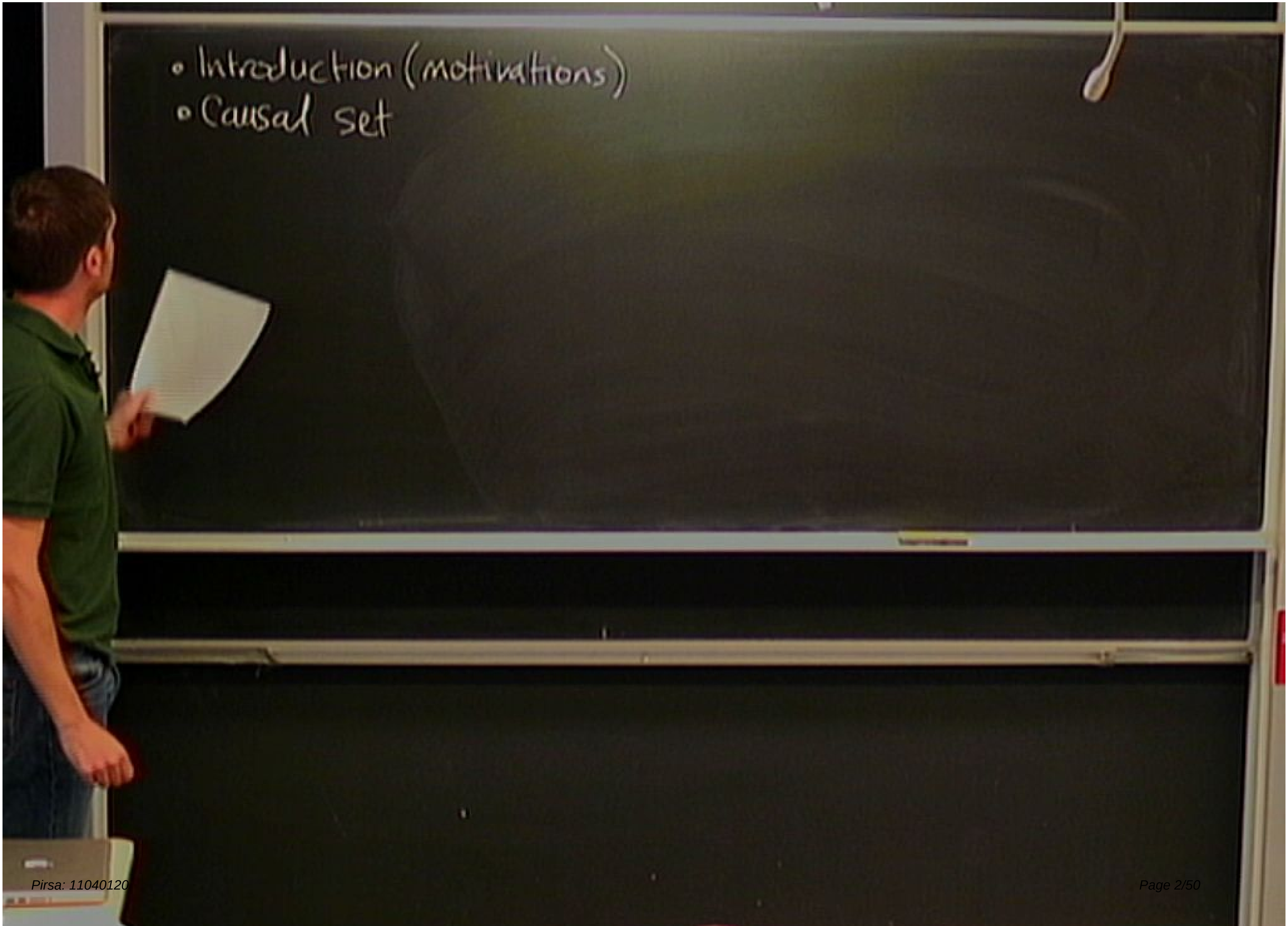
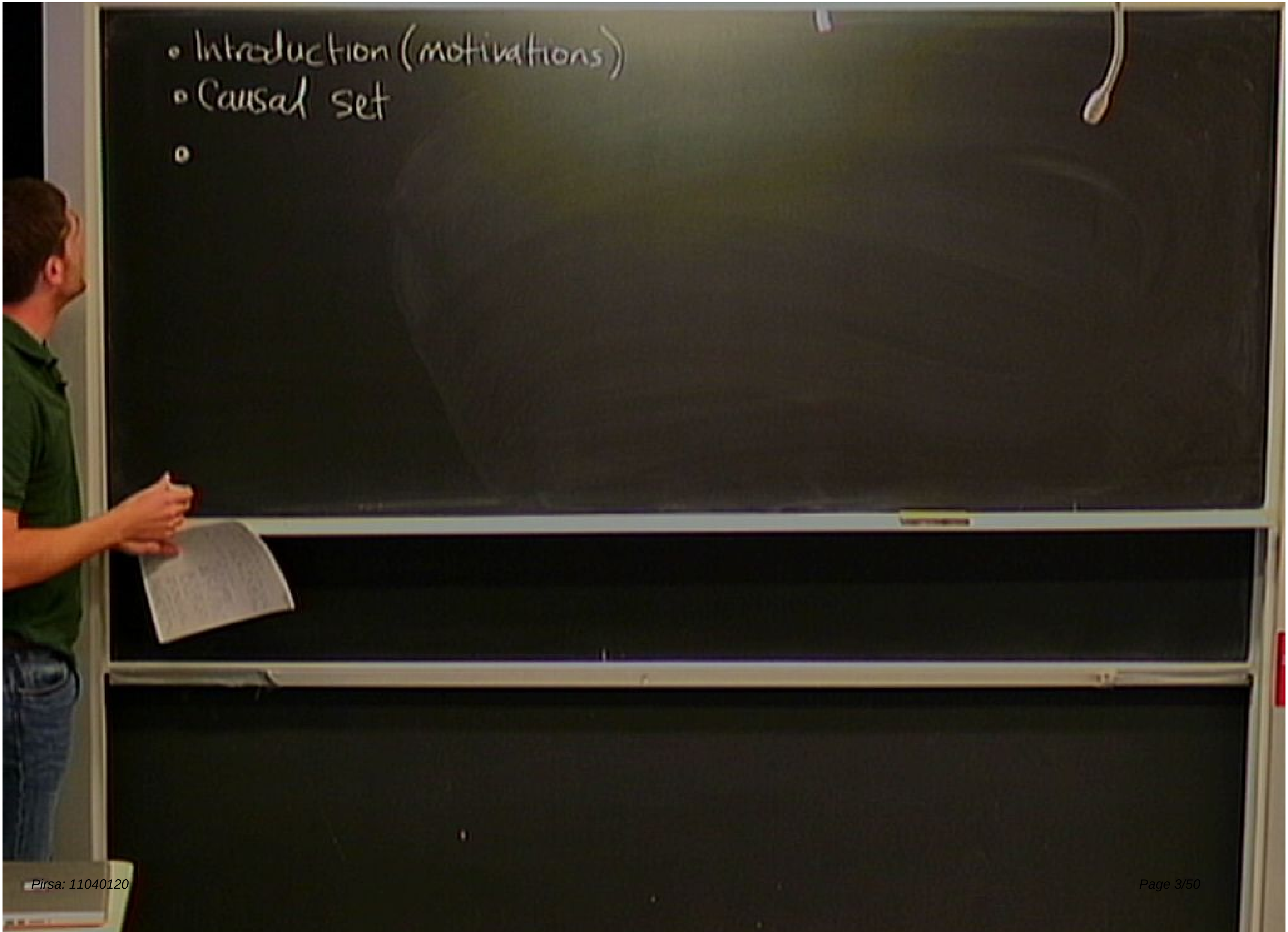
Title: Counting horizon entropy in causal set quantum gravity

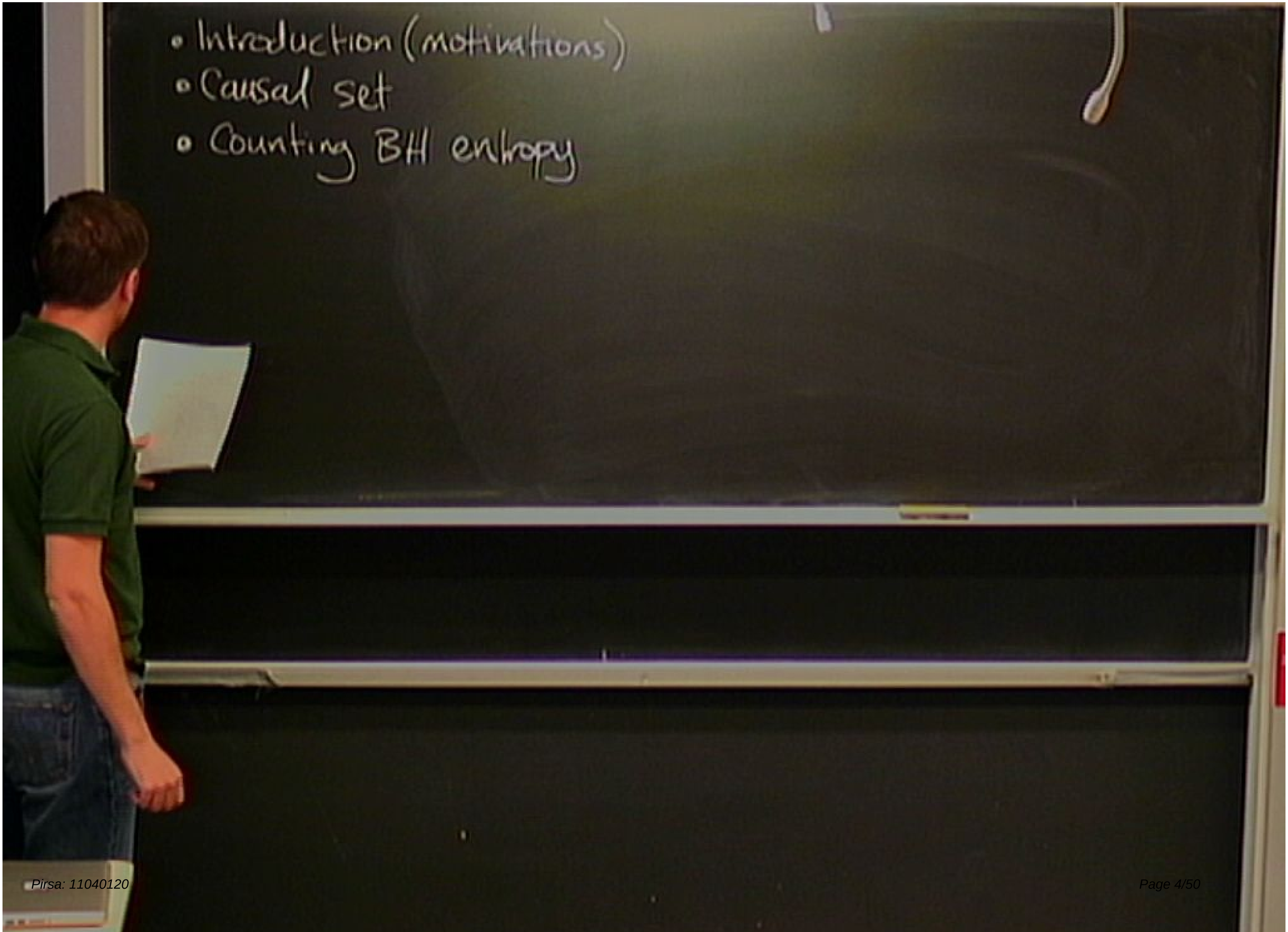
Date: Apr 28, 2011 01:00 PM

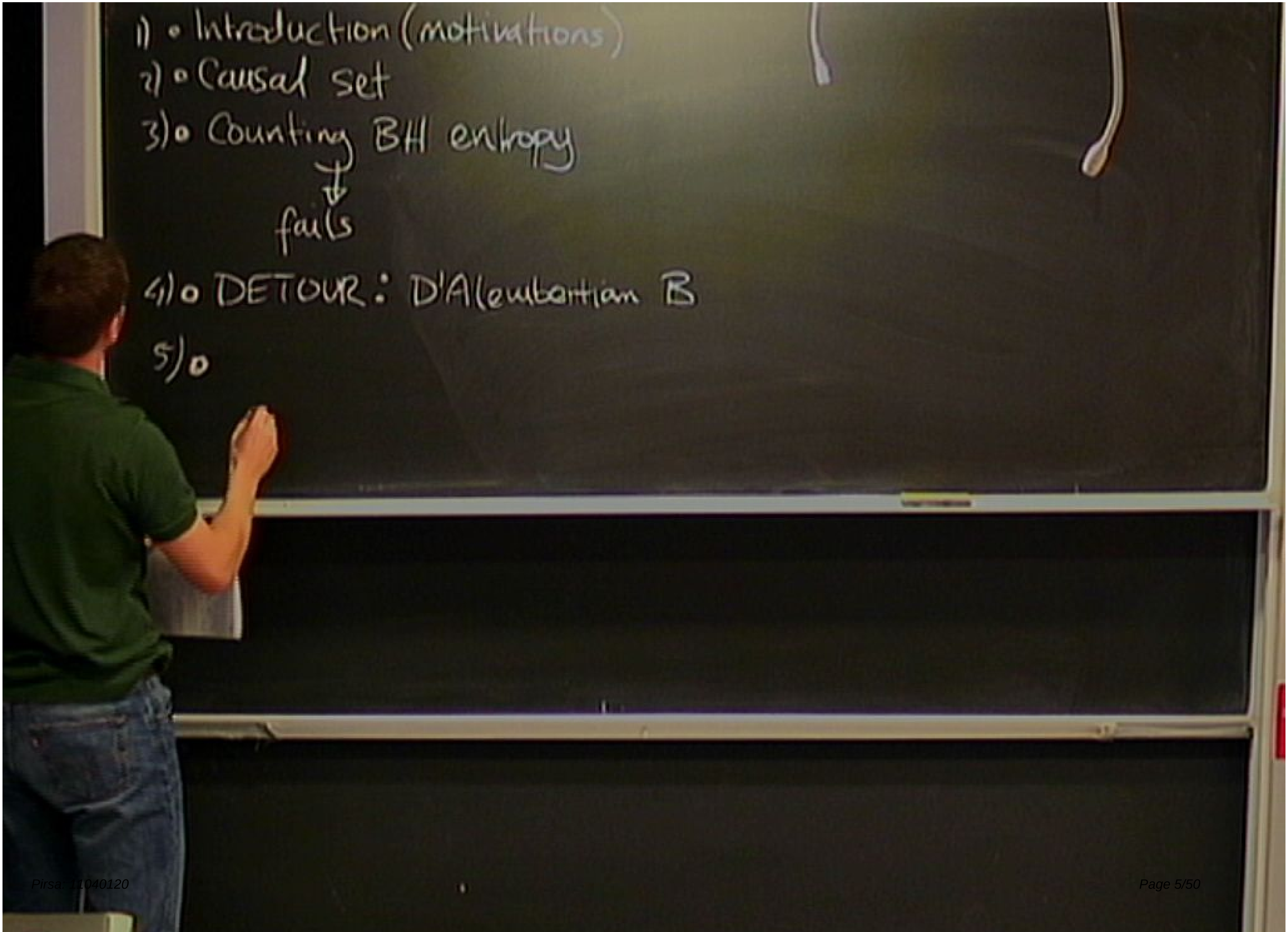
URL: http://pirsa.org/11040120

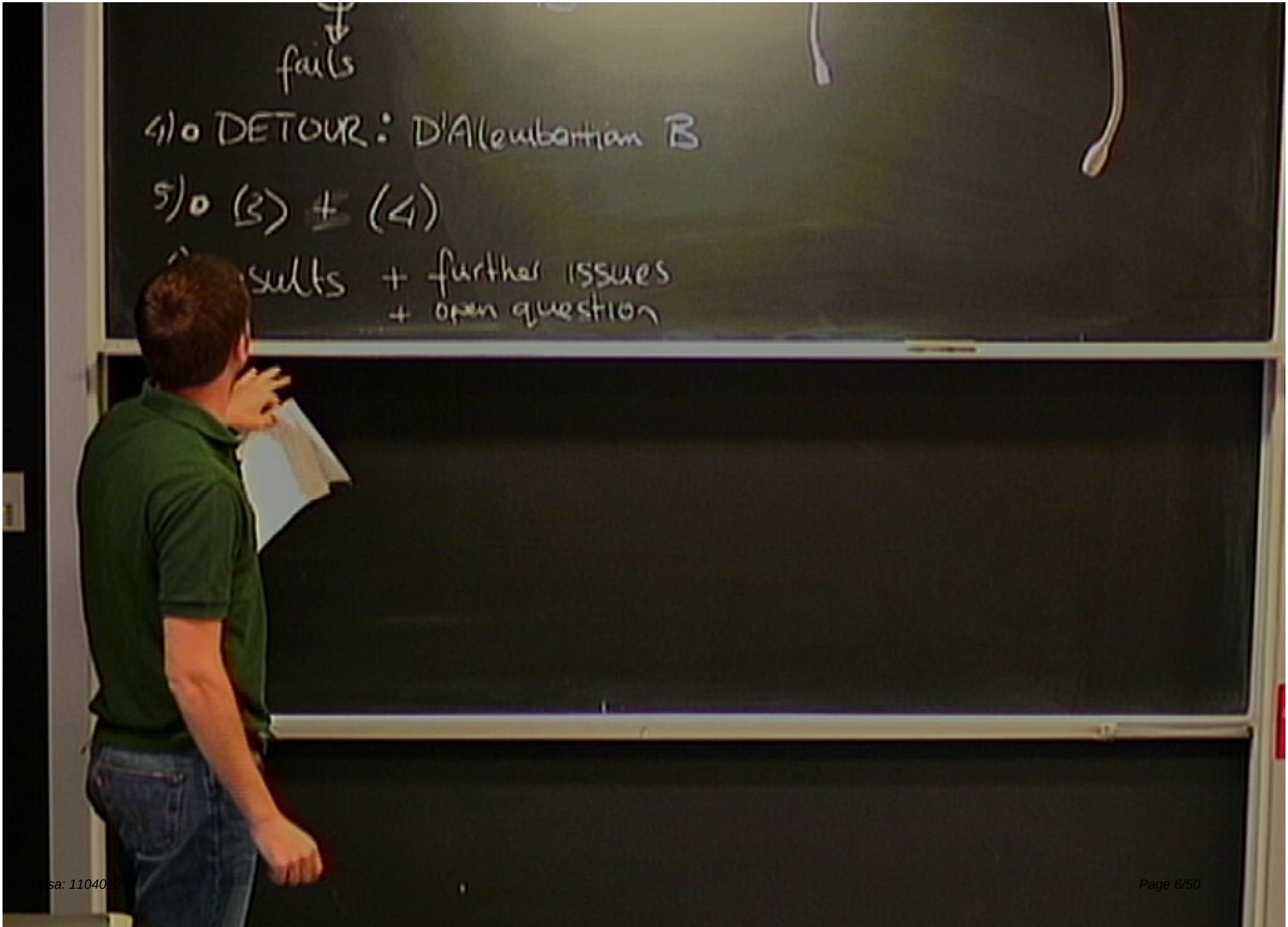
Abstract:

