Title: Three-dimensional topological sigma-model with boundaries and defects

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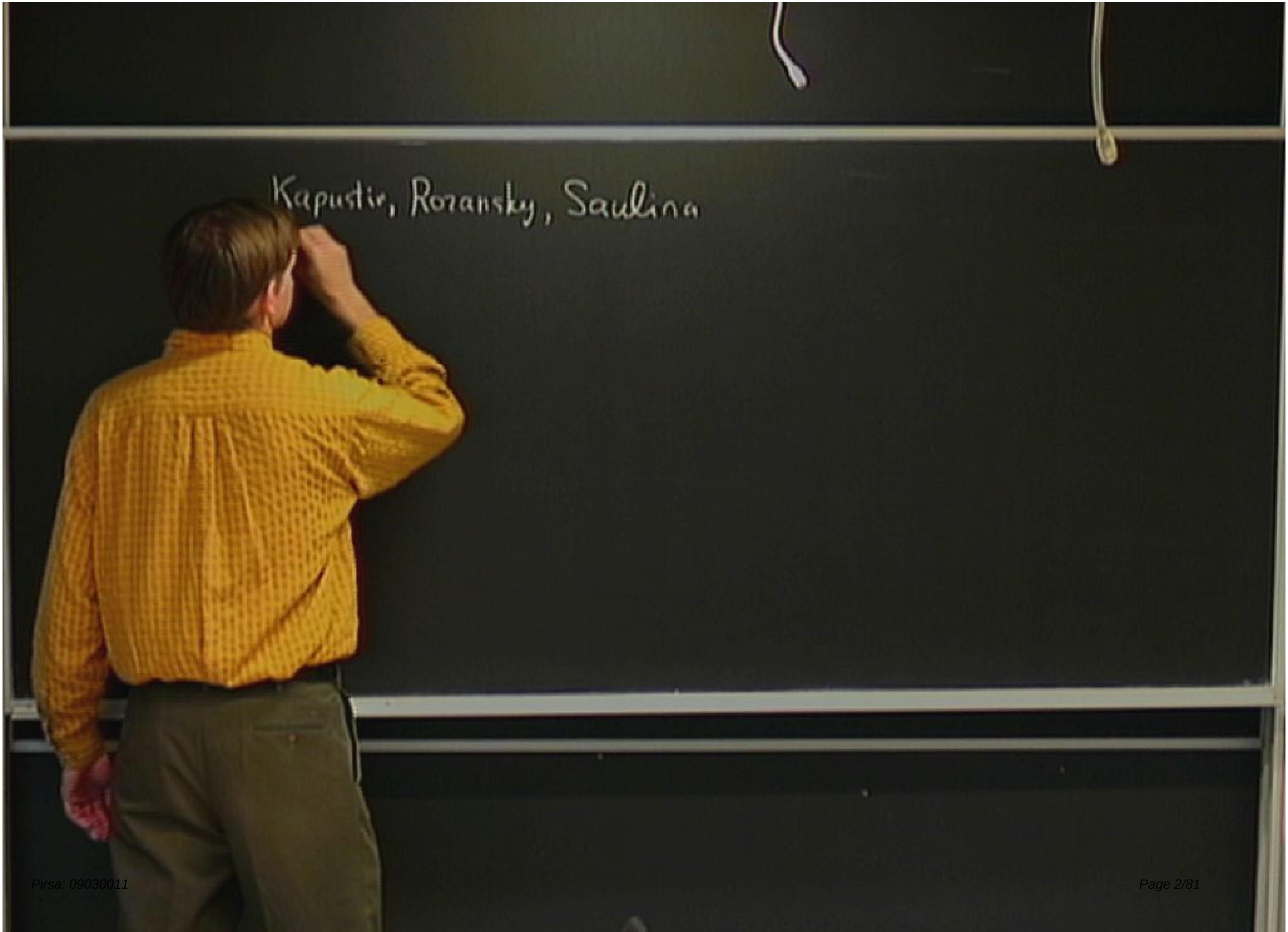
Abstract: The Rozansky-Witten model is a topological sigma-model in three dimensions whose target is a hyper-Kahler manifold. Upon compactification to 2d it reduces to the B-model with the same target. Boundary conditions for the Rozansky-Witten model can be regarded as a 3d generalization of B-branes. While branes form a category, boundary conditions in a 3d TFT form a 2-category. I will describe the structure of this 2-category for the Rozansky-Witten model and its connection with a categorification of deformation quantization. I will also discuss defects of codimension 1 (domain walls) and defects of codimension 2 (line operators) in the Rozansky-Witten model.


Kapustin, Rozansky, Saulina

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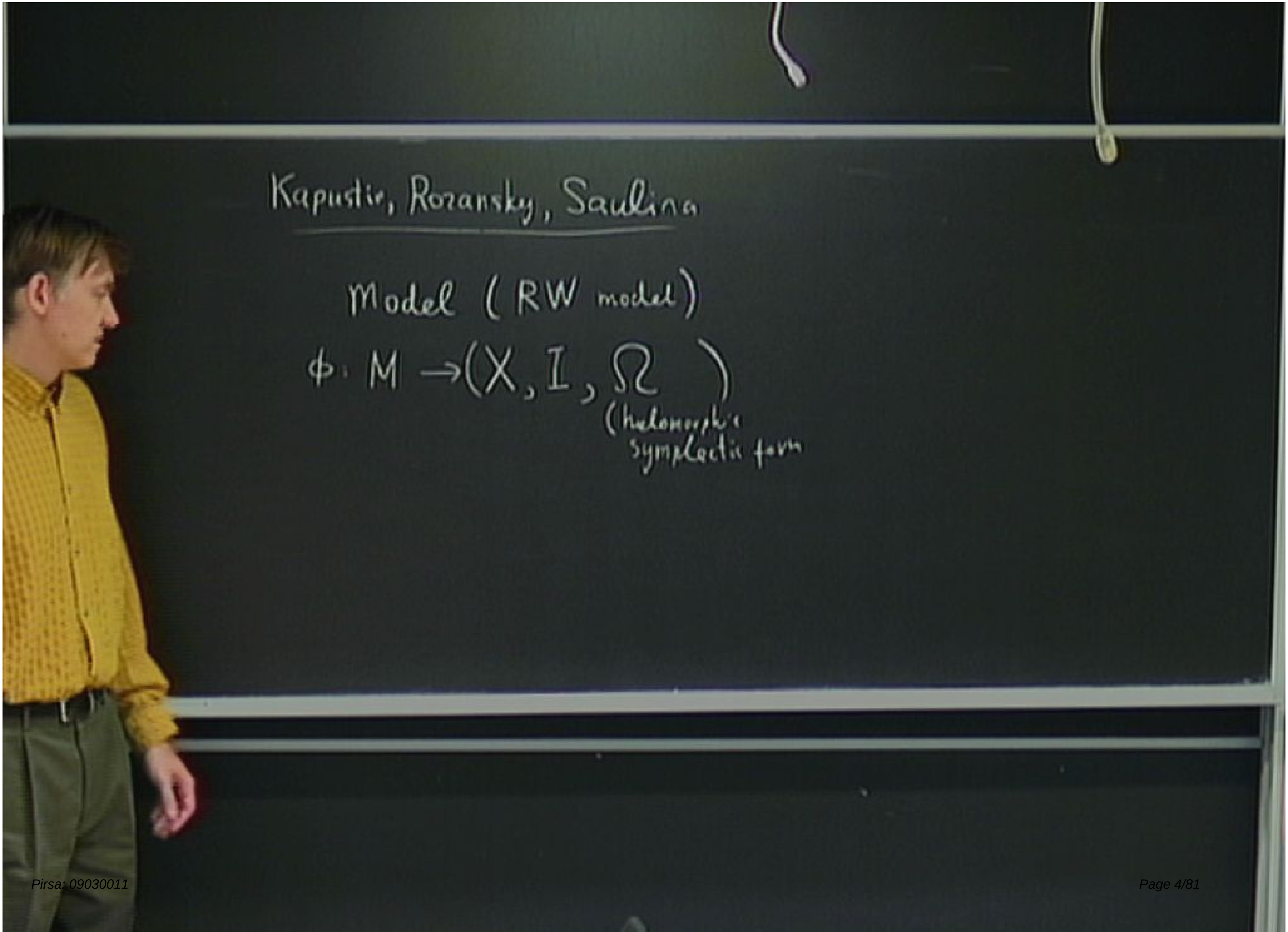
Model (RW model)

$\phi : M \to (X, I$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$\Omega \in \Omega^{2,0}$, Ω nondeg.

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$(\phi^i, \phi^{\bar i}) : M_3 \to (X, I, \Omega)$ (holomorphic symplectic form)

$\Omega = \Omega^{2,0}$, Ω nondeg.

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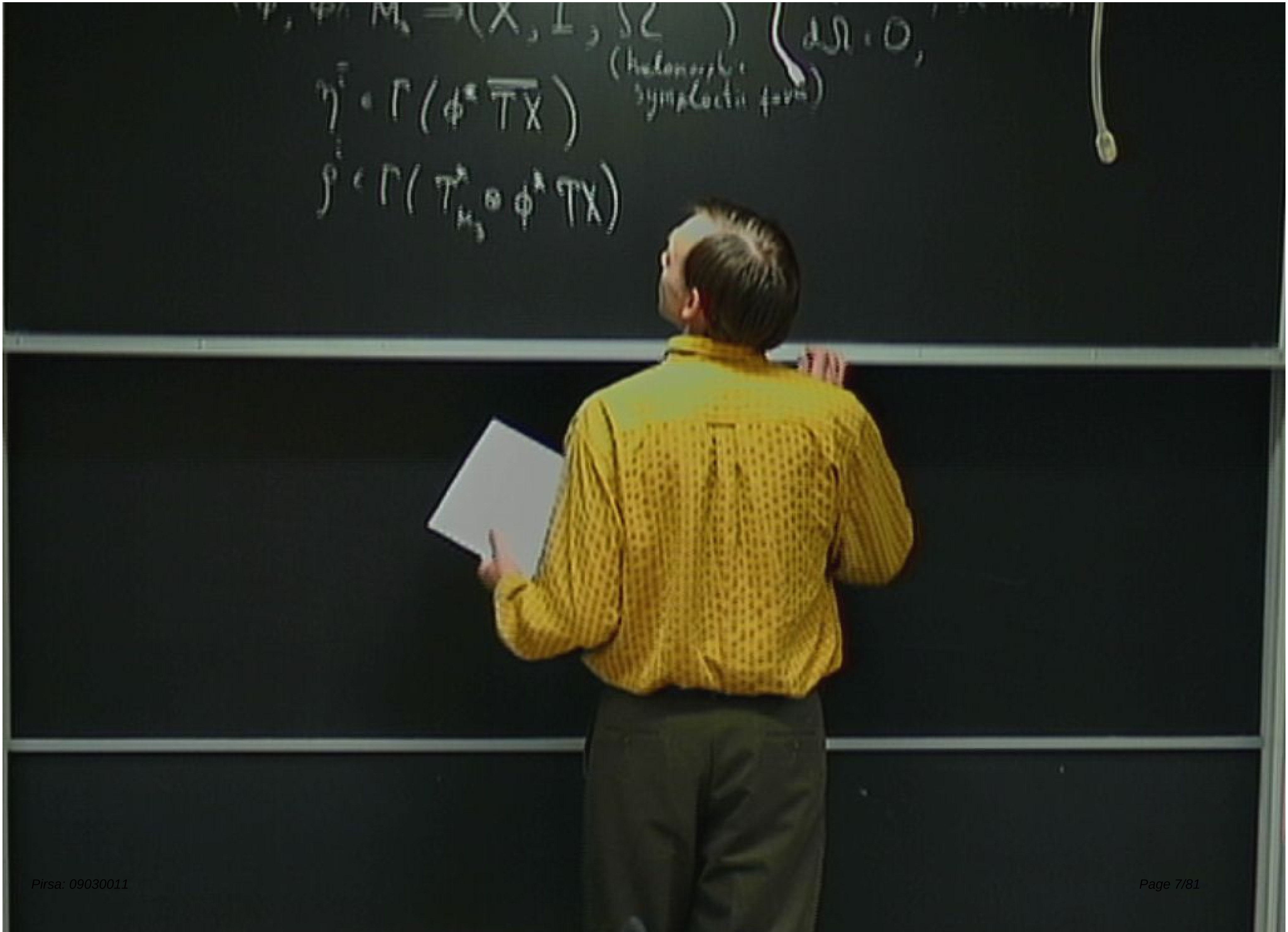
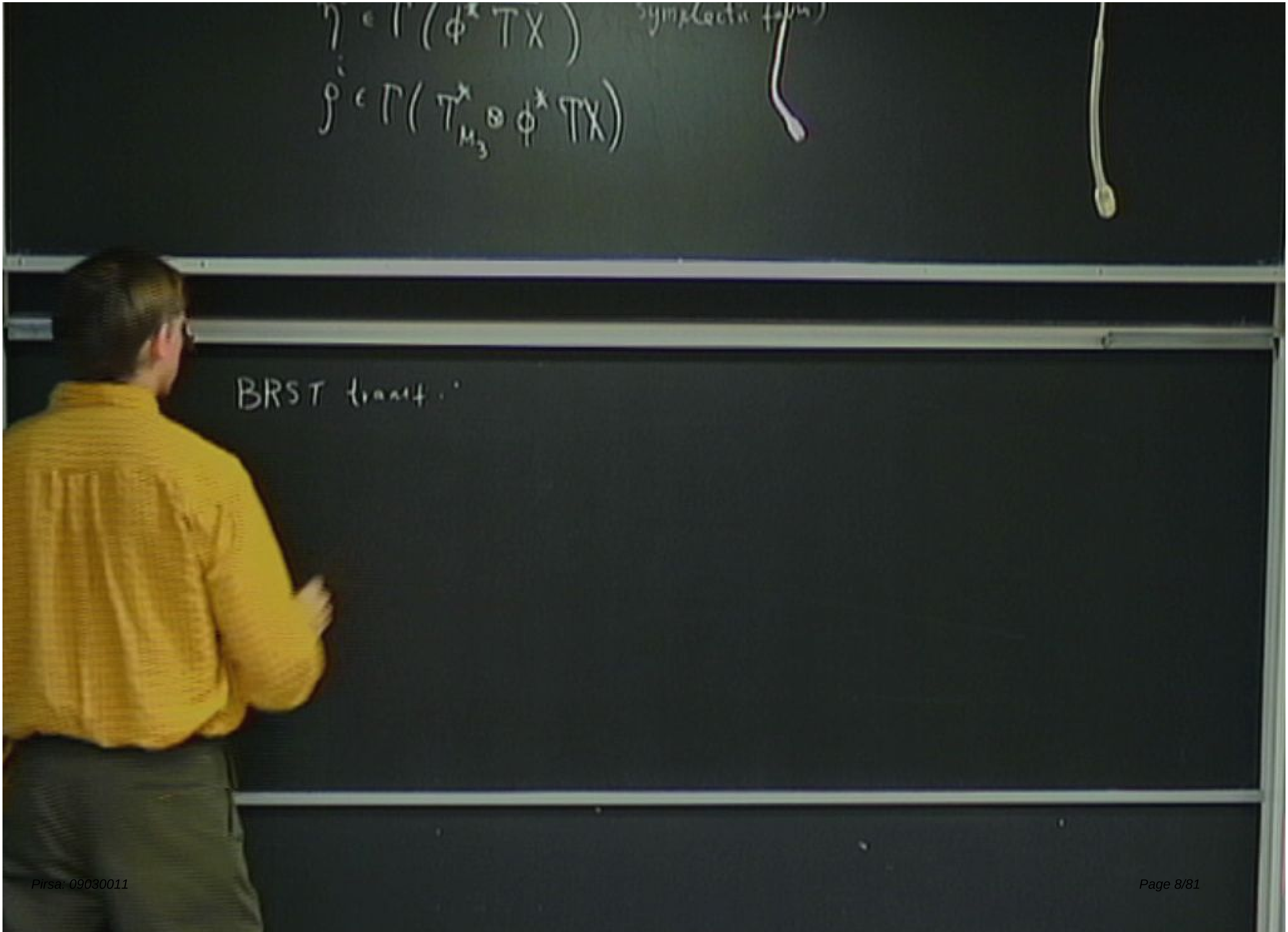
$\eta^{\bar i} \in \Gamma(\phi^* \overline{TX})$


$\phi: M_3 \to (X, I, \Omega)$
$d\Omega = 0$,
(holomorphic symplectic form)
$\eta^{\bar i} \in \Gamma(\phi^* \overline{TX})$
$\rho^i \in \Gamma(T^*_{M_3} \otimes \phi^* TX)$



η ∈ Γ(φ* TX)
symplectic form)
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Action: $S = \int_{M_3}$

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$$S = \int_{M_3} \delta\left(g_{i\bar{j}}\, \rho^i \wedge * d\phi^{\bar{j}}\right)$$

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$$S = \int_{M_3} \delta\left(g_{i\bar j}\, \rho^i \wedge * d\phi^{\bar j}\right) + \Omega_{ij}\left(\rho^i \wedge d\rho^j + \frac{2}{3} R^{i}_{k\ell\bar m}\, \rho^k \rho^\ell \rho^j \eta^{\bar m}\right)$$

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(holomorphic symplectic form)

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1). The theory is $\mathbb{Z}_2$-graded.

2)

$$\rho^i \in \Gamma(T^*_{M_3} \otimes \phi^* TX)$$

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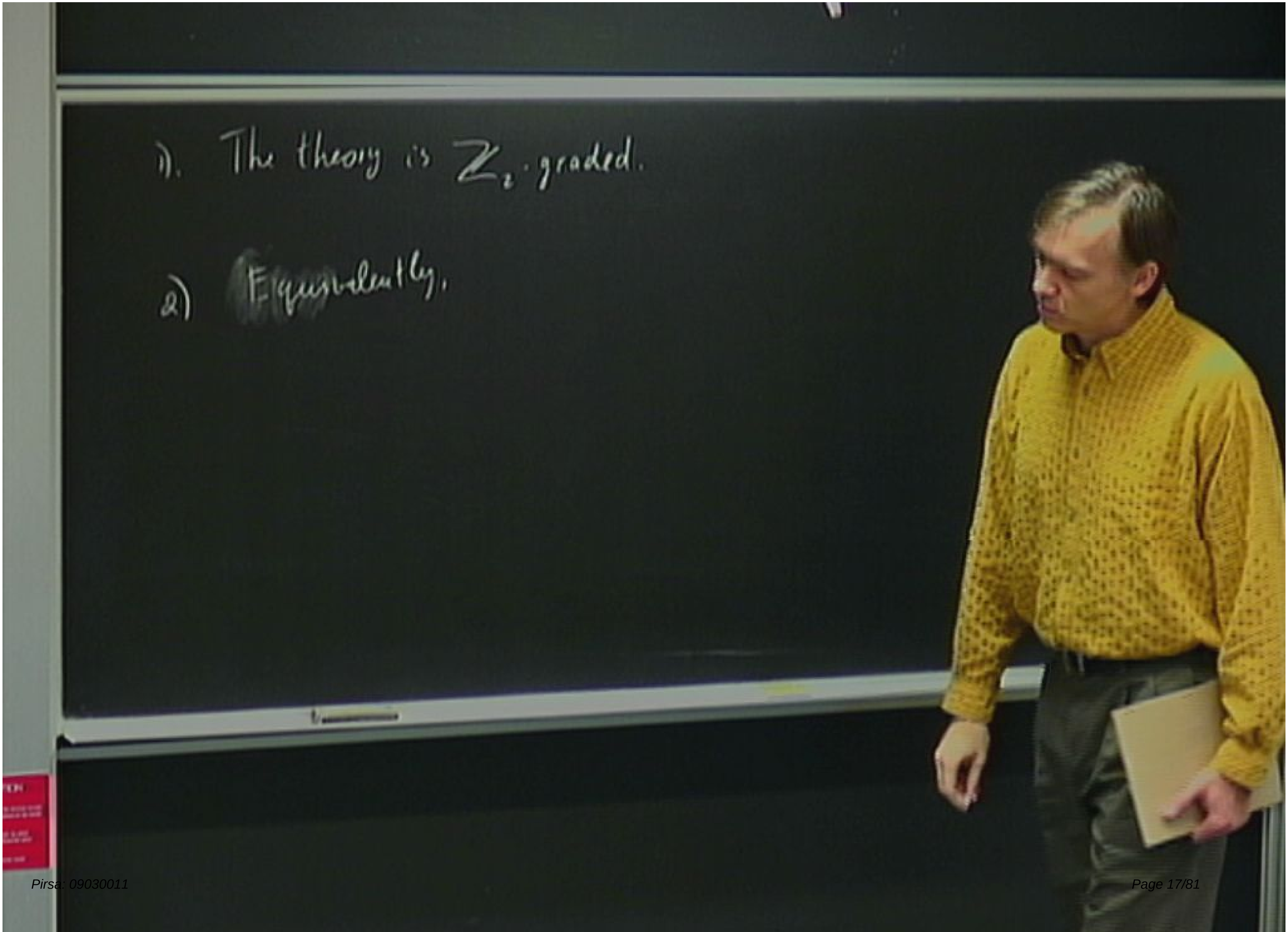
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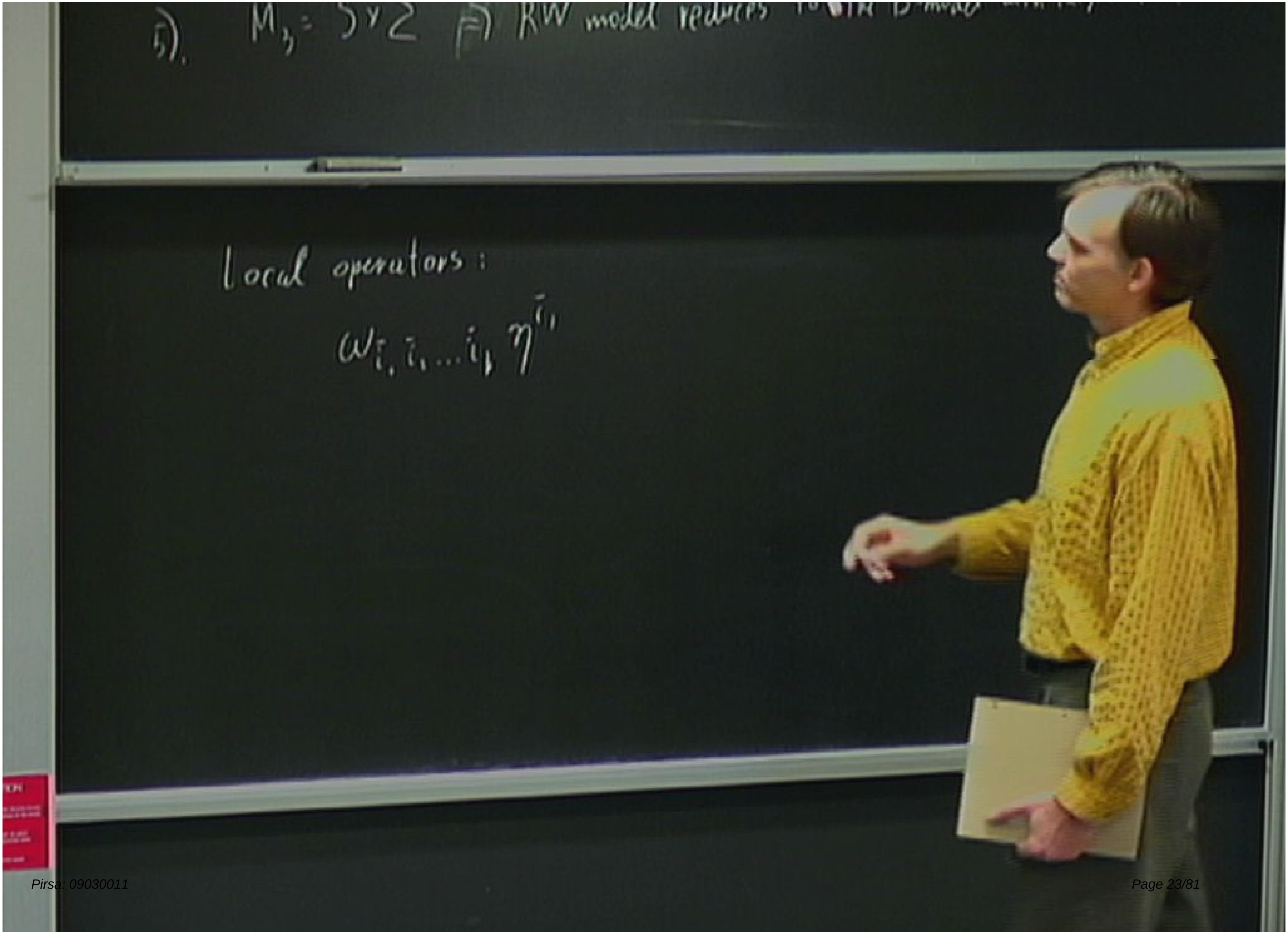
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Local operators :
$\omega_{i_1 i_2 \ldots i_p} \eta^{i_1}$

