Title: Special Topics in Physics - Lecture 14B

Date: Apr 23, 2008 08:00 PM

URL: http://pirsa.org/08040064

Abstract: The Problem of Time in Quantum Gravity and Cosmology

Causets

discreteness: cure ∞'s, "explains matter" (− + + +)

order + number = geometry

def Causet

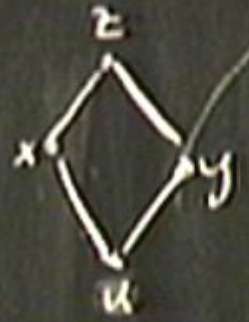
elt's x, y ...

$x \prec y$ x precedes y

x ancestor of y

$x \prec z$

$y \prec z$



...sitive $x \prec y \prec z \Rightarrow x \prec z$

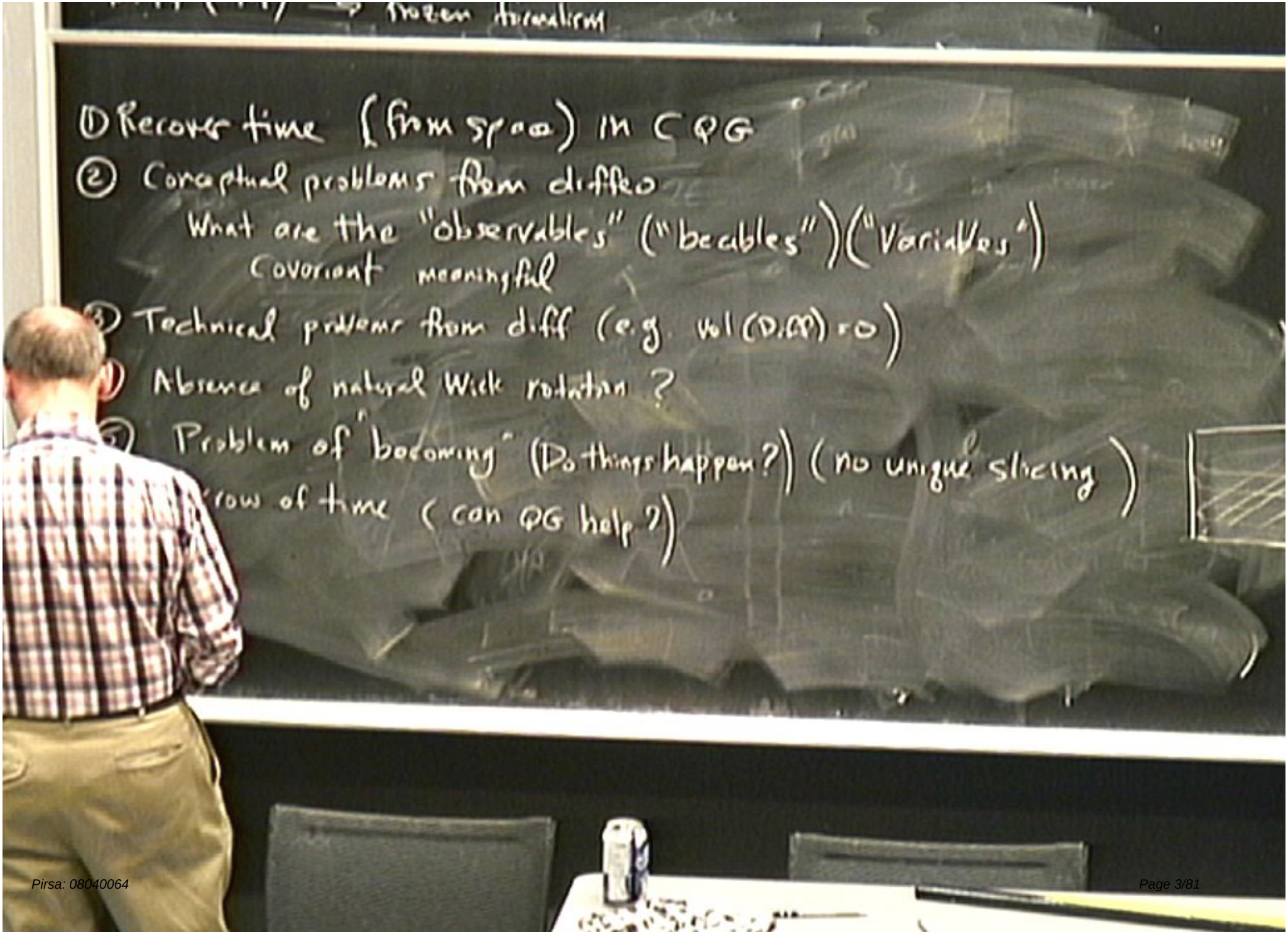
...clic $x \not\prec x$

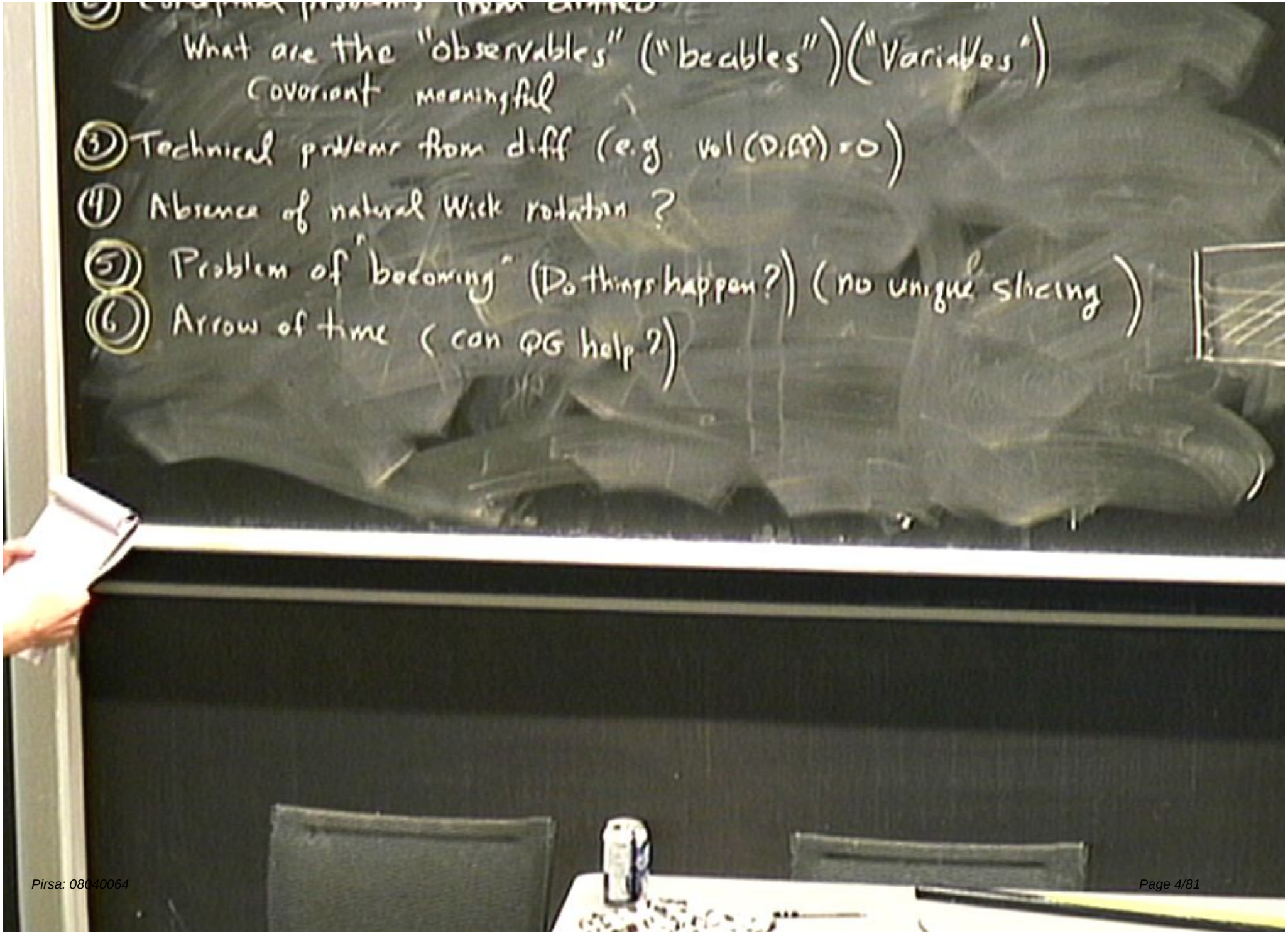
locally finite each x has finite # of ancestors

D(A, B)

↑ Lorentzian

4-geometry


① Recover time (from space) in CQG
② Conceptual problems from diffeo
What are the "observables" ("beables") ("Variables")
Covariant meaningful
③ Technical problems from diff (e.g. Vol(D,gg) = 0)
④ Absence of natural Wick rotation ?
⑤ Problem of "becoming" (Do things happen?) (no unique slicing)
Arrow of time (can QG help?)


