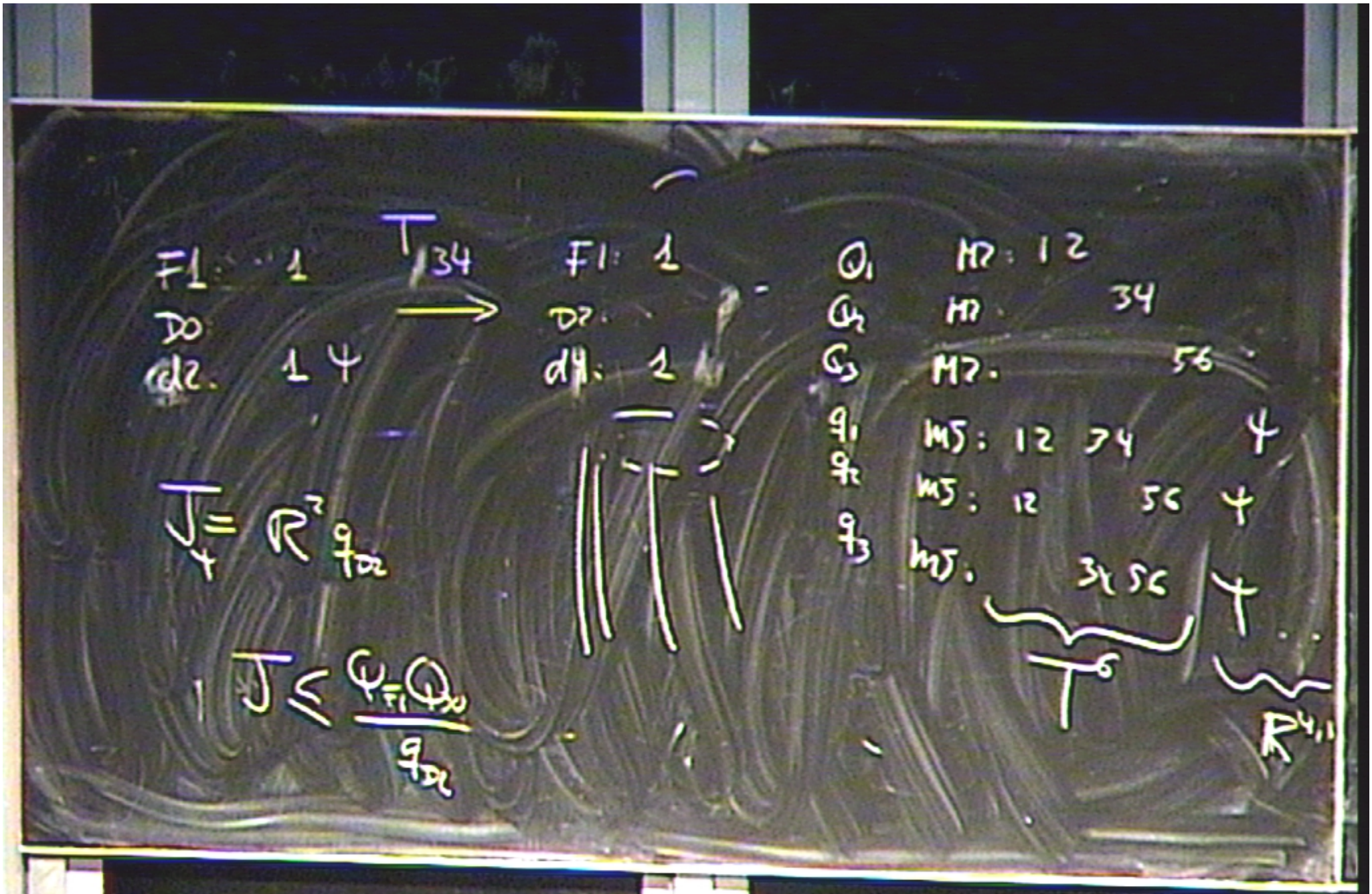

F1: 1
D0
d2. 1 4
T 34
F1: 2
D2.
d4: 2
Q1 M2: 1 2
G4 M2. 34
G3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 3 4 56
T
R4,1