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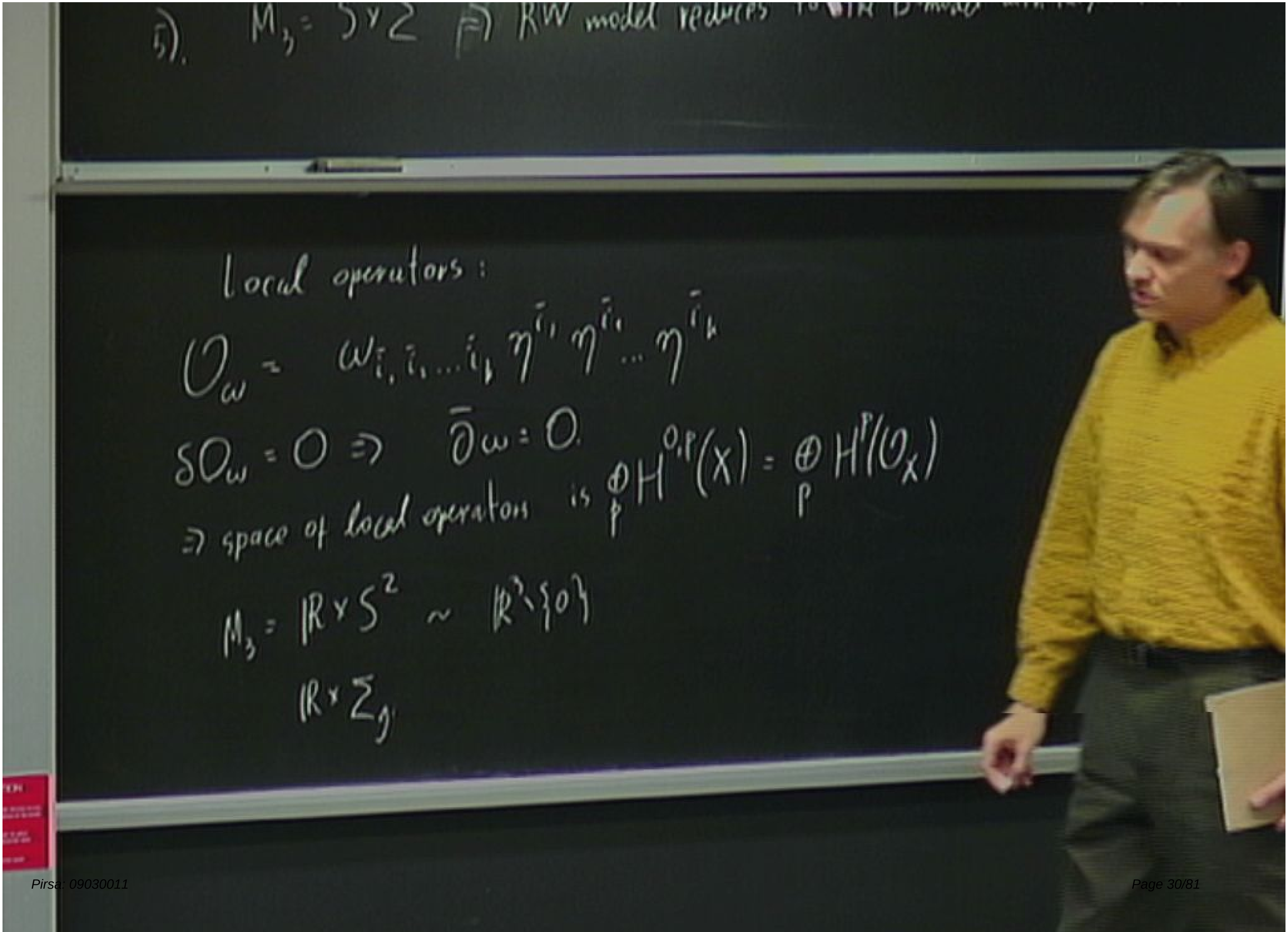
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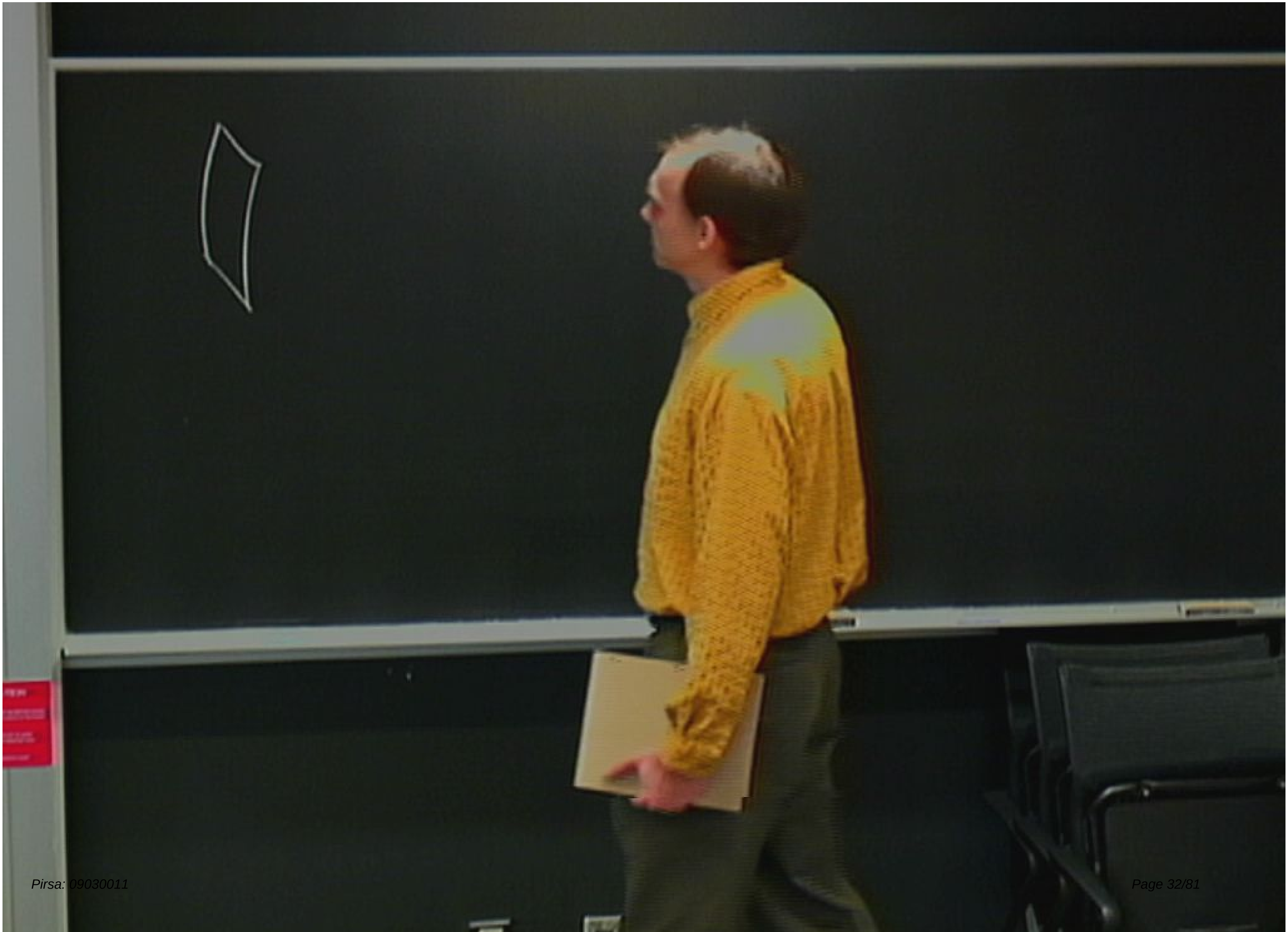
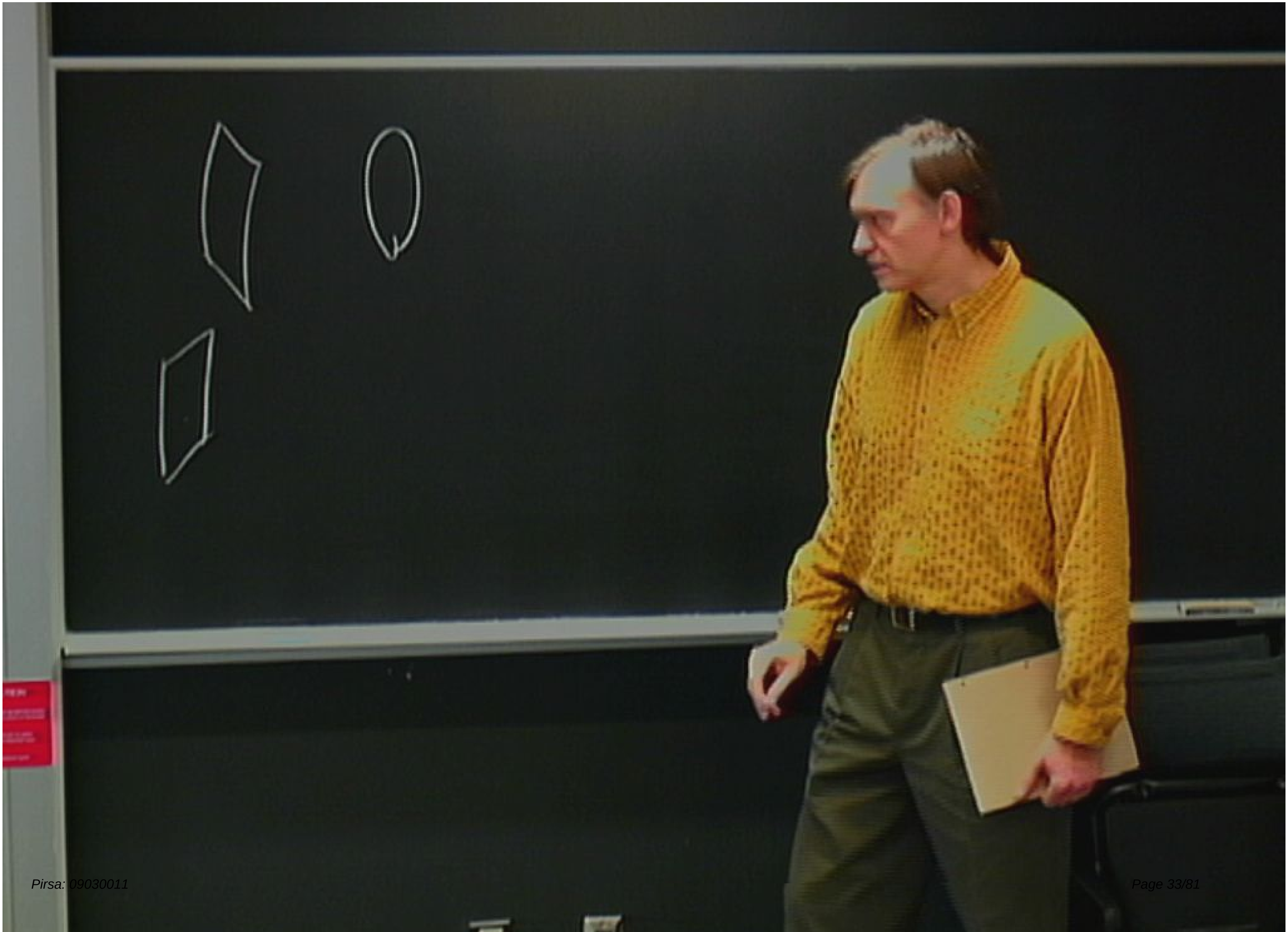
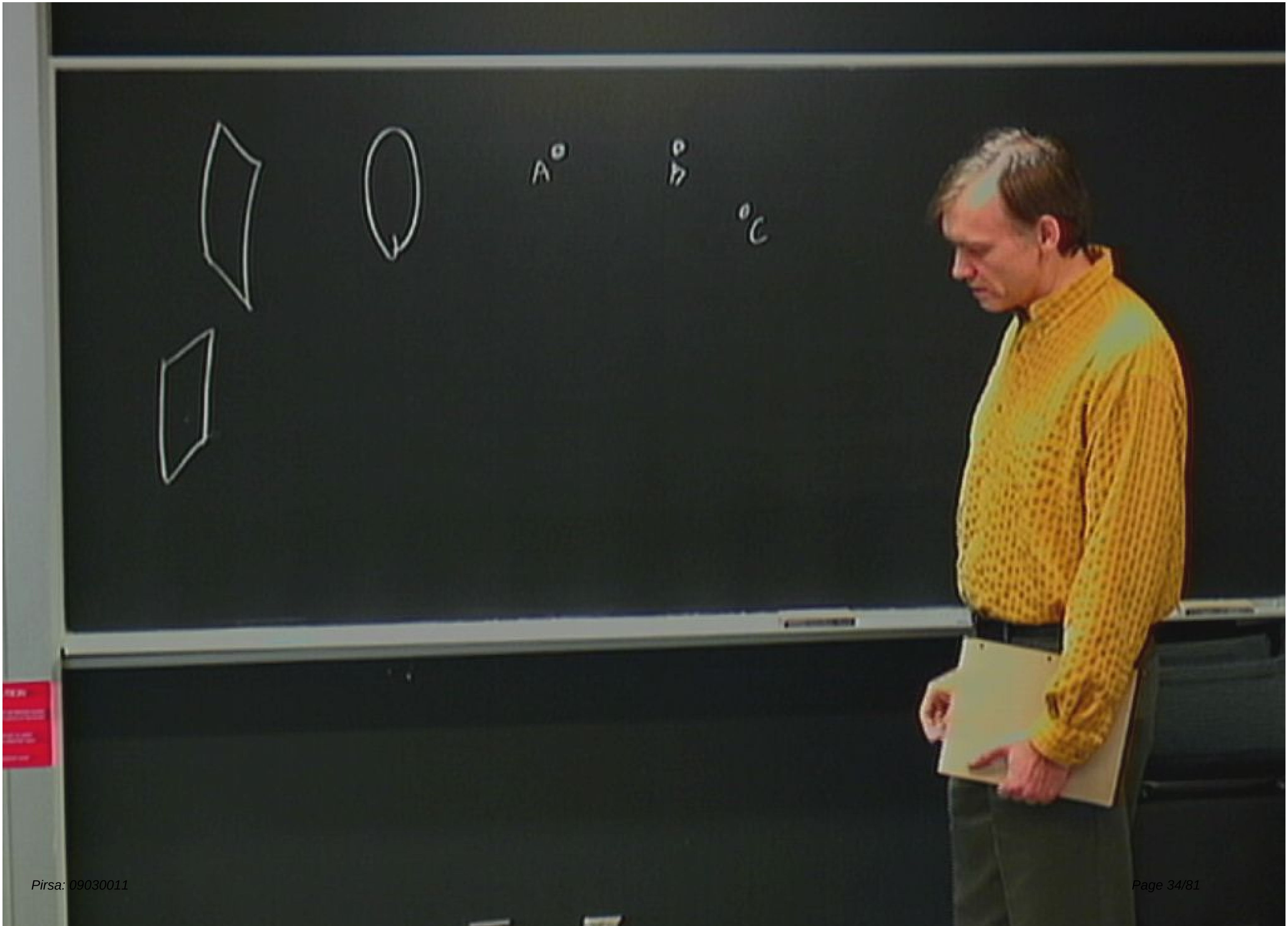
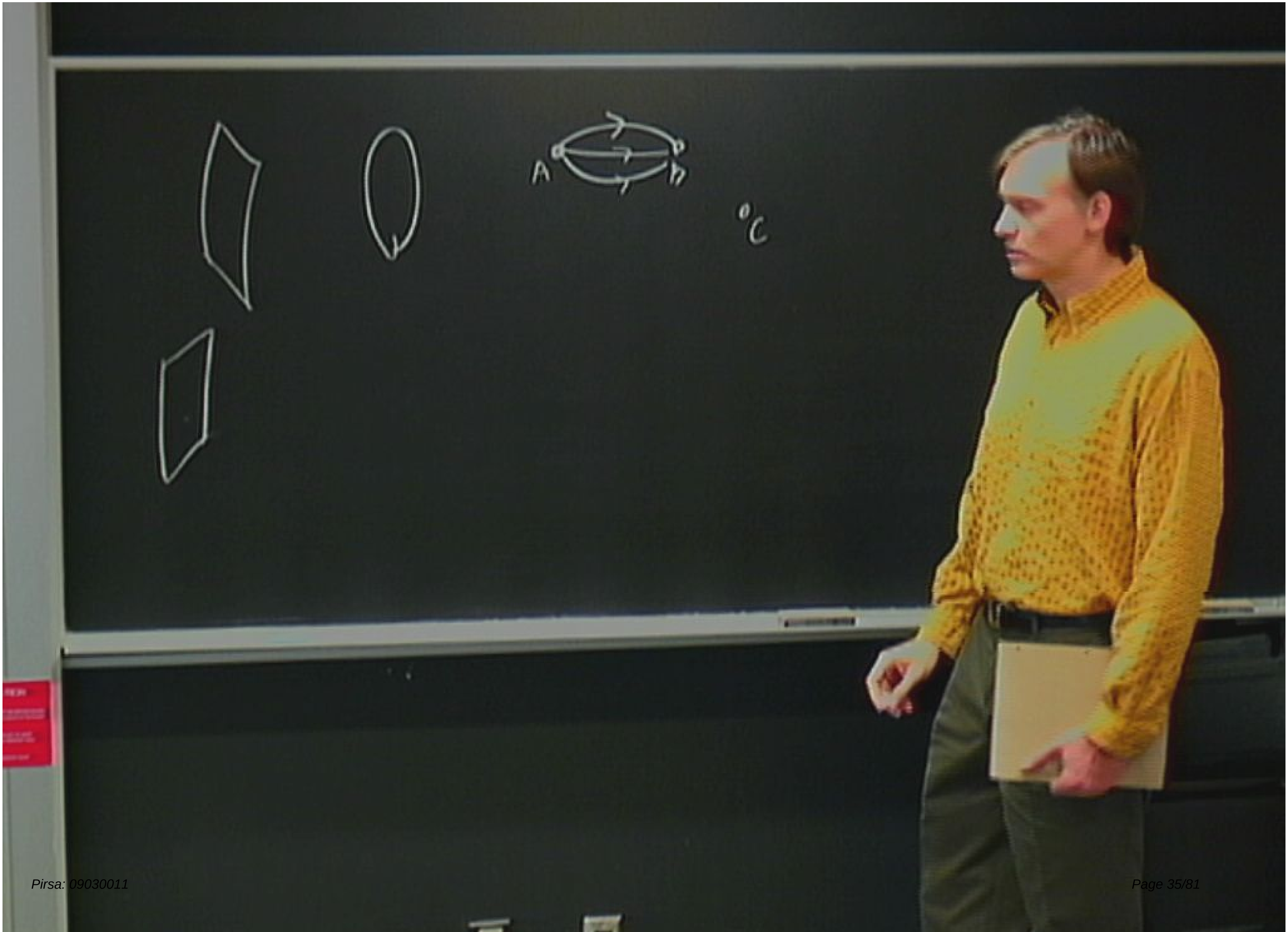
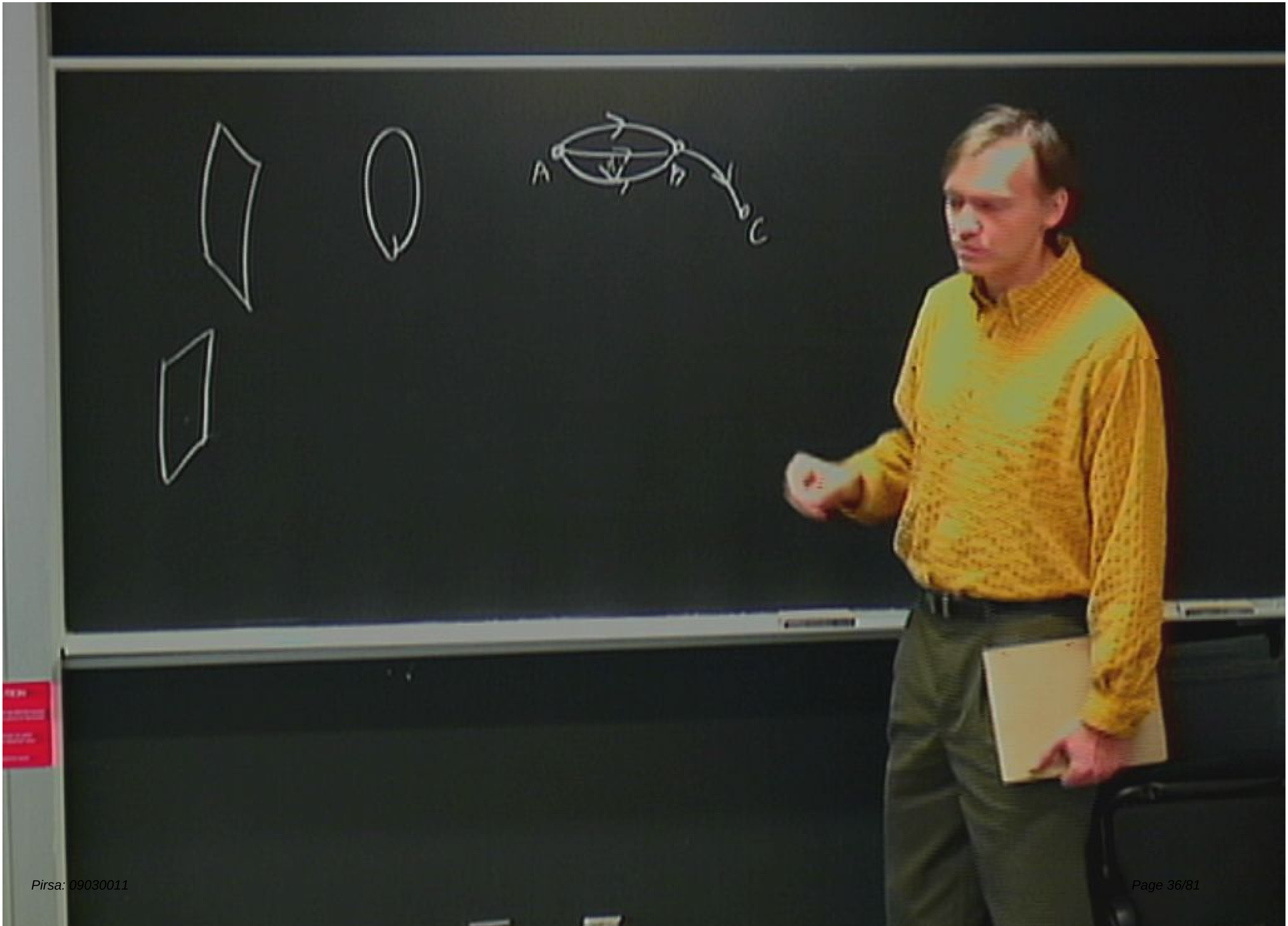
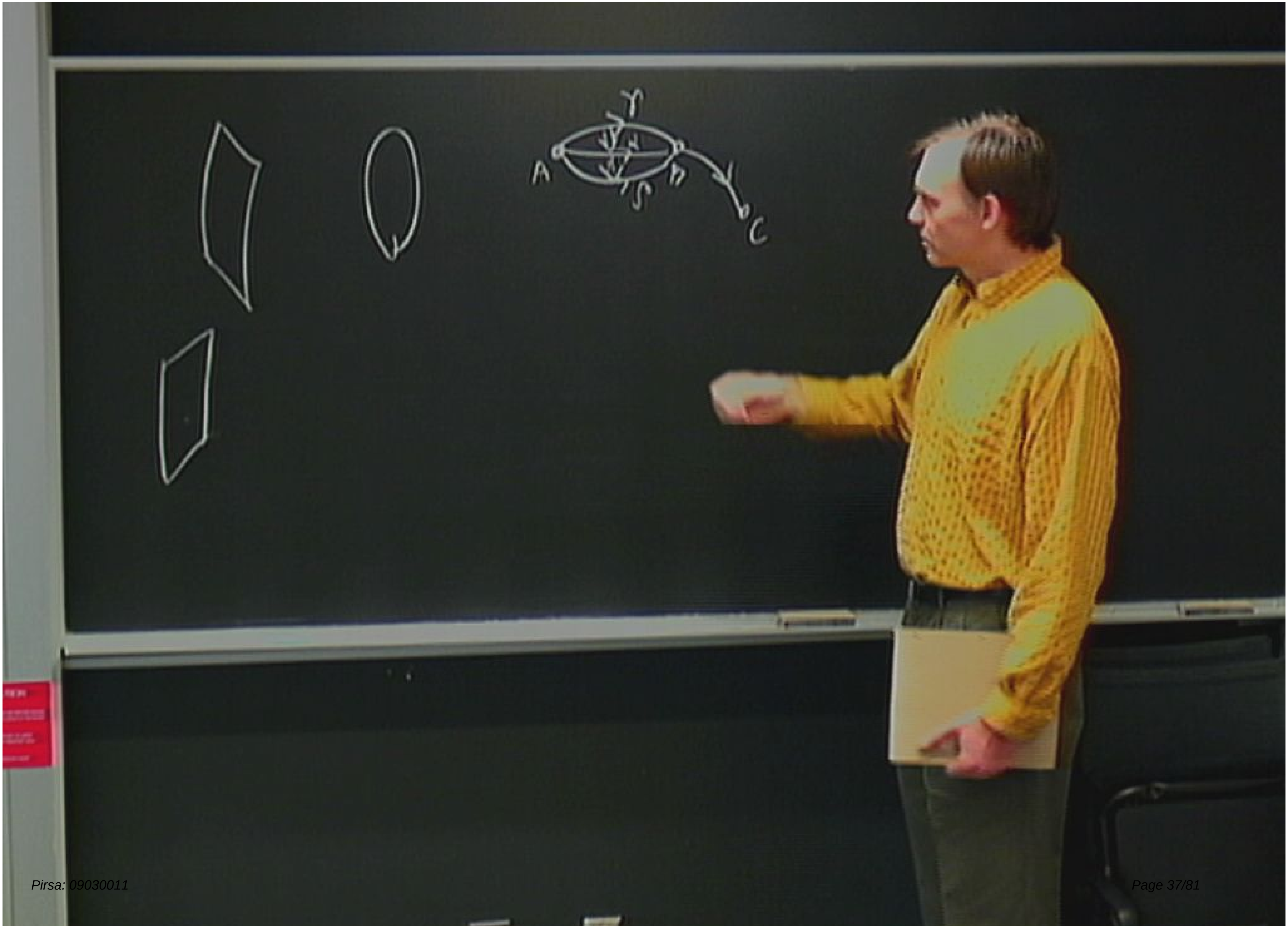