What are the "observables" ("beables") ("VariAbles")
Covariant meaningful
(3) Technical problems from diff (e.g. Vol(Diff) = 0)
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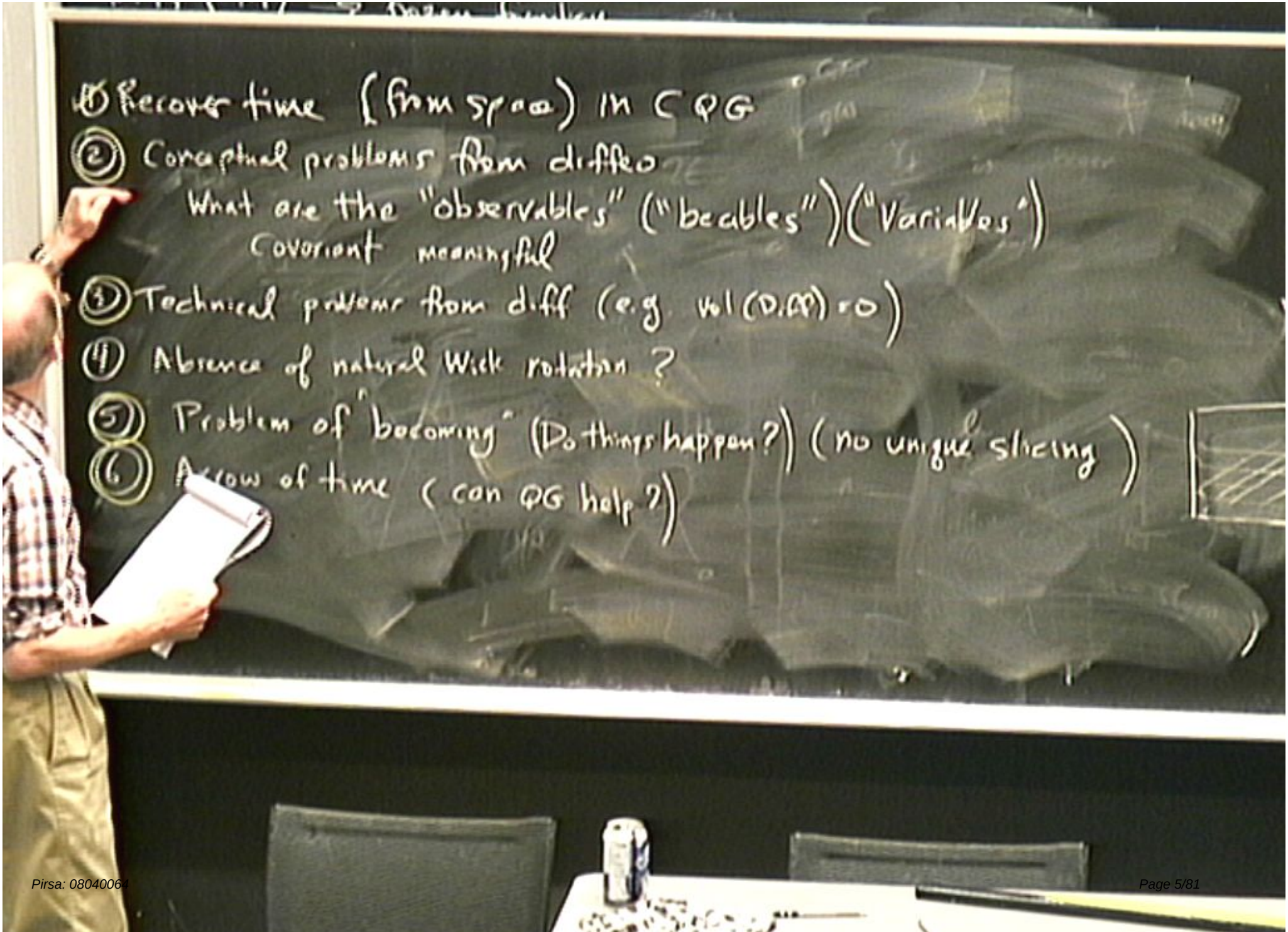
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