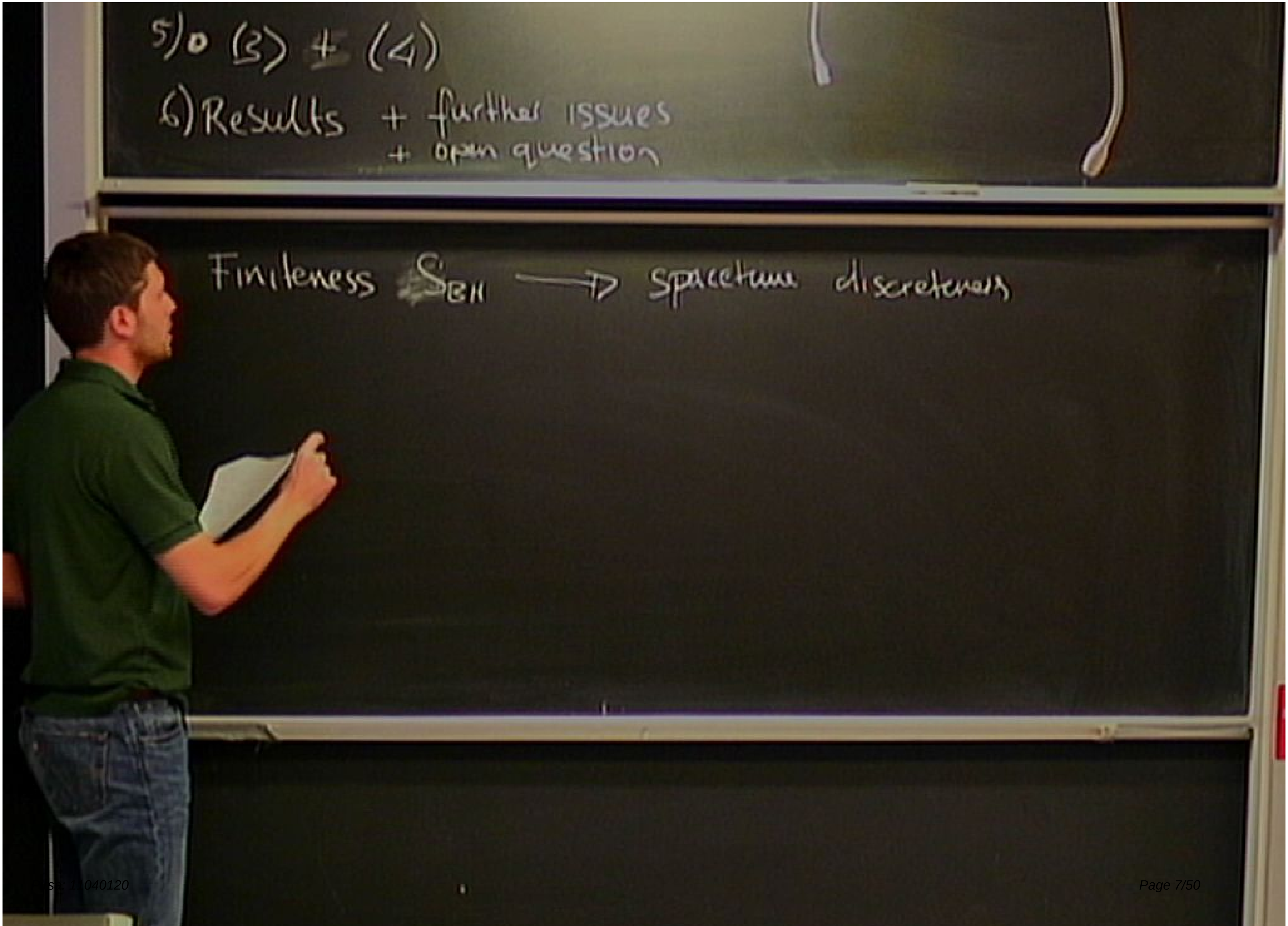

• Introduction (motivations)
• Causal set

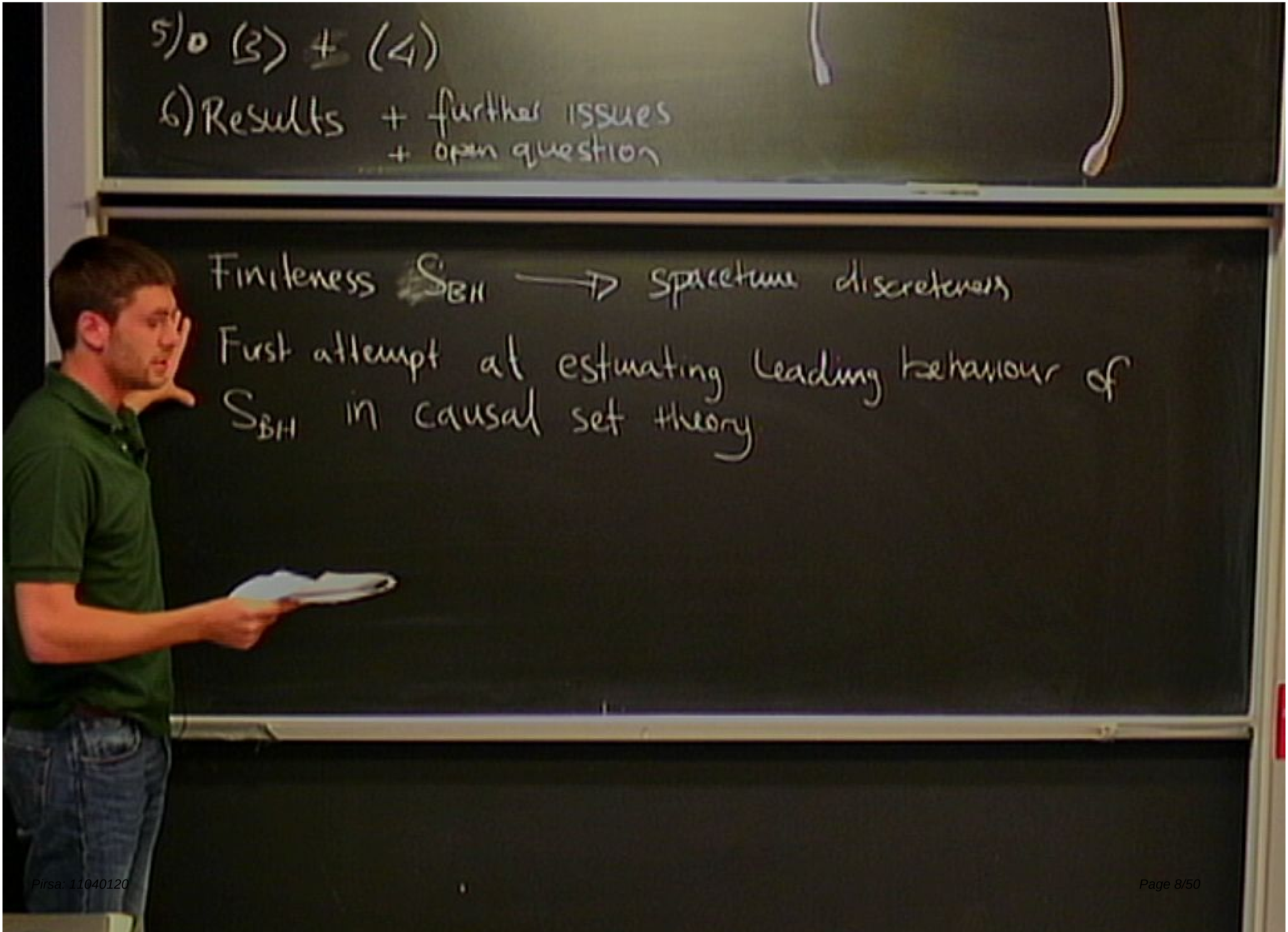

• Introduction (motivations)
• Causal set
•


• Introduction (motivations)
• Causal set
• Counting BH entropy


1) • Introduction (motivations)
2) • Causal set
3) • Counting BH entropy
fails
4) • DETOUR: D'Alembertian B
5) •


fails
4/o DETOUR: D'Alembertian B
5/o (3) ± (4)
sults + further issues
+ open question


6) Results + further issues
+ open question
Finiteness S_BH → spacetime discreteness


5) (3) + (4)
6) Results + further issues
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Finiteness S_{BH} → spacetime discreteness
First attempt at estimating leading behaviour of
S_{BH} in causal set theory

5) (3) + (4)

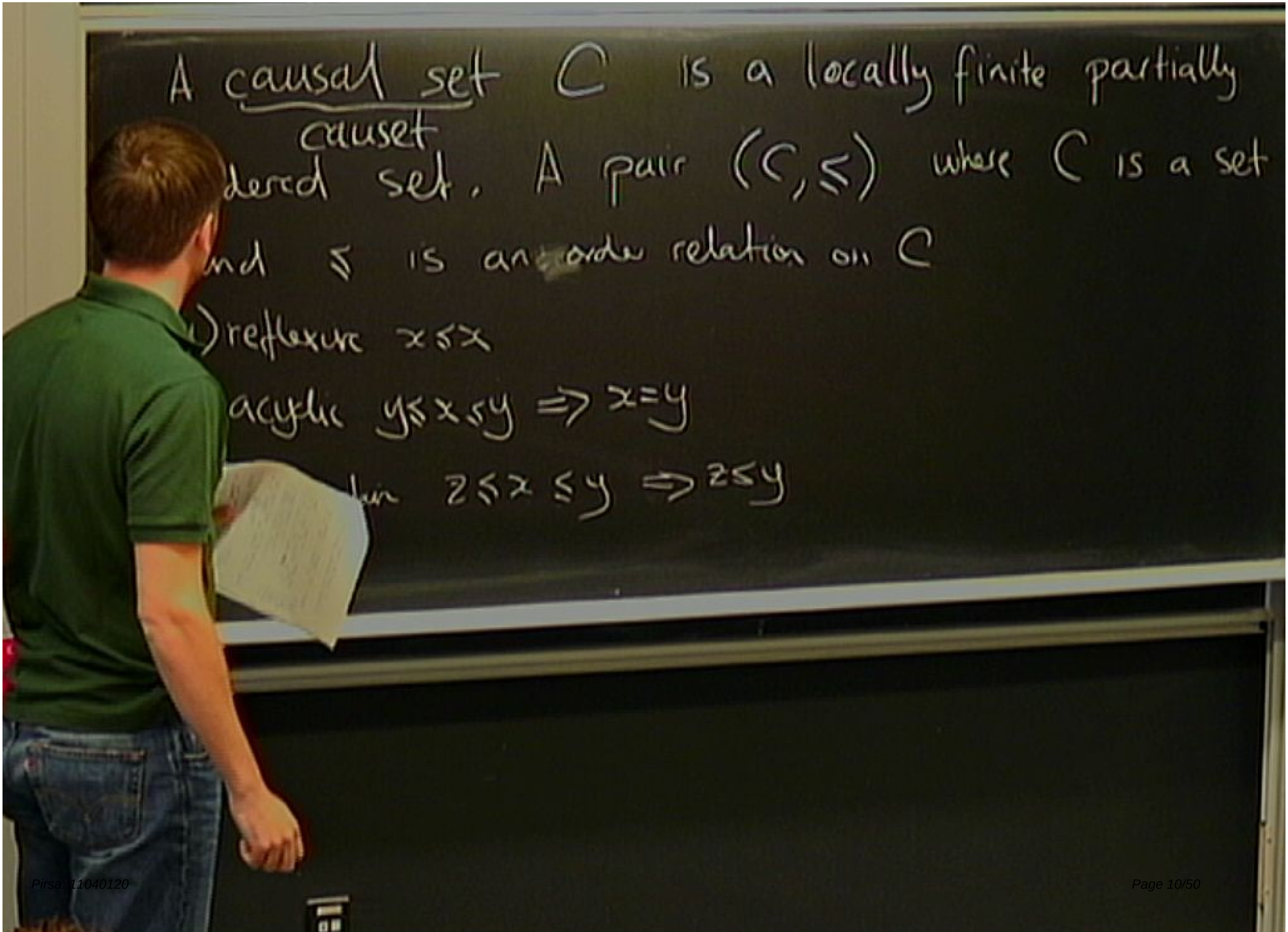
6) Results + further issues
+ open question

Finiteness S_{BH} $\longrightarrow$ spacetime discreteness

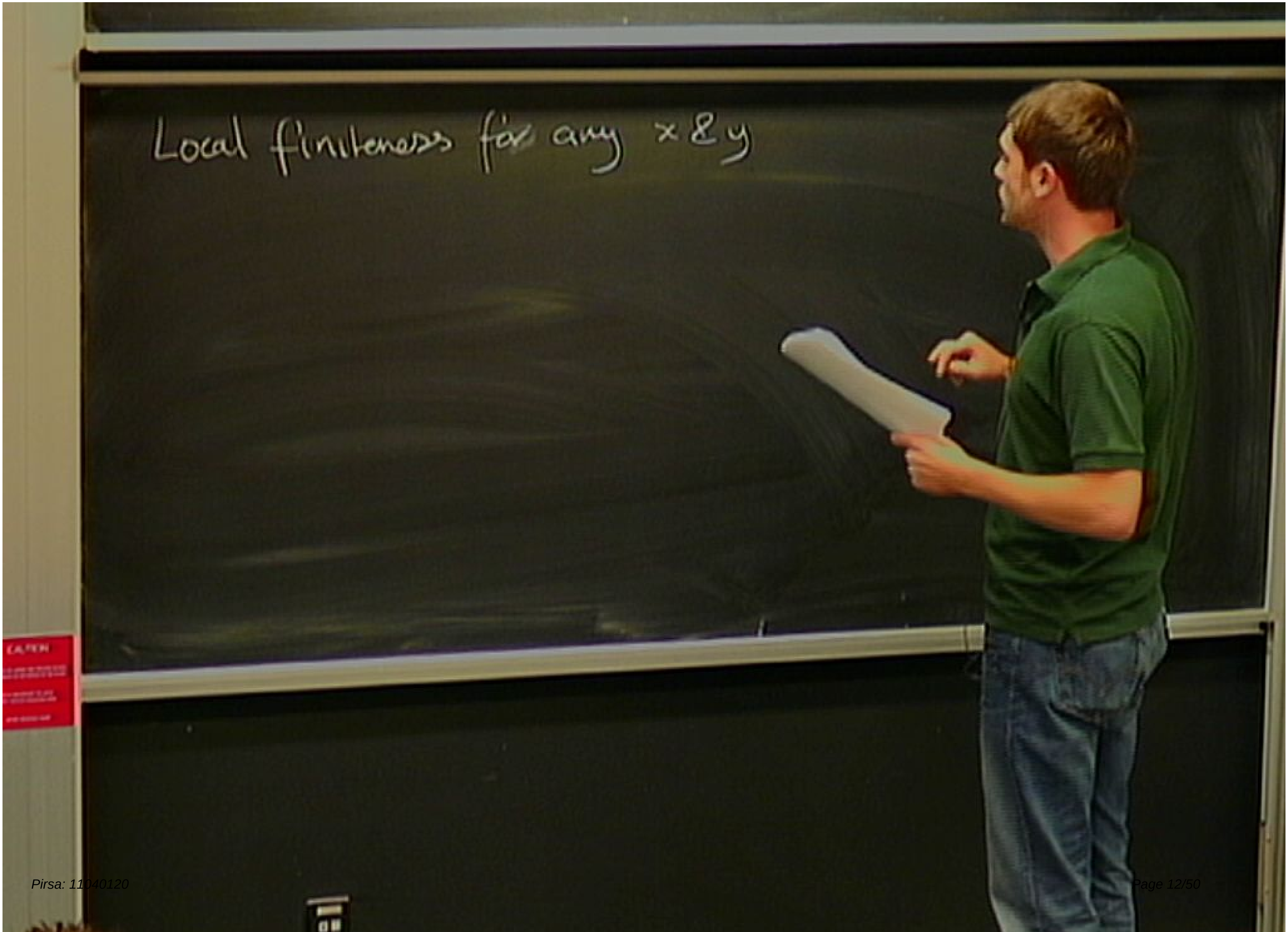
First attempt at estimating leading behaviour of S_{BH} in causal set theory