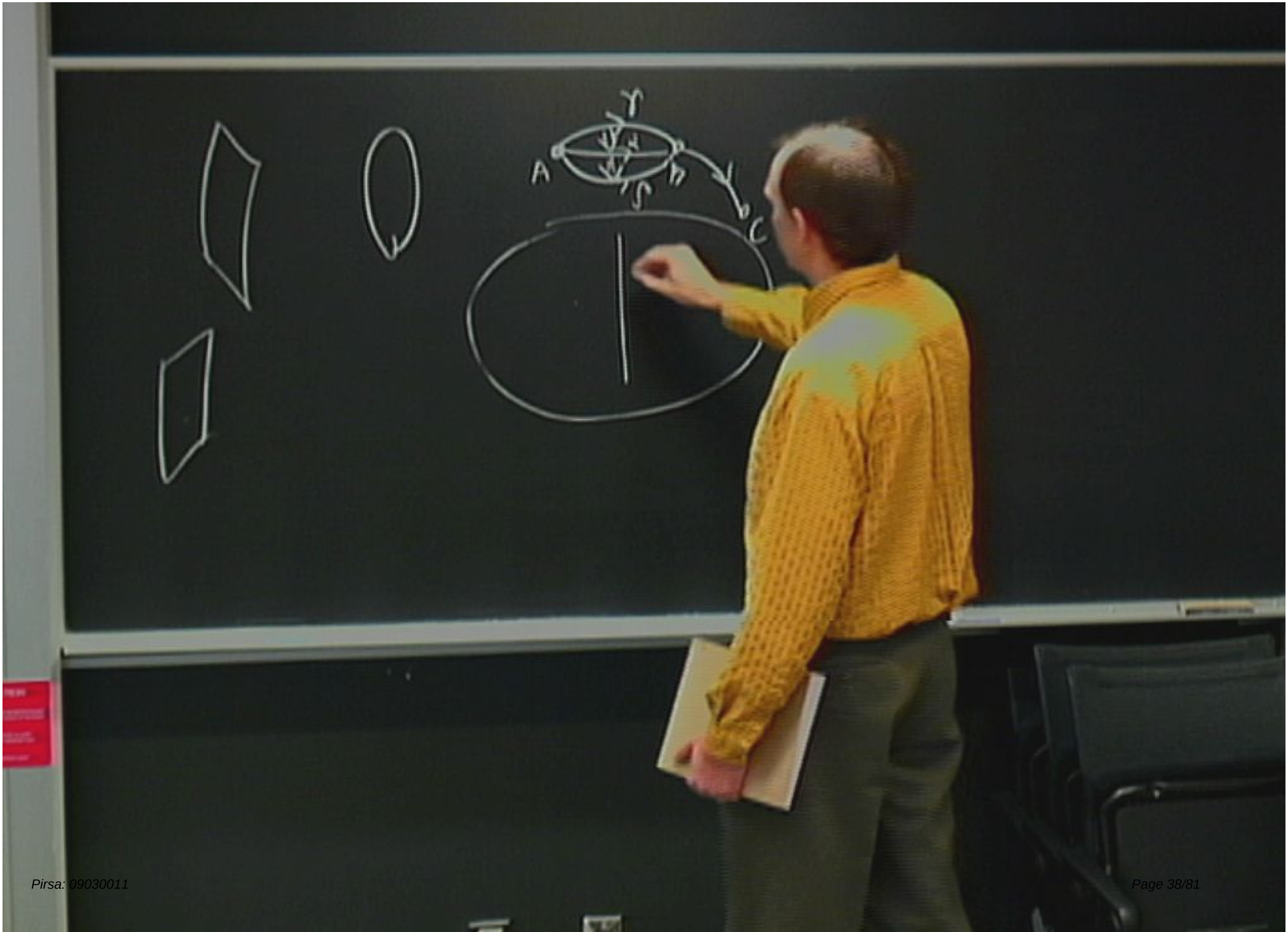


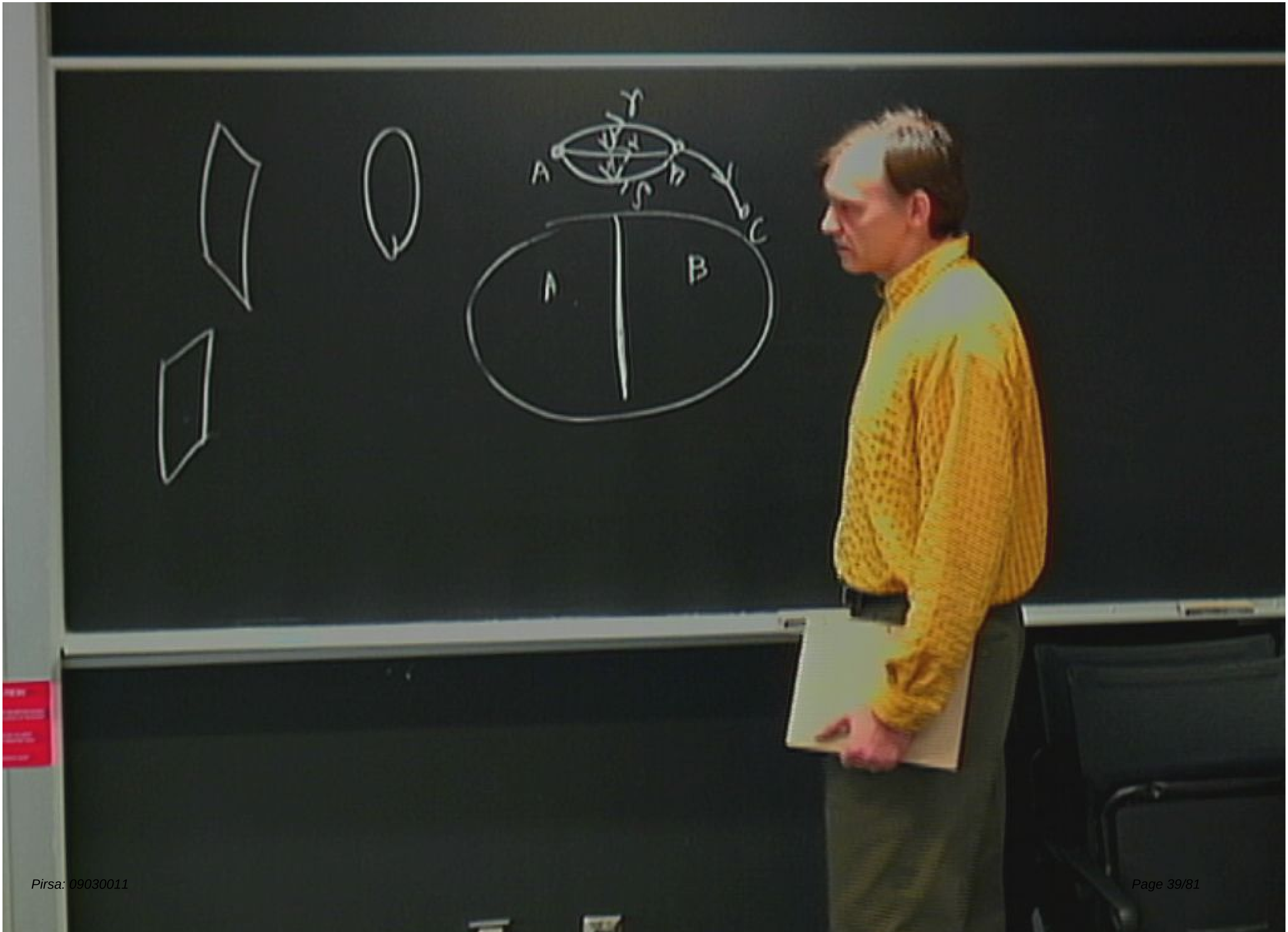

A
C

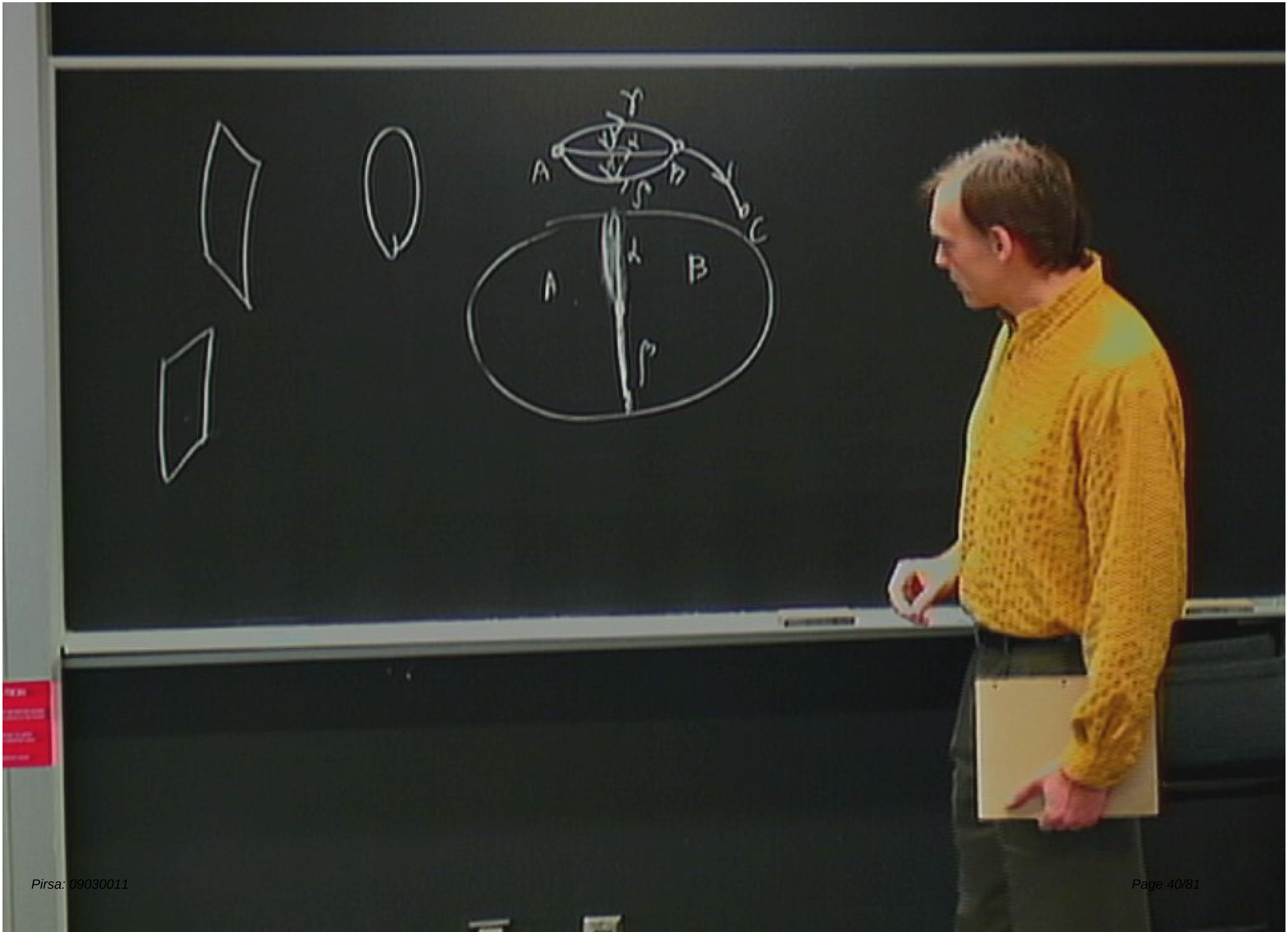

A
B
C

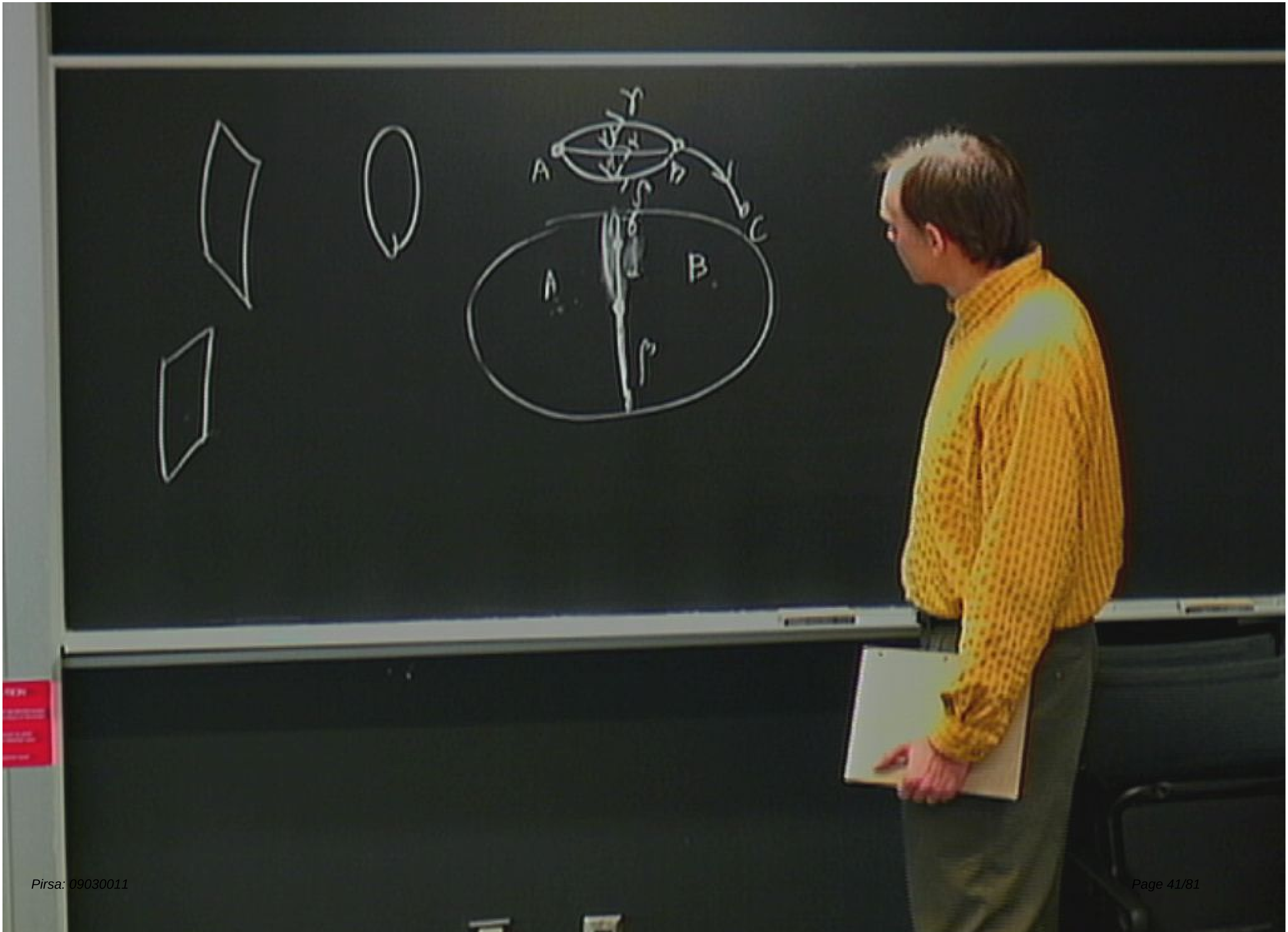


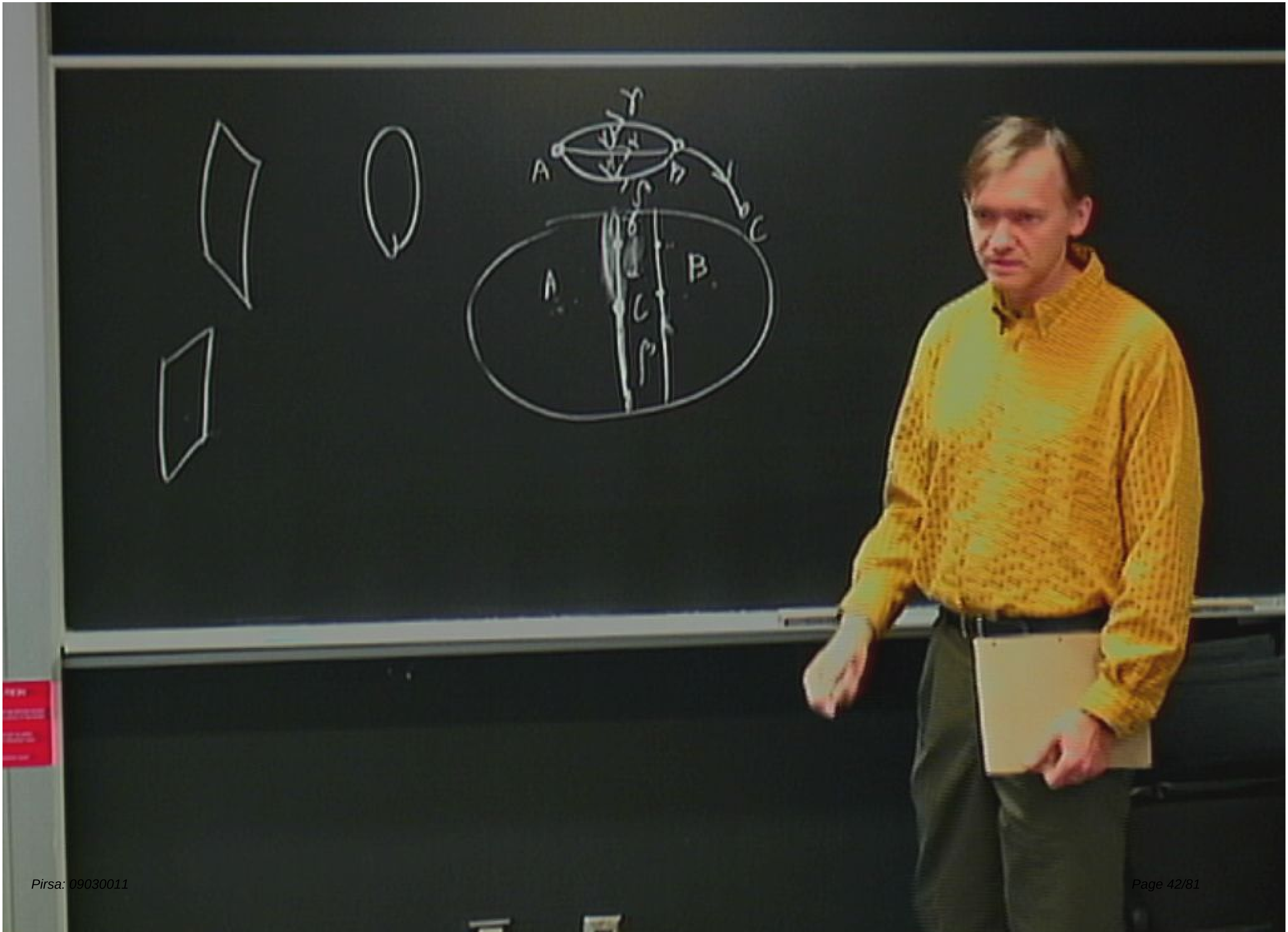

A
C

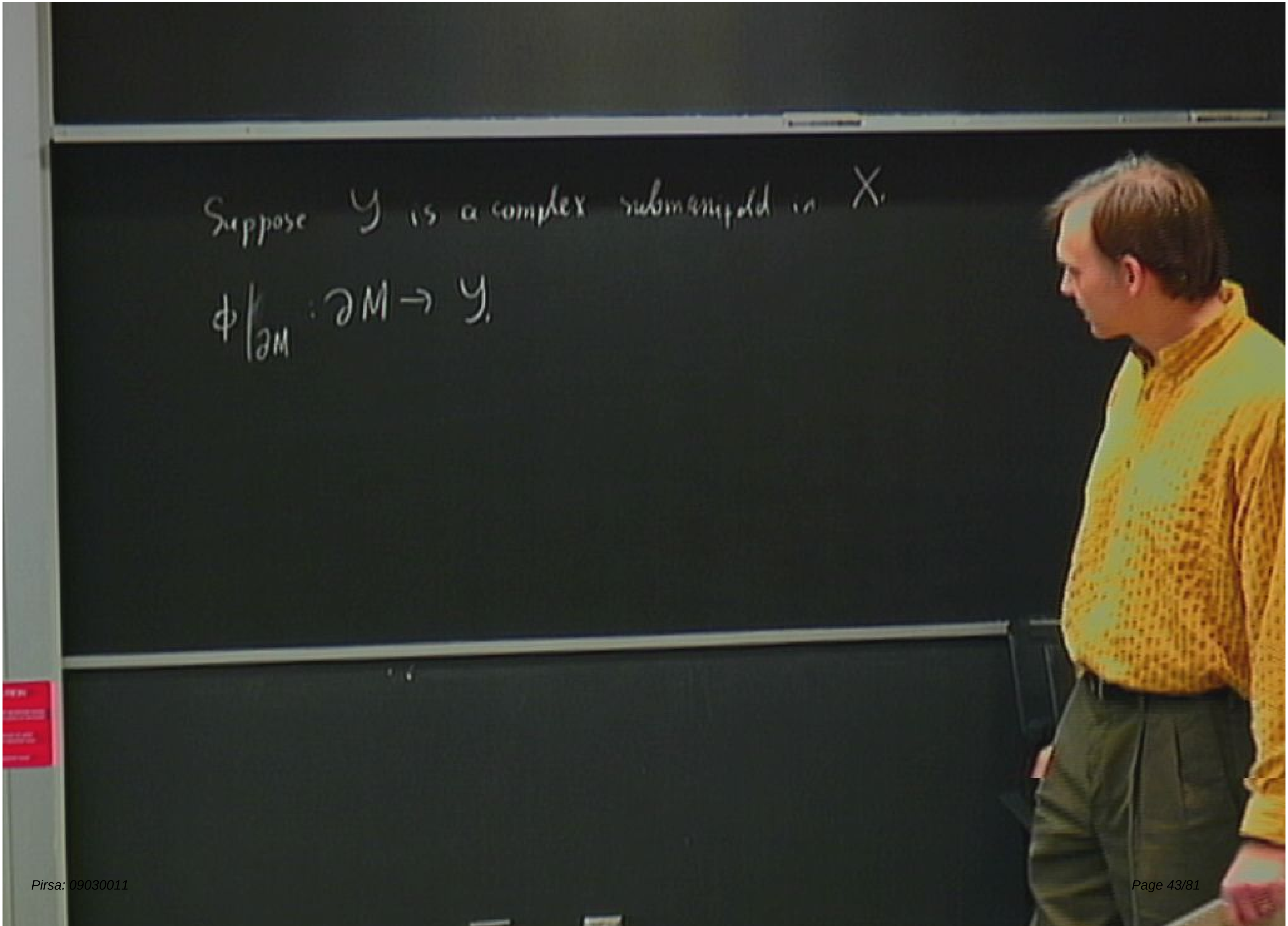