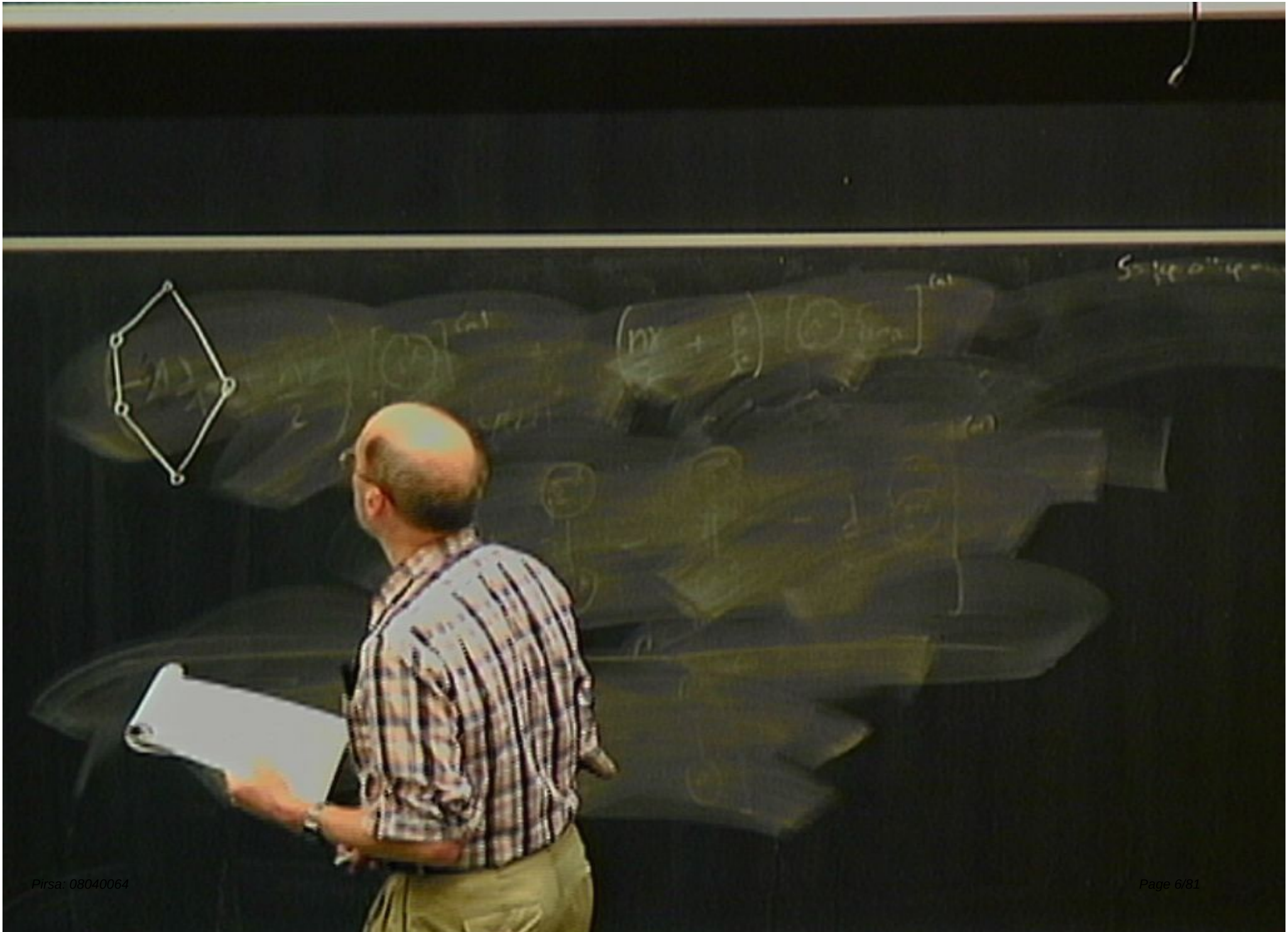
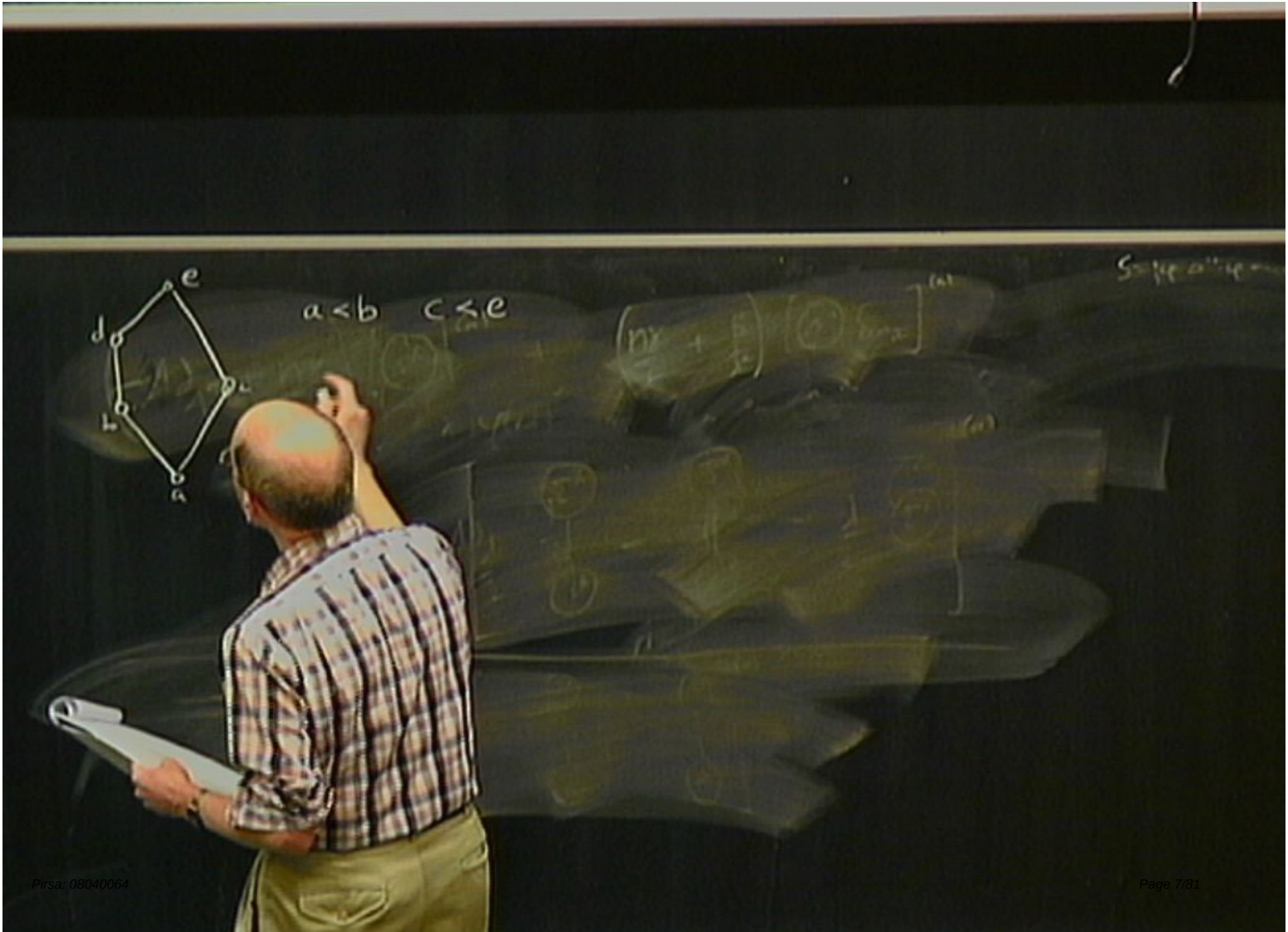
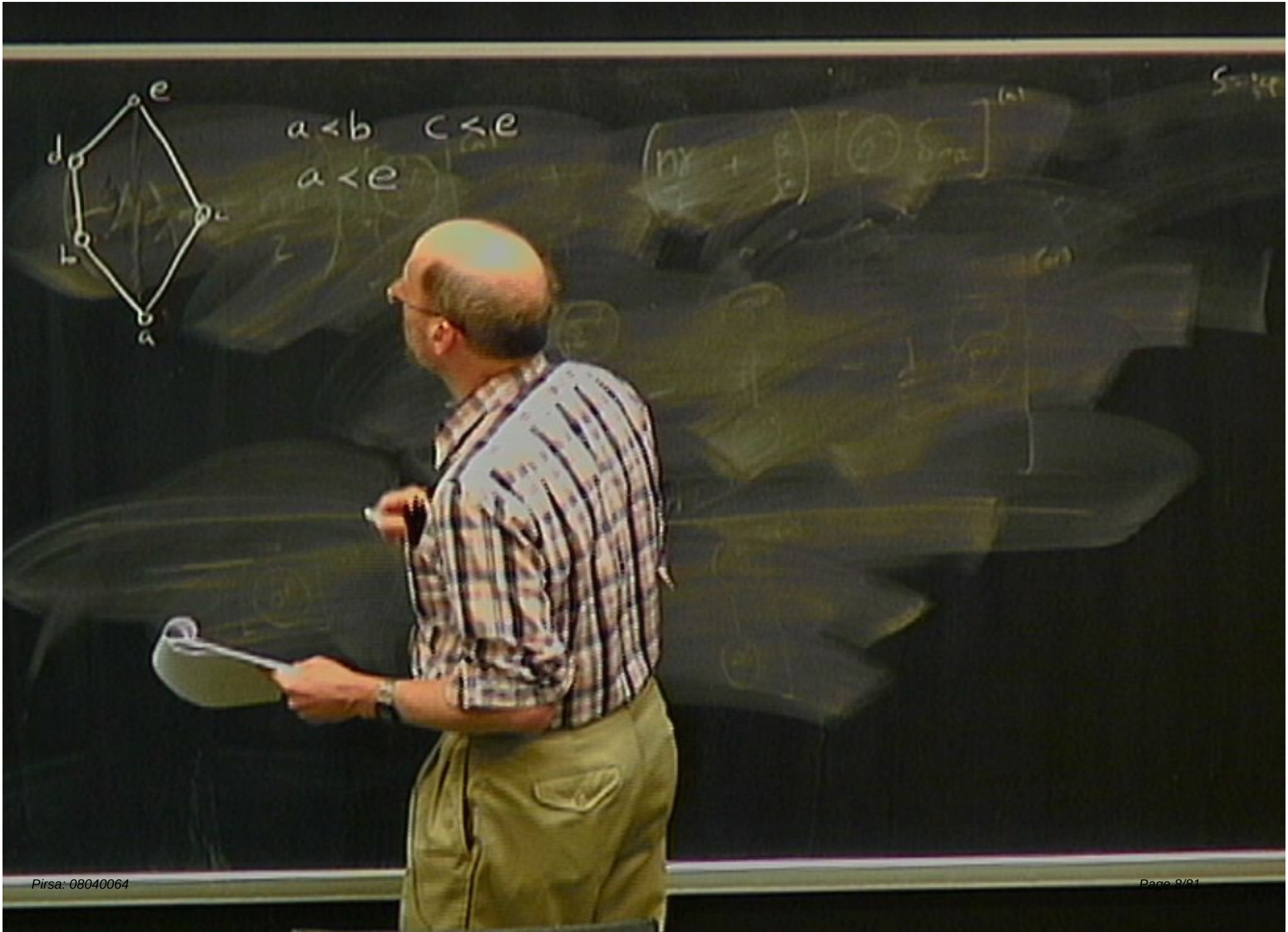
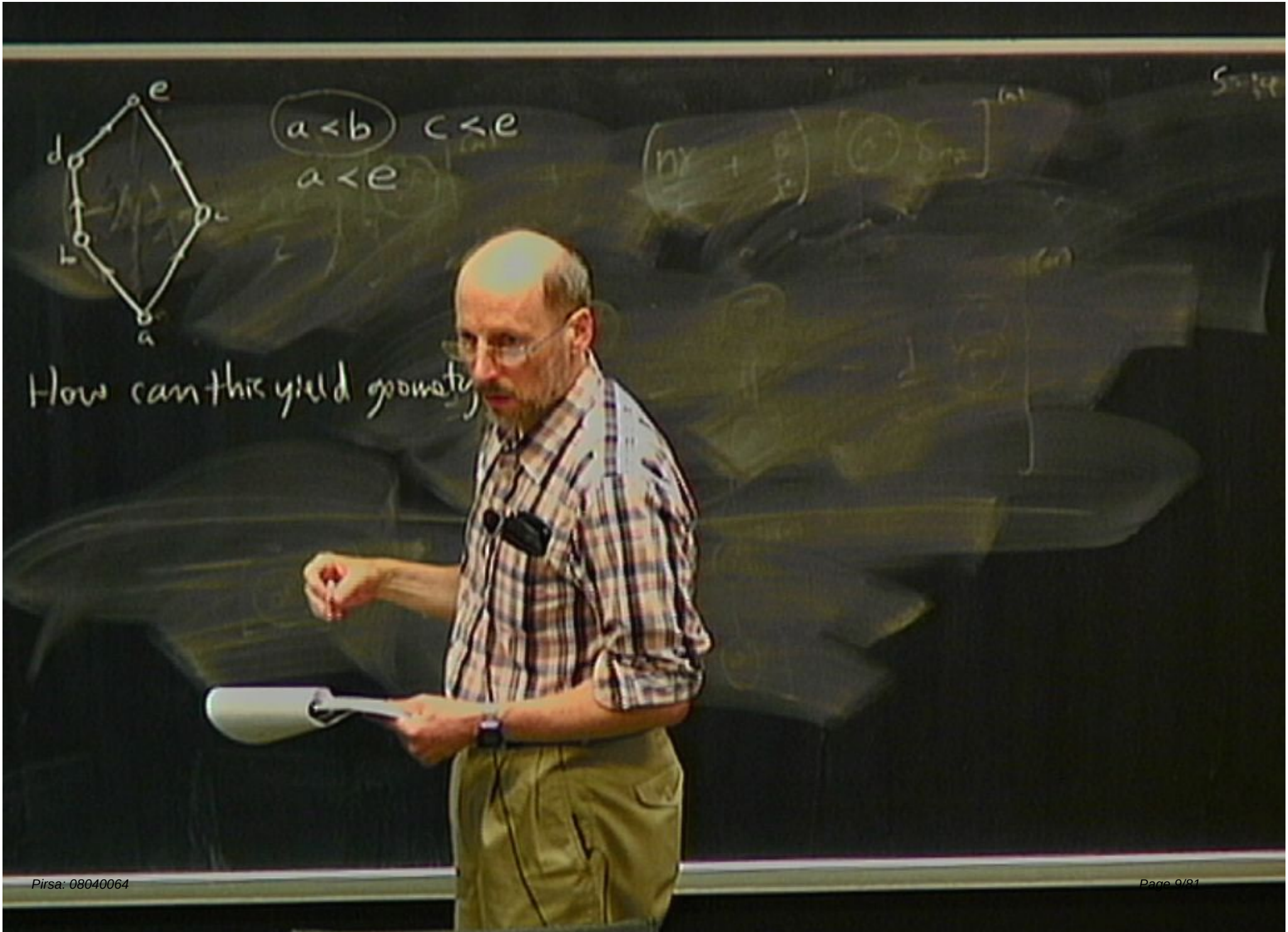
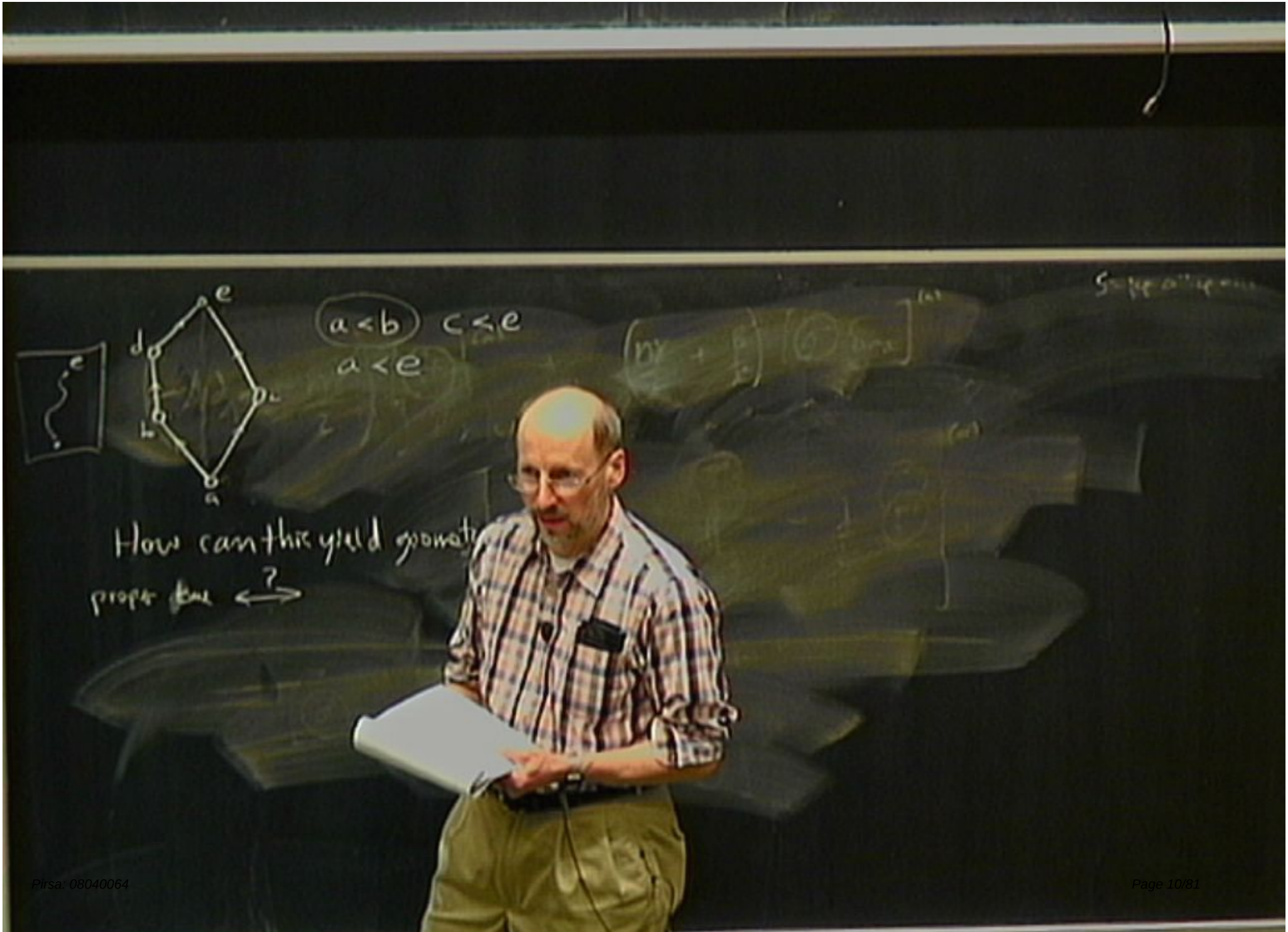
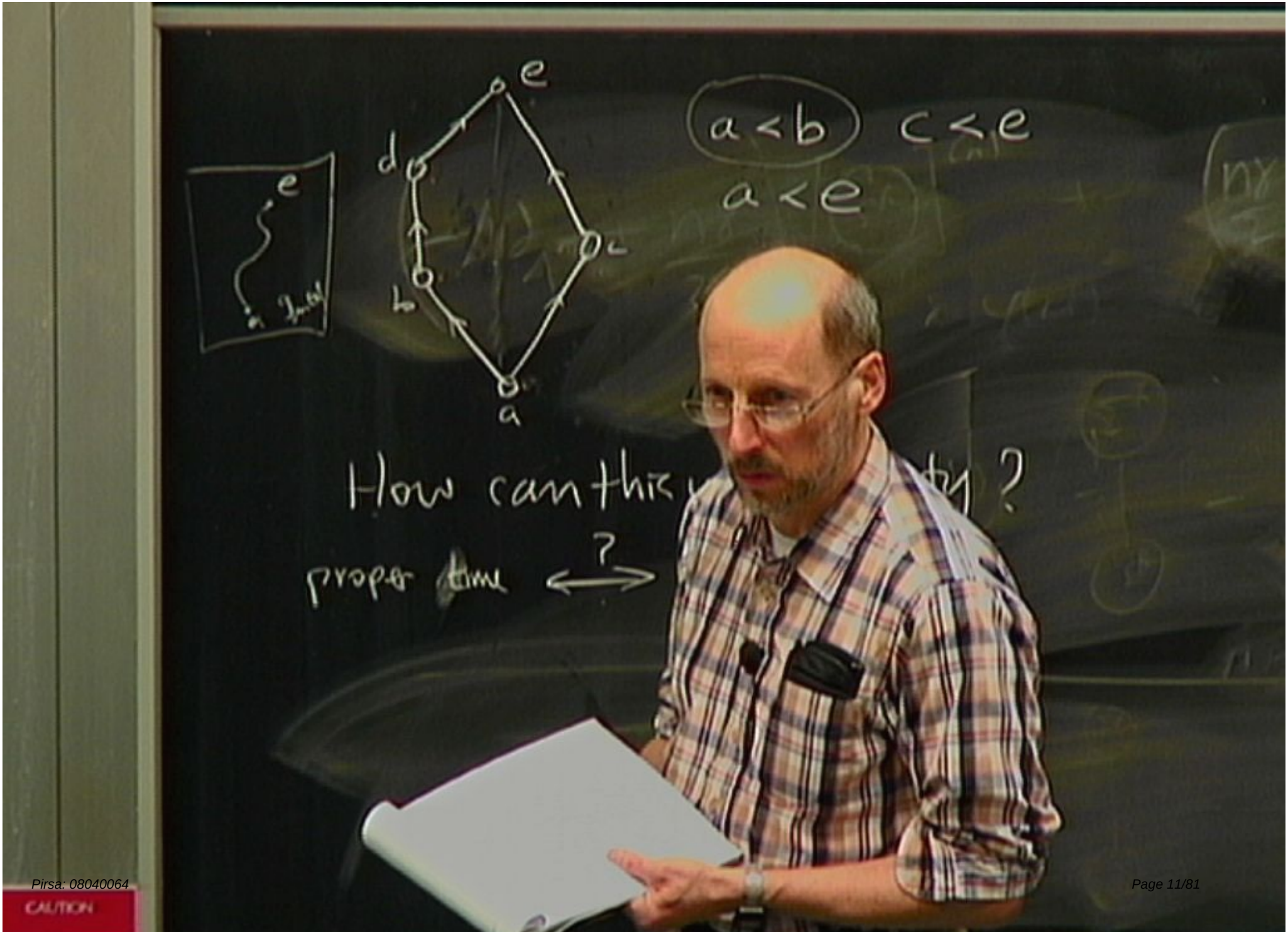