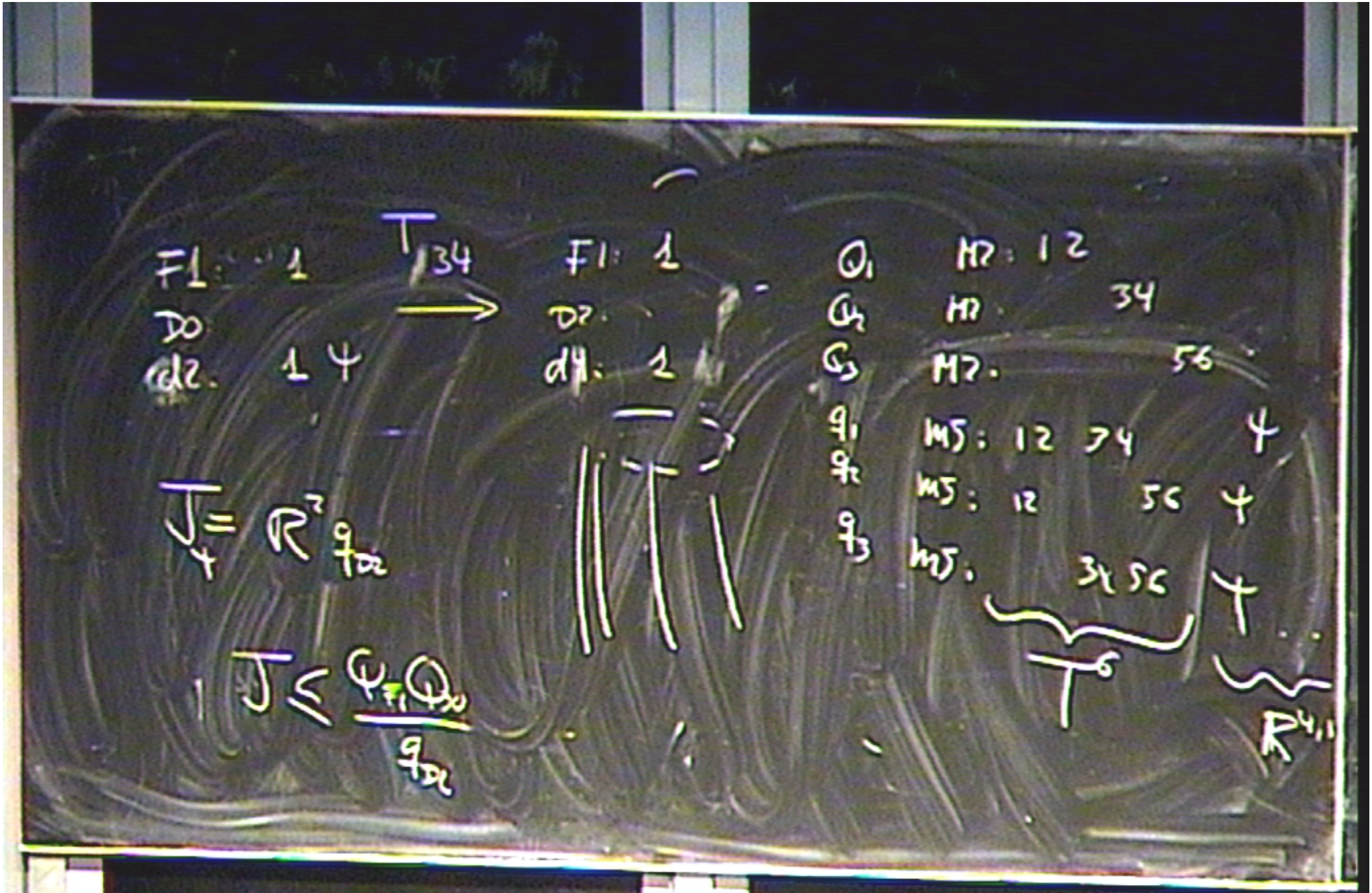

Fl: 1
Do
dz. 1 4
T34
Fl: 1
Dz.
dy: 2
Q1 M2: 12
Q2 M2 34
Q3 M2. 56
q1 M3: 12 34 4
q2 M3: 12 56 4
q3 M3. 34 56 4
J = R² q_Dz
J ≤ Ψ_Fl Q_Dz / q_Dz
T
R^4,1