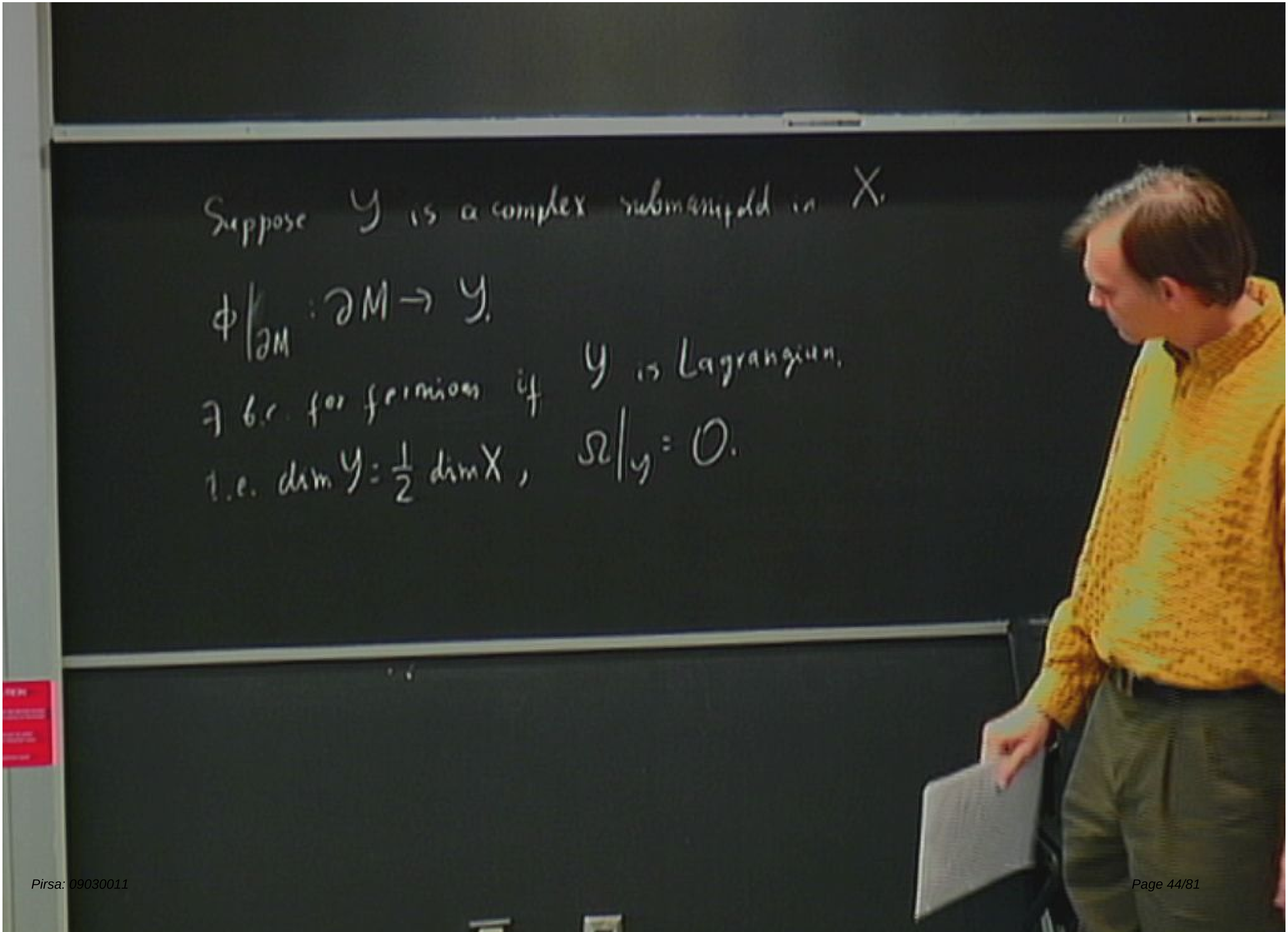

A
A
B
C

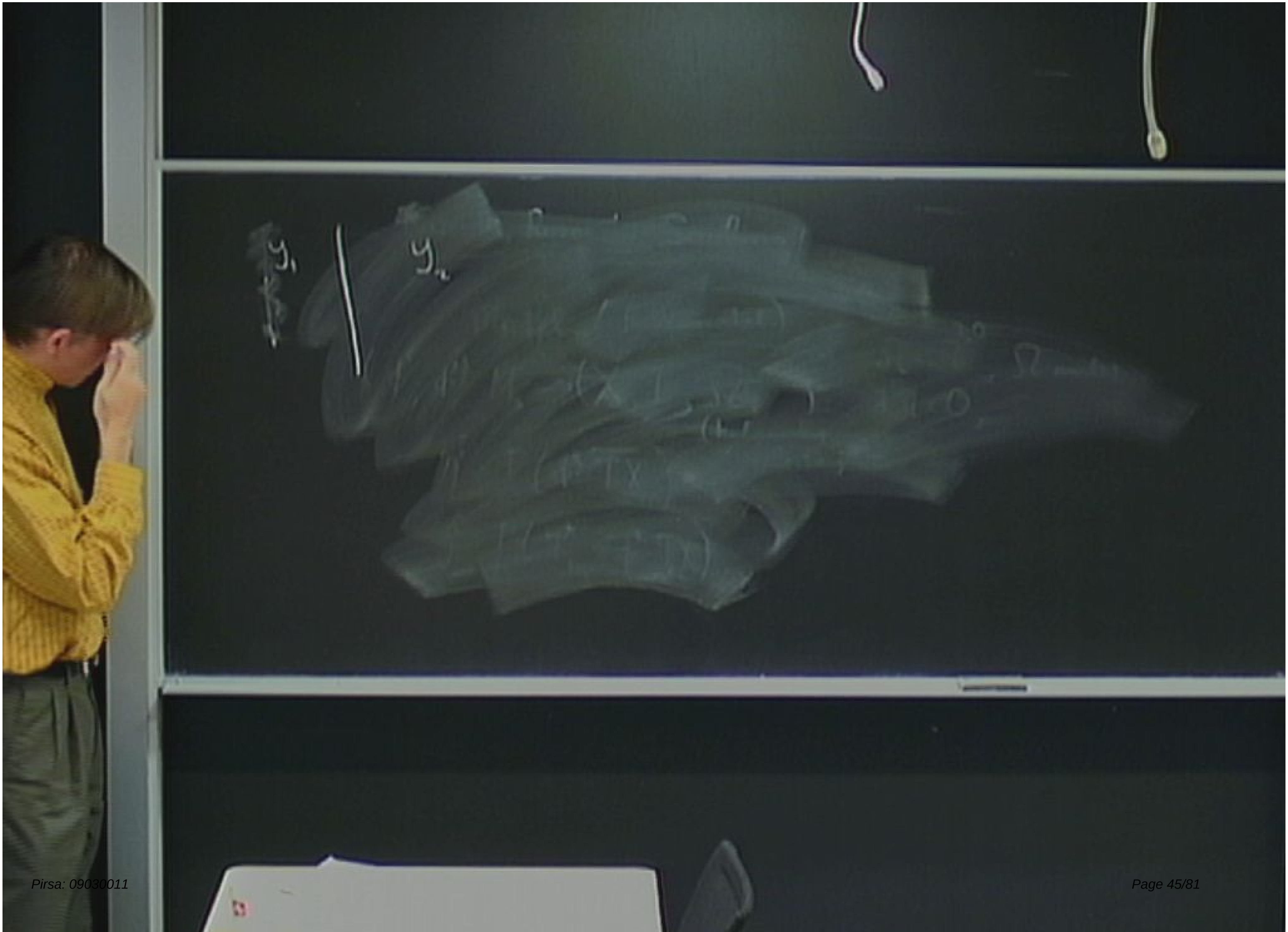



A
B

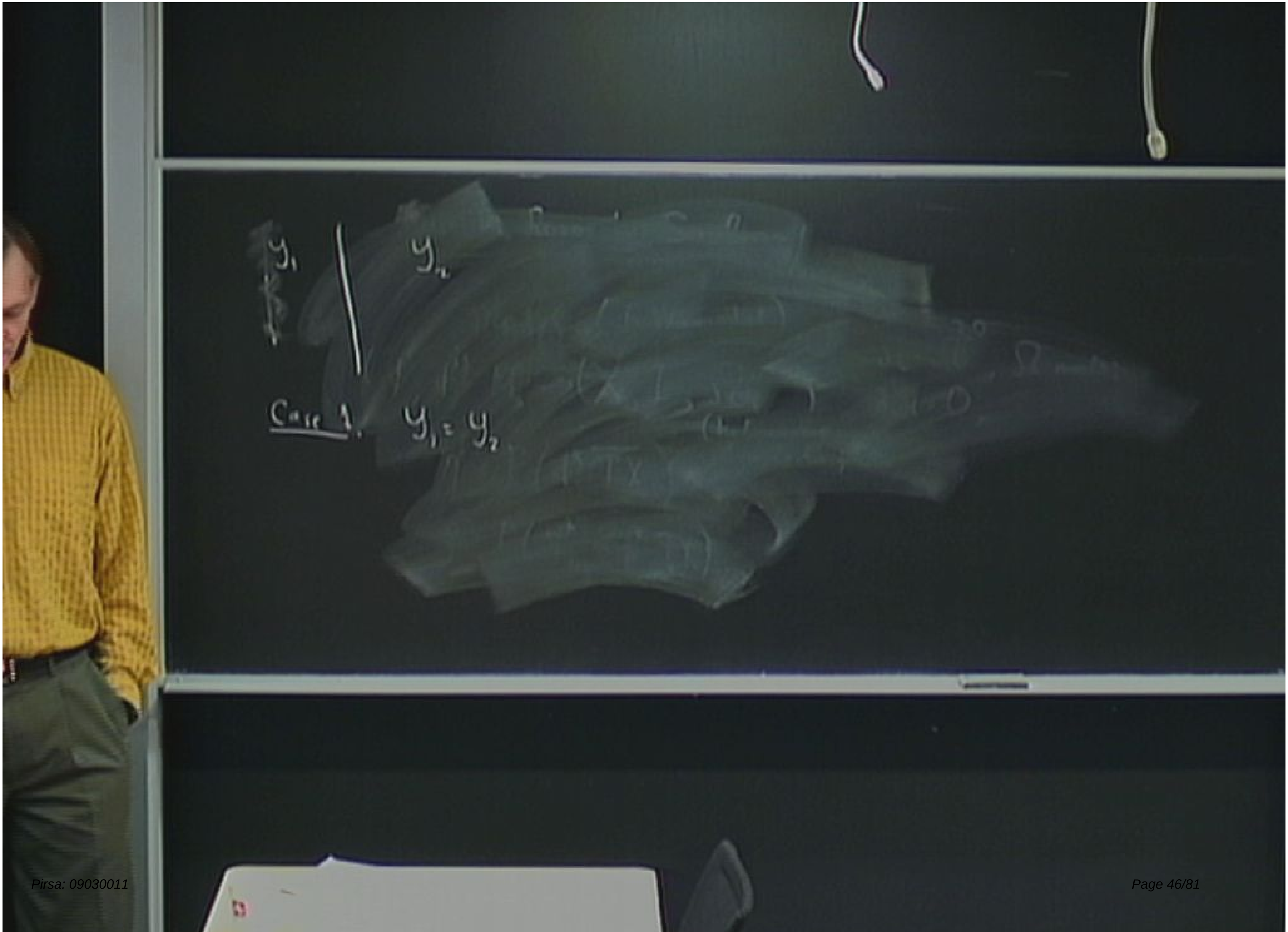


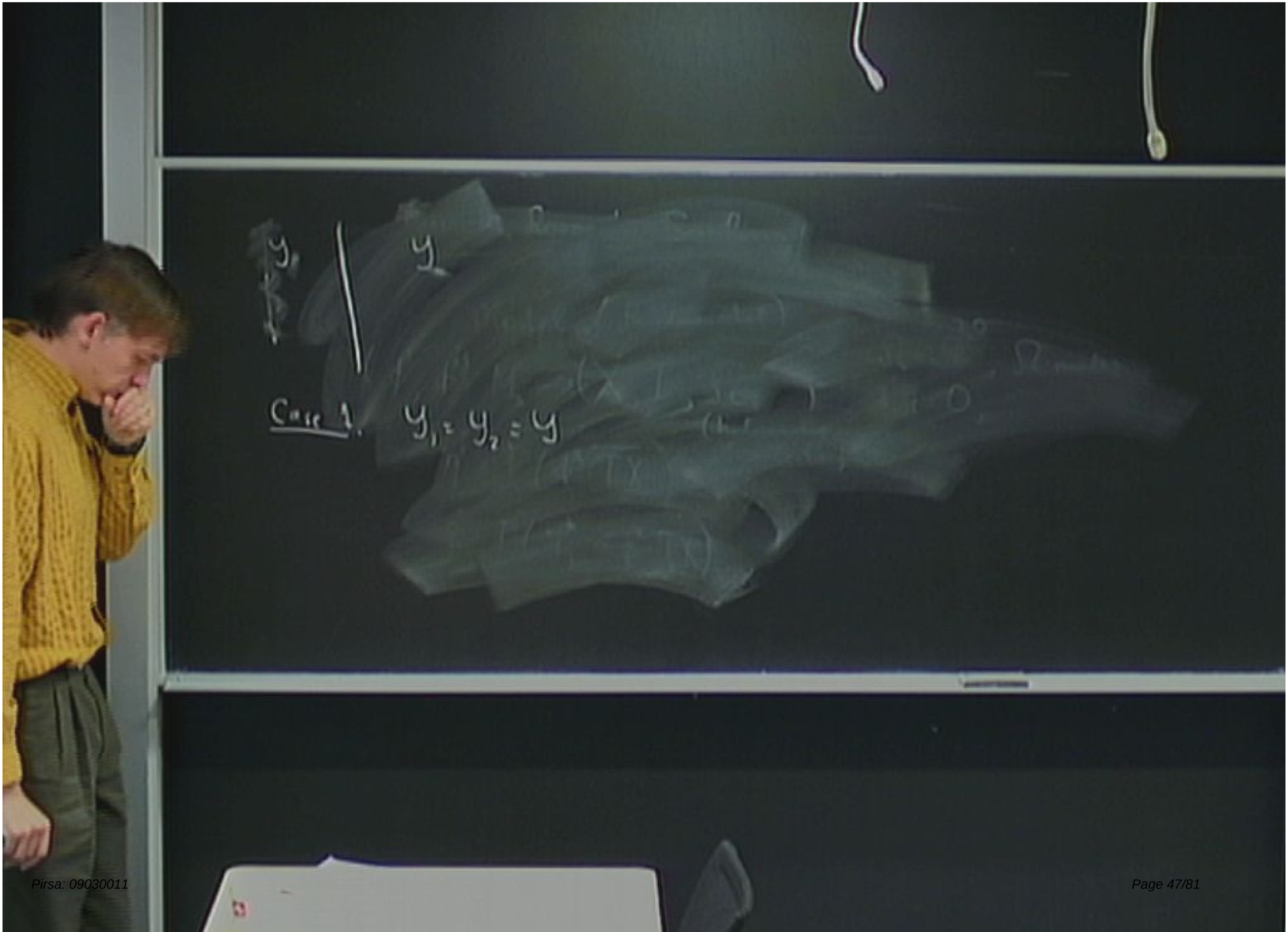

Suppose Y is a complex submanifold in X.
$\phi|_{\partial M} : \partial M \to Y$.