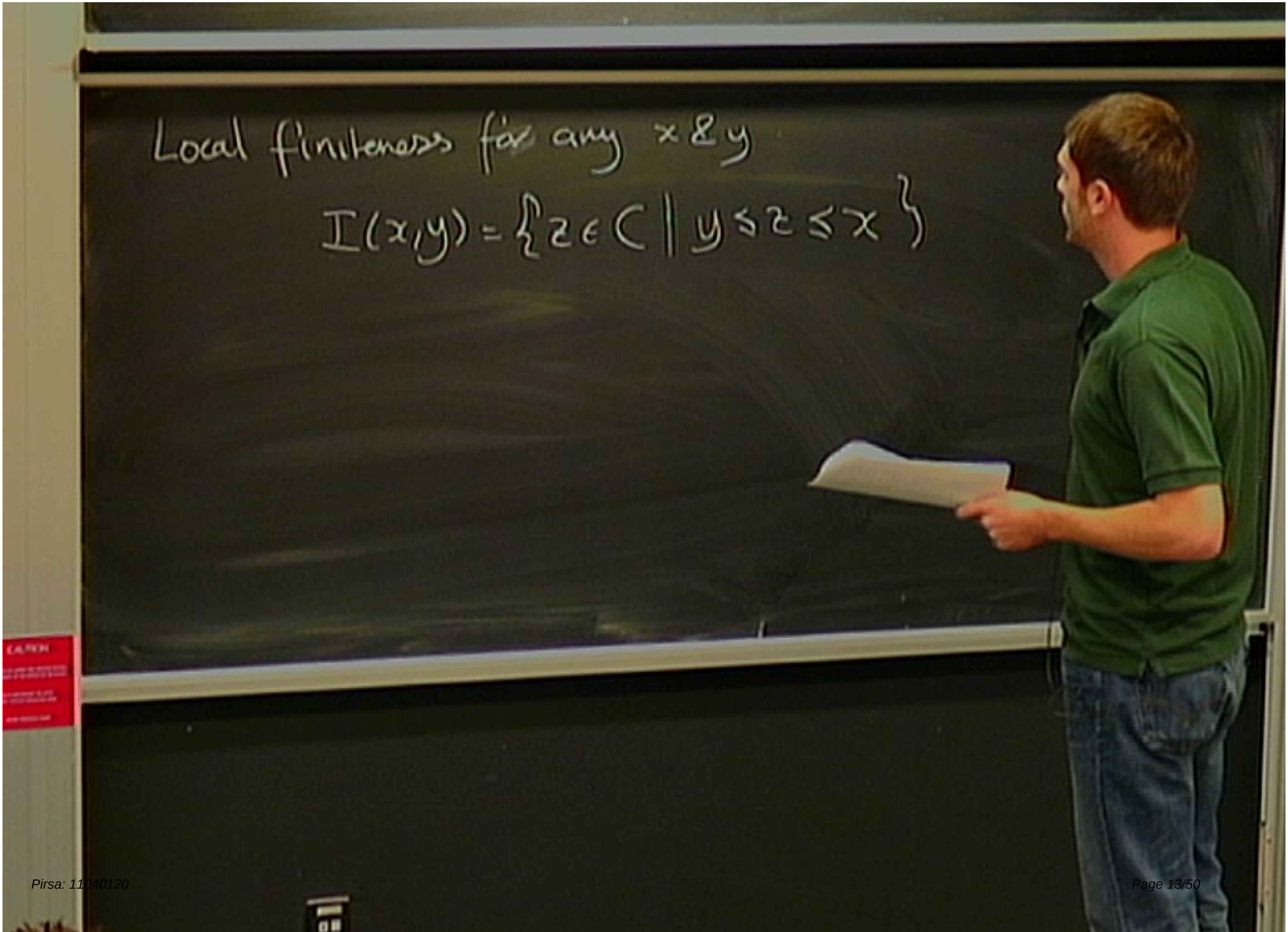
$\Updownarrow$

entropy of
hot gas by
counting # molecules


A causal set C is a locally finite partially
causet
dered set. A pair (C, ≤) where C is a set
nd ≤ is an order relation on C
) reflexive x ≤ x
acyclic y ≤ x ≤ y ⇒ x = y
z ≤ x ≤ y ⇒ z ≤ y


Local fi
s for any x & y


Local finiteness for any x & y


Local finiteness for any x & y
$I(x,y) = \{ z \in C \mid y \leq z \leq x \}$

Local finiteness for any x & y

$$I(x,y) = \{ z \in C \mid y \le z \le x \}$$

$$|I| < \infty, \quad n(x,y) \equiv |I(x,y)|$$

LINK:  $n=2$ 3-chain: 

Local finiteness for any x & y

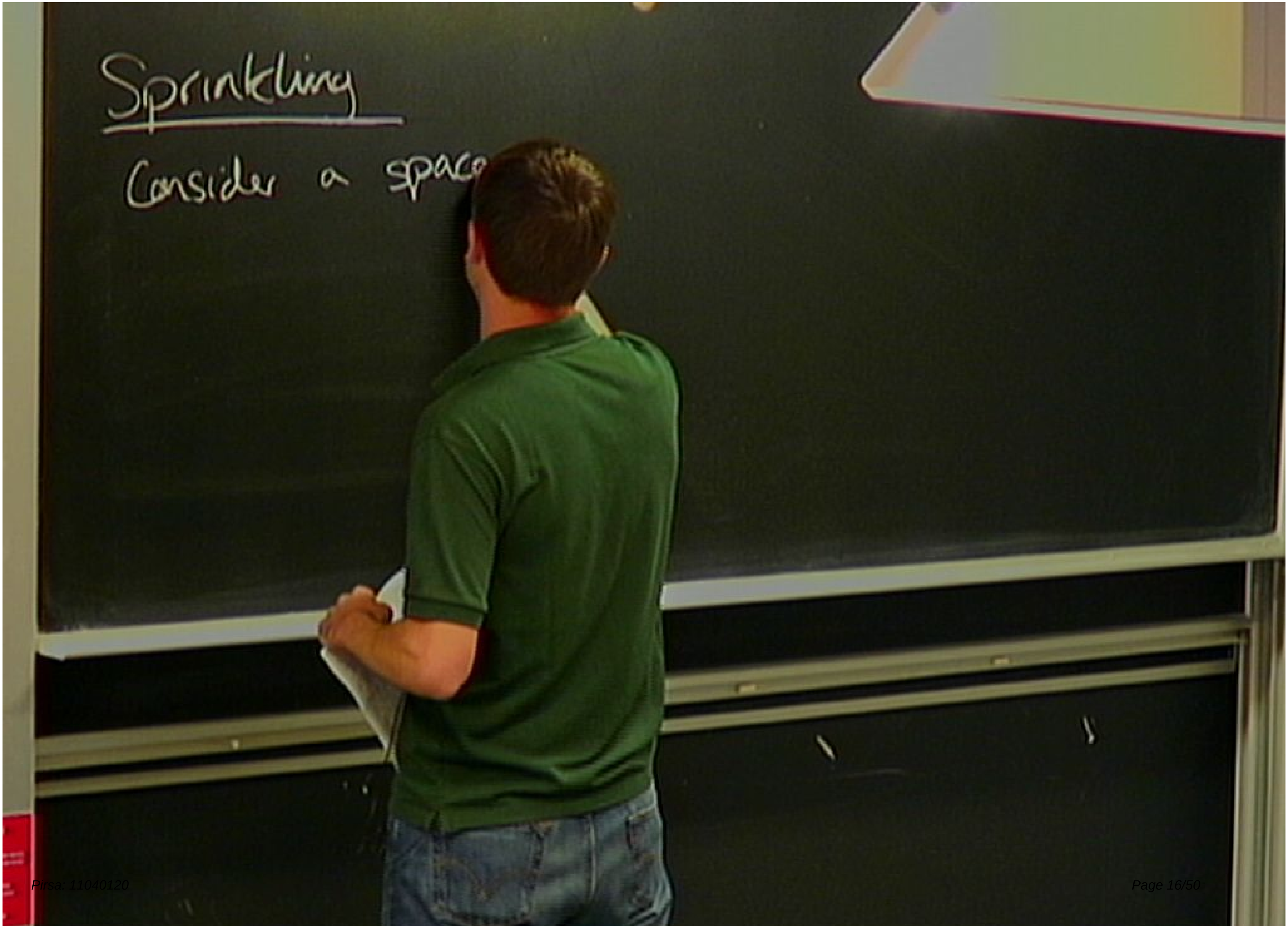
$$I(x,y) = \{ z \in C \mid y \leq z \leq x \}$$

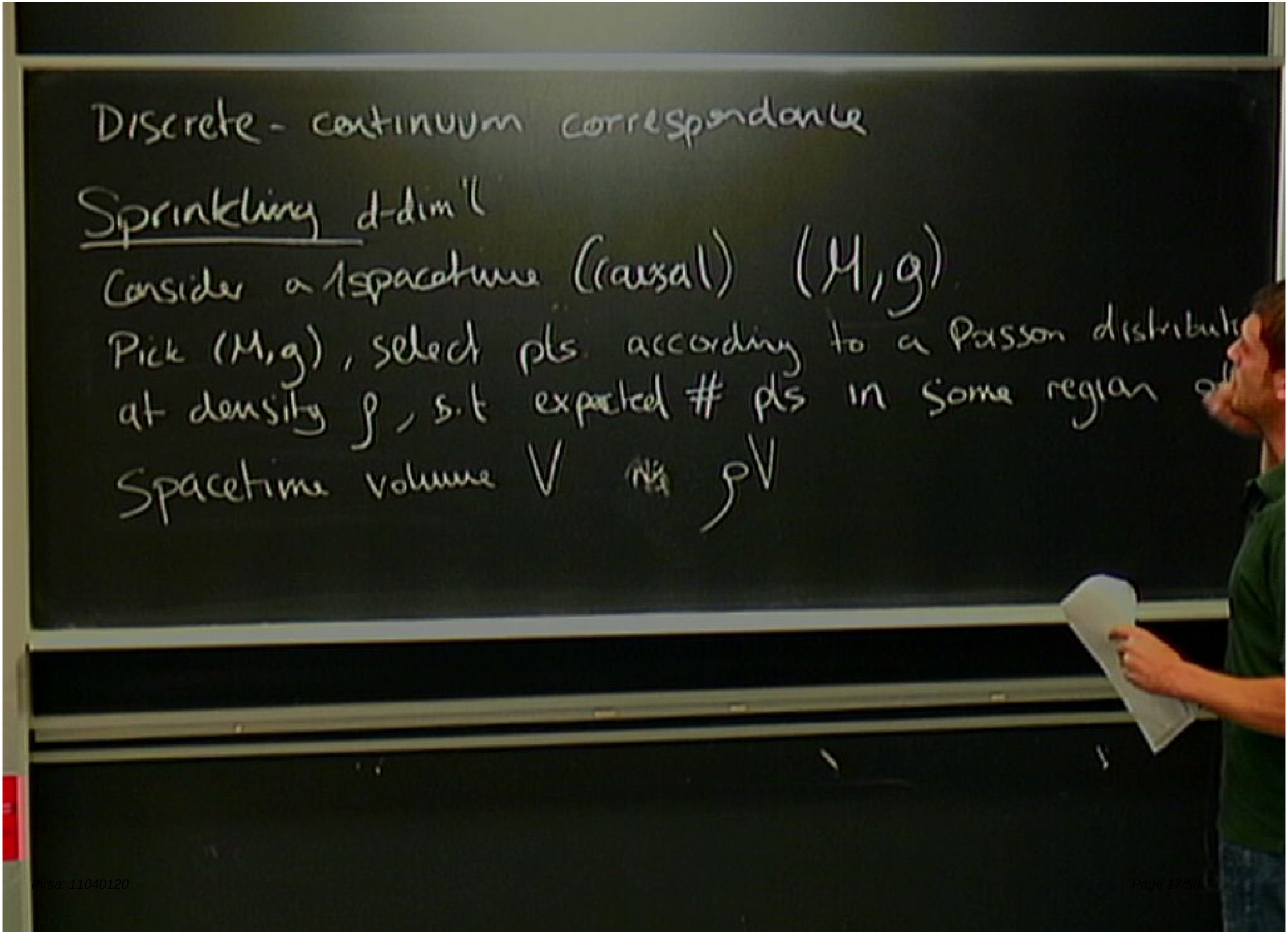
$$|I| < \infty, \quad n(x,y) \equiv |I(x,y)|$$

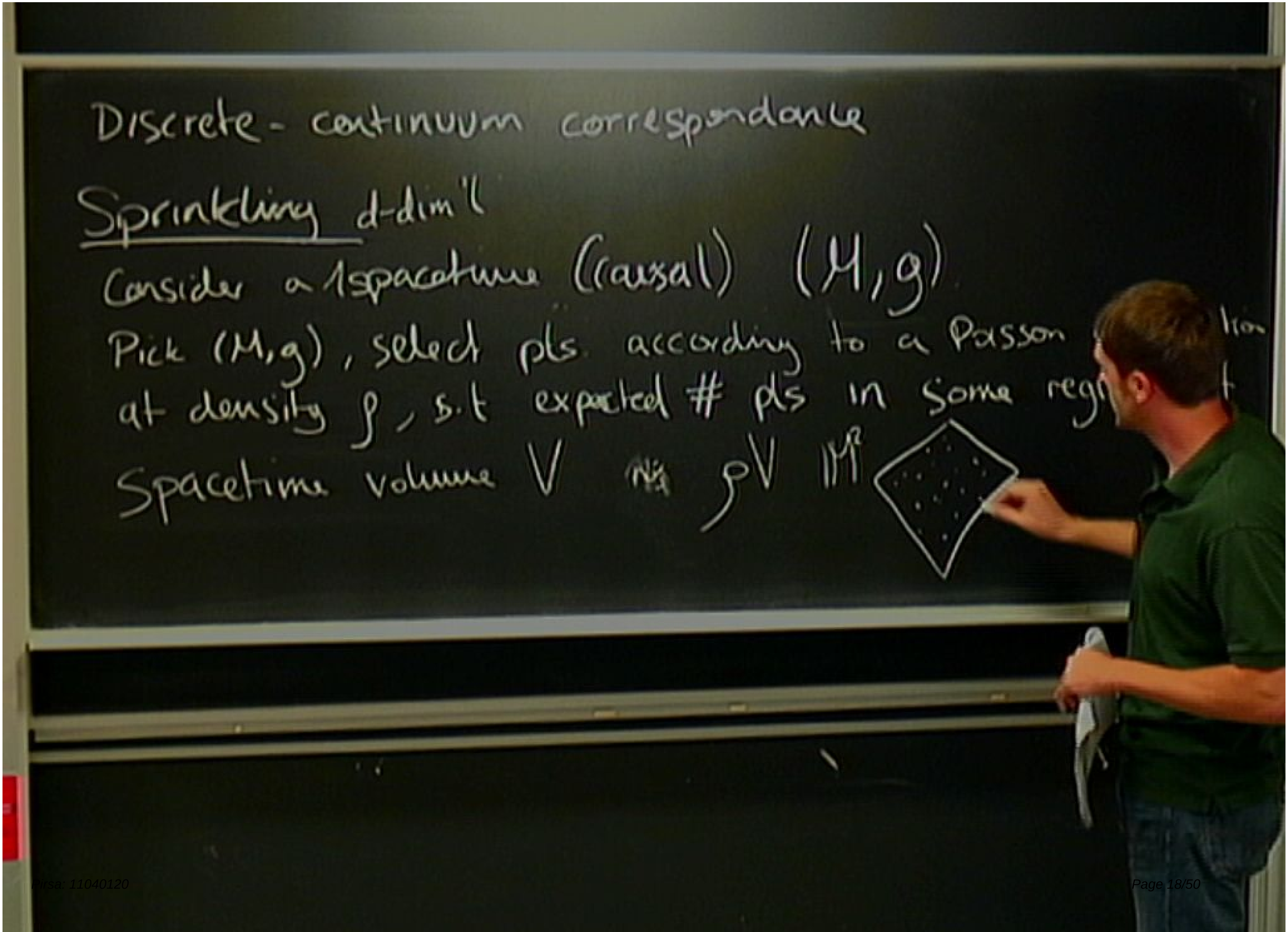
LINK:  $n=2$

3-chain: 

4-chain + diamonds:  


Sprinkling
Consider a space


Discrete - continuum correspondance
Sprinkling d-dim'l
Consider a 1 spacetime (causal) (M, g)
Pick (M, g), select pts according to a Poisson distributi
at density ρ, s.t expected # pts in some region o
Spacetime volume V ρV


Discrete - continuum correspondance
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Consider a spacetime (causal) (M,g)
Pick (M,g), select pts according to a Poisson
at density ρ, s.t expected # pts in some regi
Spacetime volume V
ρV

Discrete - continuum correspondance

<u>Sprinkling</u> d-dim'l

Consider a spacetime (causal) (M, g)

Pick (M, g), select pts according to a Poisson distribution at density ρ, s.t expected # pts in some region of spacetime volume V ρV

Discrete - continuum correspondance

Sprinkling d-dim'l

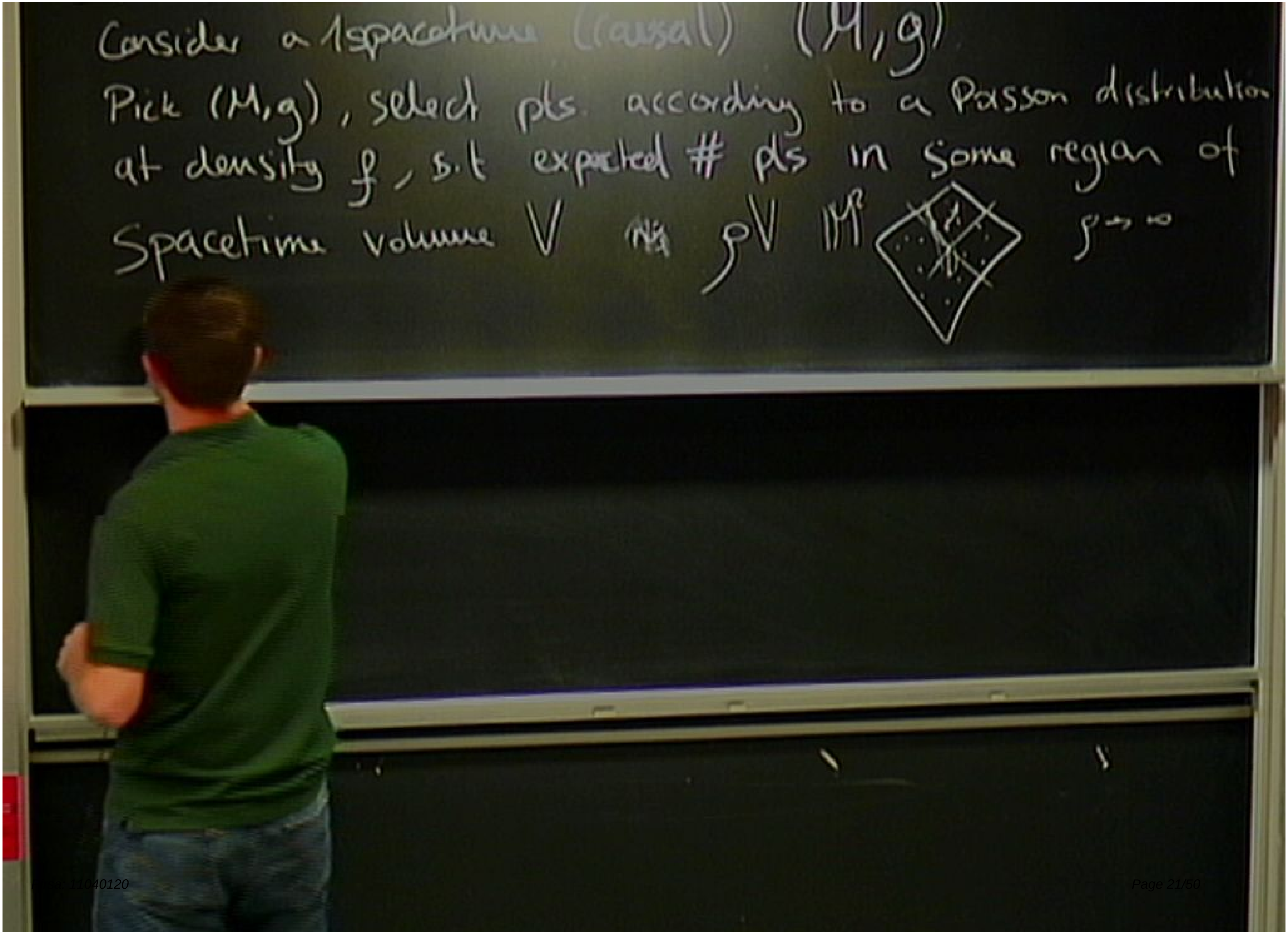
Consider a 1 spacetime (causal) (M, g)