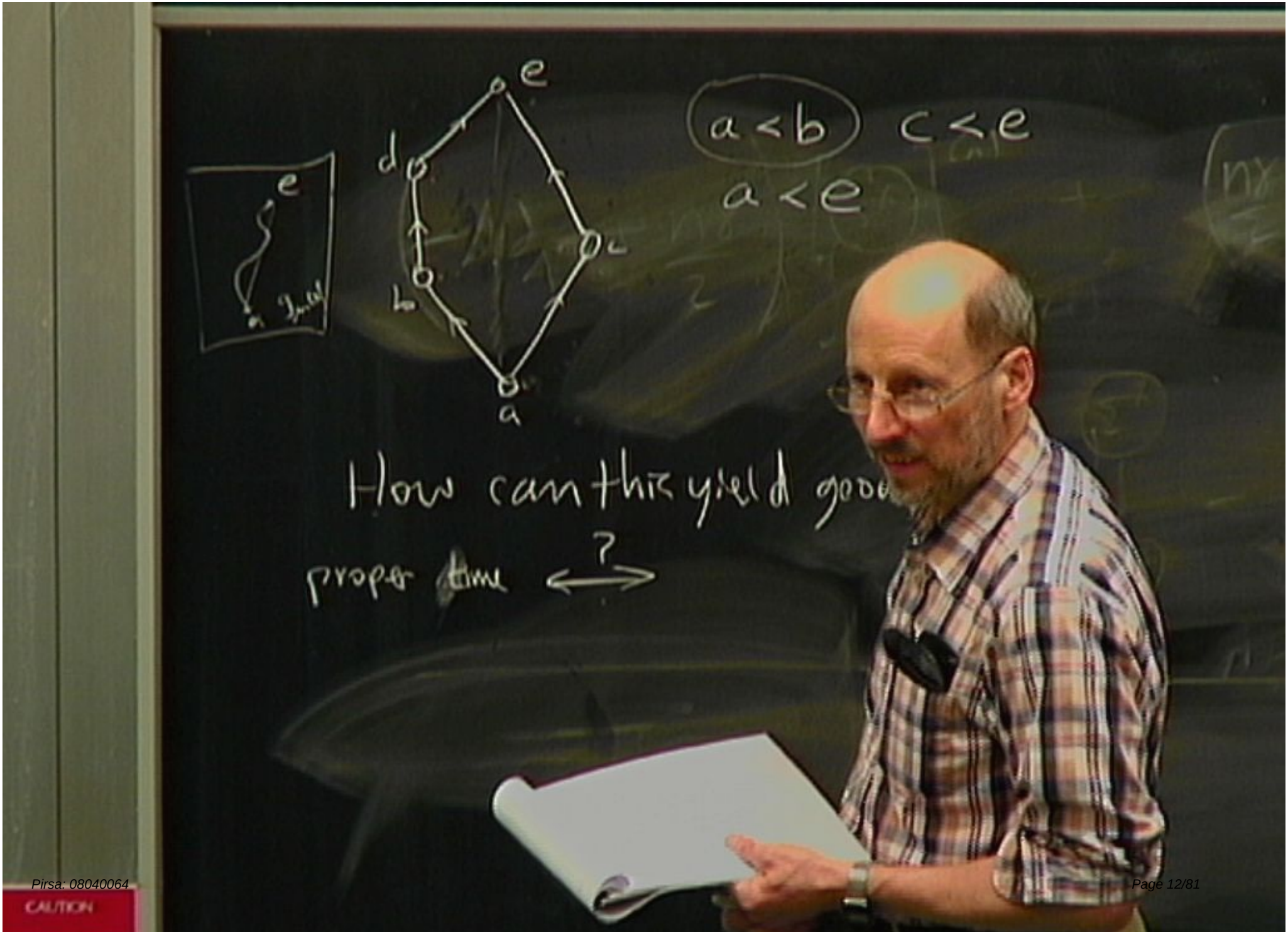

e
d
a
a<b
c≤e

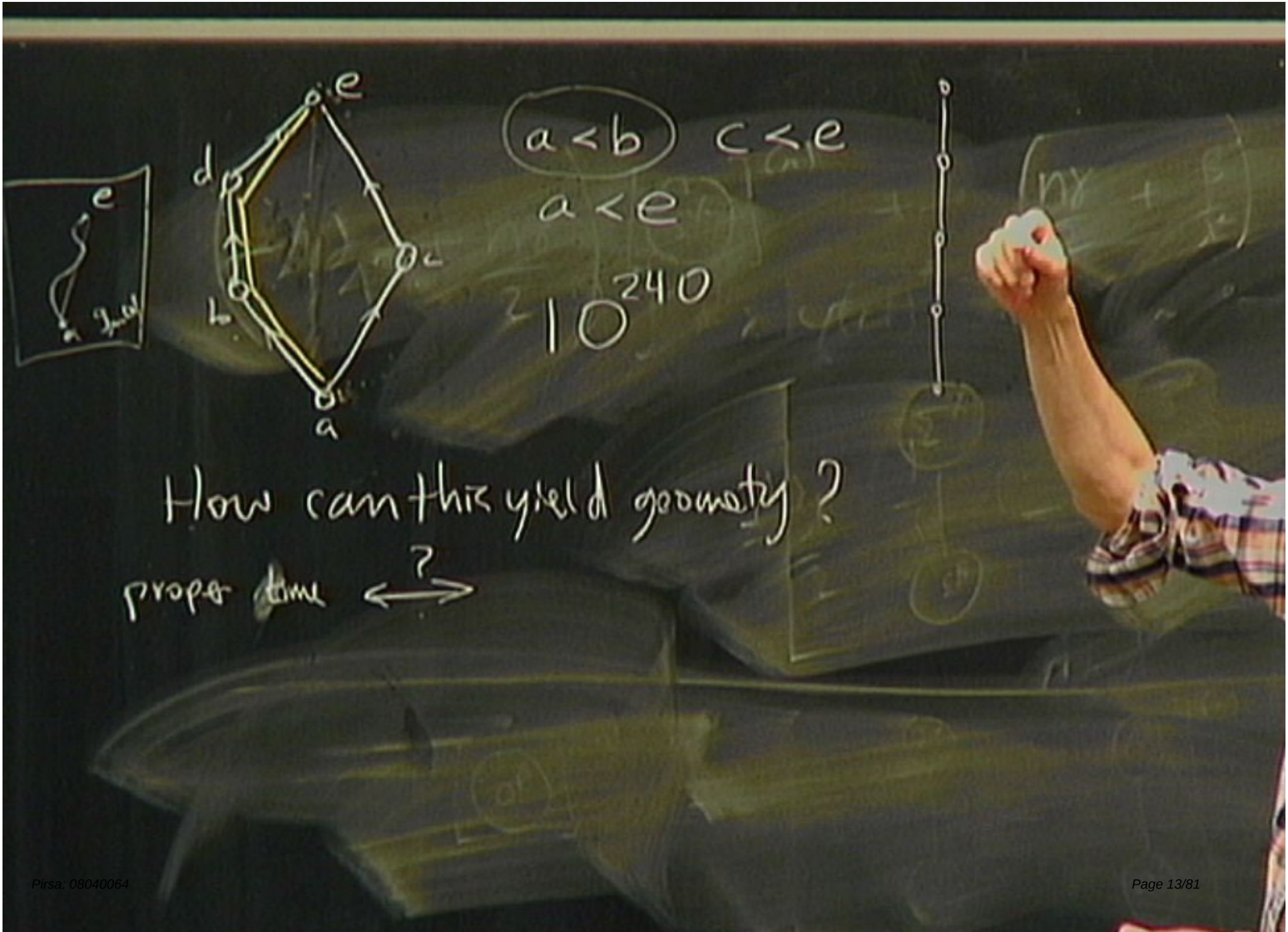

e
d
c
b
a
a < b
c < e
a < e

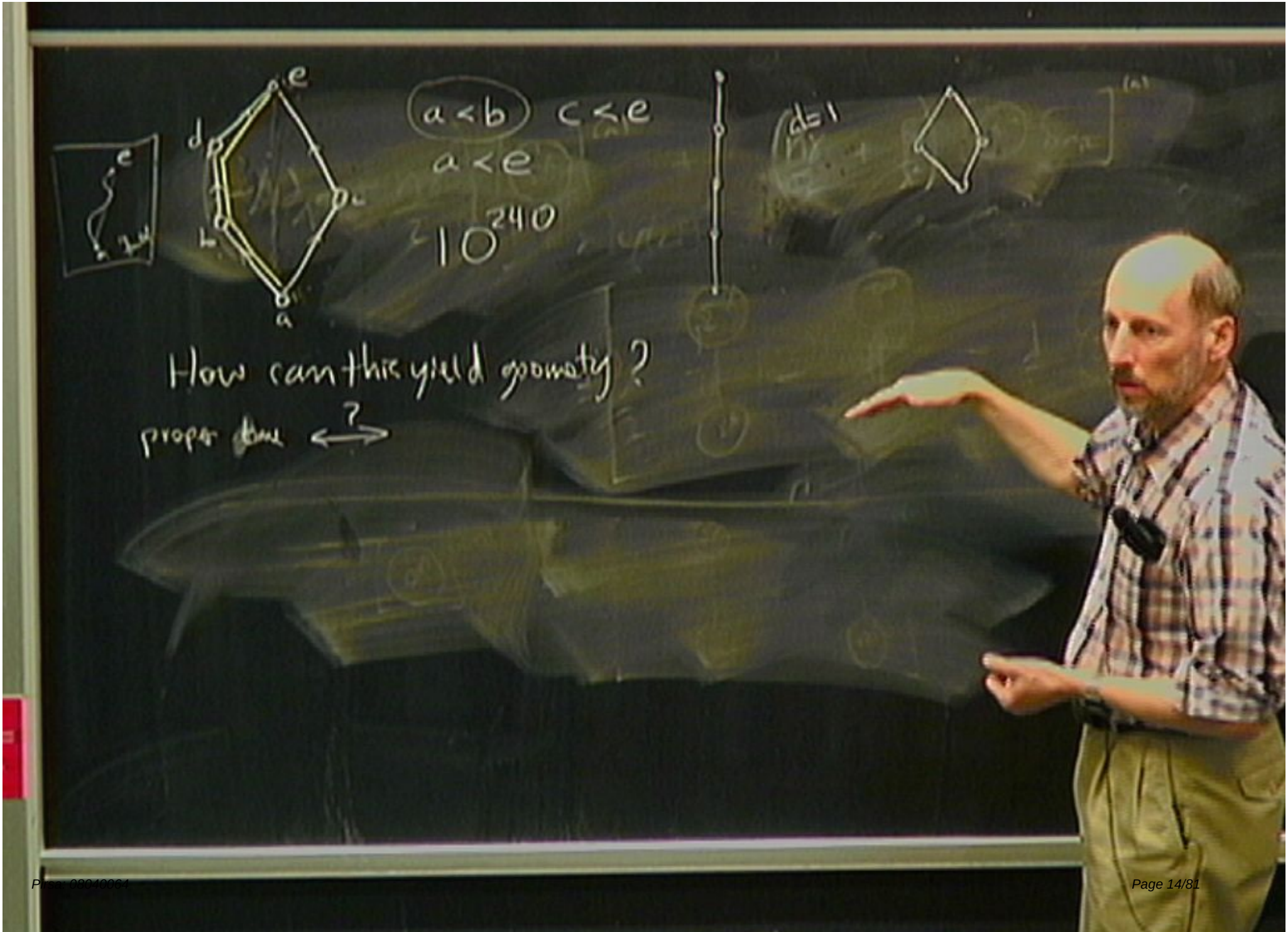

e
d
c
b
a
a<b c<e
a<e
How can this yield geometry

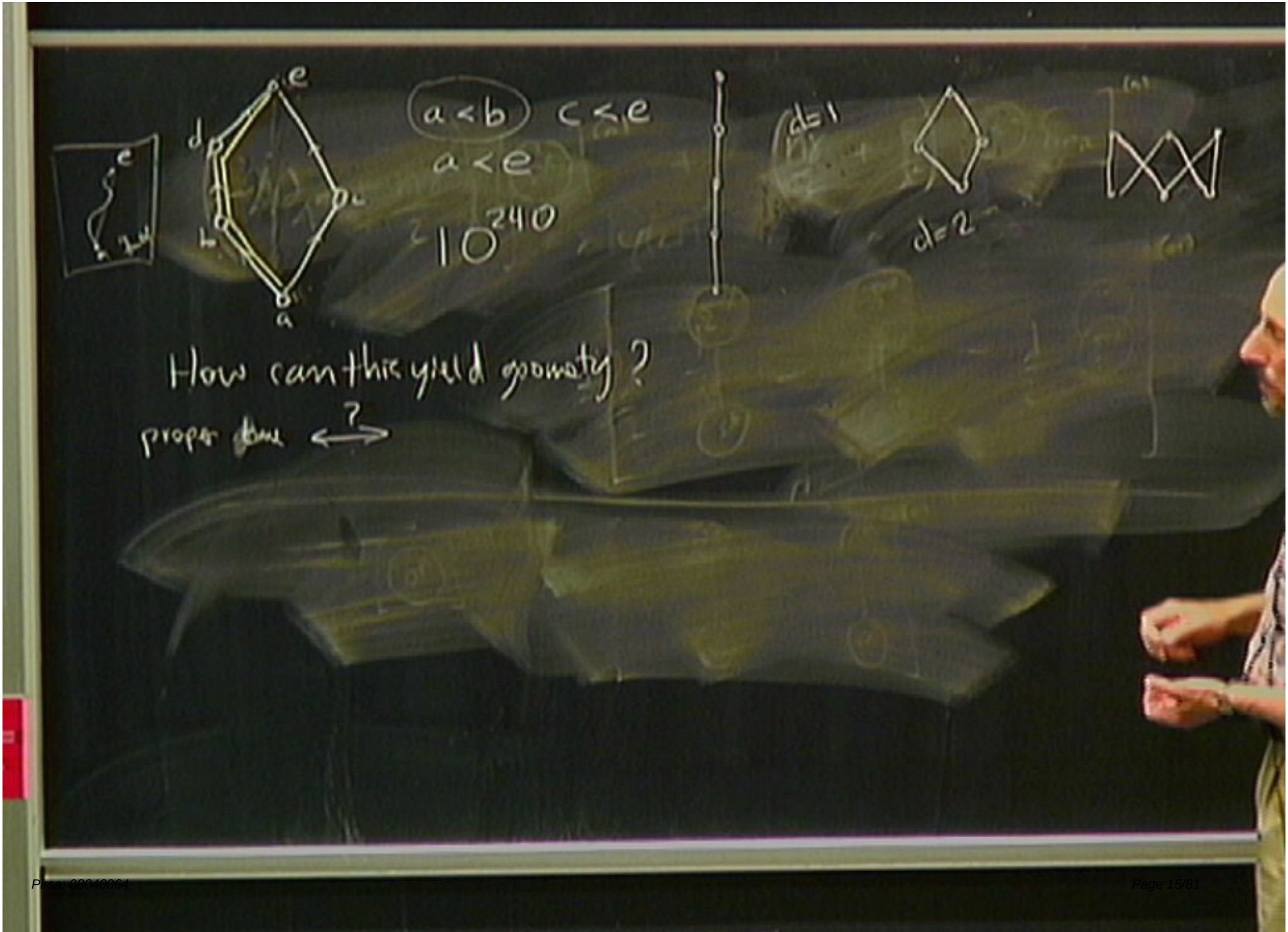

e
d
a<b
c<e
a<e
How can this yield
?