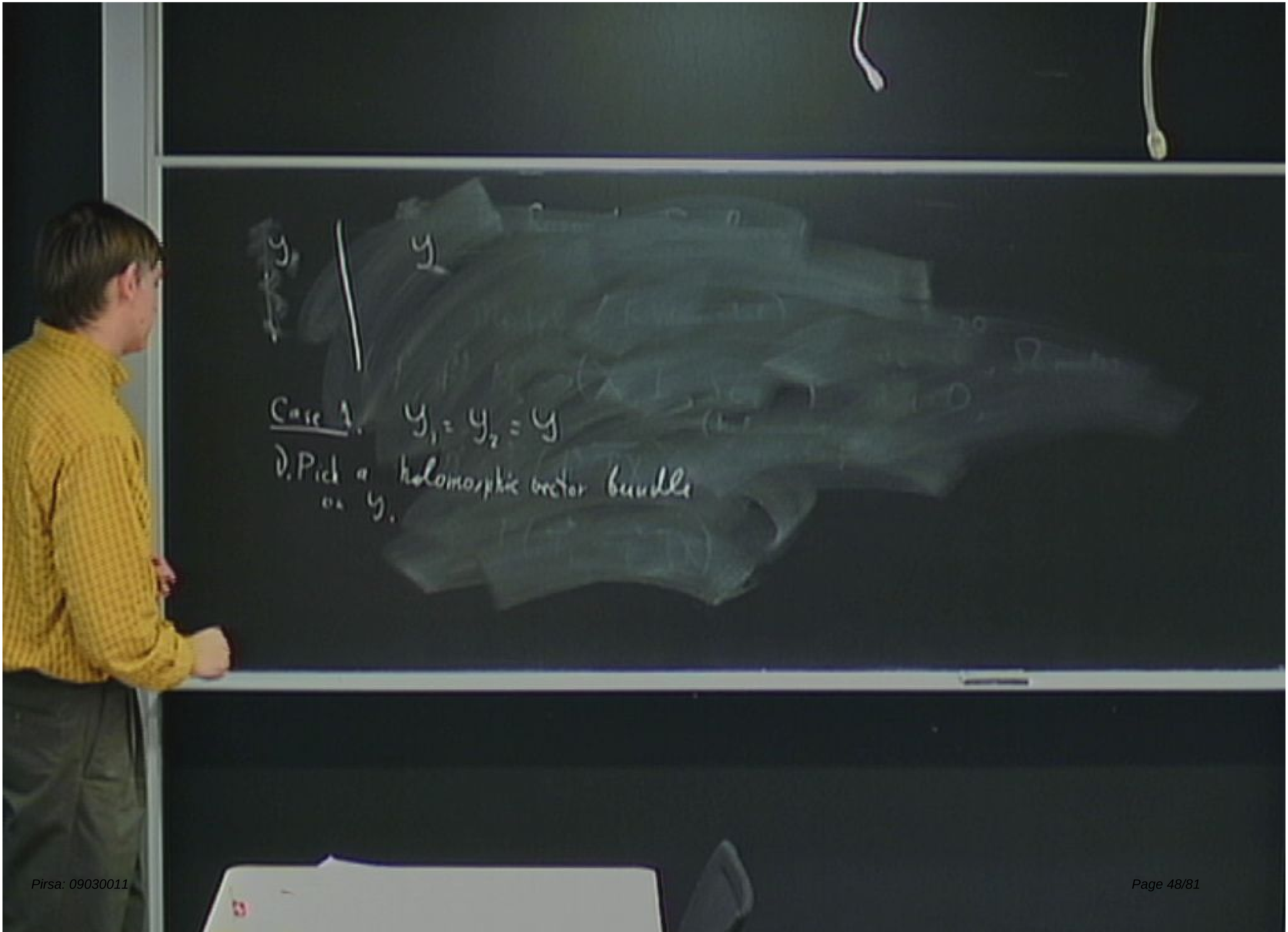

Suppose Y is a complex submanifold in X.
$\phi|_{\partial M} : \partial M \to Y$.
$\exists$ b.c. for fermions if Y is Lagrangian,
i.e. $\dim Y = \frac{1}{2}\dim X$, $\Omega|_Y = 0$.

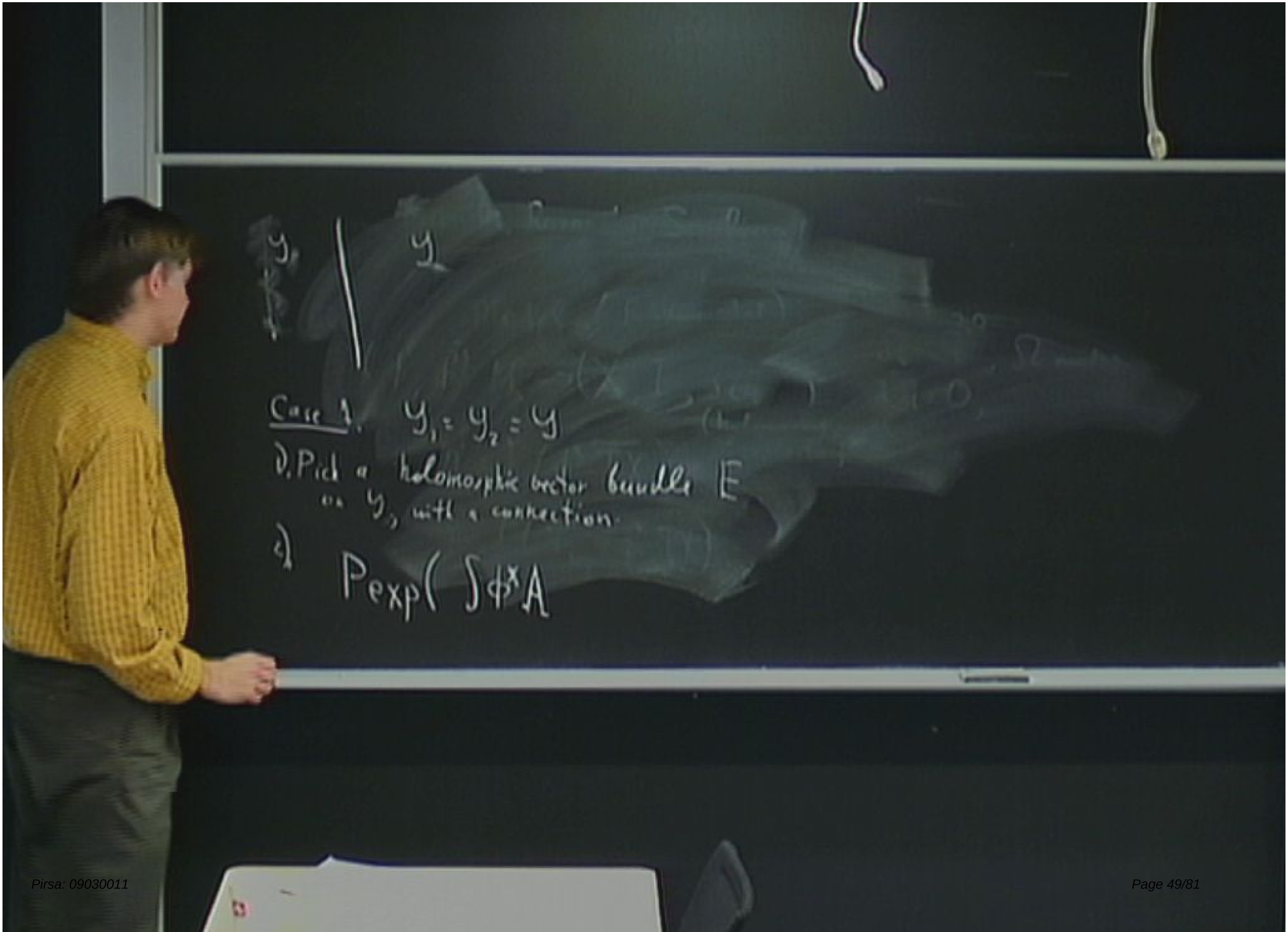


y_1
y_2

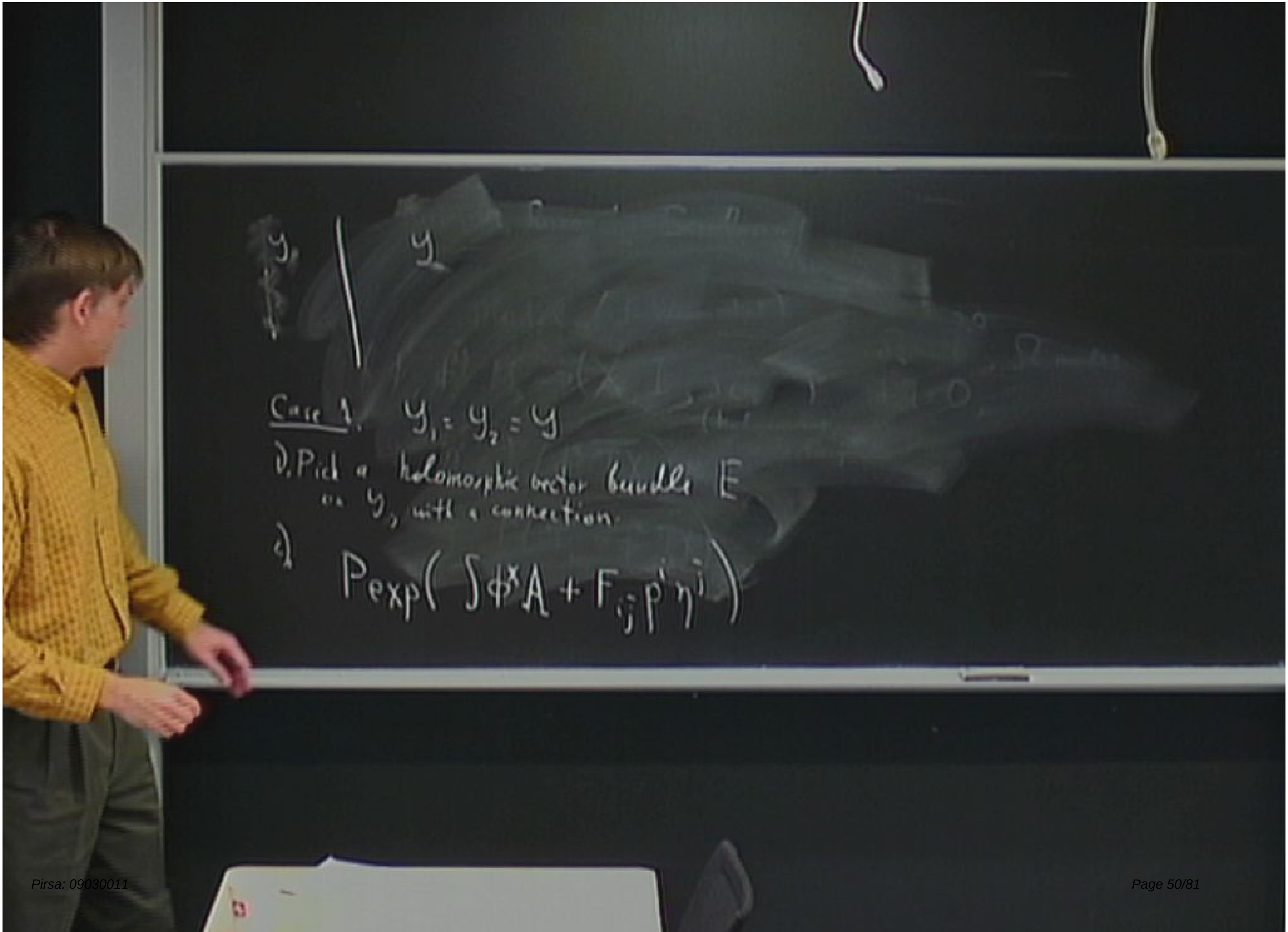

y_1 | y_2
Case 1. $y_1 = y_2$

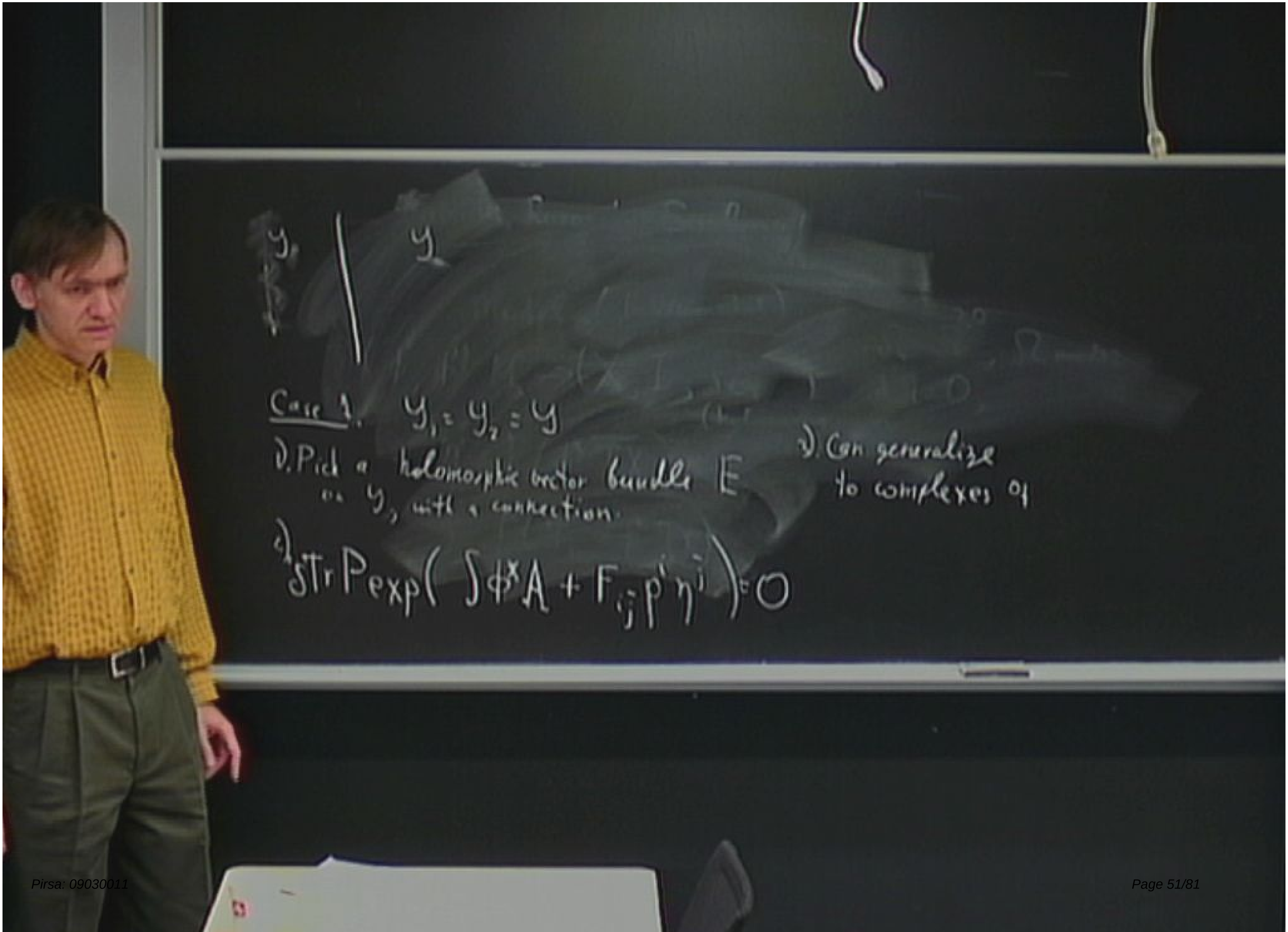

Case 1. $y_1 = y_2 = y$

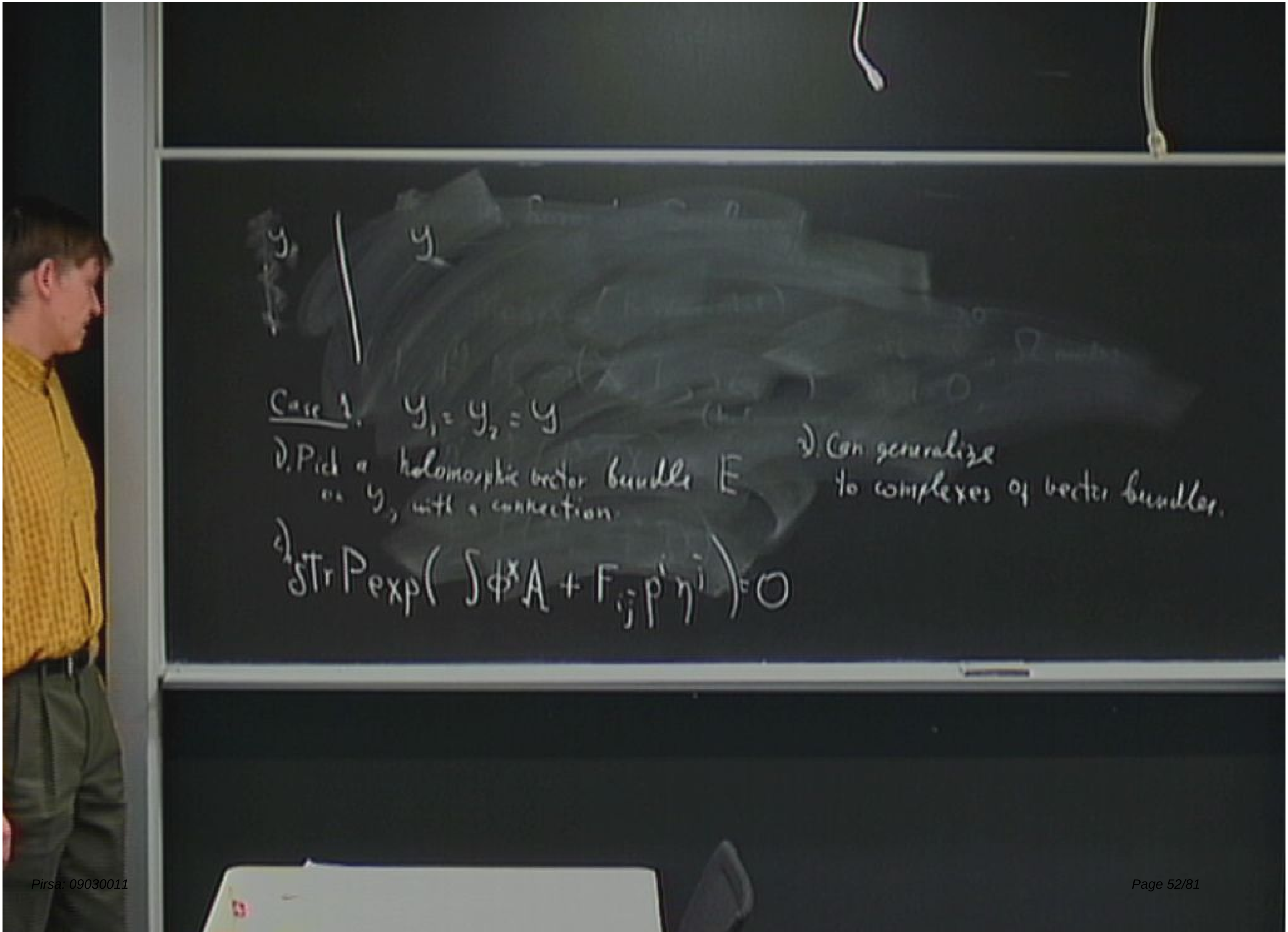

Y
Case 1. Y1 = Y2 = Y
1) Pick a holomorphic vector bundle
on Y.