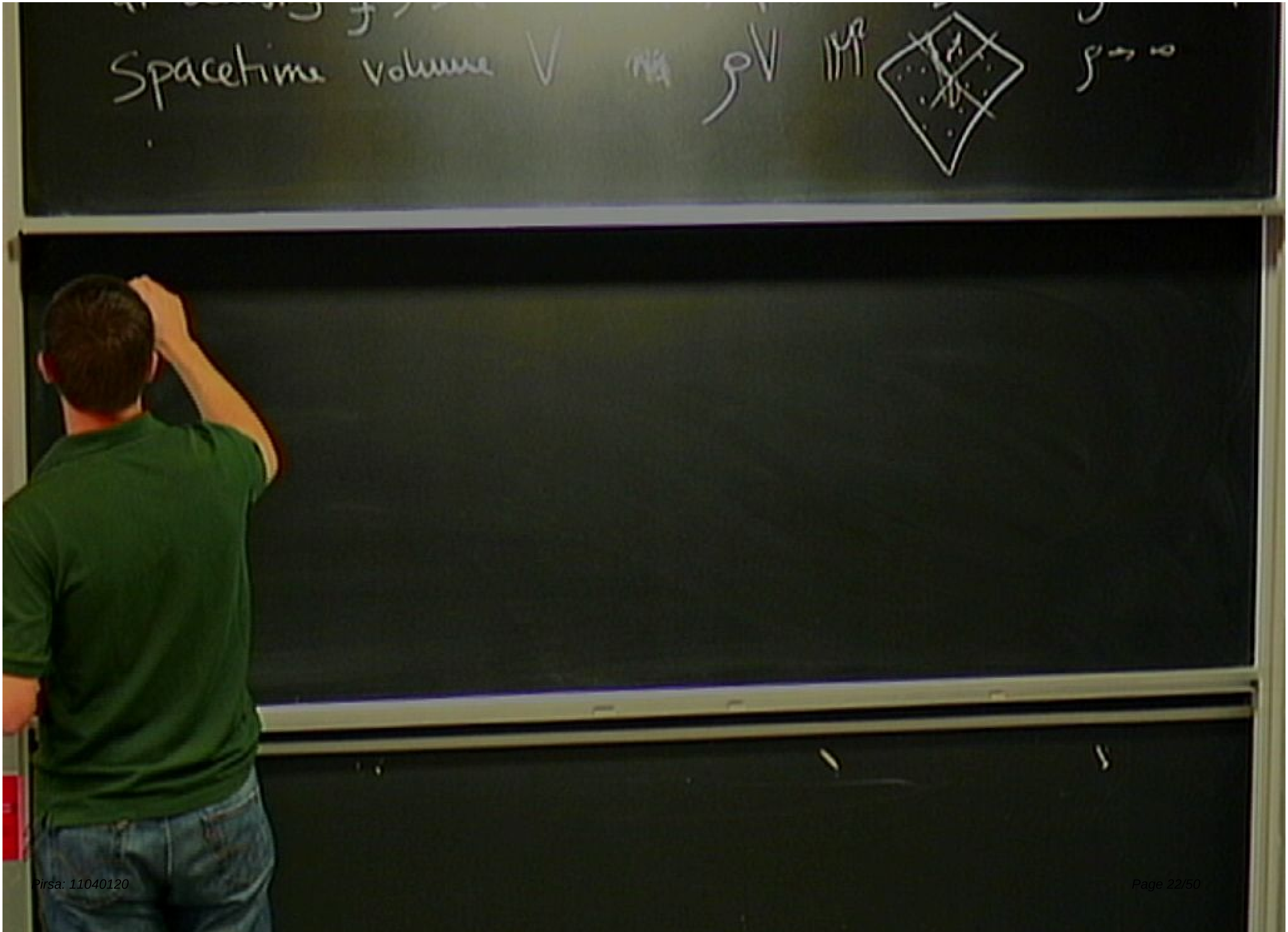
Pick (M, g), select pts according to a Poisson distri

at density ρ, s.t expected # pts in some region

Spacetime volume V ρV

$\rho \to \infty$


Consider a spacetime (causal) (M,g)
Pick (M,g), select pts according to a Poisson distribution
at density ρ, s.t expected # pts in some region of
Spacetime volume V ρV
ρ → ∞


Spacetime volume V
ρV
ρ → ∞

Spacetime volume V ρV

$\rho \to \infty$

A causal set is said to be well-approx by a spacetime $(\mathcal{M}, g)$ if it could have arisen (with relatively high prob) from a sprinkling in $(\mathcal{M}, g)$

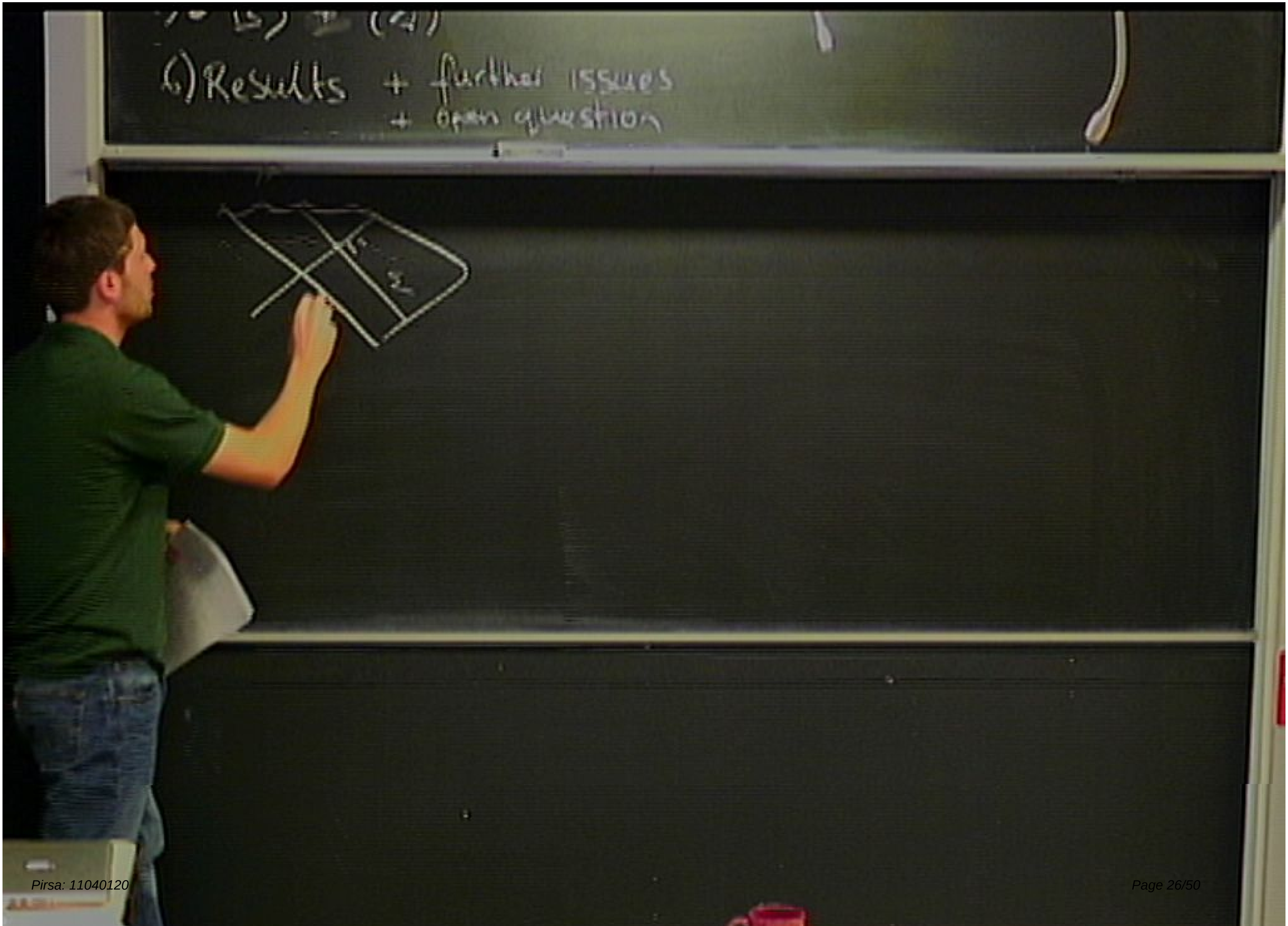
Spacetime volume V ρV $\rho \to \infty$

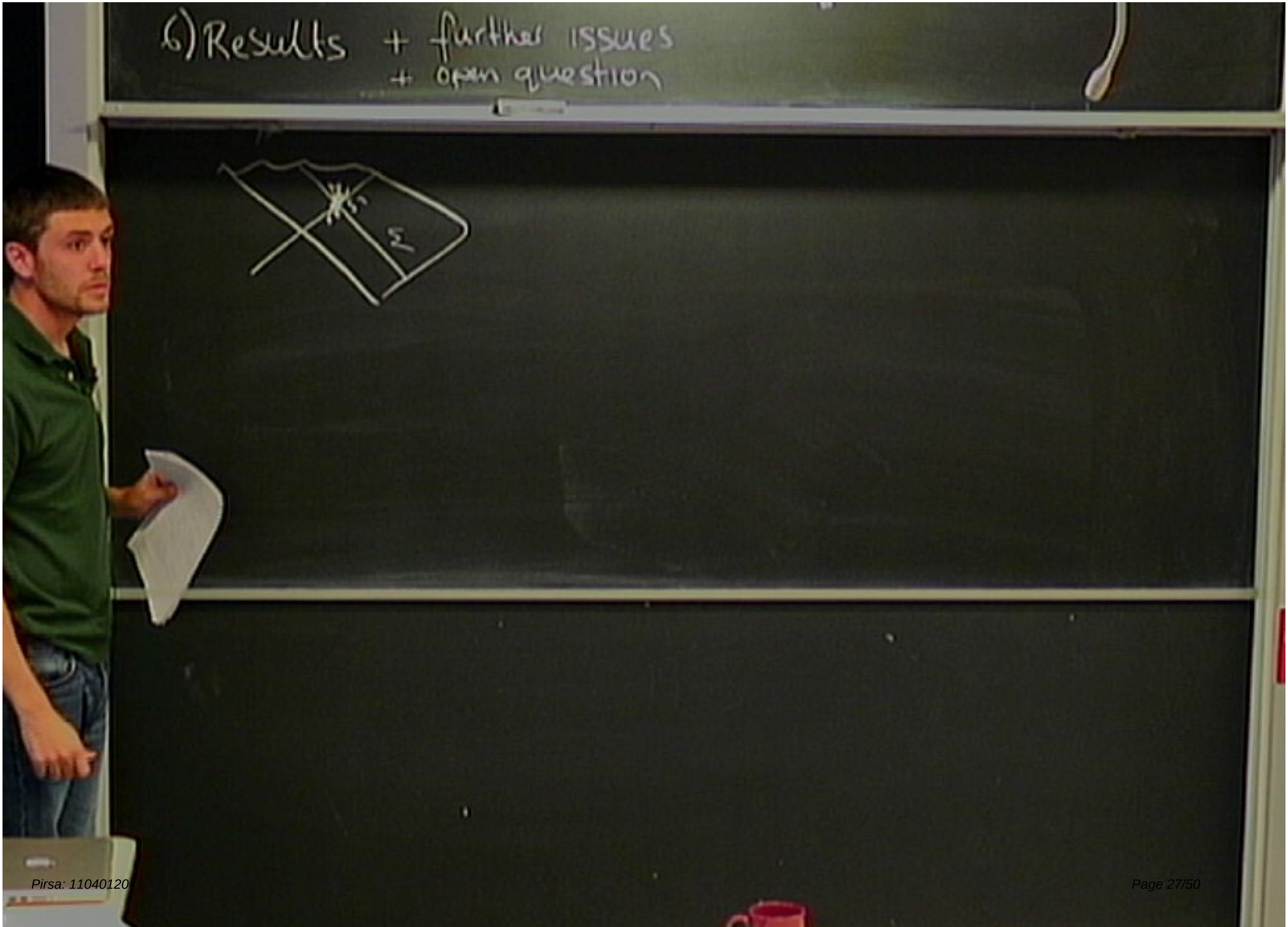
A causal set is said to be well-approx by a spacetime $(\mathcal{M}, g)$ if it could have arisen (with relatively high prob) from a sprinkling in $(\mathcal{M}, g)$

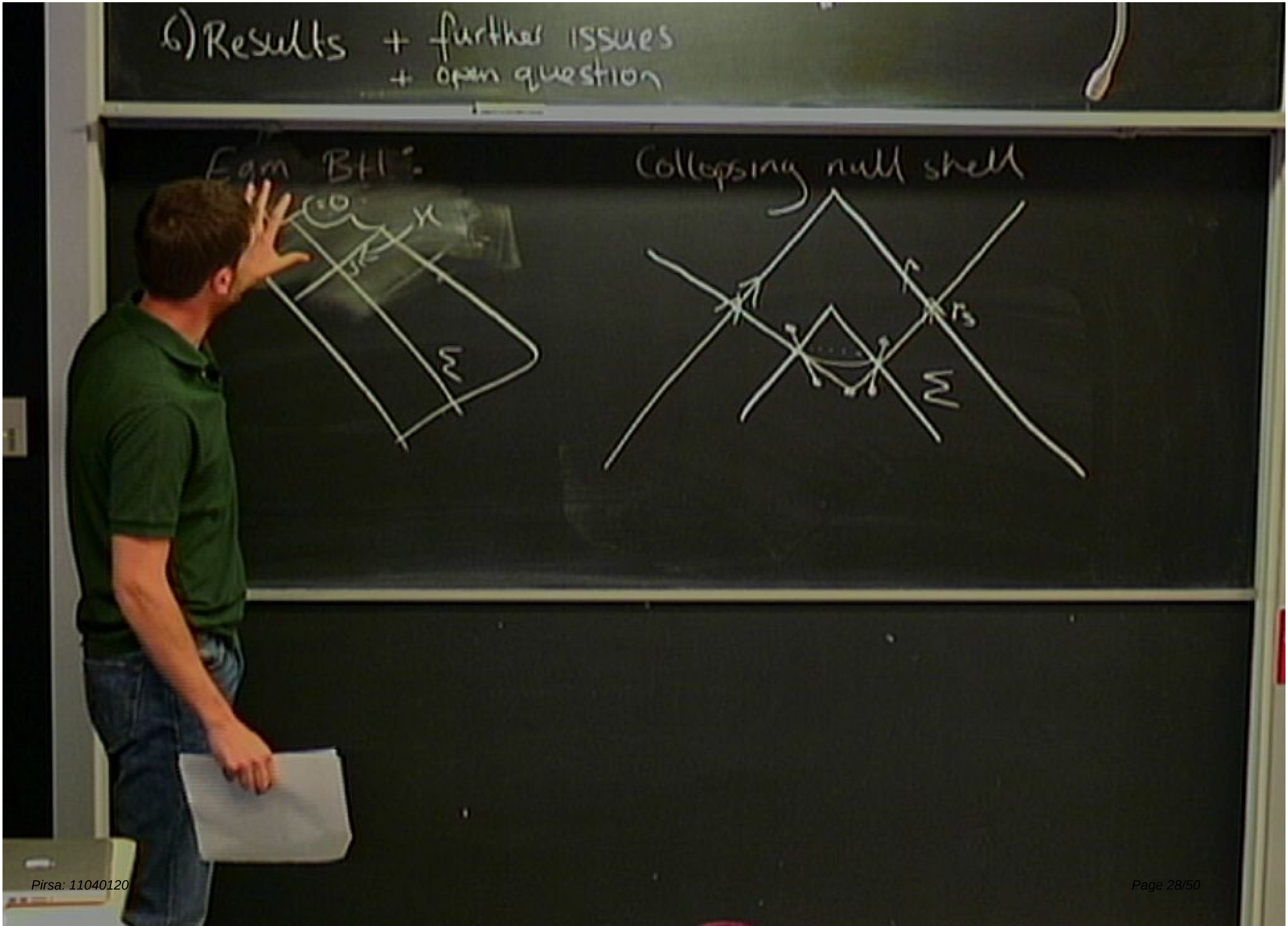
Spacetime volume V ρV

$\rho \to \infty$

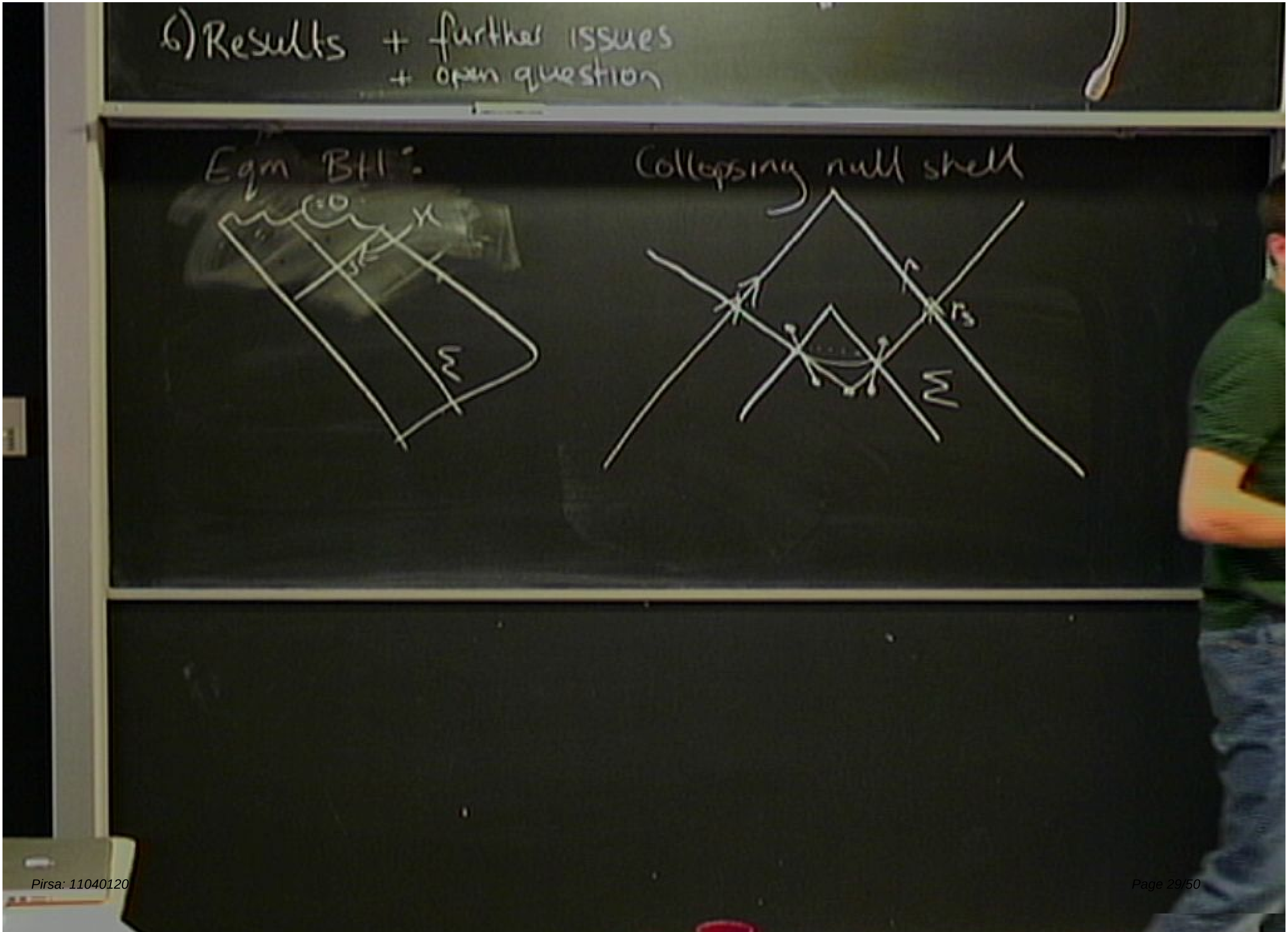
spacetime $(\mathcal{M}, g)$ if it could have arisen (with relatively high prob) from a sprinkling in $(\mathcal{M}, g)$