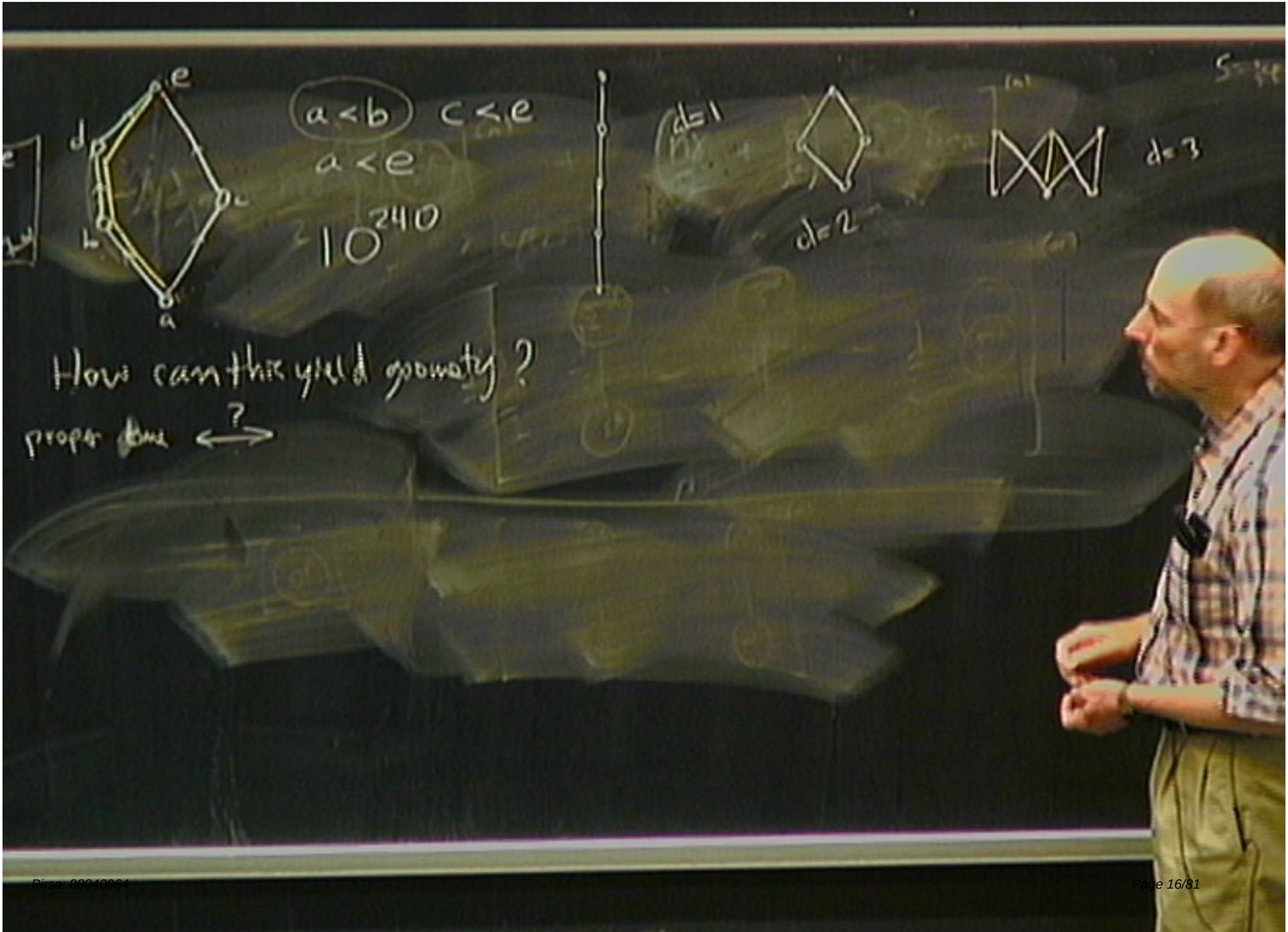

e
d
c
b
a
a < b
c < e
a < e
How can this
proper time
?
?

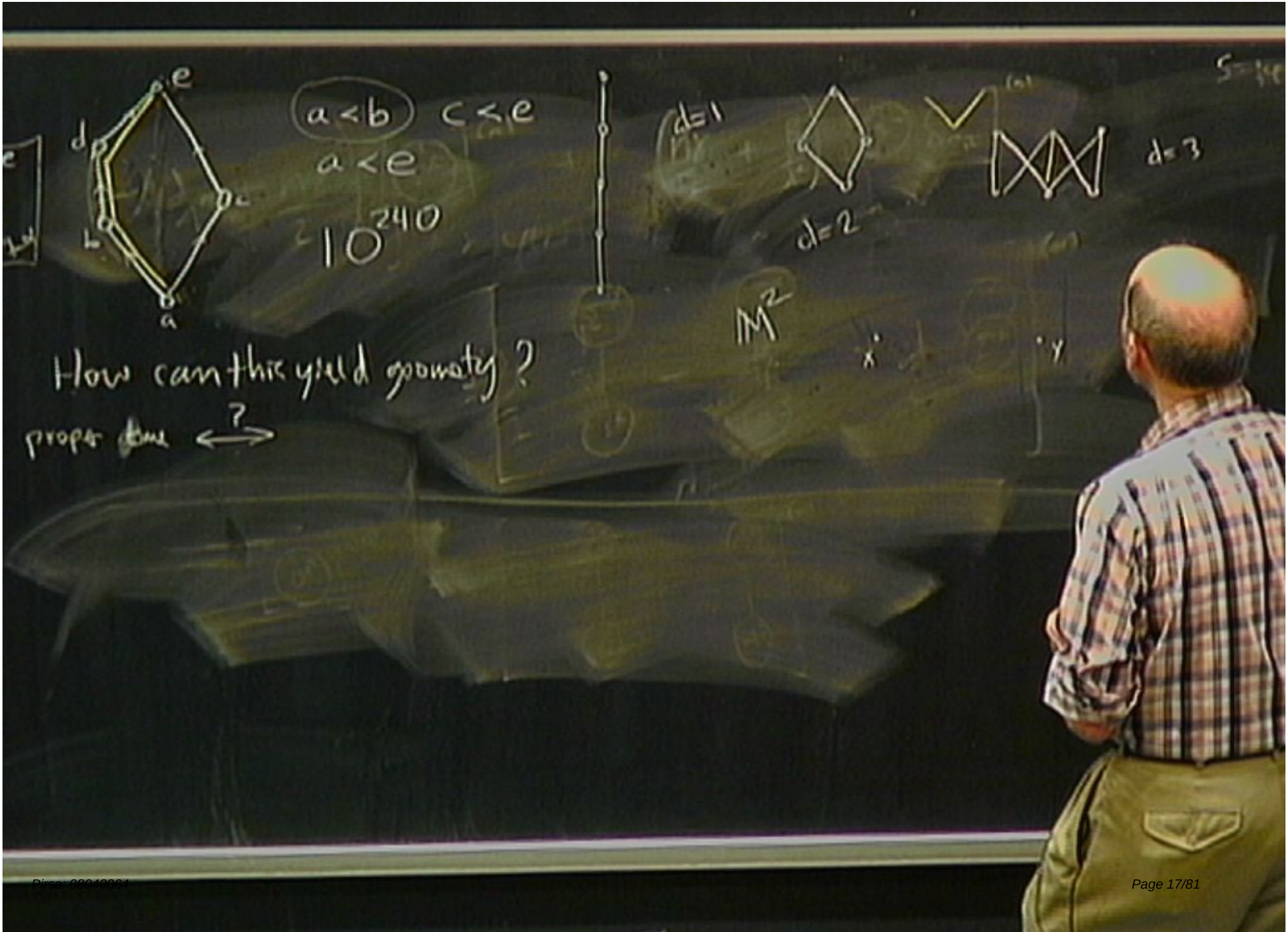

e
d
c
b
a
a<b
c<e
a<e
How can this yield good
proper time
?

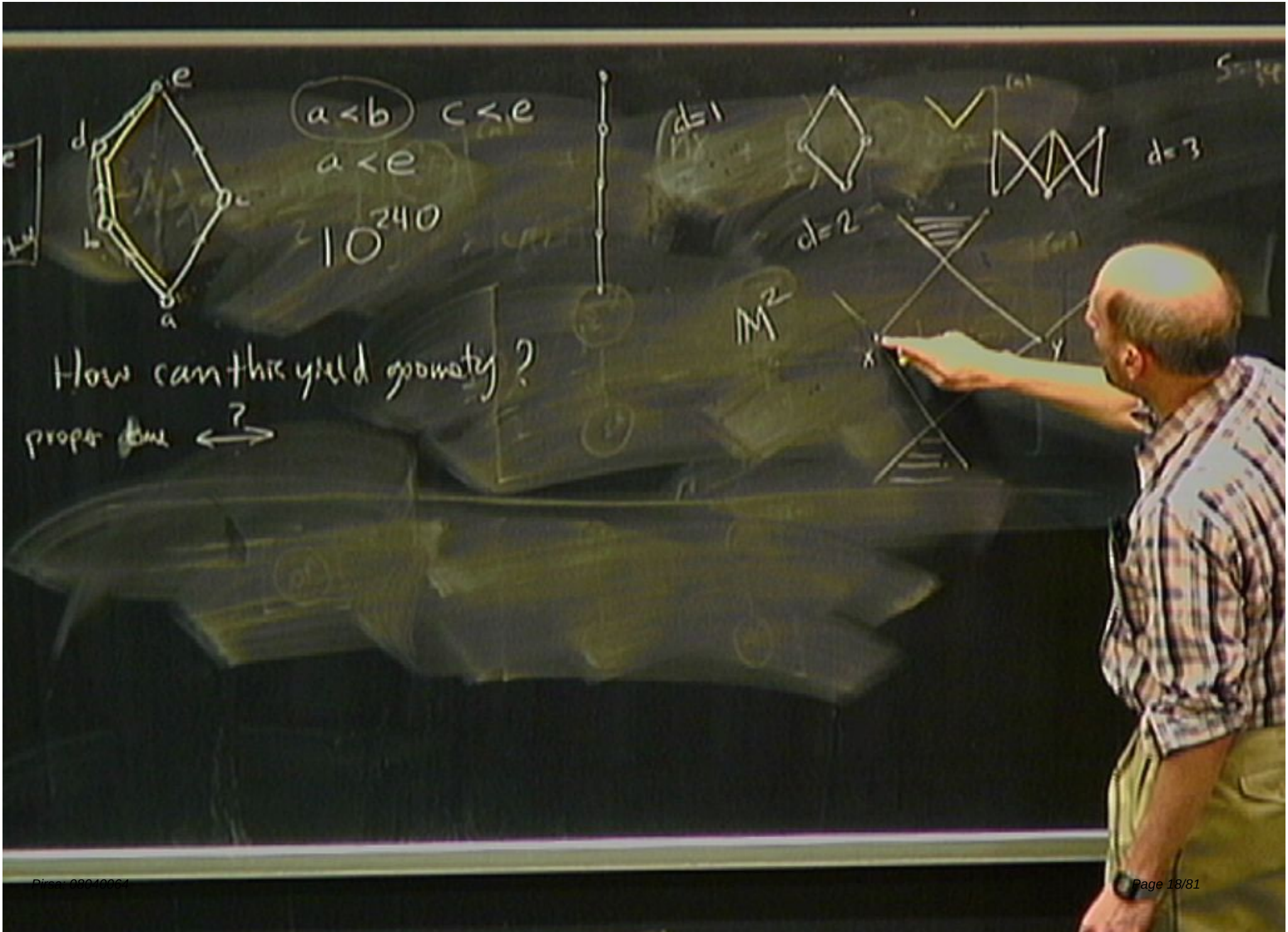

e
d
c
b
a
a<b c<e
a<e
10^{240}
How can this yield geometry ?
proper time ?