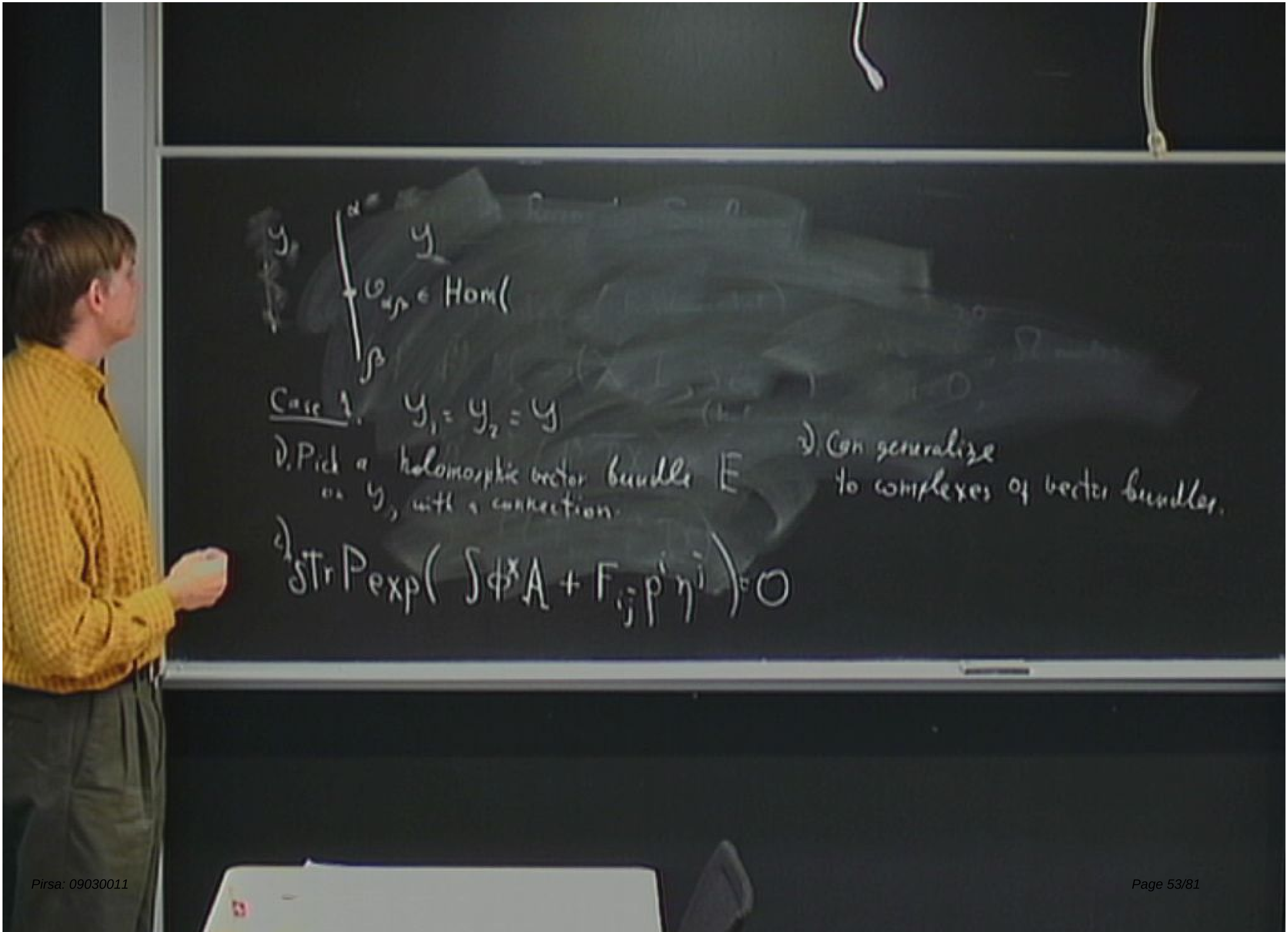


Y1 | Y
Case 1. Y1 = Y2 = Y
1) Pick a holomorphic vector bundle E on Y1 with a connection.
2) Pexp(∫φ*A


Y_1
Y
Case A. $Y_1 = Y_2 = Y$
1) Pick a holomorphic vector bundle E on Y_2 with a connection.
2) $P\exp\left(\int \phi^* A + F_{ij}\rho^i\eta^j \right)$


Y_1 | Y
Case 1. Y_1 = Y_2 = Y
1). Pick a holomorphic vector bundle E on Y_1 with a connection.
2) STr P exp(∫ φ*A + F_{i j̄} ρ^i η^j̄) = O
3). Can generalize to complexes of


Y_1 | Y_2
Case 1. $Y_1 = Y_2 = Y$
1). Pick a holomorphic vector bundle E on Y, with a connection.
2) $\mathrm{STr}\, P\exp\left(\int \phi^* A + F_{i\bar{j}} \rho^i \eta^{\bar{j}} \right) = 0$
3). Can generalize to complexes of vector bundles.


Y_1
α
Y
$\varphi_{\alpha\beta} \in \mathrm{Hom}($
β
Case 1. $Y_1 = Y_2 = Y$
1) Pick a holomorphic vector bundle E on Y, with a connection.
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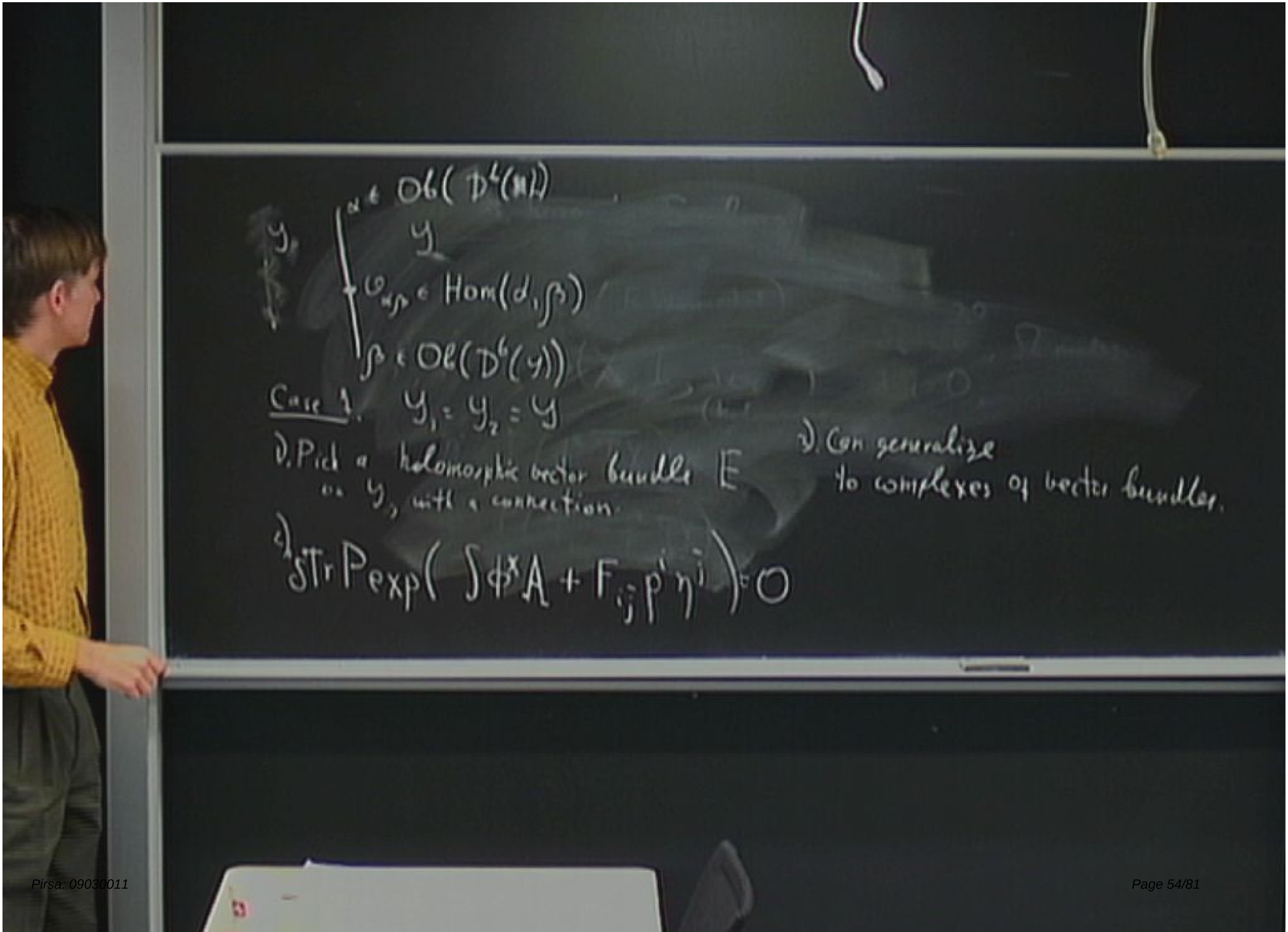
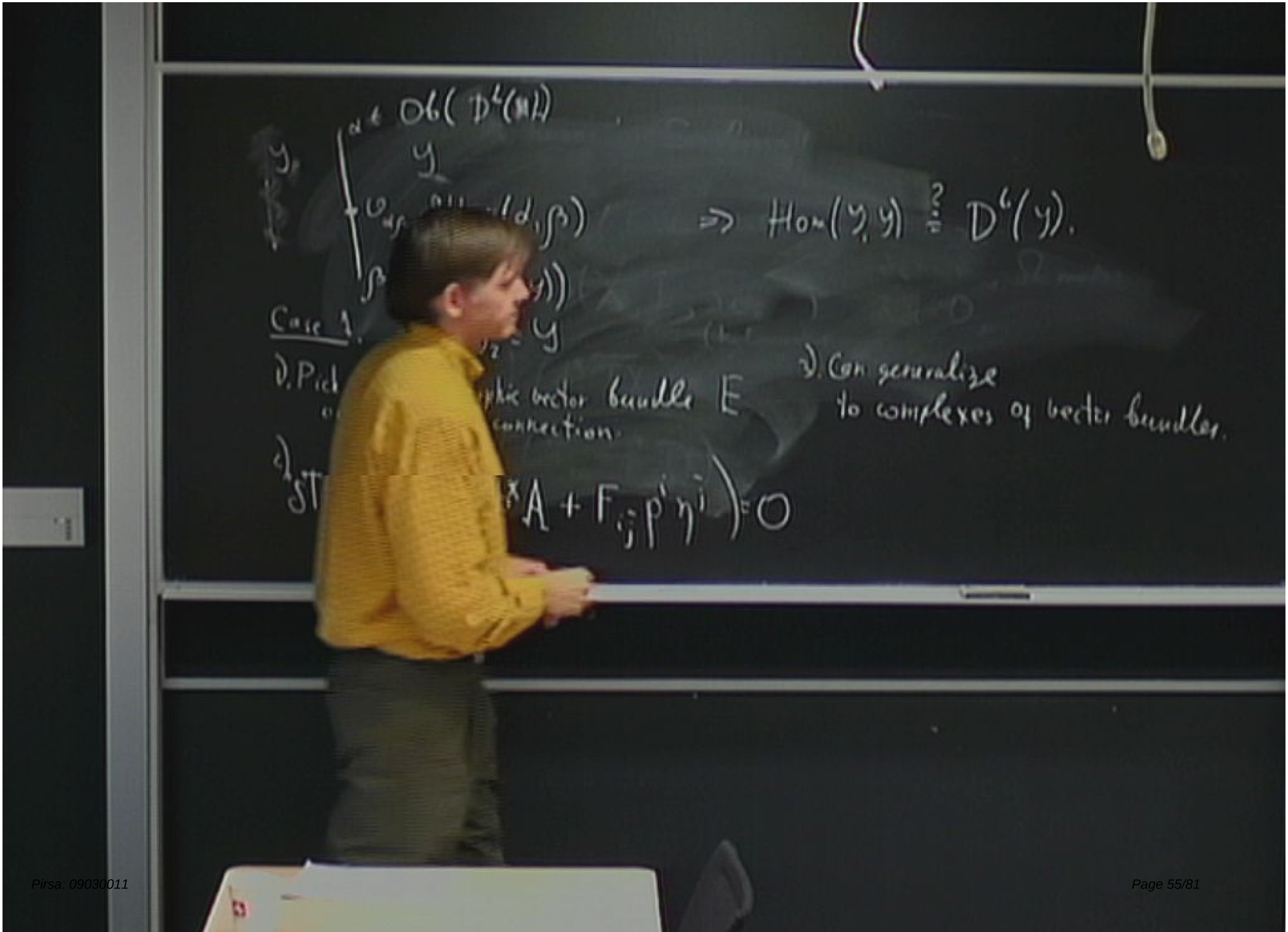
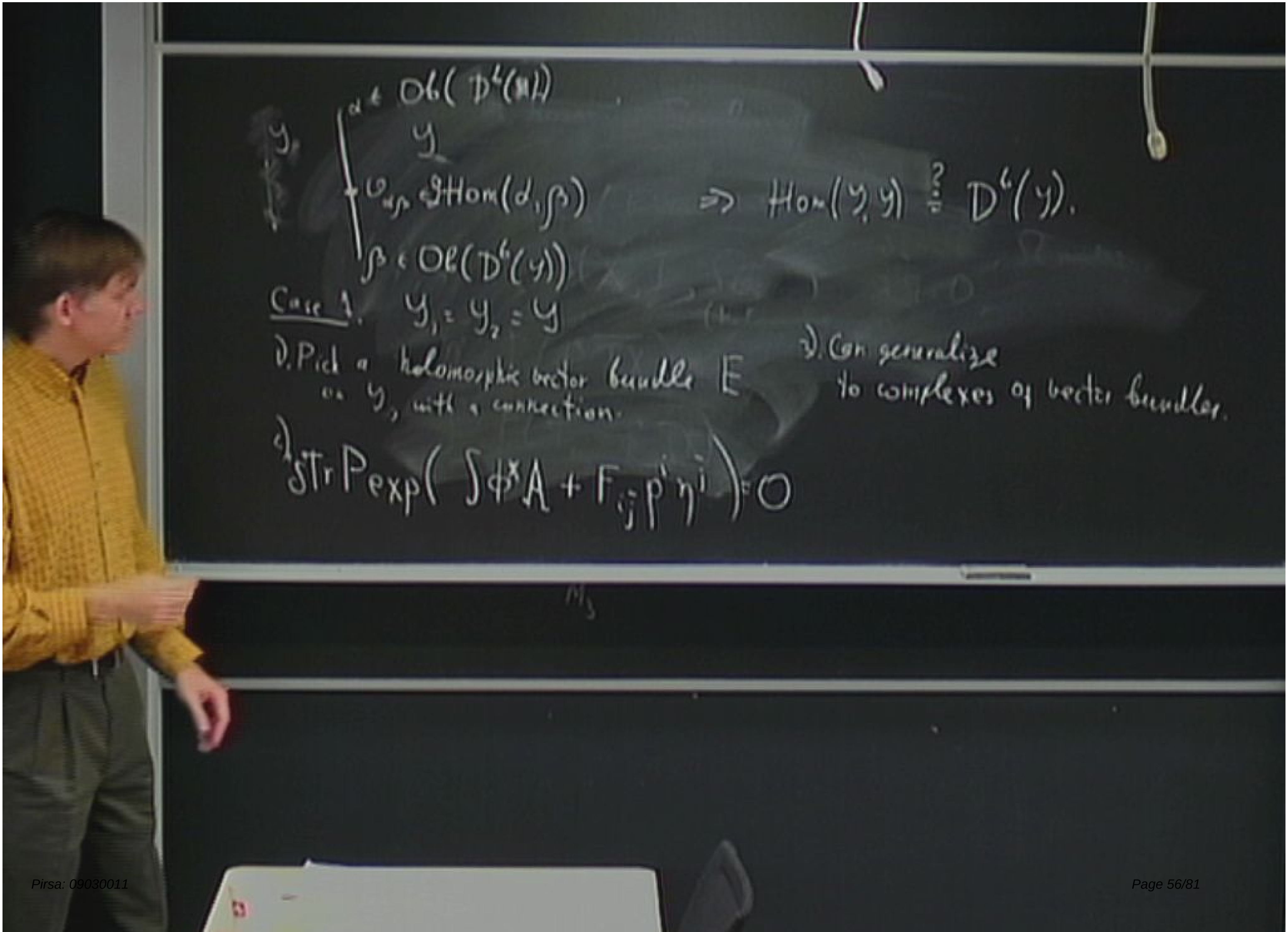
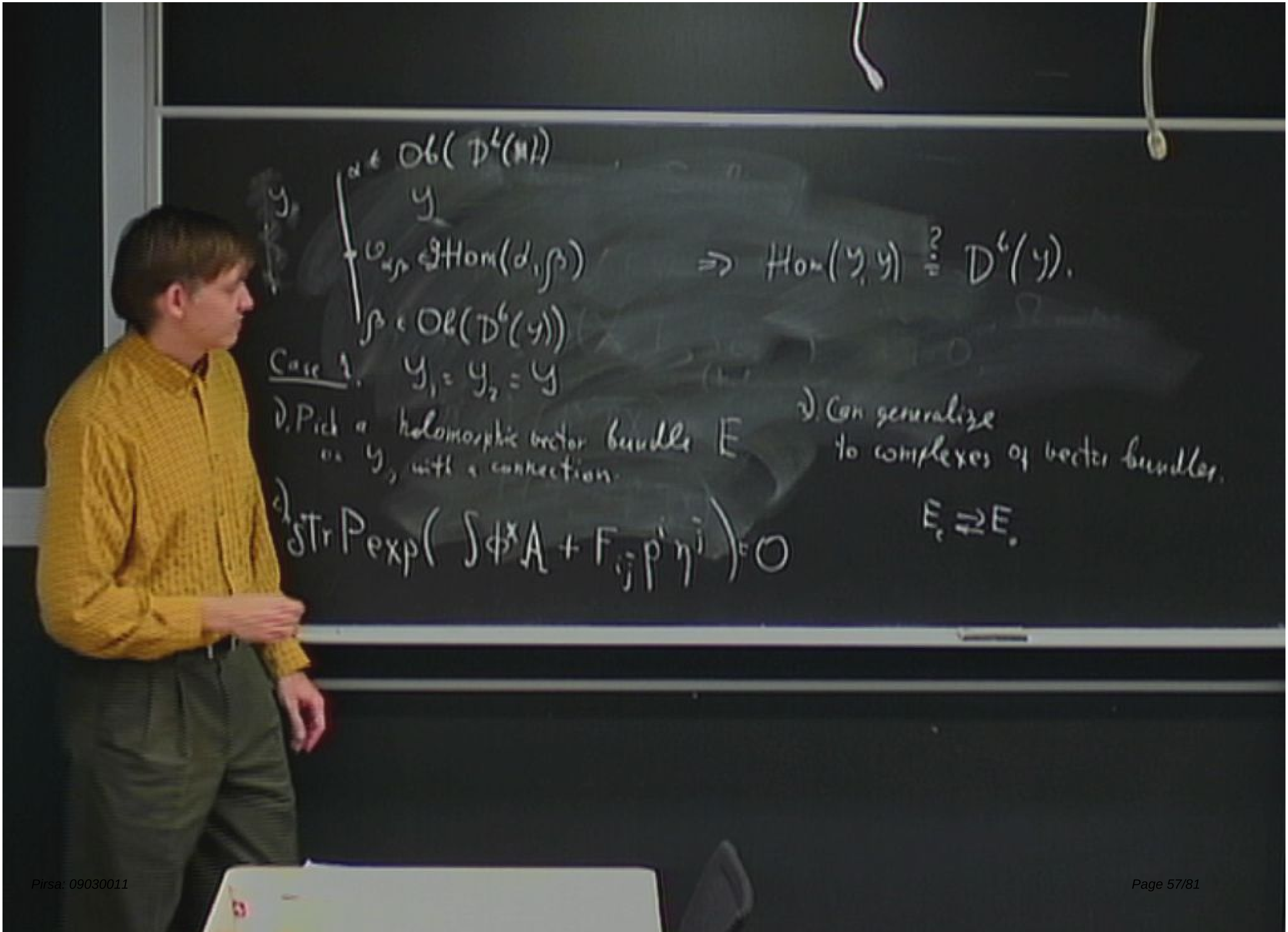

α ∈ Ob(D^b(Y_1))
φ_{αβ} ∈ Hom(α, β)
β ∈ Ob(D^b(Y_2))
Case 1. Y_1 = Y_2 = Y
1). Pick a holomorphic vector bundle E on Y, with a connection.
2) STr Pexp(∫φ*A + F_{ij̄} ρ^i η^j̄) = O
3). Can generalize to complexes of vector bundles.