6) Results + further issues
+ open question


6) Results + further issues
+ open question
Σ



6) Results + further issues
+ open question
Eqm BH:
Collapsing null shell
Σ
Σ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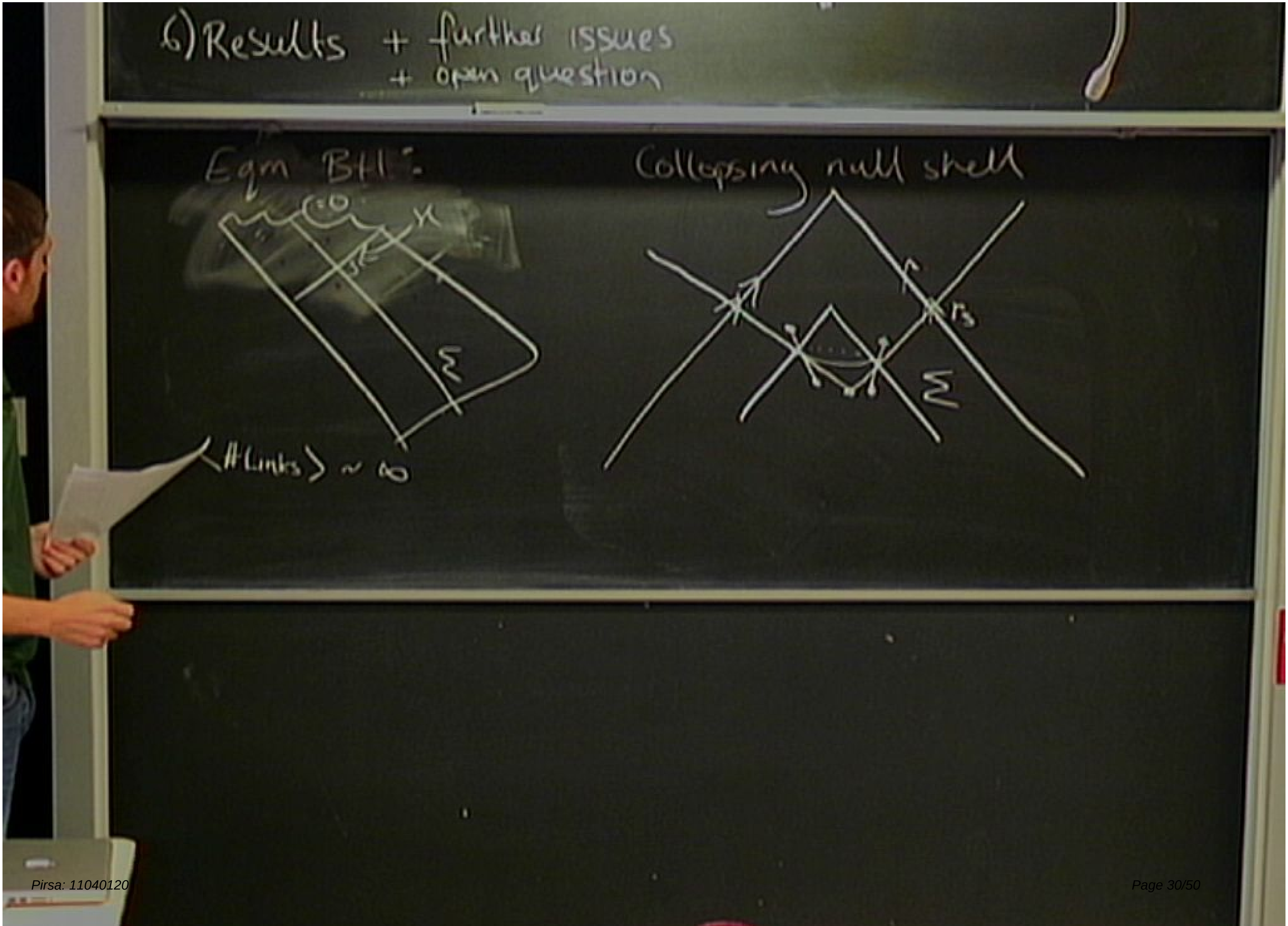
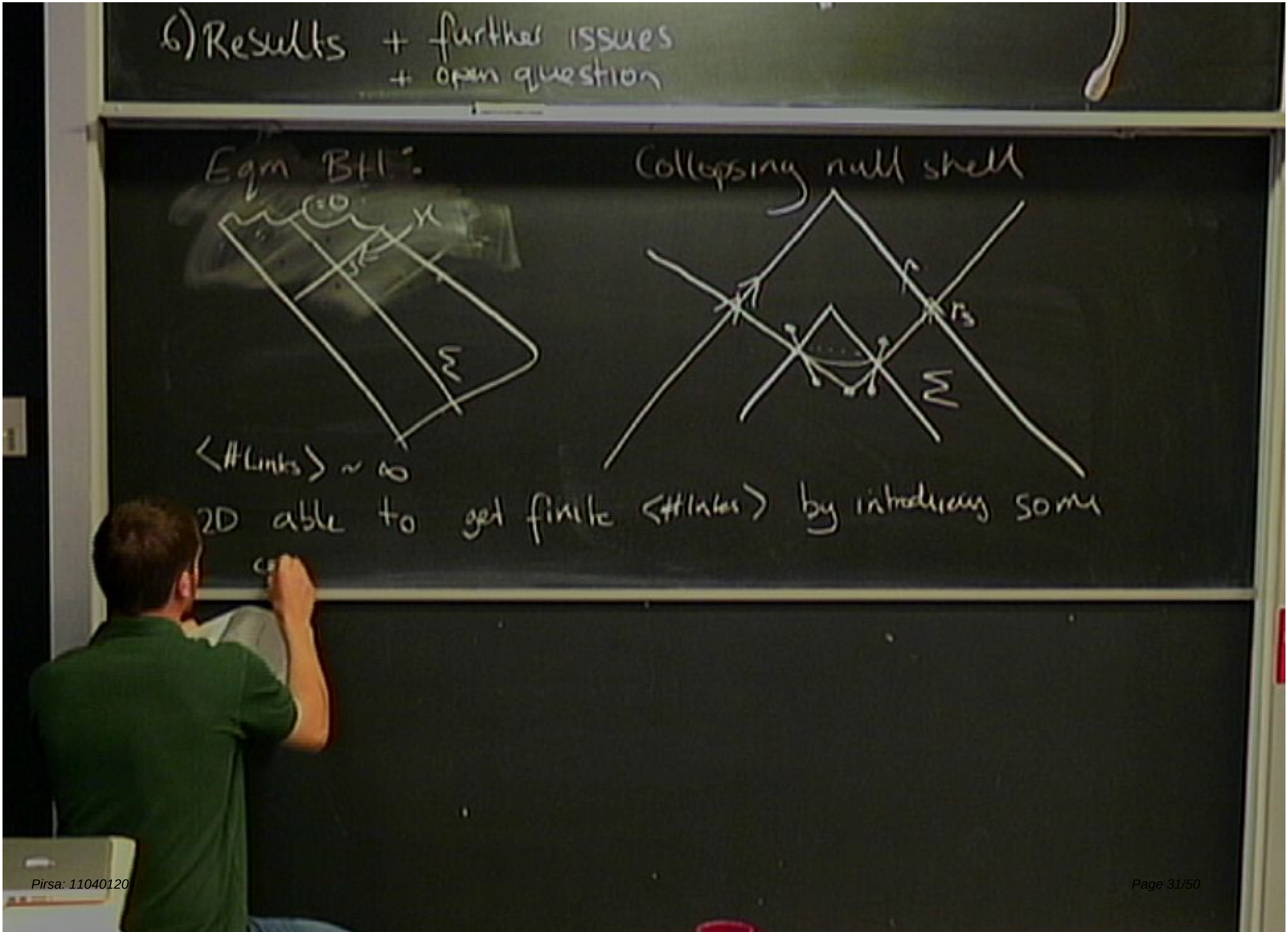
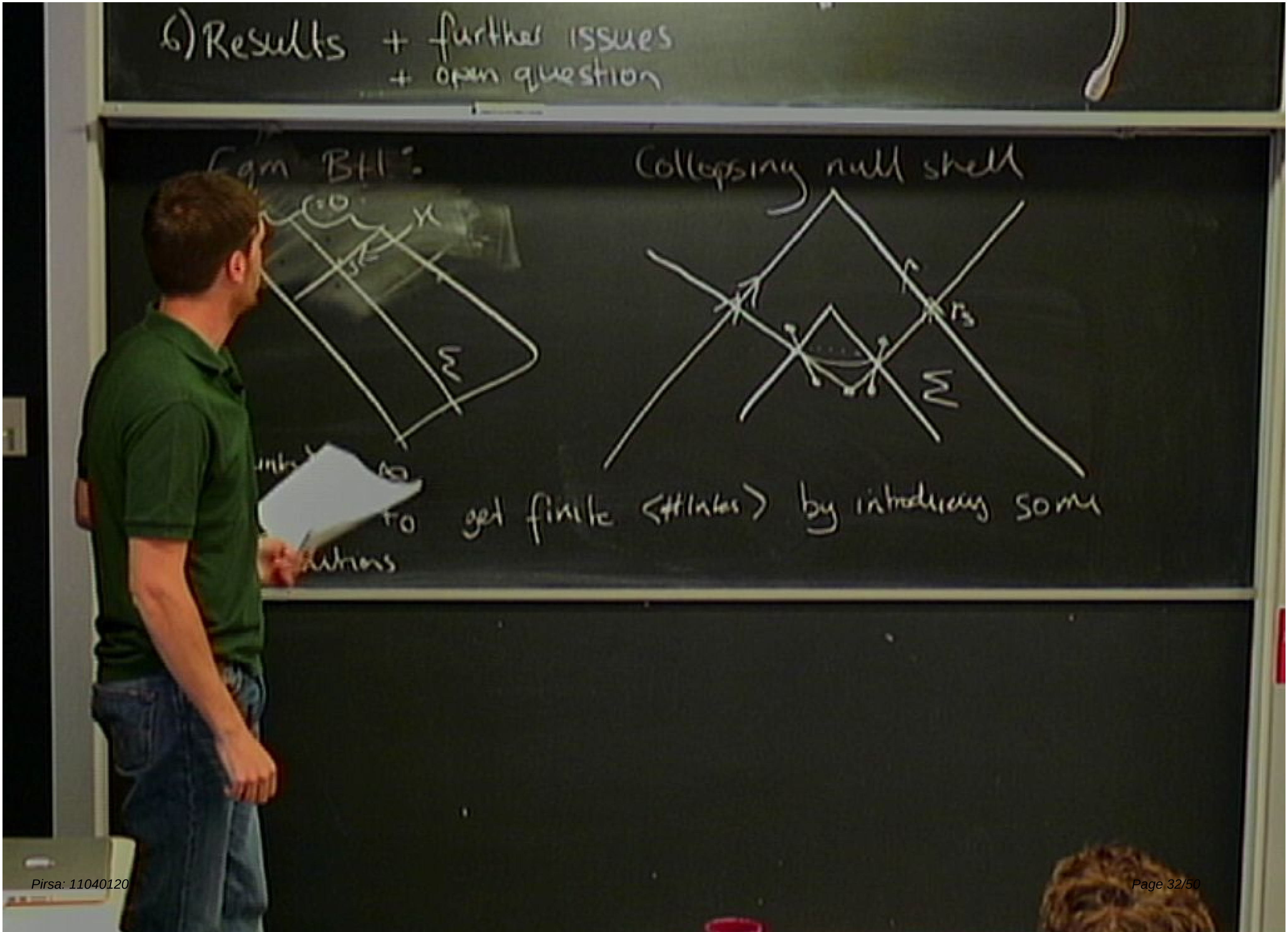
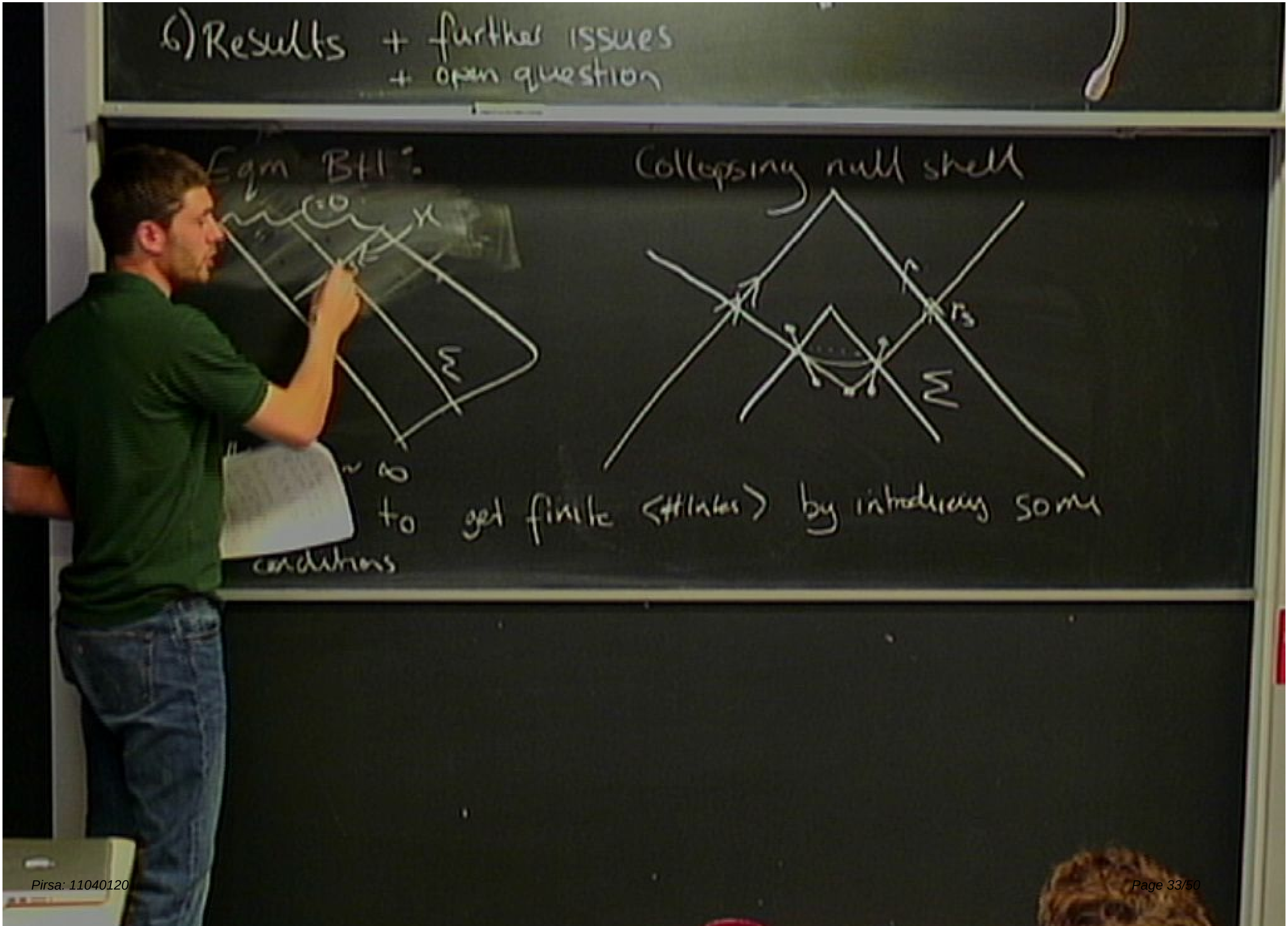
Collapsing null shell
Σ
Σ