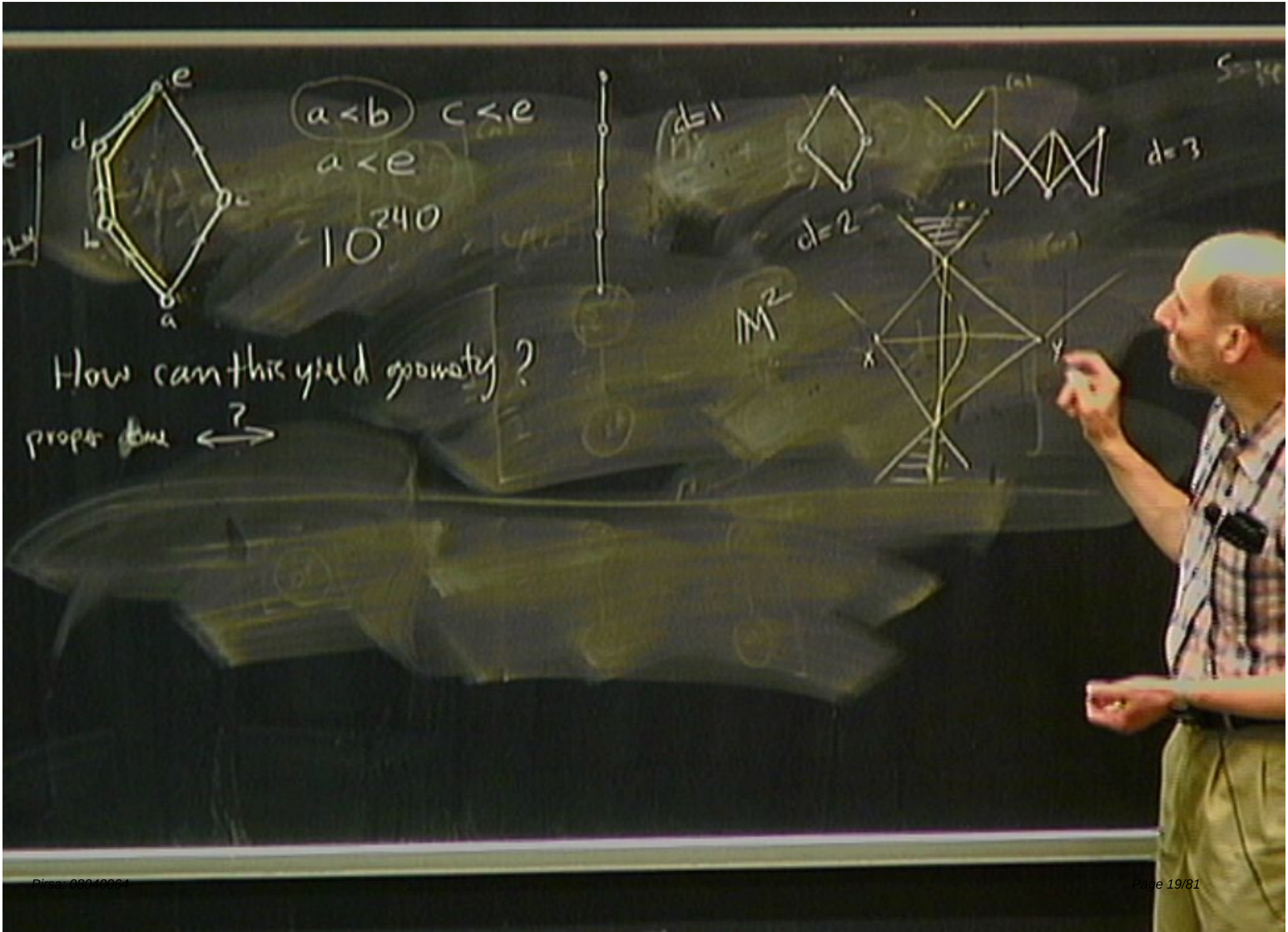

e
d
c
b
a
a<b
c<e
a<e
10^{240}
d=1
How can this yield geometry?
proper ?

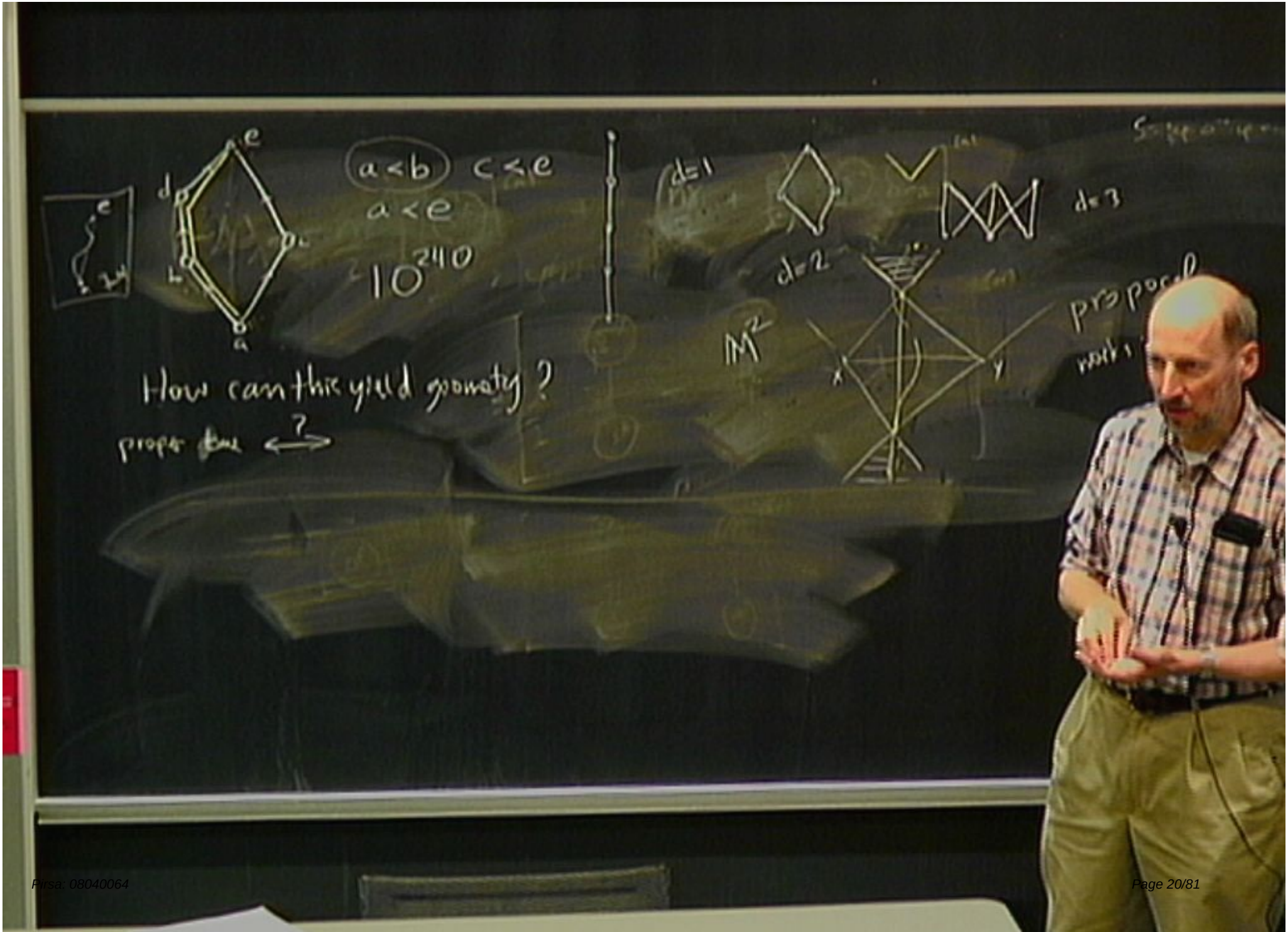

e
d
c
b
a
a<b
c<e
a<e
10^{240}
d=1
d=2
How can this yield geometry?
proper dim
?

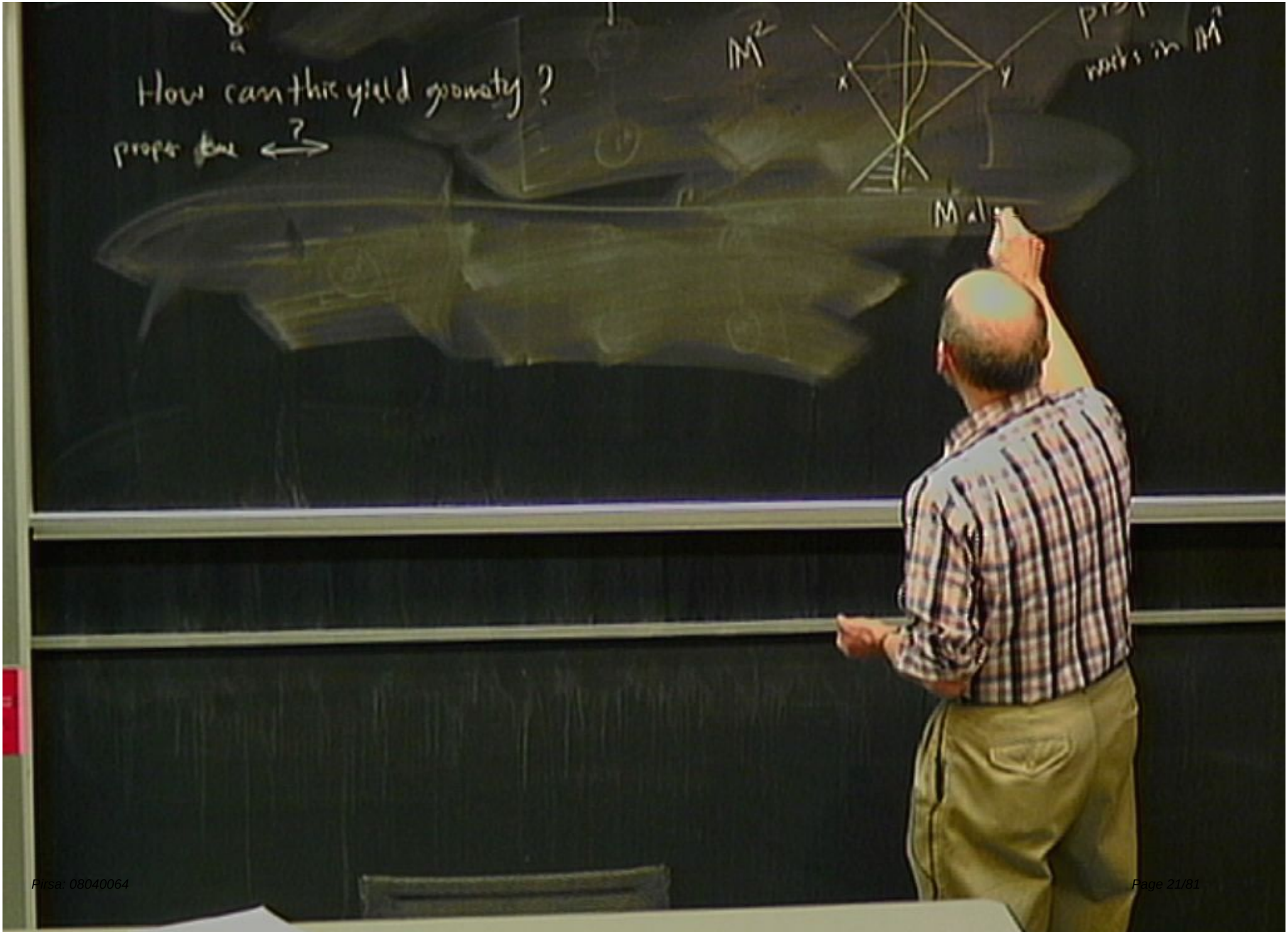

e
d
c
b
a
a<b
c<e
a<e
10^{240}
d=1
d=2
d=3
How can this yield gravity?
proper time
?