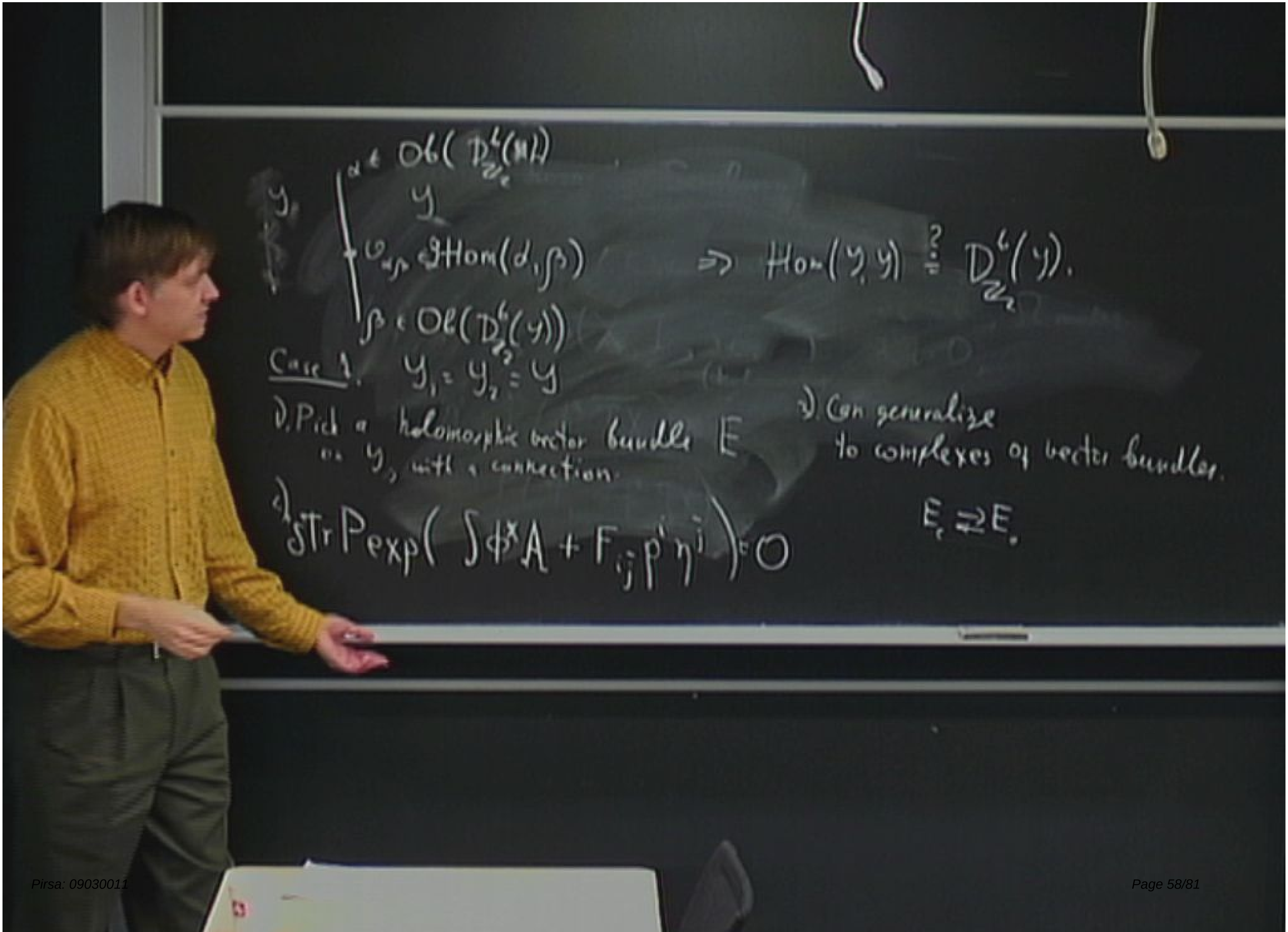


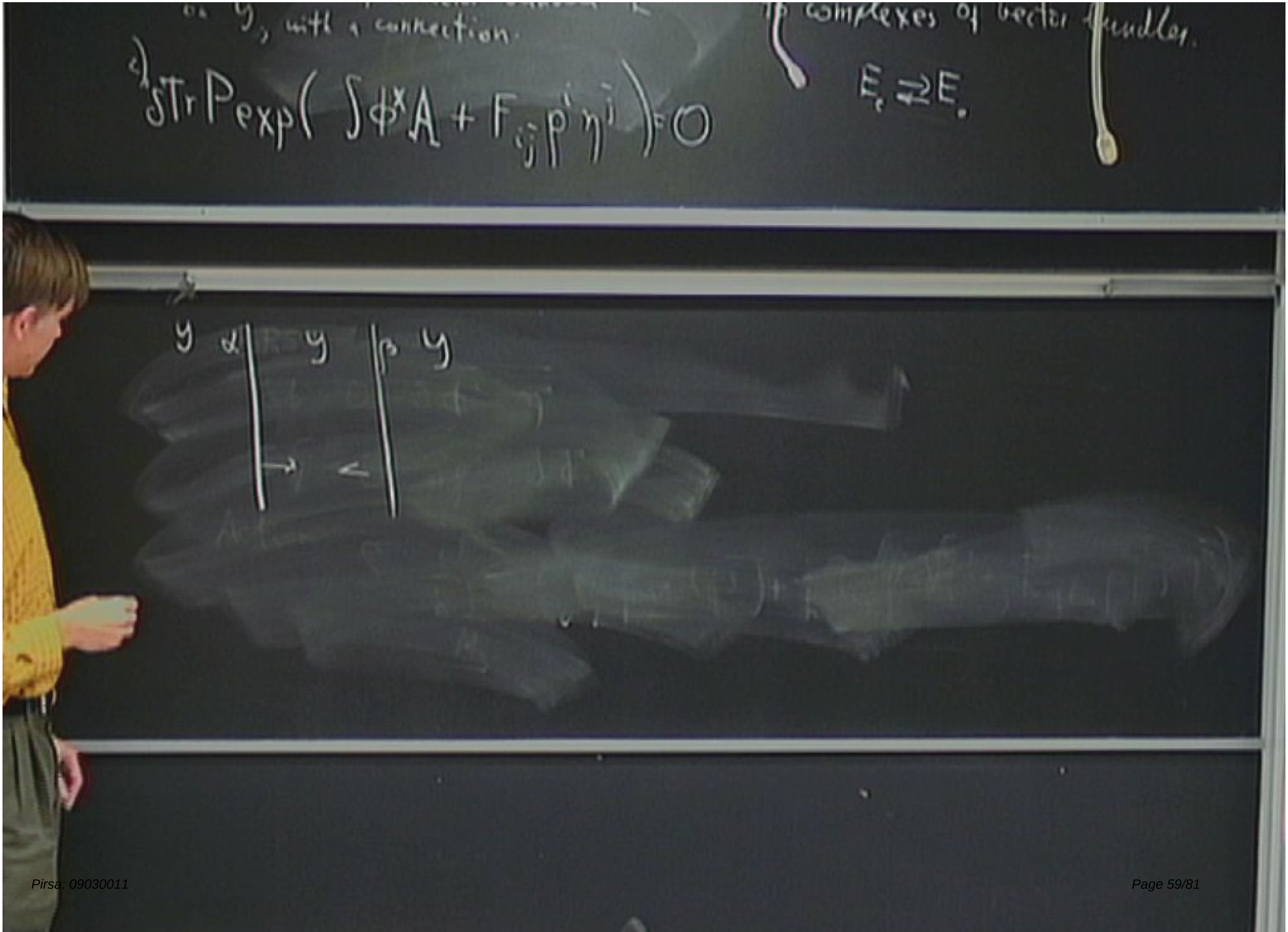
Case 1.
Can generalize
to complexes of vector bundles.
vector bundle E
connection.



$\alpha \in Ob(D^b(M_1))$
Y
$\theta_{\alpha\beta} \in Hom(\alpha, \beta)$ $\Rightarrow$ $Hom(Y, Y) \overset{?}{=} D^b(Y).$
$\beta \in Ob(D^b(Y))$
Case 1. $Y_1 = Y_2 = Y$
i). Pick a holomorphic vector bundle E on Y, with a connection.
ii). Can generalize to complexes of vector bundles.
ii) $STr\, P\exp\left(\int \phi^* A + F_{ij}\rho^i\eta^j\right) = O$


α ∈ Ob(D^b(M))
Y
θ_αβ ∈ Hom(α, β)
⇒ Hom(Y, Y) =? D^b(Y).
β ∈ Ob(D^b(Y))
Case 1. Y_1 = Y_2 = Y
1). Pick a holomorphic vector bundle E on Y, with a connection.
2) STr P exp(∫ φ*A + F_ij ρ^i η^j) = 0
3). Can generalize to complexes of vector bundles.
E_1 ⇄ E_0


Y_1
$\alpha \in Ob(D^b_{Z_2}(Y_1))$
Y
$\theta_{\alpha\beta} \in Hom(\alpha, \beta)$ ⇒ $Hom(Y, Y) \overset{?}{=} D^b_{Z_2}(Y)$.
$\beta \in Ob(D^b_{Z_2}(Y))$
Case 1. $Y_1 = Y_2 = Y$
1) Pick a holomorphic vector bundle E on Y, with a connection.
2) $sTr\, P\exp\left(\int d\phi^x A + F_{ij}\rho^i\eta^j\right) = O$
3) Can generalize to complexes of vector bundles.
$E_1 \rightleftarrows E_0$


on Y, with a connection.
complexes of vector bundles.
sTr P exp(∫ φ*A + F_ij ρ^i η^i) = 0
E₁ ⇄ E₀
Y α Y β Y

on Y, with a connection.

2) $\mathrm{STr}\, P\exp\left(\int \phi^* A + F_{ij}\rho^i\eta^j \right) O$

complexes of vector bundles.

$E_1 \rightleftarrows E_0$

$$Y \;\; \alpha \,\Big|\; Y \;\Big|\, \beta \;\; Y$$

$$\mapsto \quad \leftarrow$$

$(\alpha, \beta) \mapsto \alpha \cdot \beta.$

on Y, with a connection.

$$\mathrm{sTr}\, P\exp\left(\int \phi^* A + F_{ij}\rho^i \eta^j \right) = 0$$

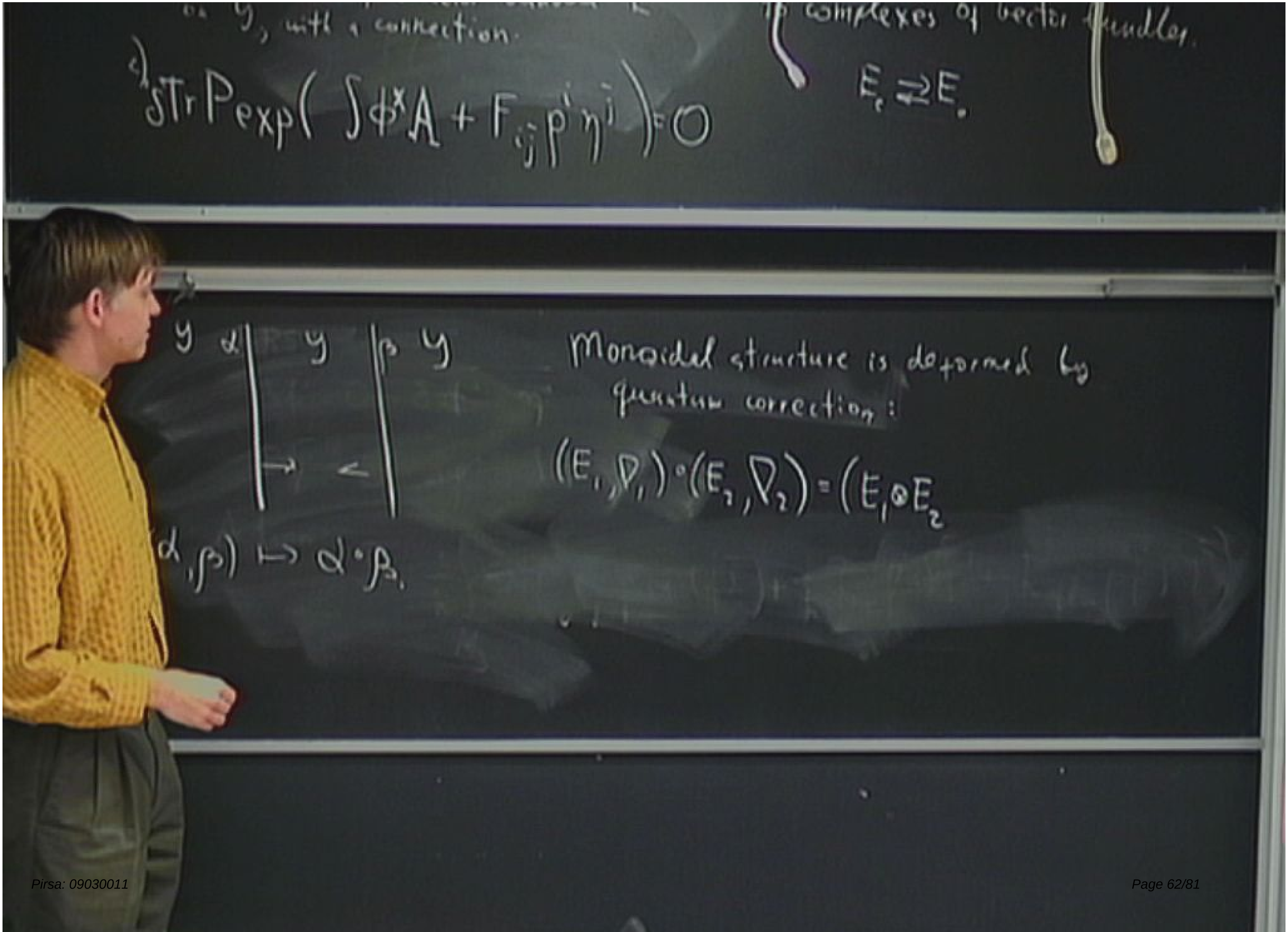
complexes of vector bundles.

$$E_1 \rightleftarrows E_0$$

$Y \quad \alpha \quad Y \quad \beta \quad Y$

Monoidal structure is deformed by quantum correction:

$$(\alpha, \beta) \mapsto \alpha \circ \beta.$$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d STr Pexp(∫φ*A + F_ij ρ^i η^i) = 0
complexes of vector bundles.
E_1 ⇄ E_0
Y α | Y | β Y
(α, β) ↦ α∘β.
Monoidal structure is deformed by quantum correction:
((E_1, ∇_1)∘(E_2, ∇_2) = (E_1 ⊗ E_2

on Y, with a connection.

$$\delta\, \mathrm{STr}\, P\exp\left(\int \phi^* A + F_{ij}\, \rho^i \eta^j \right) = 0$$

complexes of vector bundles.

$$E_1 \rightleftarrows E_0$$

$$Y \quad \alpha \quad Y \quad \beta \quad Y$$

$$(\alpha, \beta) \mapsto \alpha \circ \beta.$$

Monoidal structure is deformed by quantum correction:

$$(E_1, \nabla_1) \circ (E_2, \nabla_2) = \left(E_1 \otimes E_2,\ \nabla_{1\otimes 2} + \beta F^{(1)} F^{(2)} \right.$$

on Y, with a connection.

d) $\mathrm{sTr}\, P\exp\left(\int \phi^* A + F_{ij}\rho^i\eta^j\right) = 0$

to complexes of vector bundles.

$E_1 \rightleftarrows E_0$

$Y \quad \alpha \quad Y \quad \beta \quad Y$

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$$d_S \operatorname{Tr} P\exp\left(\int \phi^* A + F_{ij}\rho^i \eta^j \right) = 0$$

complexes of vector bundles.

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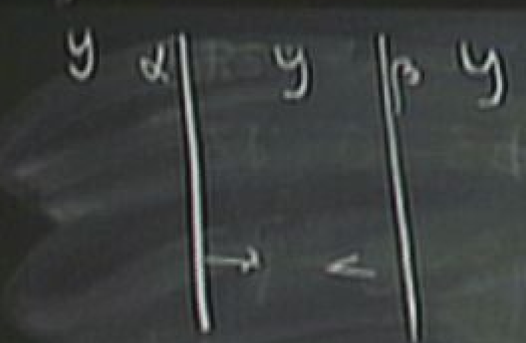

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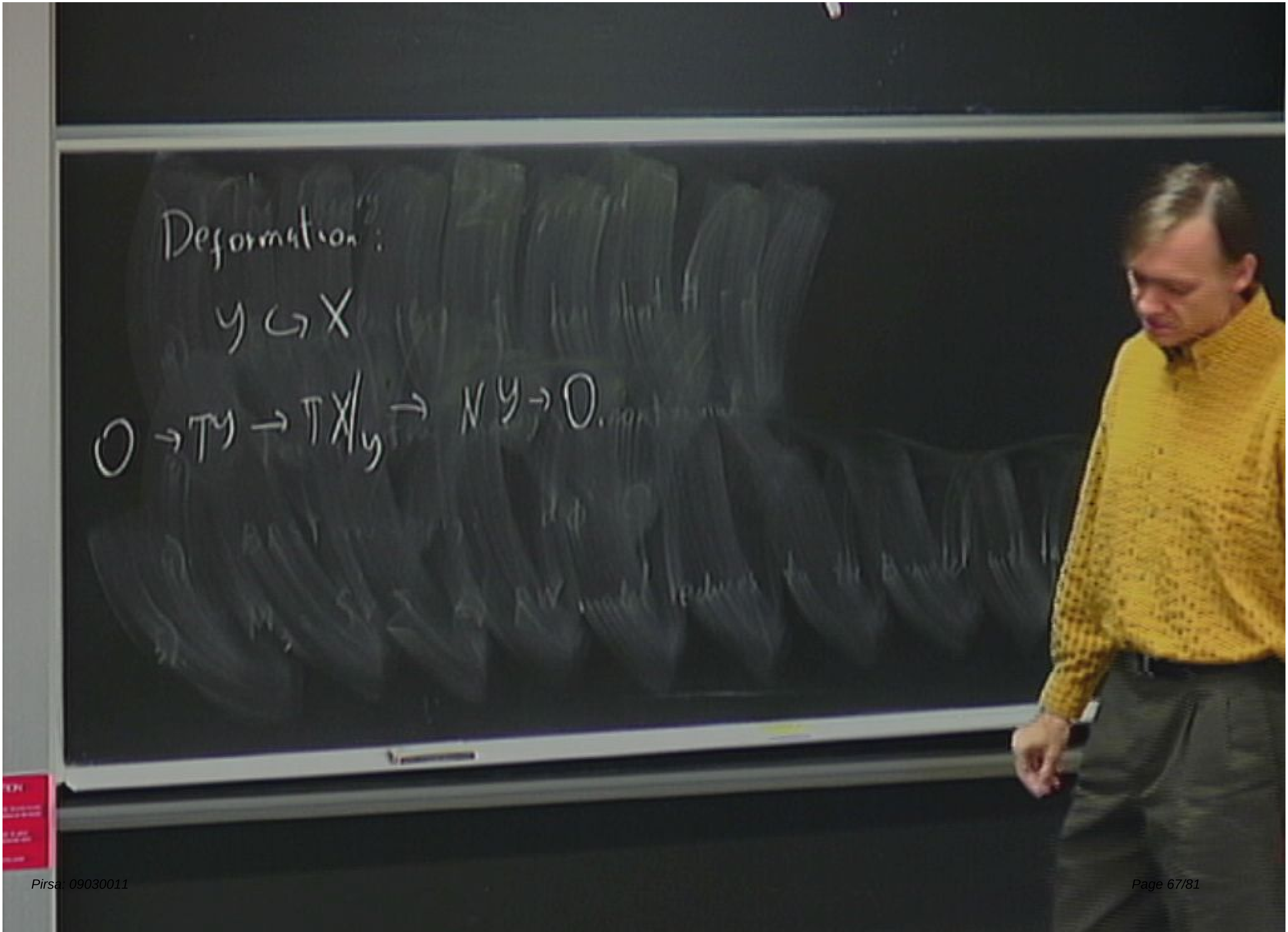
Deformation:

$Y \hookrightarrow X$


Deformation:
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Deformation:

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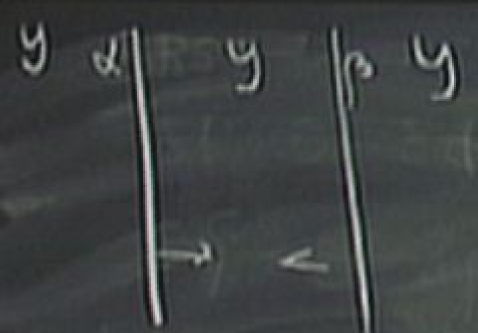
It appears that defs. of tensor product on $D^b(Y)$ are in 1-1 correspondence with defs. of T^*Y which are complex-symplectic.

on Y, with a connection.

$$\delta\, \mathrm{STr}\, P\exp\left(\int \phi^* A + F_{ij}\, \rho^i \eta^j \right) = 0$$

complexes of vector bundles.