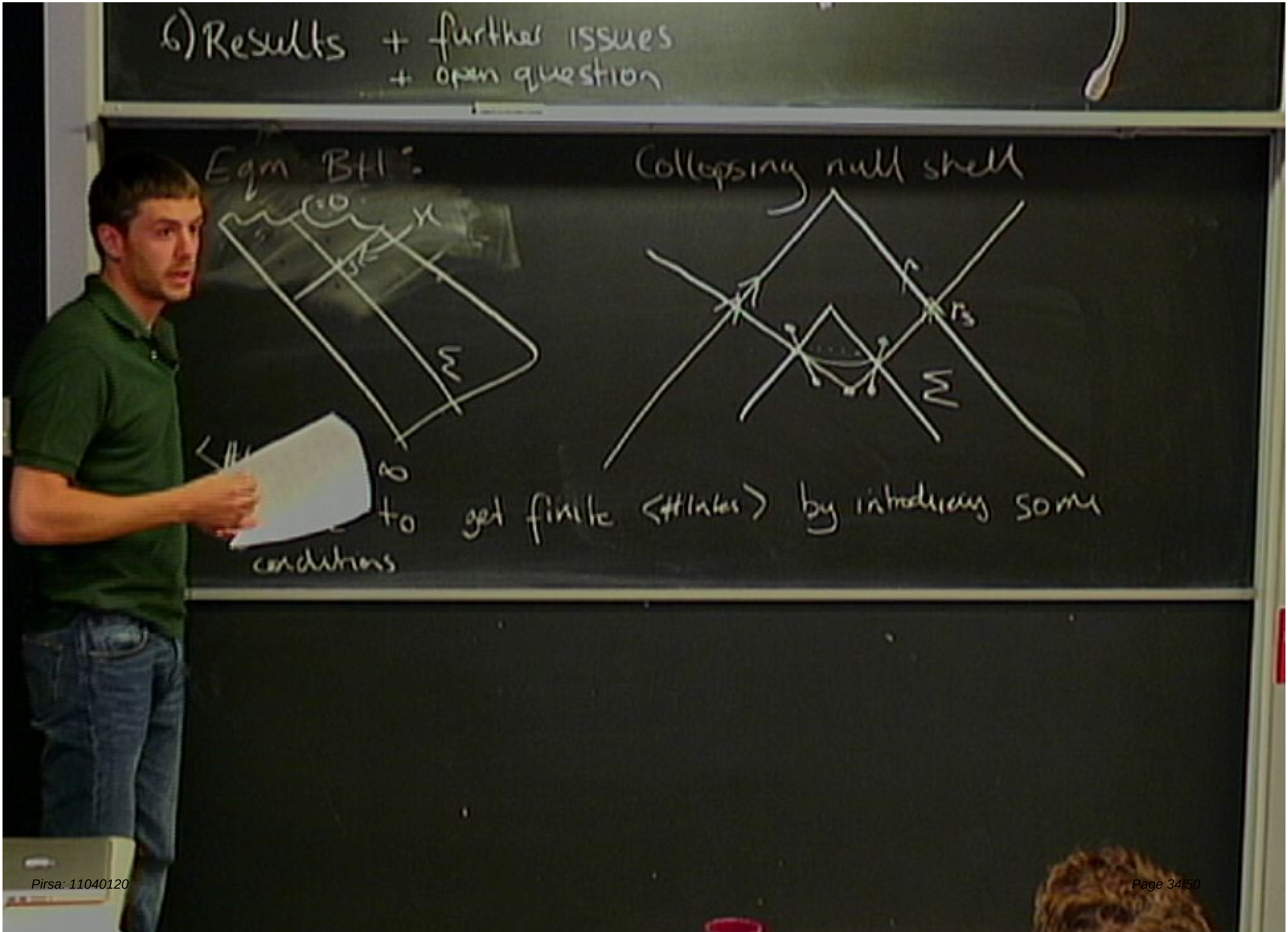

6) Results + further issues
+ open question
Eqm BH:
Collapsing null shell
Σ
Σ
⟨#Links⟩ ~ ∞



6) Results + further issues
+ open question
Eqm BH:
Collapsing null shell
X
Σ
Σ
<#Links> ~ ∞
2D able to get finite <#links> by introducing some


6) Results + further issues
+ open question
Collapsing null shell
Σ
Σ
get finite
by introducing some


6) Results + further issues
+ open question
Eqm BH:
Collapsing null shell
Σ
Σ
to get finite <Hinter> by introducing some
conditions


6) Results + further issues
+ open question
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Collapsing null shell
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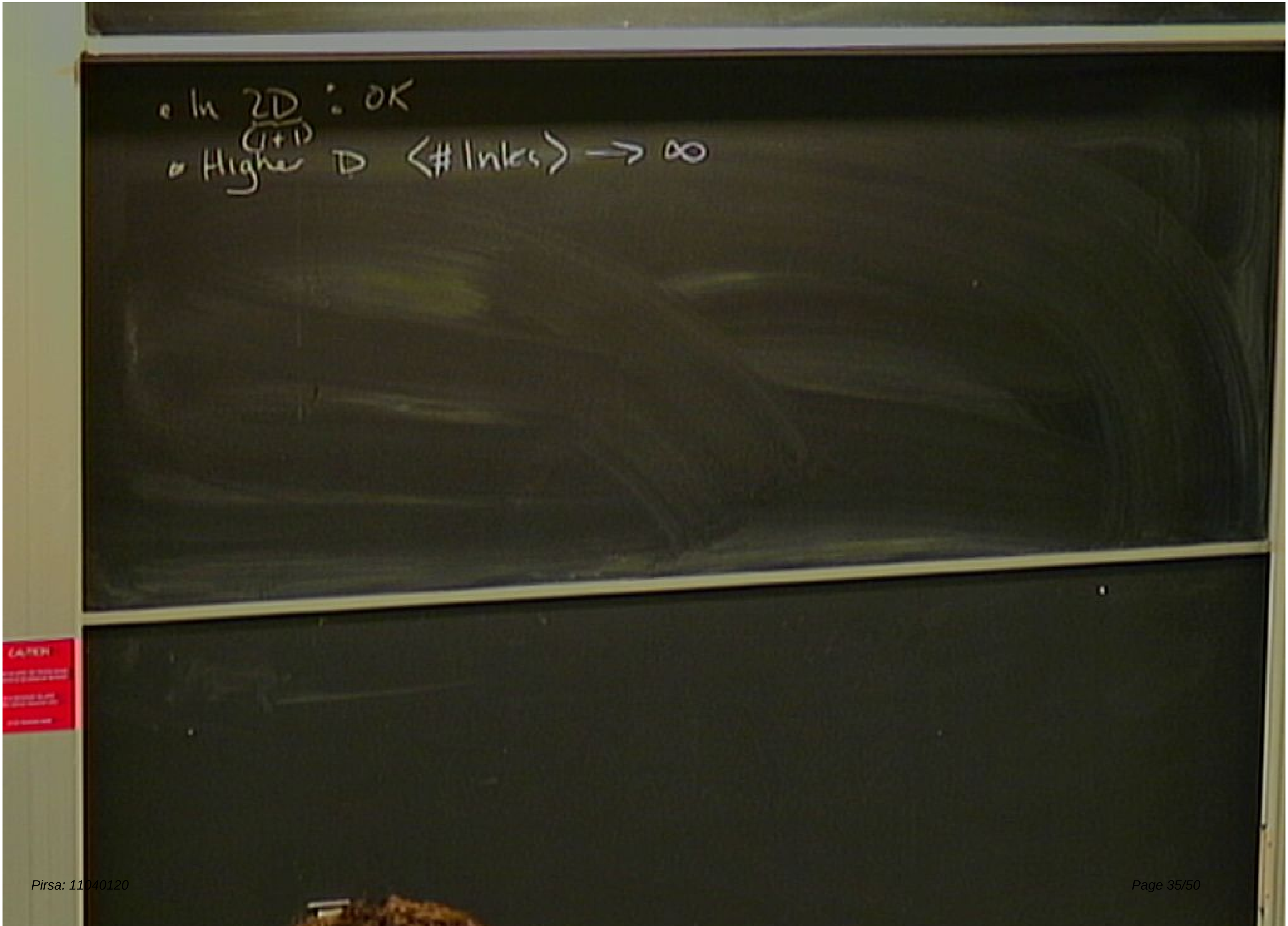
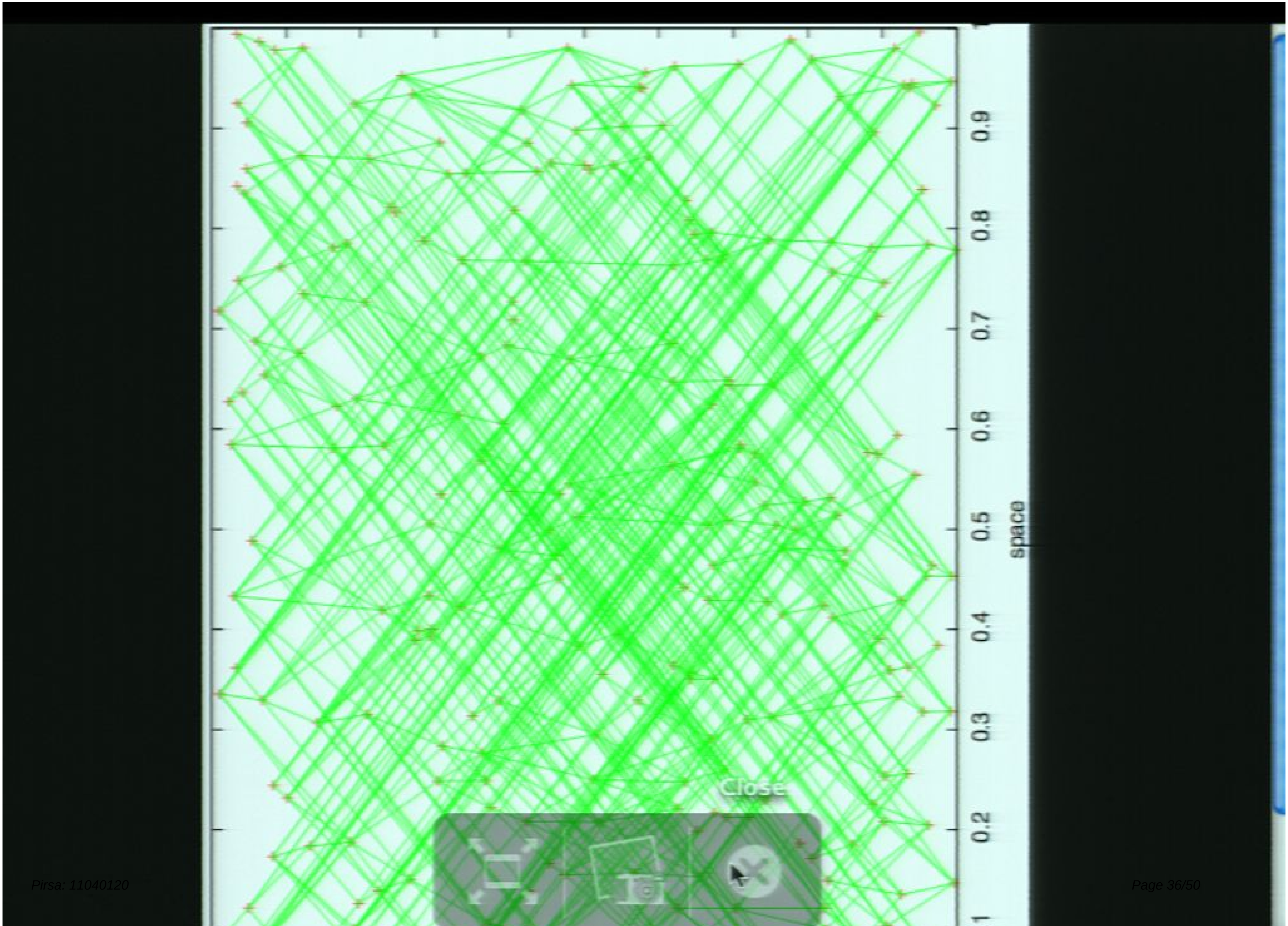
to get finite <Hinter> by introducing some
conditions


• In $\underbrace{2D}_{(1+1)}$: OK
• Higher D $\langle \# \text{links} \rangle \longrightarrow \infty$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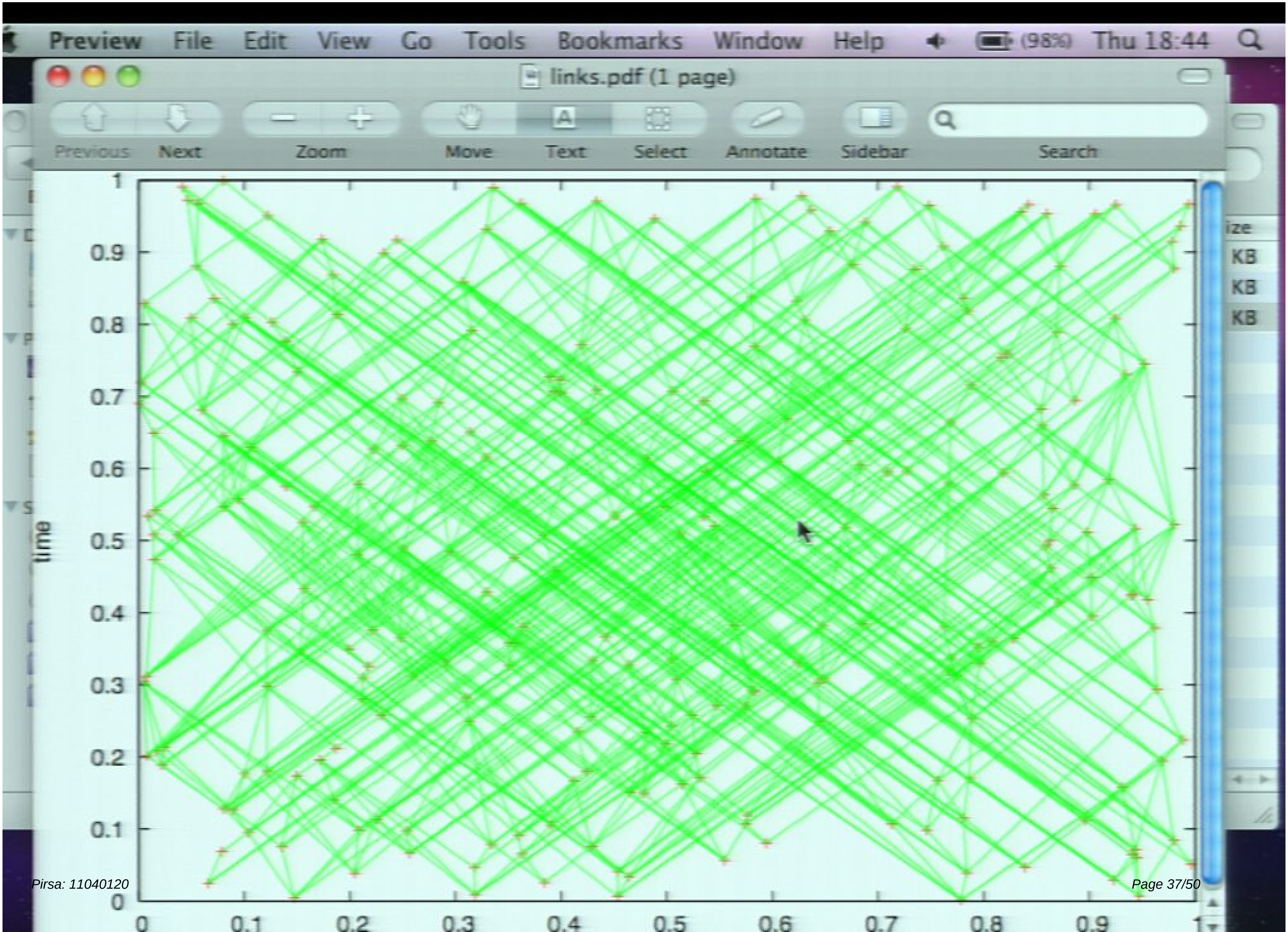

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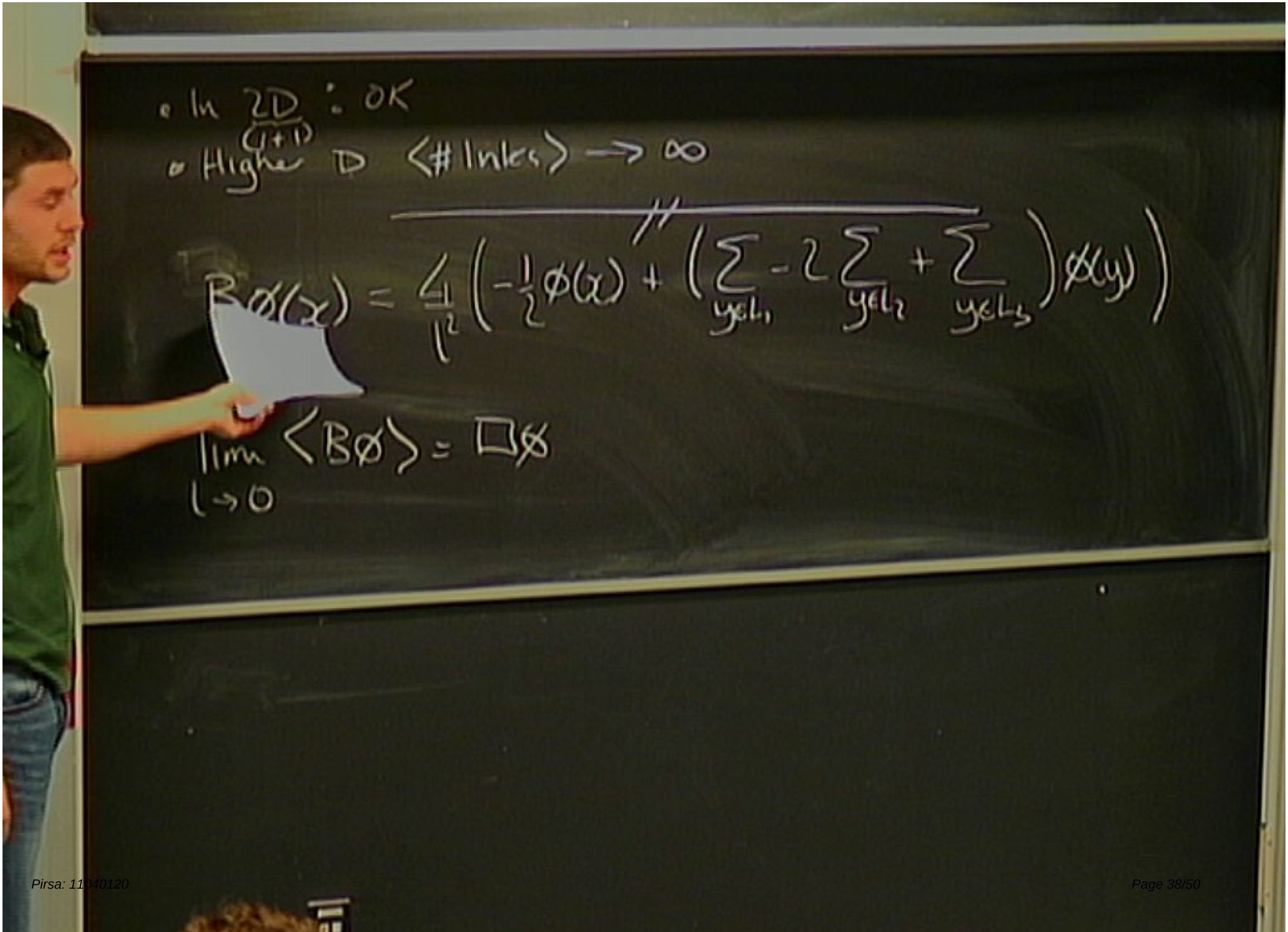