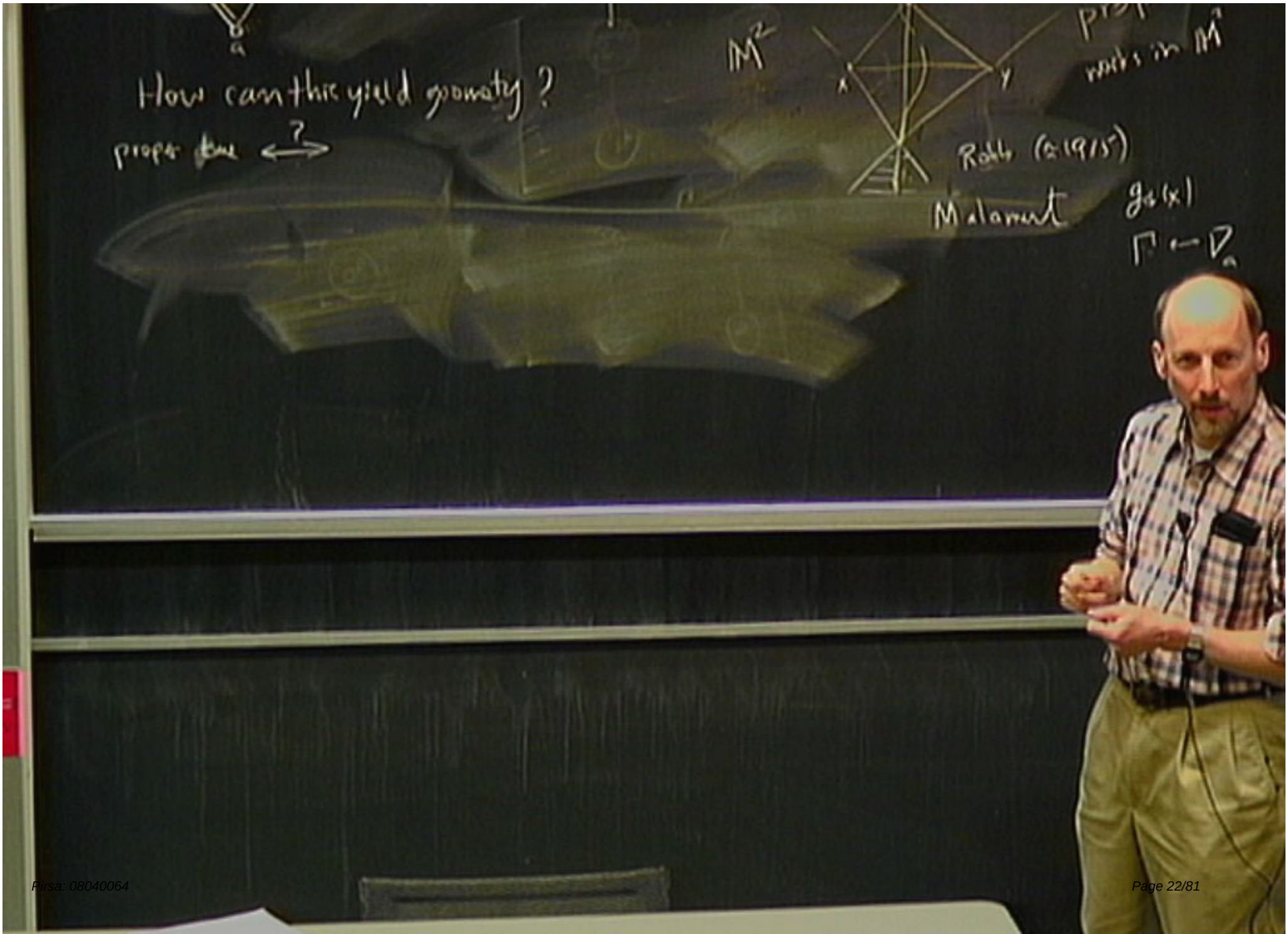

e
d
a
b
a<b c<e
a<e
10^{240}
d=1
d=2
d=3
M^2
How can this yield geometry ?
proper time
?

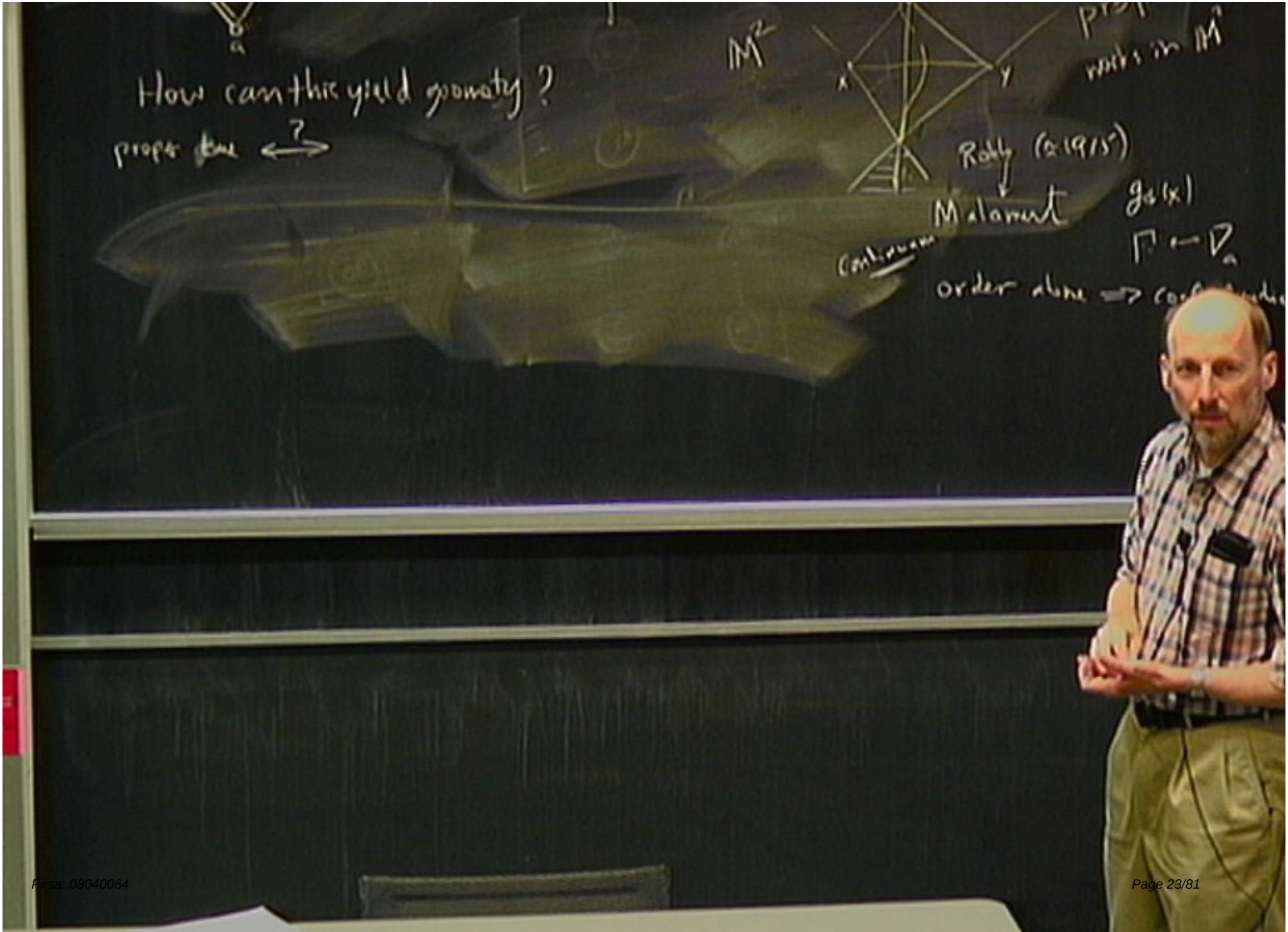

e
d
a
b
a<b
c<e
a<e
10^{240}
d=1
d=2
d=3
M^2
How can this yield geometry?
proper time
?

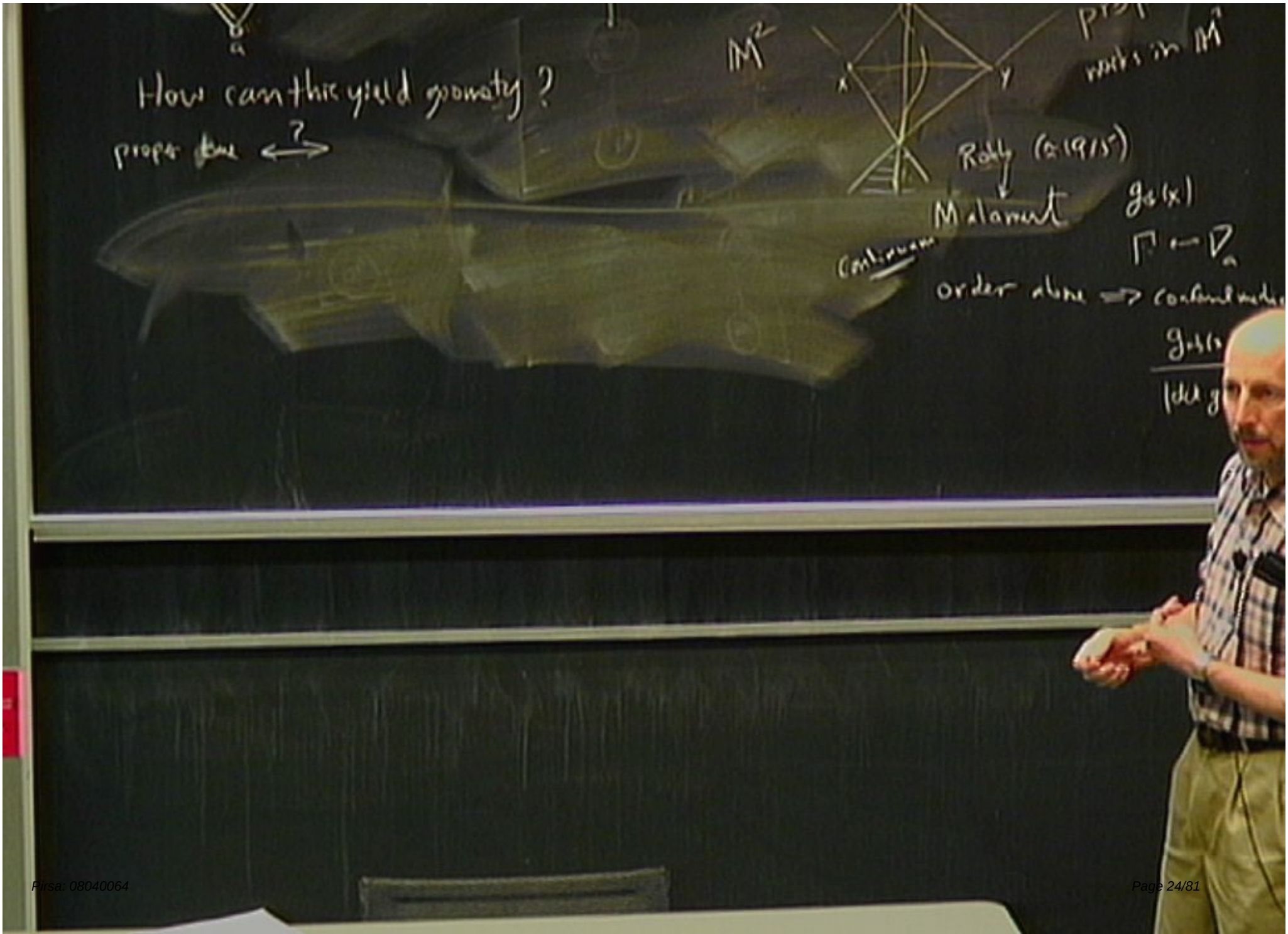

e
d
a
b
a<b
c<e
a<e
10^{240}
d=1
d=2
d=3
M^2
How can this yield geometry?
proper time
?