$$E_1 \rightleftarrows E_0$$



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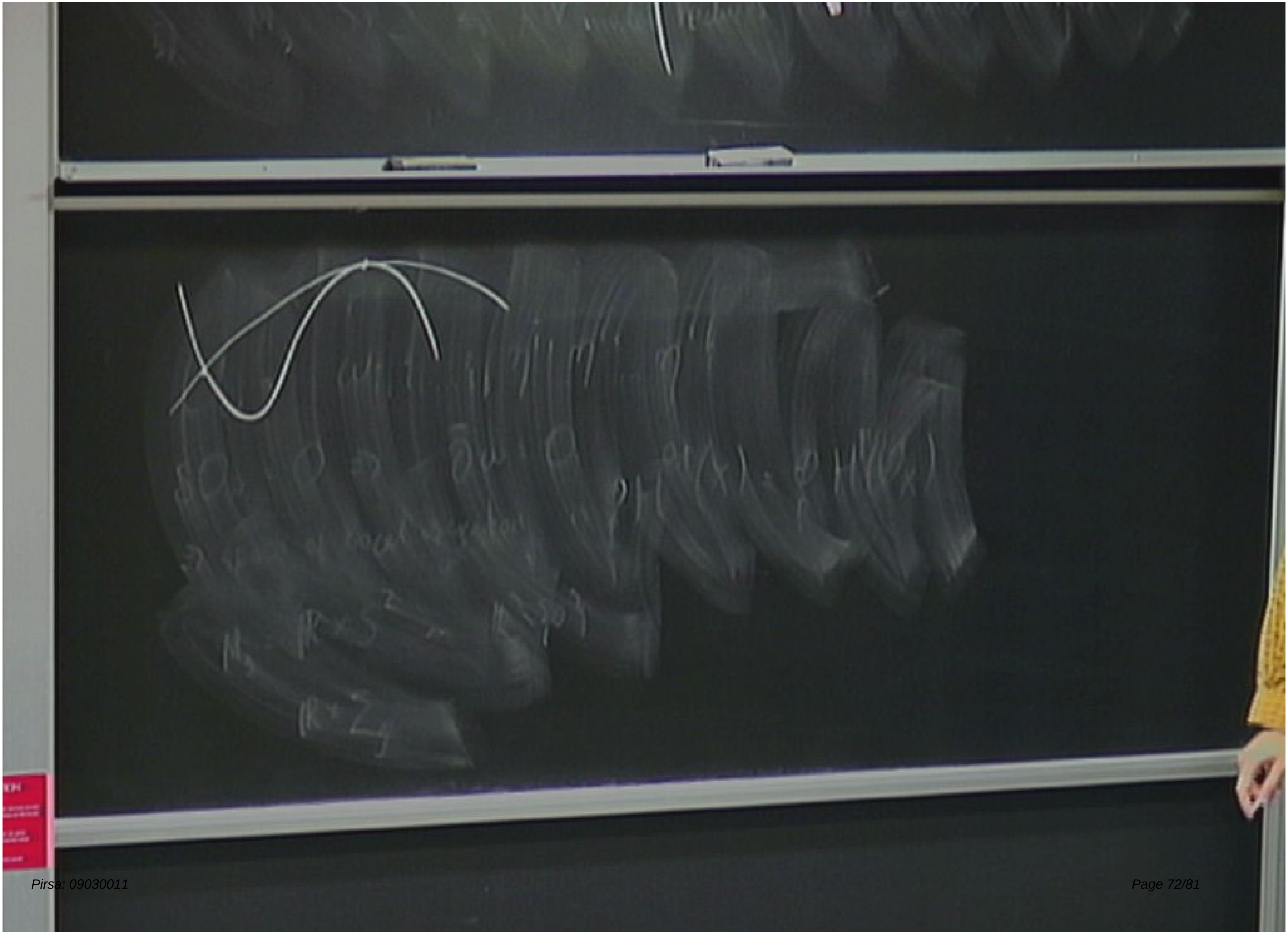
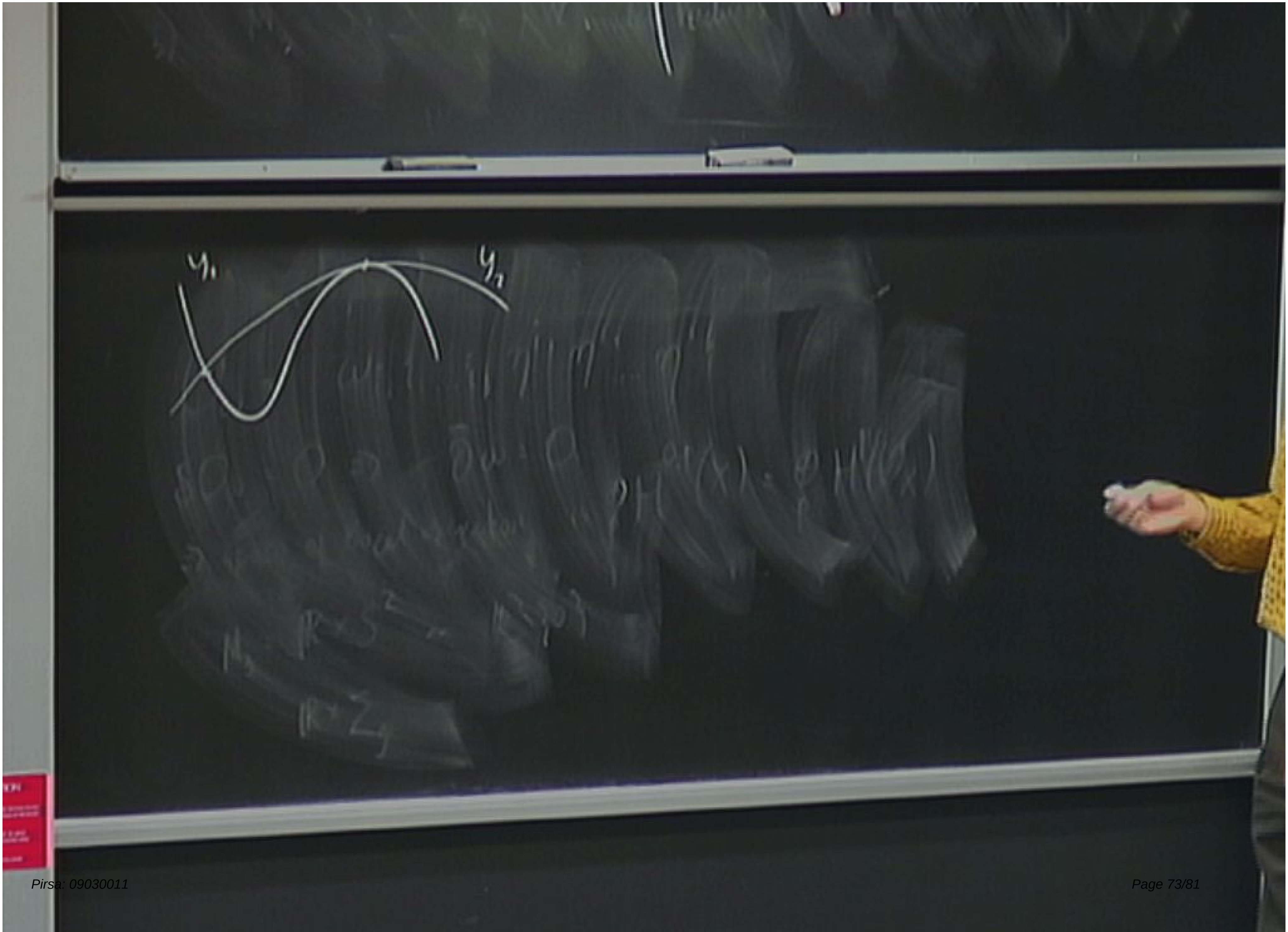
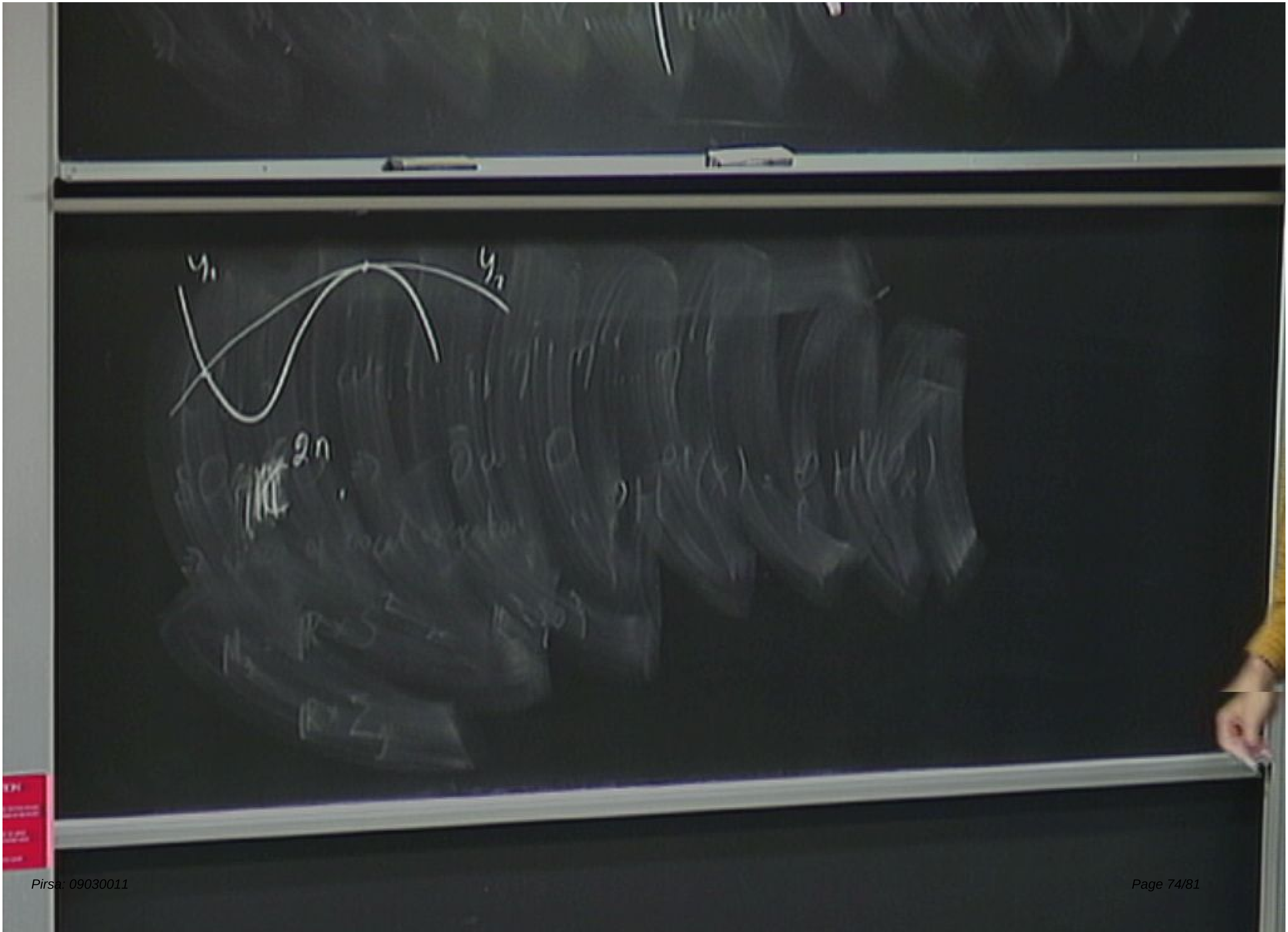
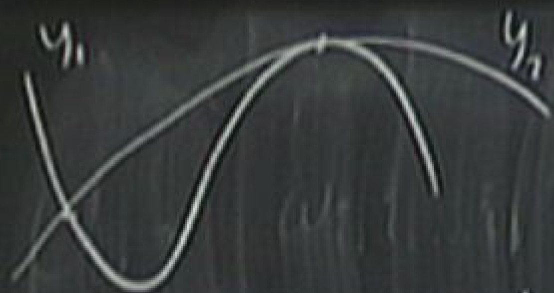



y_1
y_2


y1
y2



$\mathbb{R}^{2n}$, $\Omega = dp_i\, dq^i$,

$$Y_1 = \left\{ (p, q) \;\middle|\; p_i = \frac{\partial W_1}{\partial q^i} \right\},$$

$$Y_2 = \left\{ (p, q) \;\middle|\; p_i = \frac{\partial W_2}{\partial q^i} \right\}$$

$\to (\mathbb{C}^{2n},$

$\mathbb{R}^{2n}, \quad \Omega = dp_i\, dq^i,$

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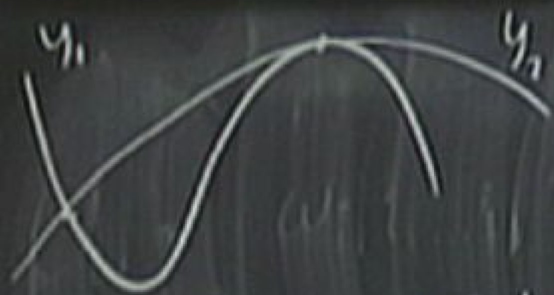

$\Rightarrow (\mathbb{C}^{2n}, W_1 - W_2)$

$\mathbb{C}^{2n}$: $\Omega = dp_i\, dq^i$

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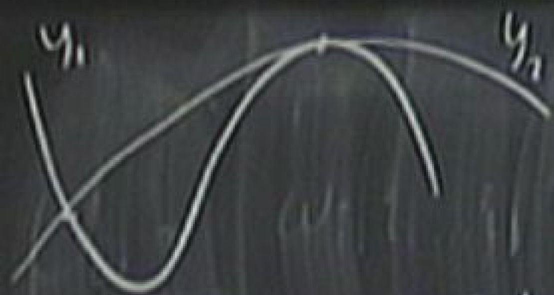

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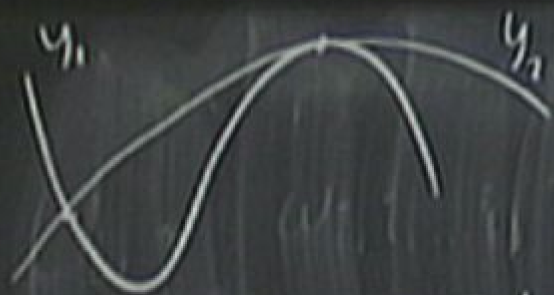
$$\Rightarrow \left(\mathbb{C}^{2n}, W_1 - W_2 \right)$$

Consider Landau-Ginzburg model with superpotential $W_1 - W_2$.



$\mathbb{C}^{2n}$, $\Omega = dp_i\, dq^i$.

$$y_1 = \left\{ (p, q) \mid p_i = \frac{\partial W_1}{\partial q^i} \right\},$$

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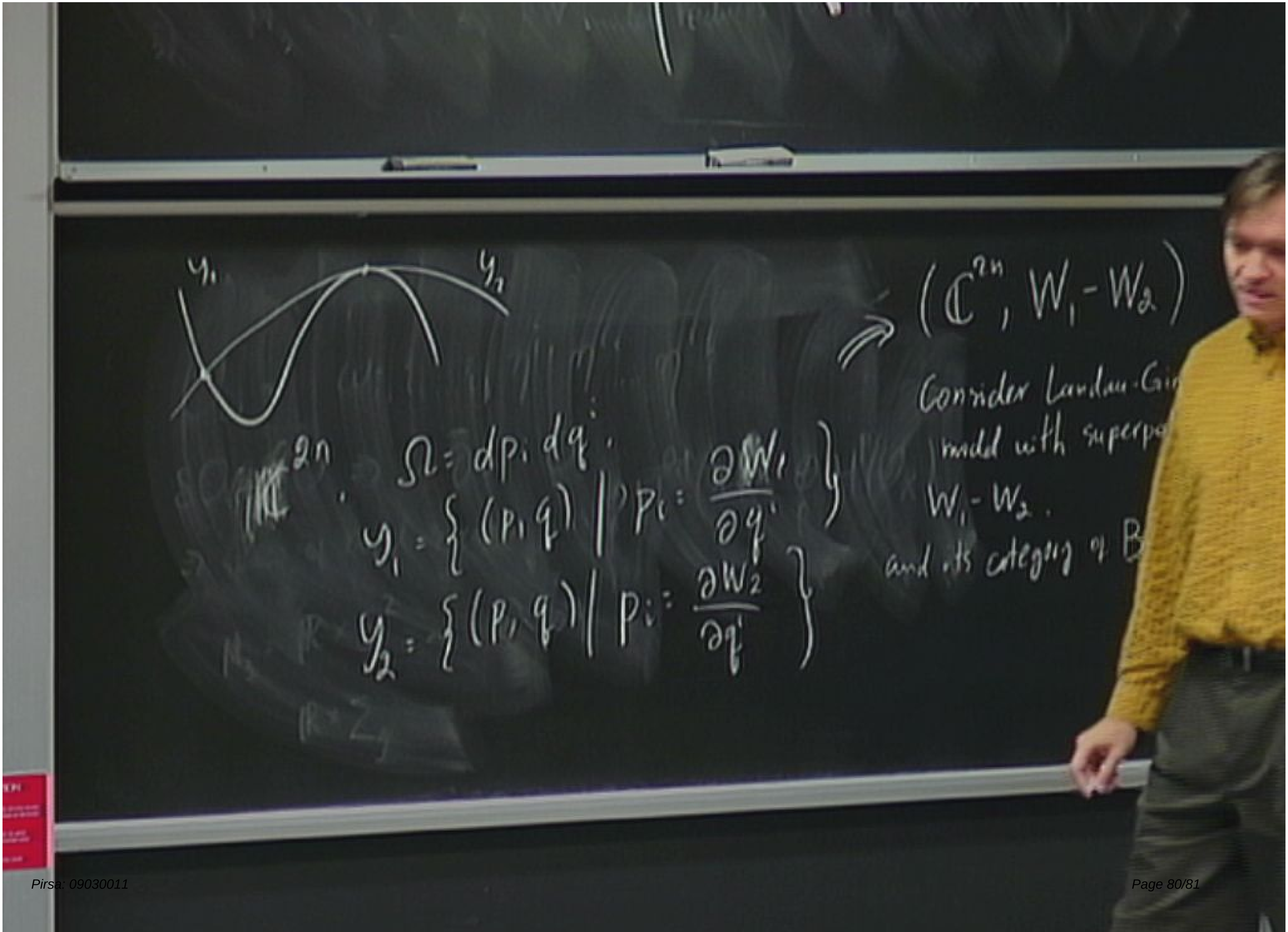
Consider Landau-Ginzburg model with superpotential $W_1 - W_2$.

and its category of B-branes


Y_1
Y_2
$(\mathbb{C}^{2n}, W_1 - W_2)$
Consider Landau-Gi
model with superpo
$W_1 - W_2$.
and its category of B
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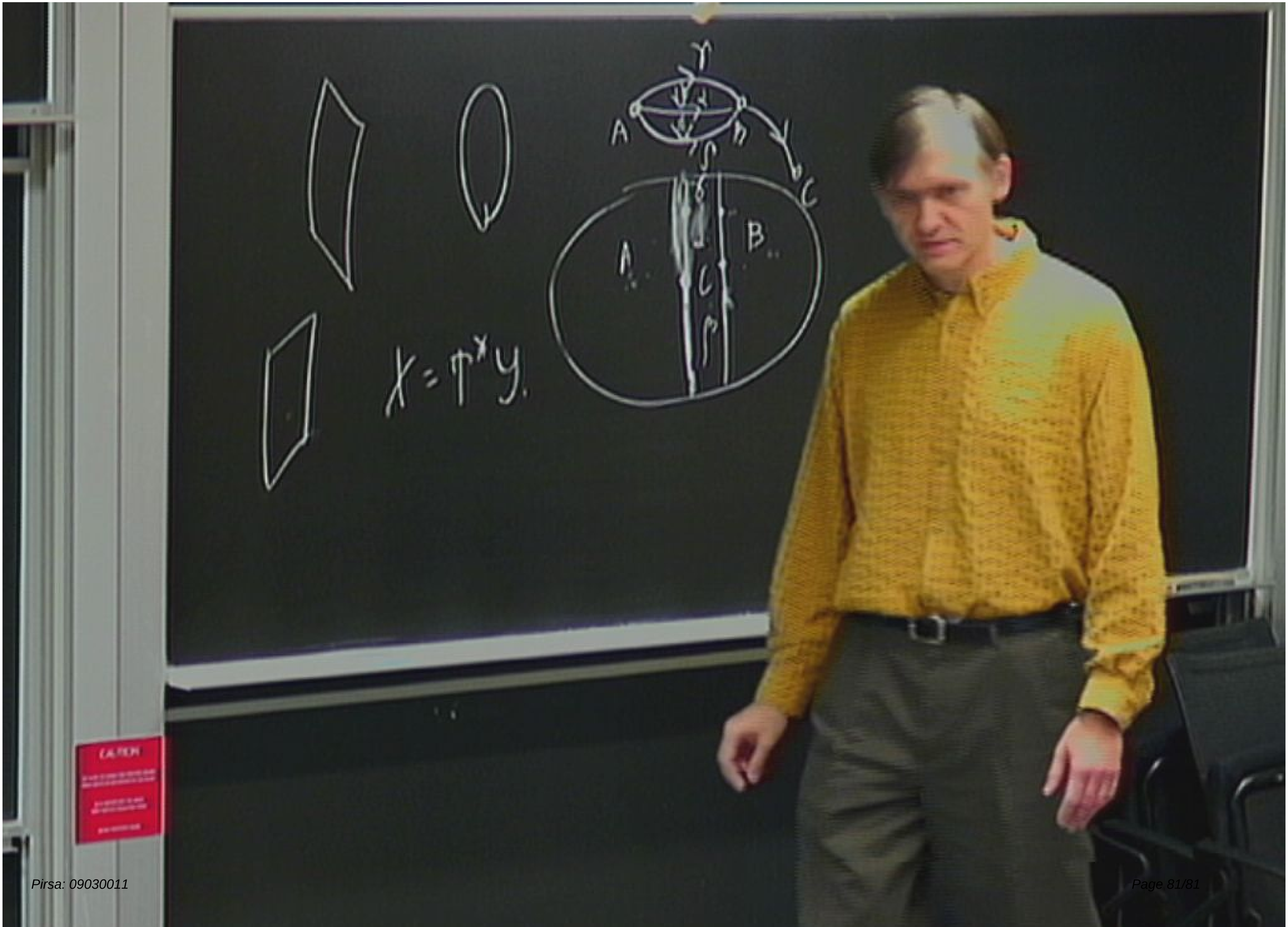
CAUTION