• In 2D (1+1) : OK
• Higher D ⟨# links⟩ → ∞
$B\phi(x) = \frac{4}{l^2}\left(-\frac{1}{2}\phi(x) + \left(\sum_{y\in L_1} - 2\sum_{y\in L_2} + \sum_{y\in L_3}\right)\phi(y)\right)$
$\lim_{l\to 0} \langle B\phi \rangle = \Box\phi$

- In $\underbrace{2D}_{(1+1)}$: OK
- Higher D $\langle \# \text{links} \rangle \longrightarrow \infty$

$$\Box \updownarrow$$

$$B\phi(x) = \frac{4}{l^2}\left(-\frac{1}{2}\phi(x) + \left(\sum_{y\in L_1} - 2\sum_{y\in L_2} + \sum_{y\in L_3}\right)\phi(y)\right)$$

$$\lim_{l\to 0} \langle B\phi \rangle = \Box\phi$$

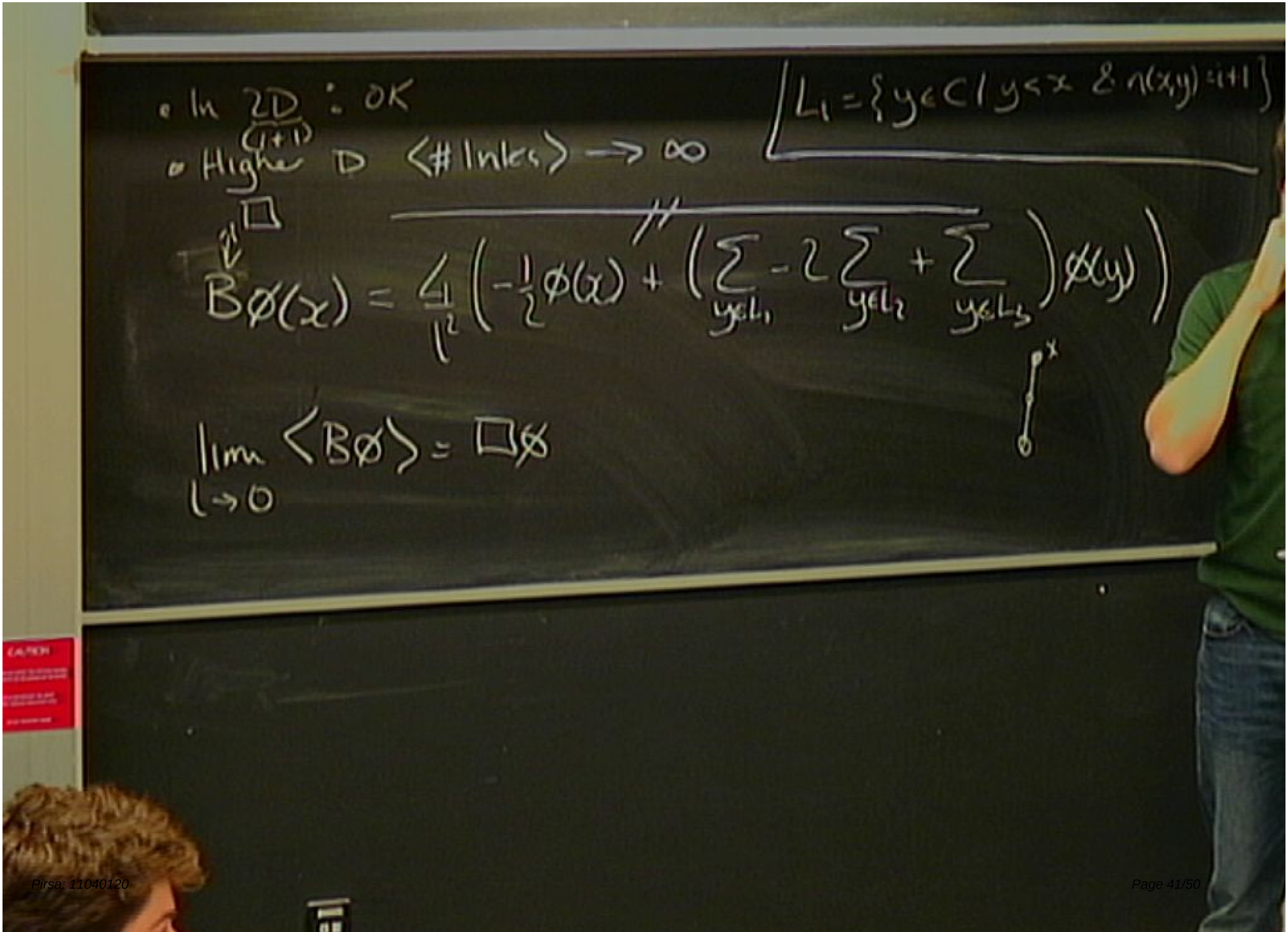
- In $\underbrace{2D}_{(1+1)}$: OK
- Higher D $\langle \#\,\text{links} \rangle \longrightarrow \infty$

$$\boxed{L_i = \{ y \in C \mid y < x \ \& \ n(x,y) = i+1 \}}$$

$$\Box$$

$$B\phi(x) = \frac{4}{l^2}\left(-\frac{1}{2}\phi(x) + \left(\sum_{y \in L_1} - 2 \sum_{y \in L_2} + \sum_{y \in L_3} \right) \phi(y) \right)$$

$$\lim_{l \to 0} \langle B\phi \rangle = \Box \phi$$


• In 2D (1+1) : OK
• Higher D $\langle \# \text{links} \rangle \to \infty$
$L_1 = \{ y \in C \mid y < x \ \& \ n(x,y) = i+1 \}$
$B\phi(x) = \frac{4}{l^2} \left(-\frac{1}{2}\phi(x) + \left(\sum_{y \in L_1} - 2 \sum_{y \in L_2} + \sum_{y \in L_3} \right) \phi(y) \right)$
$\lim_{l \to 0} \langle B\phi \rangle = \Box \phi$

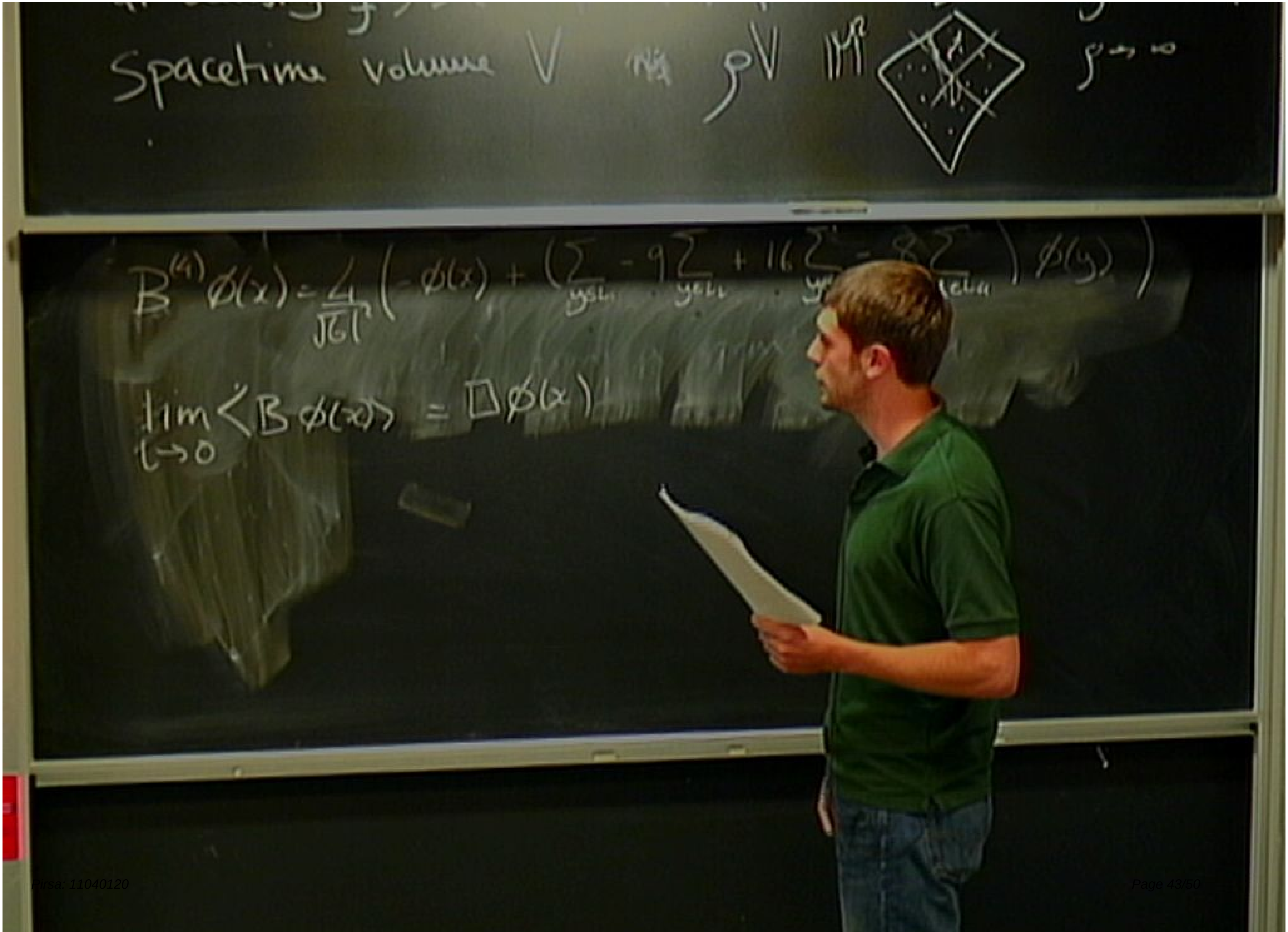
• In $\underset{(1+1)}{2D}$: OK

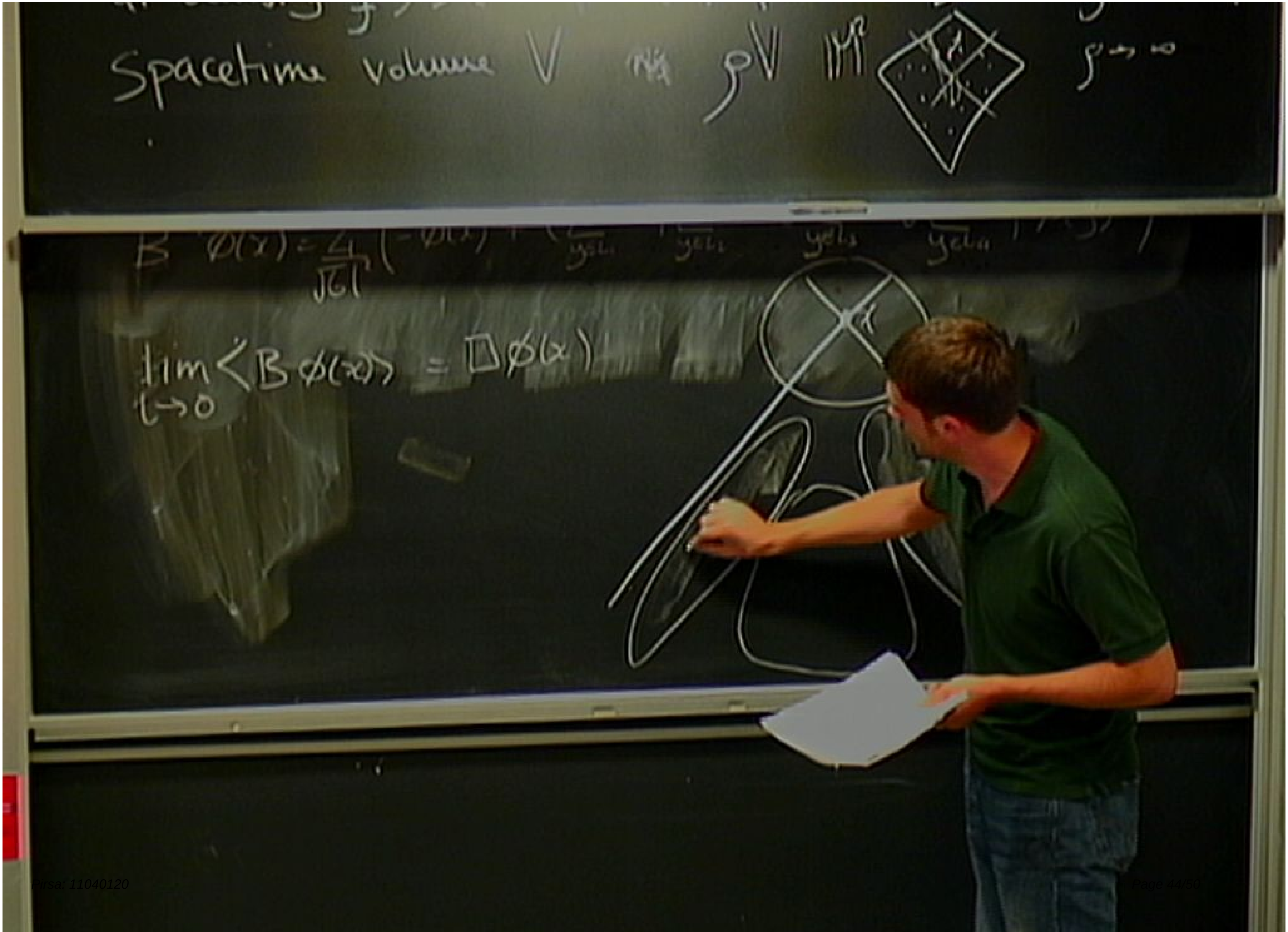
• Higher D $\langle \#\,\text{links} \rangle \longrightarrow \infty$

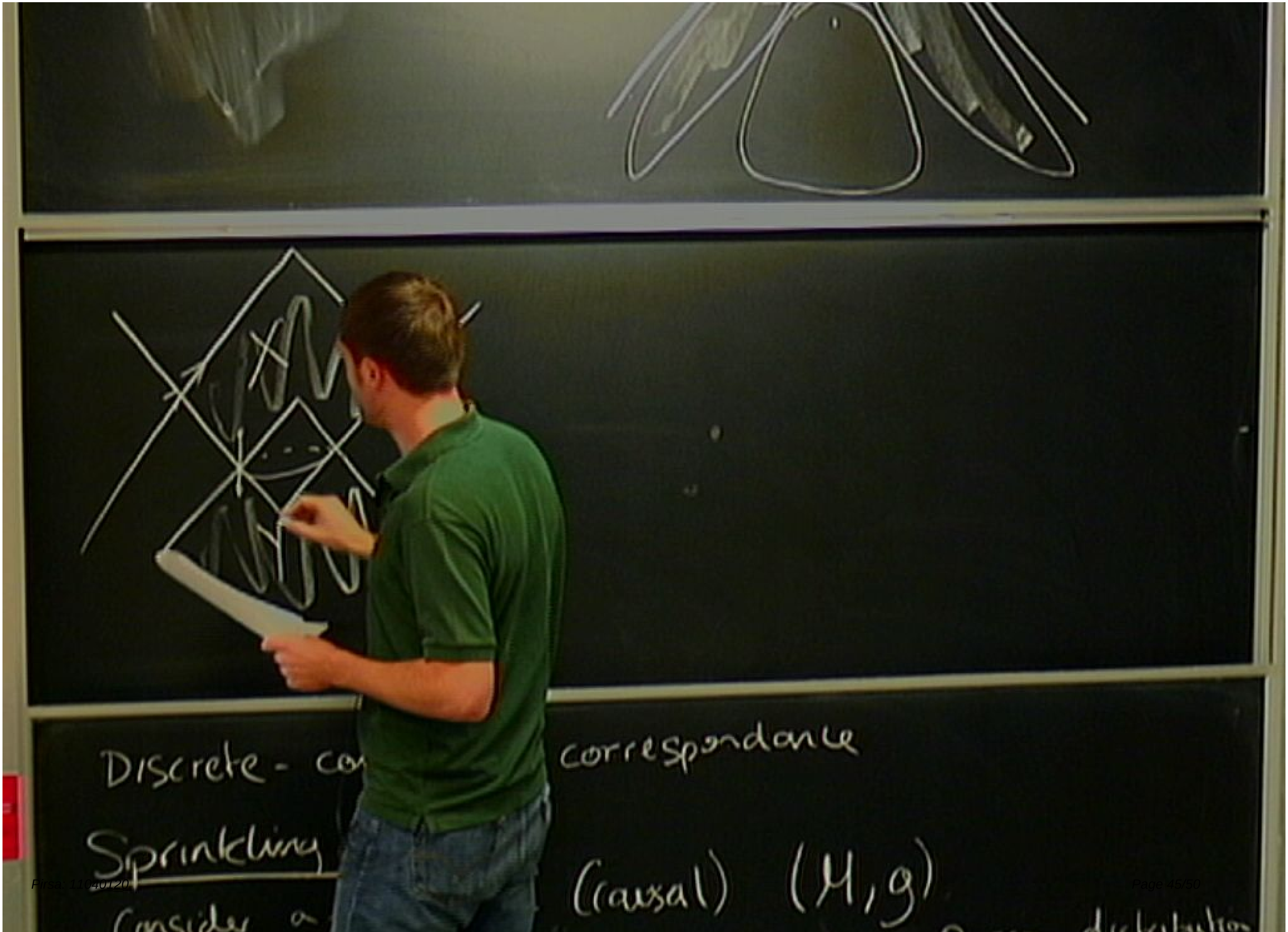
$$L_i = \{ y \in C \mid y < x \ \& \ n(x,y) = i+1 \}$$