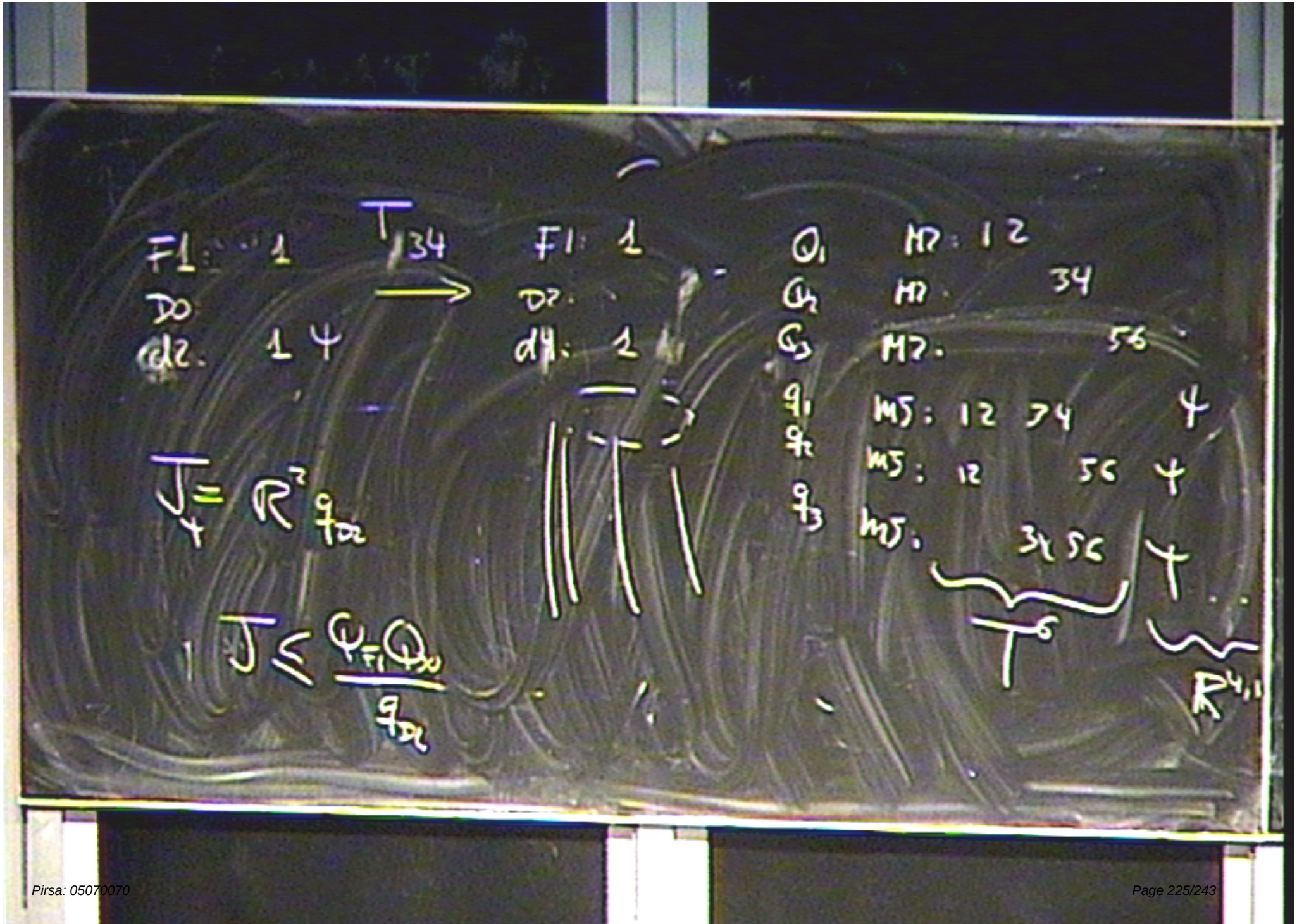

F1: 1
D0
dz. 1 4
T34
F1: 1
D2.
d4: 2
Q1 M2: 12
Q4 M2 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56 4
T
R4,1


F1: 1
D0
d2. 1 ψ
T34
F1: 1
D2.
d4: 2
Q1 M2: 12
G4 M2. 34
G3 M2. 56
q1 M5: 12 34 ψ
q2 M5: 12 56 ψ
q3 M5. 34 56 ψ
J = R^2 q_D2
J ≤ Ψ_F1 Q_D0 / q_D2
T^6
R^4,1


Fl: 1
Do
dz. 1 4
T34
Fl: 1
D2.
d4: 2
Q1 M2: 12
Q2 M2 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56
T6
R4,1


T34
R^{4,1}


F1: 1
D0
dz. 1 4
T 34
F1: 1
D2.
d4: 2
Q1 M2: 12
G4 M2. 34
G3 M2. 56
q1 M3: 12 34 4
q2 M3: 12 56 4
q3 M3. 34 56
T
R4,1

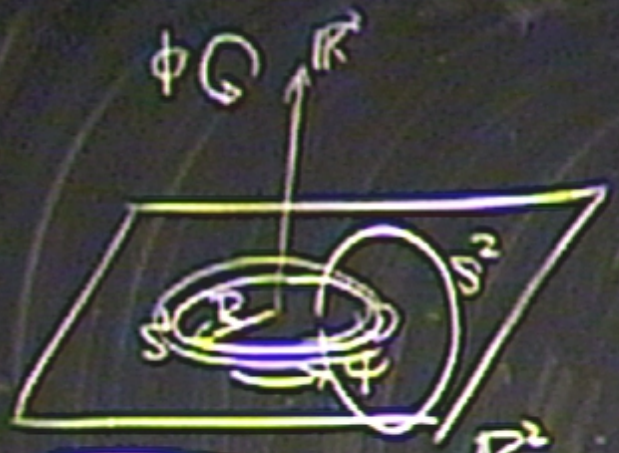

F1: 1
D0
d2. 1 4
T34
F1: 1
D2.
d4: 1
Q1 M2: 12
Q2 M2 34
Q3 M2. 56
q1 M5: 12 34 4
q2 M5: 12 56 4
q3 M5. 34 56
T
R4,1



$D = q_1 q_2 q_3$

Q, q_i, J_4

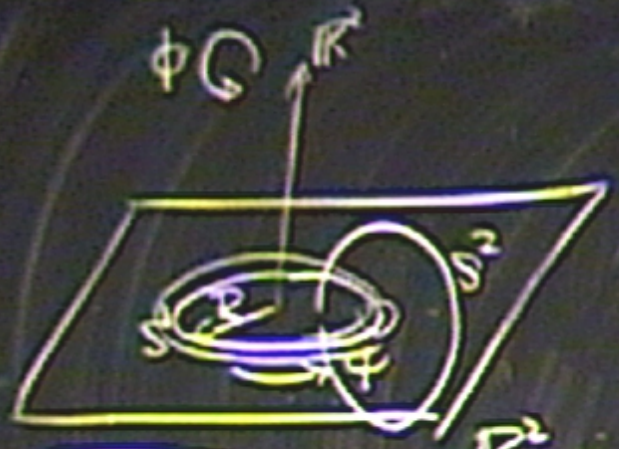
$$S = \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$