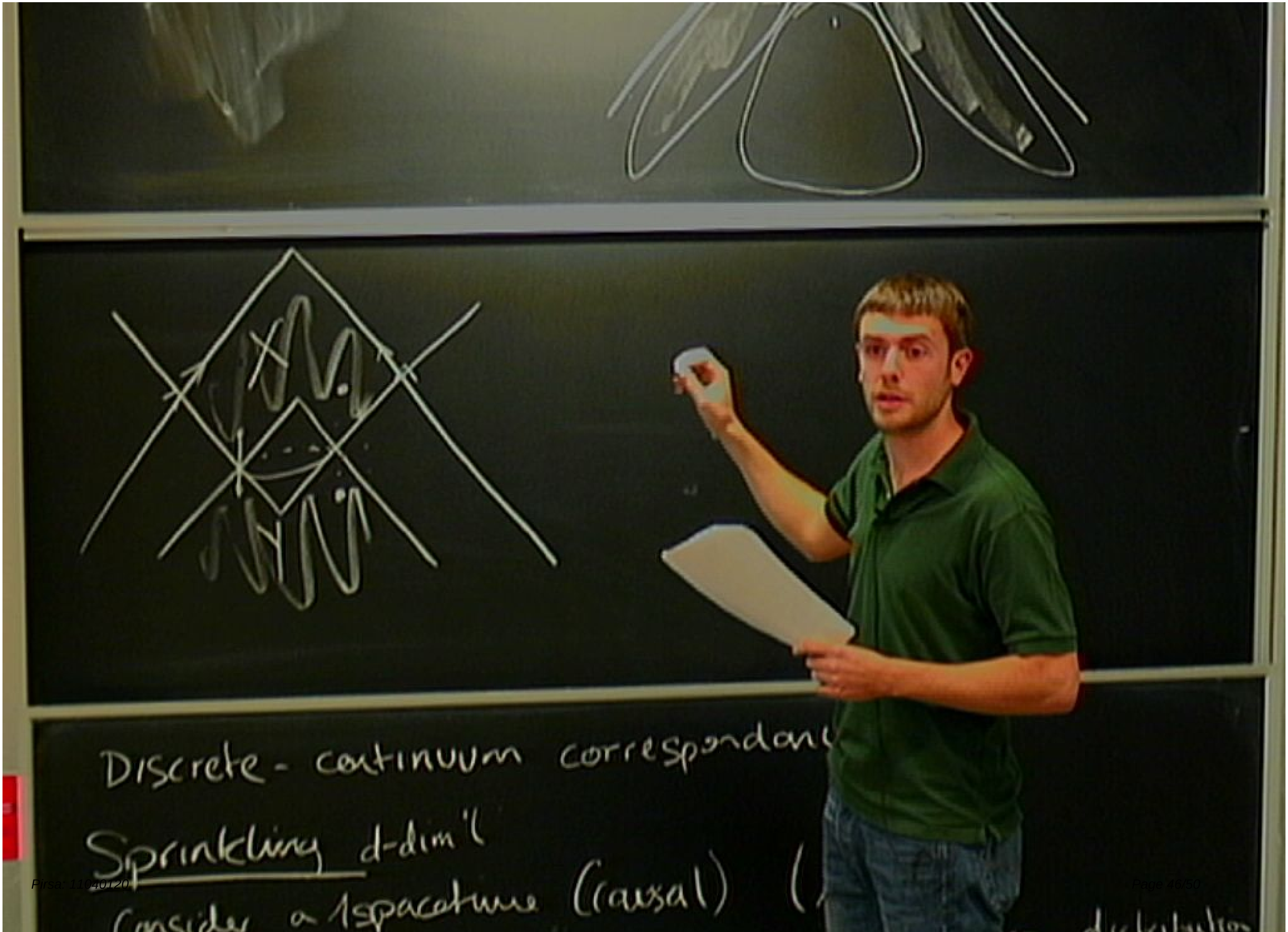
$$B\phi(x) = \frac{4}{l^2}\left(-\frac{1}{2}\phi(x) + \left(\sum_{y \in L_1} - 2\sum_{y \in L_2} + \sum_{y \in L_3} \right)\phi(y) \right)$$

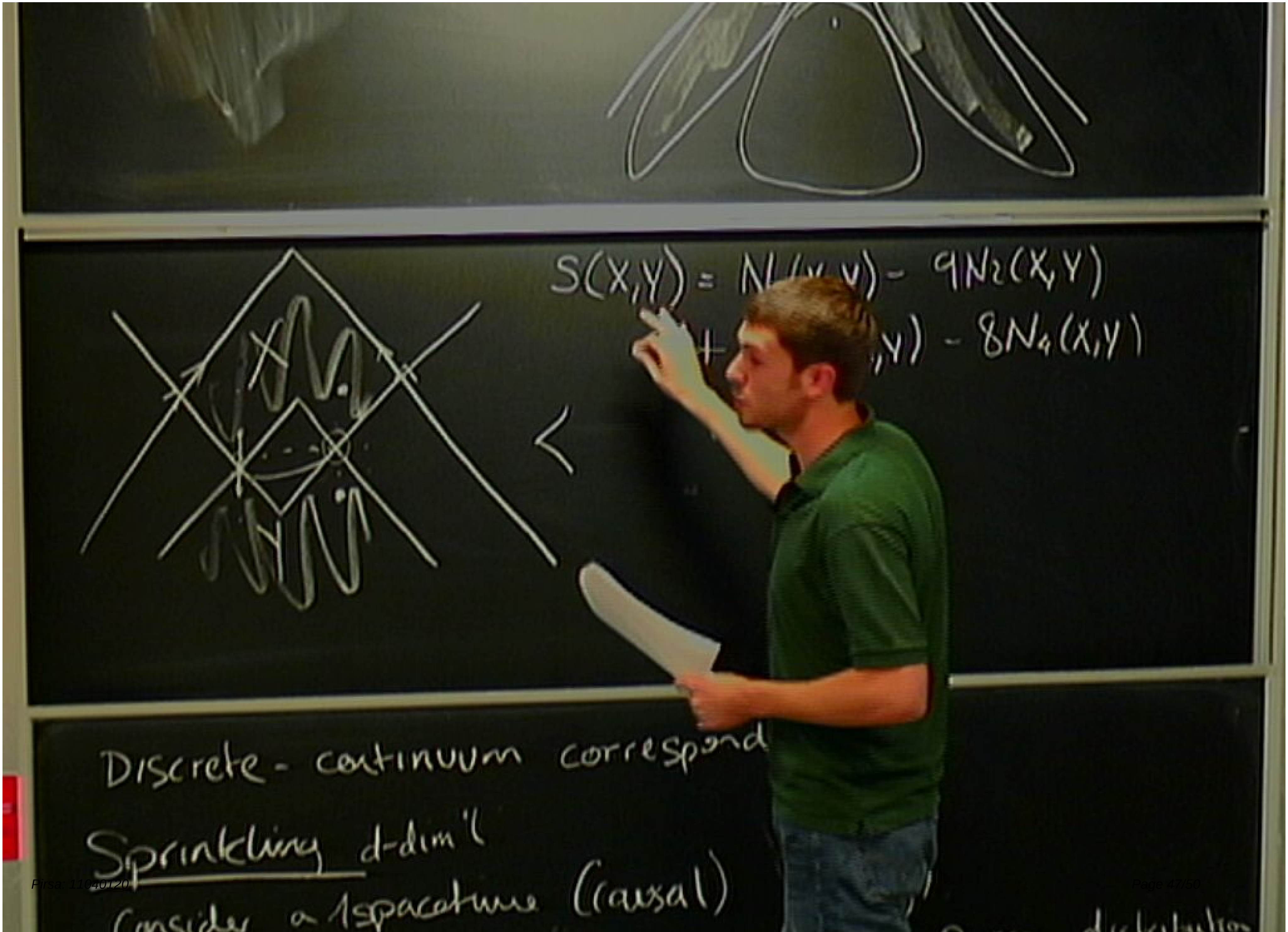
$$\lim_{l \to 0} \langle B^{(l)}\phi \rangle = \Box^{(l)}\phi$$

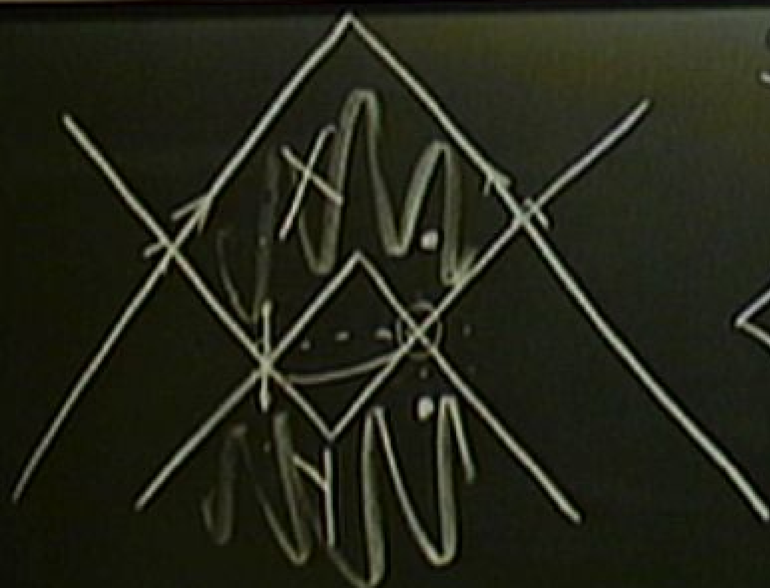

Spacetime volume V
ρV
B(4) φ(x) = 4/√6 l² (-φ(x) + (Σ - 9 Σ + 16 Σ - 8 Σ) φ(y))
lim ⟨B φ(x)⟩ = □ φ(x)
l→0


Spacetime volume V
ρV
ρ → ∞
lim ⟨B φ(x)⟩ = □φ(x)
l → 0


Discrete -
correspondance
Sprinkling
(causal) (M,g)
Consider a


Discrete - continuum correspondanc
Sprinkling d-dim'l
Consider a 1spacetime (causal) (


S(x,y) = N
- 9N2(x,y)
- 8N4(x,y)
Discrete - continuum correspond
Sprinkling d-dim'l
Consider a 1spacetime (causal)



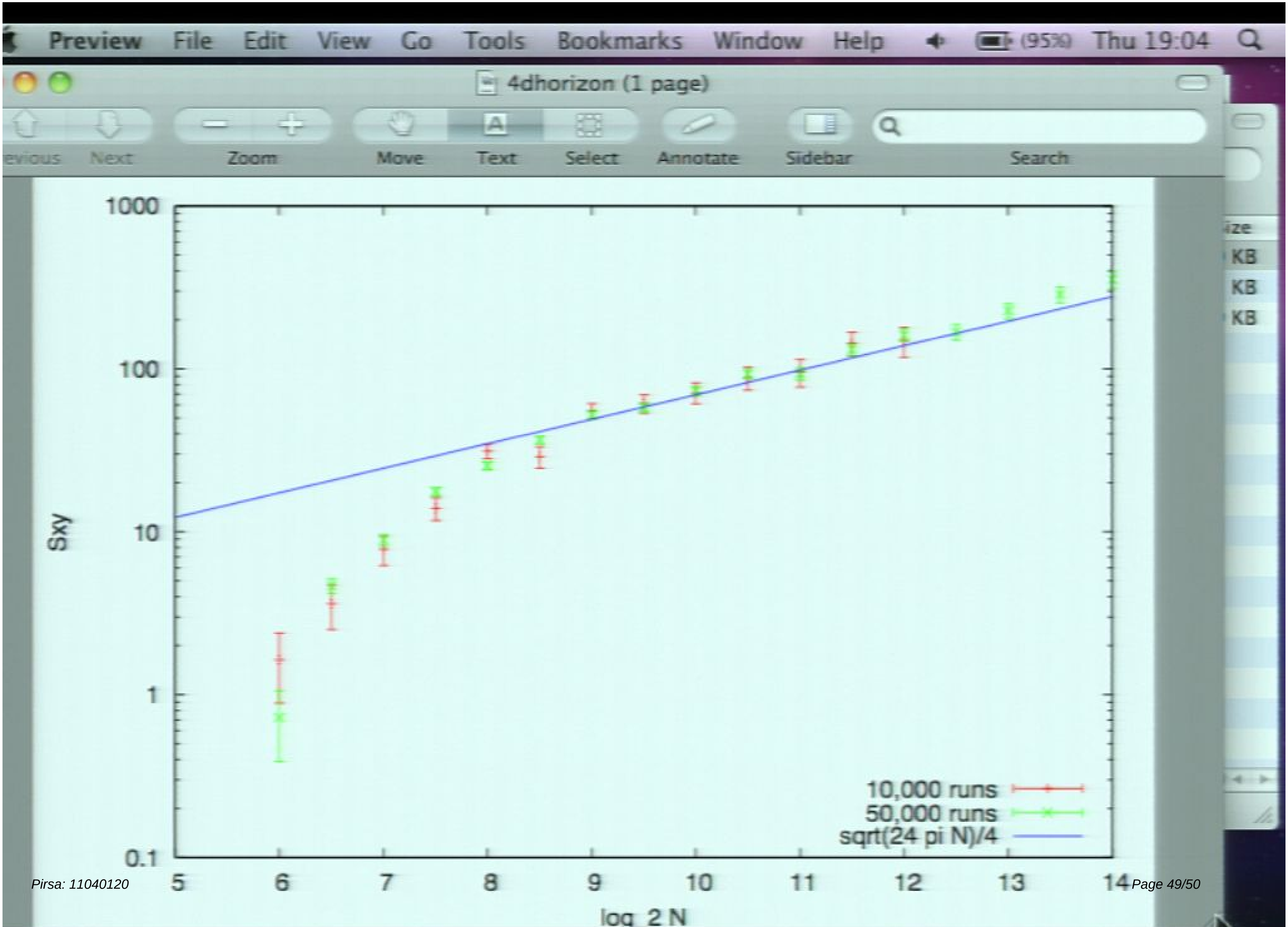
$$S(x,y) = N_1(x,y) - 9N_2(x,y) + 16N_3(x,y) - 8N_4(x,y)$$

$$\langle S(x,y) \rangle = \frac{A(S^2)}{l^2}$$

Discrete - continuum correspondance

Sprinkling d-dim'l

Consider a spacetime (causal) (M,g)



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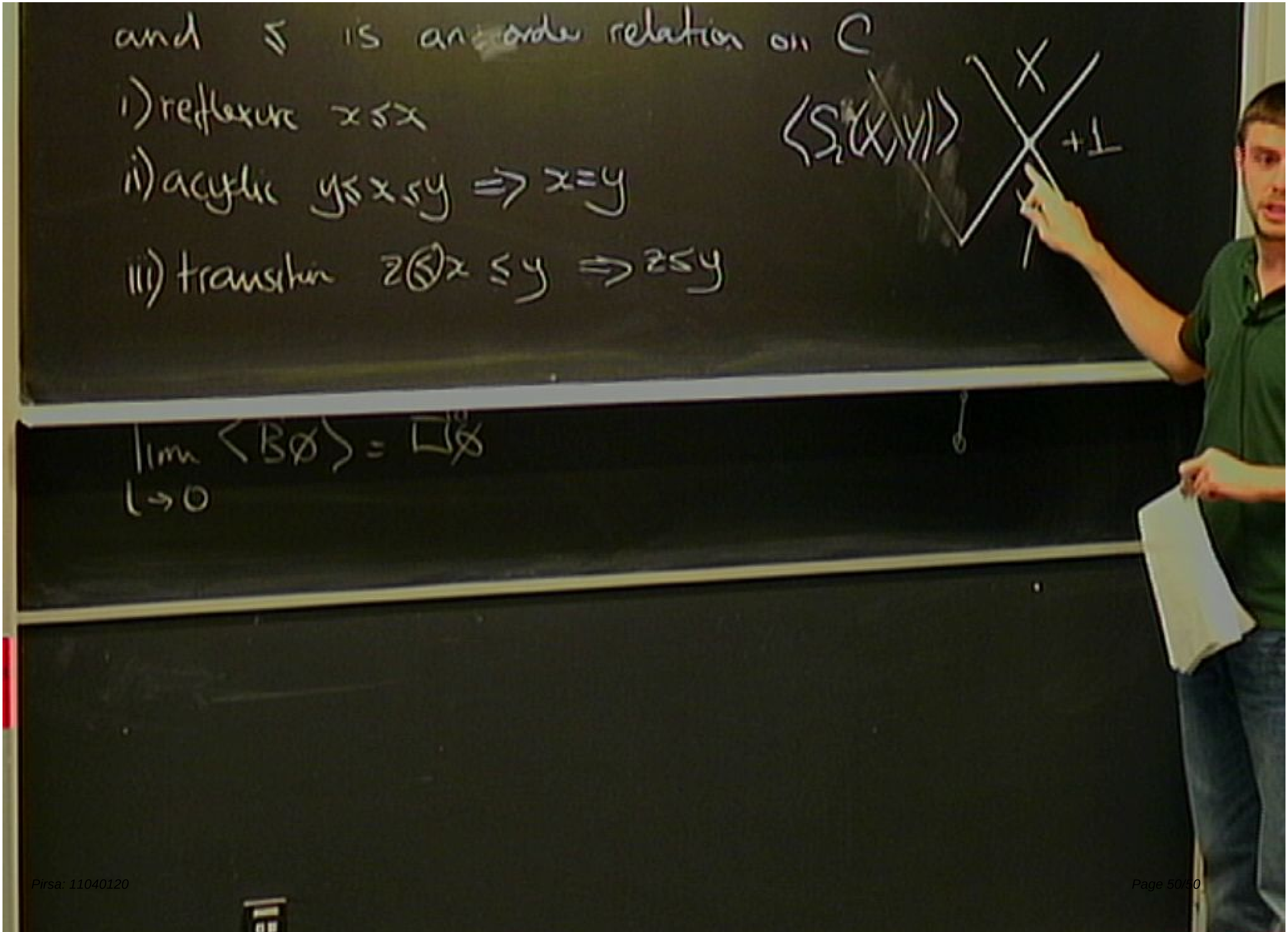
log_2 N
10,000 runs
50,000 runs
sqrt(24 pi N)/4


and ≤ is an order relation on C
i) reflexive x≤x
ii) acyclic y≤x≤y ⇒ x=y
iii) transitive z≤x≤y ⇒ z≤y
⟨S,(x,y)⟩
x
+1
lim ⟨Bφ⟩ = □φ
l→0