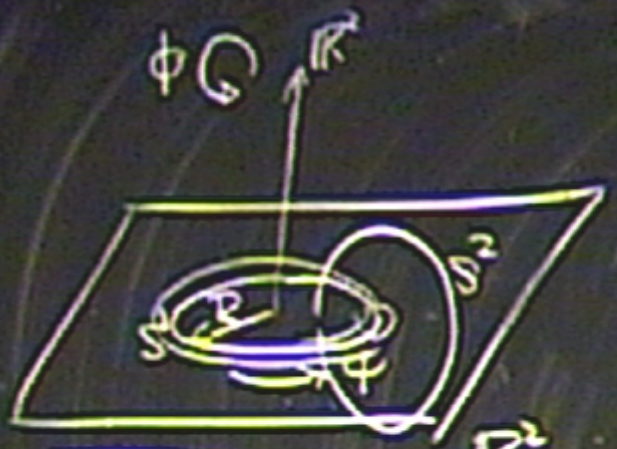
Q, q_i, J_4

$$S = 2\pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$ $\quad Q, q_i, J_4$

$$S = 2\pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$

Q, q_i, J_4

$$S = 2\pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$ $\quad Q, q_i, J_4$

$$S = \pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$

Q, q_i, J_4

$$S = 2\pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$ $\quad Q, q_i, J_4$

$$S = 2\pi\sqrt{\frac{D^2}{4} - DJ_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$



$D = q_1 q_2 q_3$ $\quad Q, q_i, J_4$

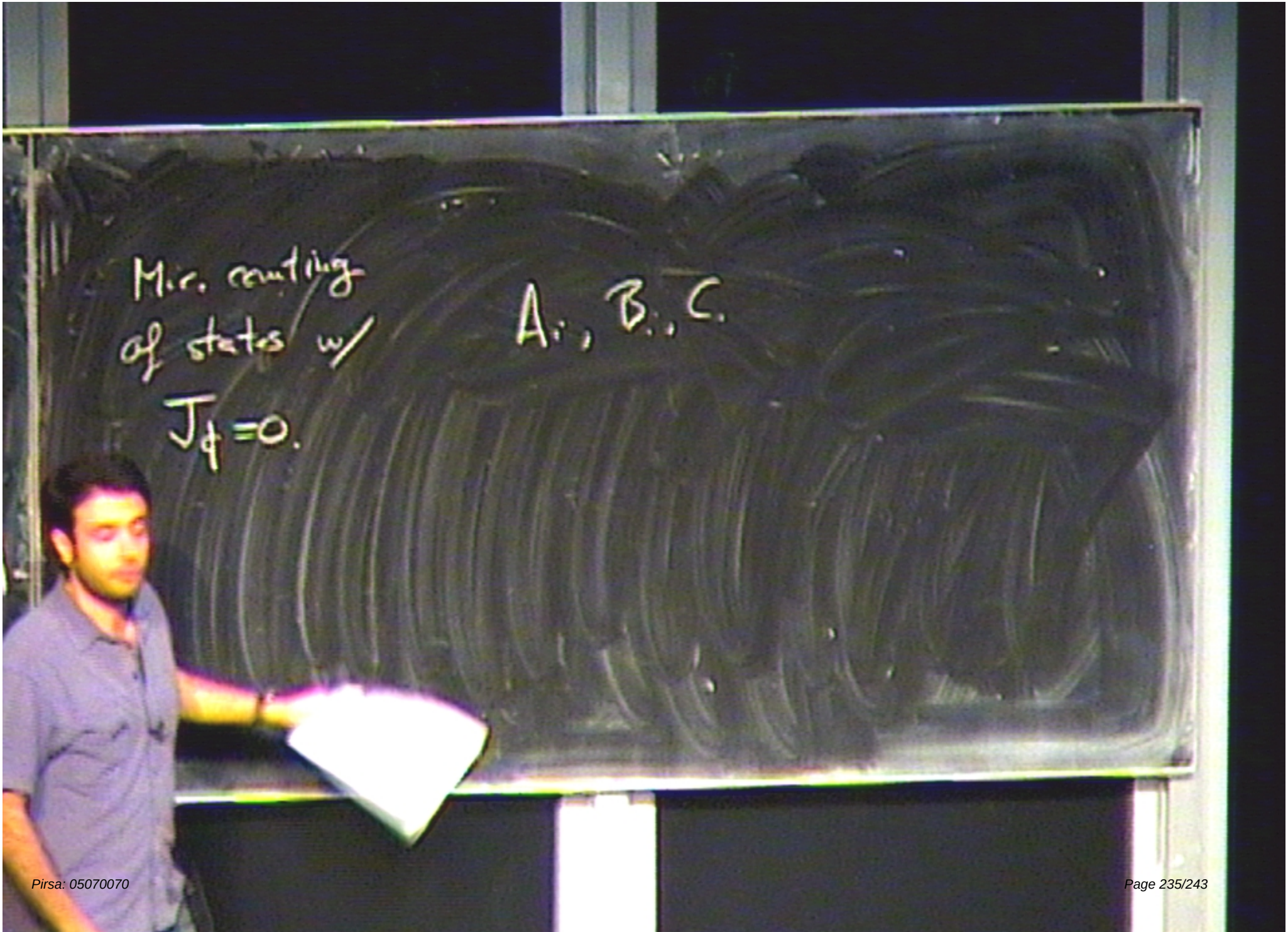
$$S = 2\pi\sqrt{\frac{D^2}{4} - DJ_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$

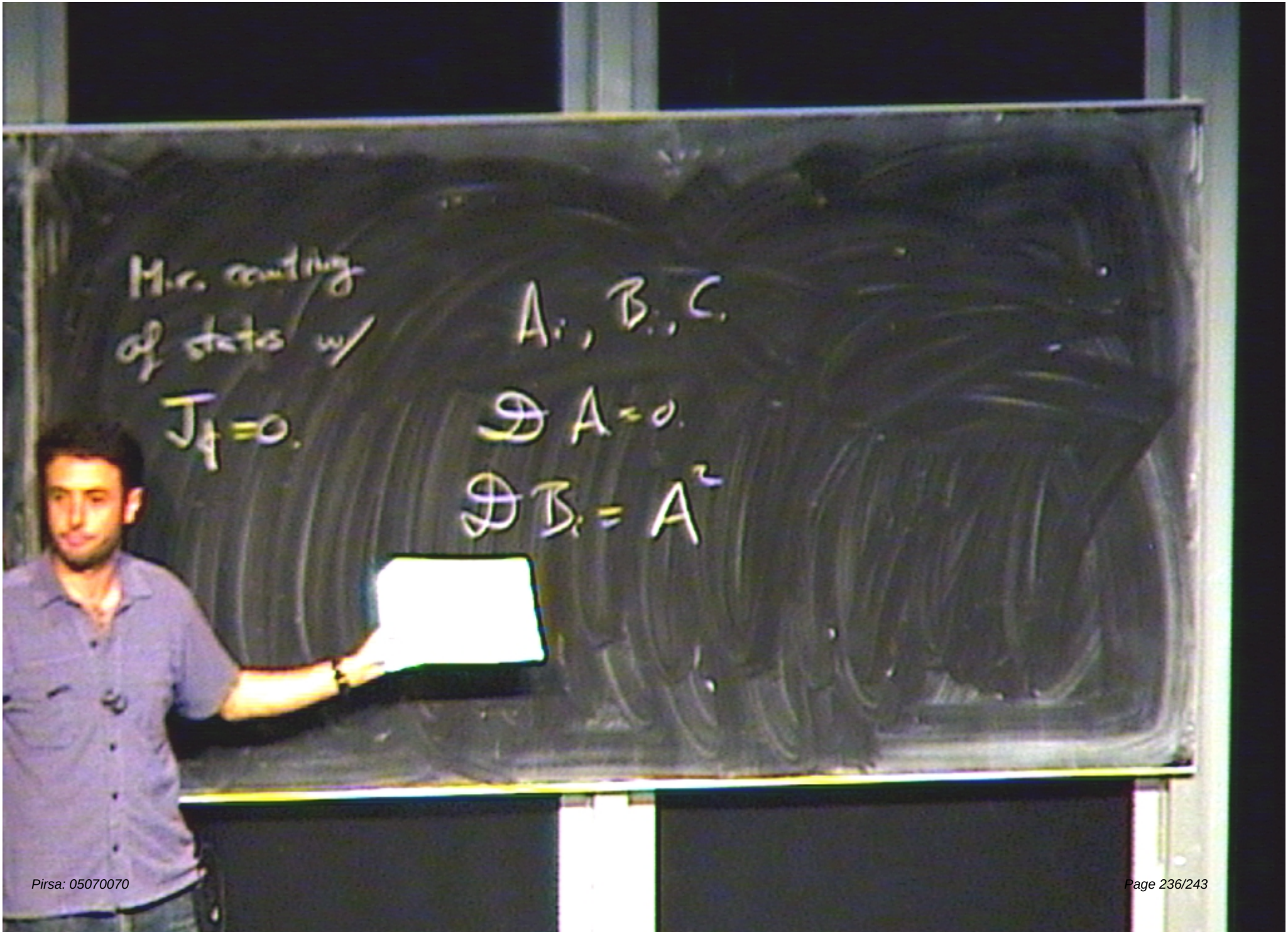


$D = q_1 q_2 q_3$

Q, q_i, J_4

$$S = 2\pi \sqrt{\frac{D^2}{4} - D J_4 - \frac{1}{4}\left(q_1^2 Q_1^2 + q_2^2 Q_2^2 + q_3^2 Q_3^2\right) + \frac{D}{2}\left(\frac{Q_1 Q_2}{q_3} + \frac{Q_2 Q_3}{q_1} + \frac{Q_1 Q_3}{q_2}\right)}$$


M.c. counting
of states w/
$J_f = 0$.
A_i, B_i, C_i


Micr. counting
of states w/
$J_4 = 0$.
A_i, B_i, C_i
$\mathcal{D} A = 0$.
$\mathcal{D} B_i = A^2$

M.c. counting of states w/ $J_4 = 0$.

A_i, B_i, C_i

$\mathcal{D} A = 0$.

$\mathcal{D} B_i = A^2$

$\mathcal{D} C_i = A^3, \partial$

Micr. counting of states w/ $J_4 = 0$.

A_i, B_i, C_i

$\mathfrak{D} A = 0$.

$\mathfrak{D} B_i = A^2$

$\mathfrak{D} C_i = A^2, \pi$

Micro counting of states w/ $J_4 = 0$.

A_i, B_i, C_i

$\mathfrak{D}\, A = 0$.

$\mathfrak{D}\, B_i = A^2$

$\mathfrak{D}\, C_i = A^2, \partial$

Micro counting of states w/ $J_4 = 0$.

A_i, B_i, C_i

$\mathfrak{D} A = 0$.

$\mathfrak{D} B_i = A^2$

$\mathfrak{D} C_i = A^2, \Pi$

Micro counting of states w/ $J_4 = 0$.

A_i, B_i, C_i

$\mathfrak{D}\, A = 0$.

$\mathfrak{D}\, B_i = A^2$

$\mathfrak{D}\, C_i = A^3, \pi$

M.c. counting of states w/ $J_q = 0$.

A_i, B_i, C_i

$\mathcal{D} A = 0$.

$\mathcal{D} B_i = A^2$

$\mathcal{D} C_i = A^2, \bar{\Pi}$

M.c. counting of states w/ $J_q = 0$.

A_i, B_i, C_i

$\sum A = 0$.

$\sum B_i = A^2$

$\sum C_i = A^2, \bar{D}$