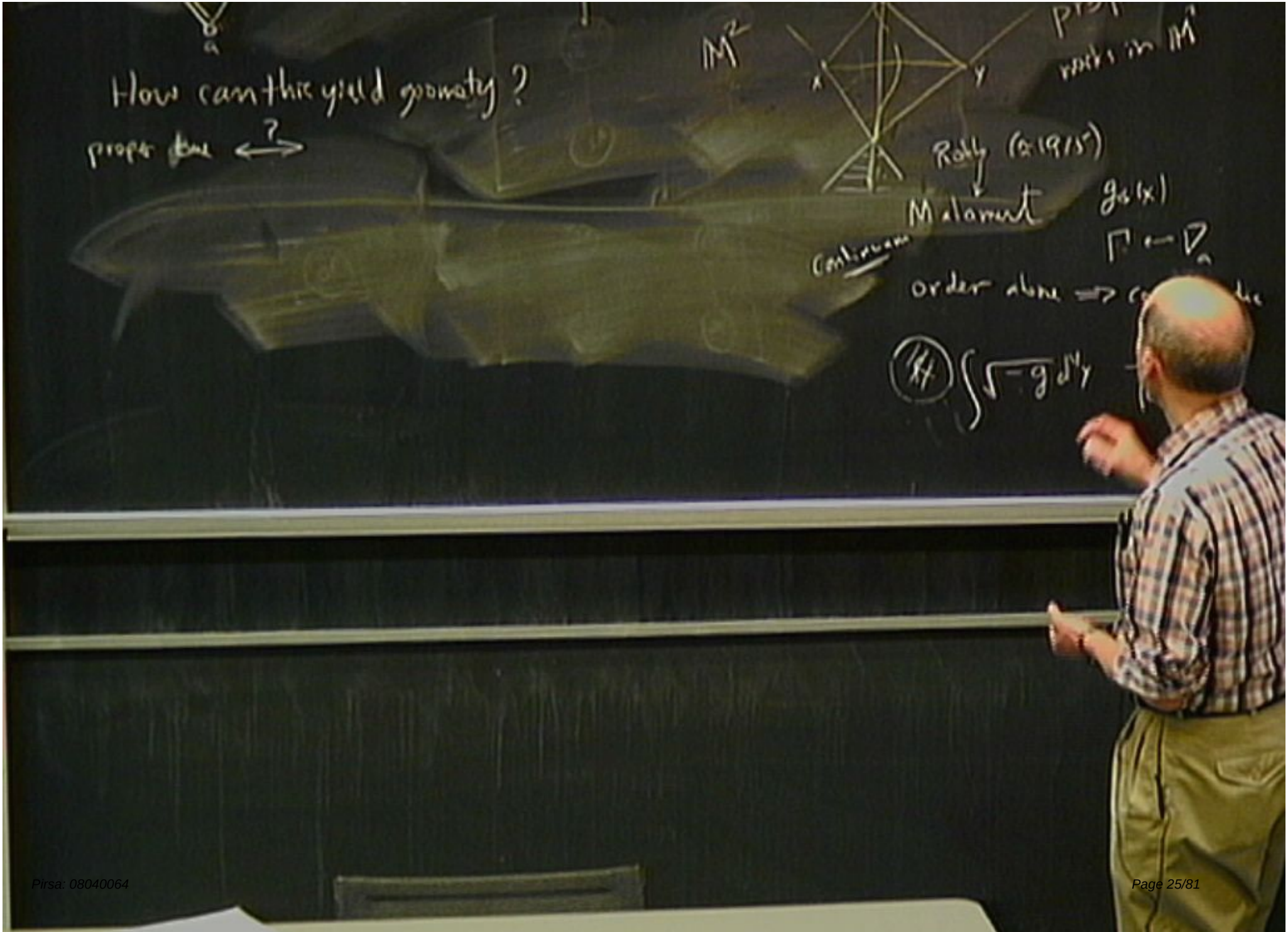

a<b c<e
a<e
10^{240}
d=1
d=2
d=3
M^2
How can this yield geometry ?

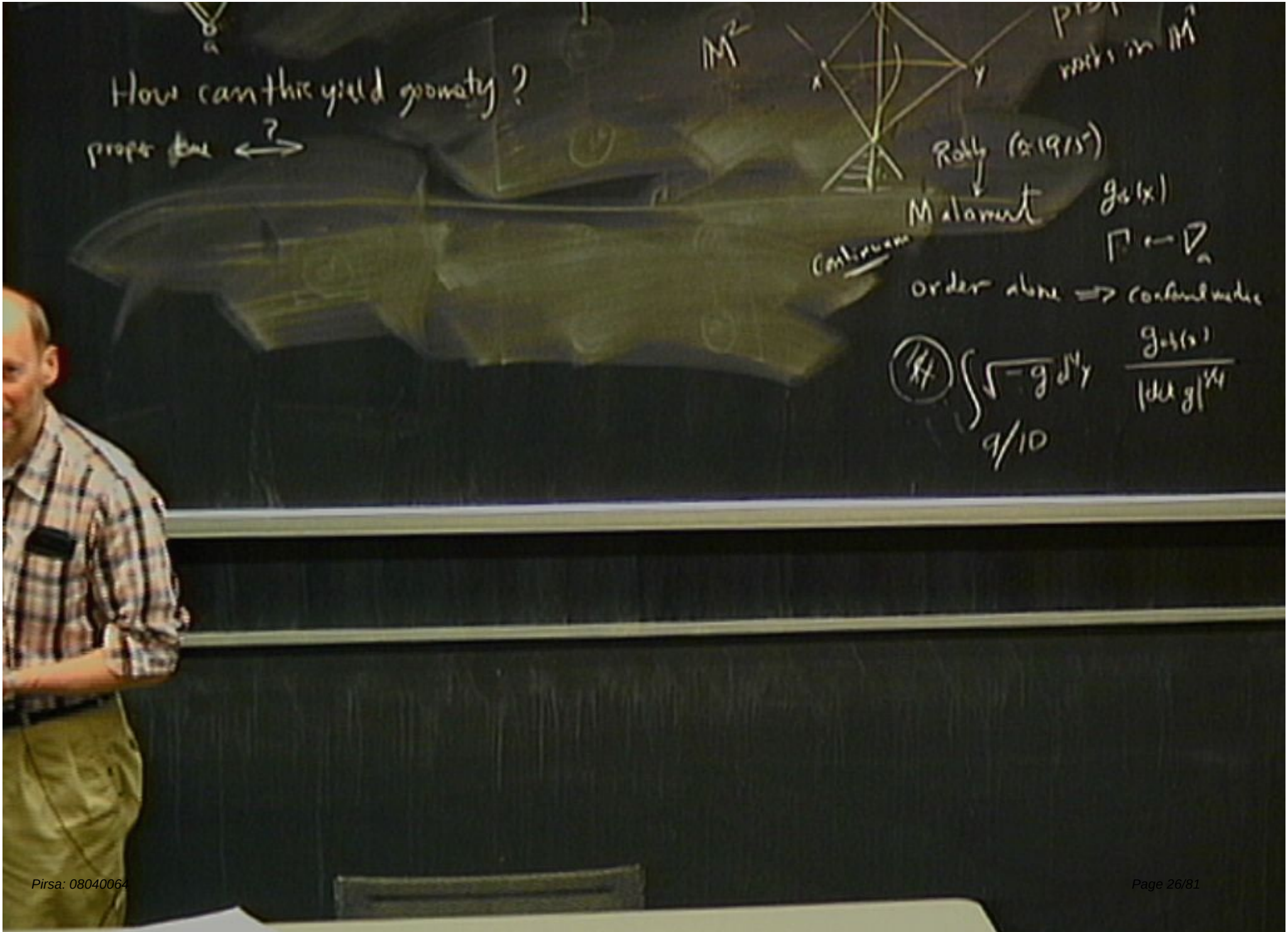

How can this yield geometry ?
proper ?
M^2

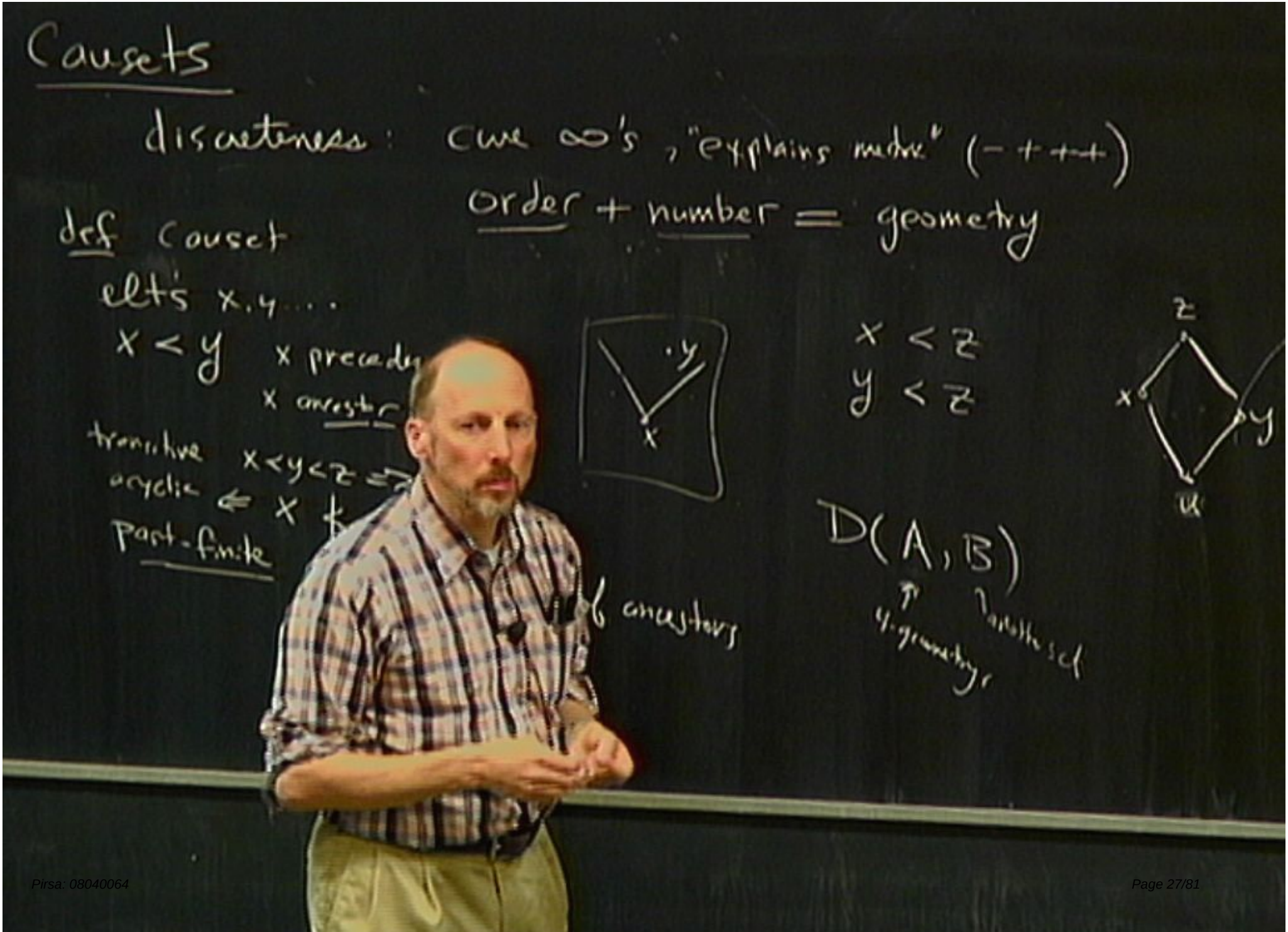

How can this yield geometry ?
Robb (c. 1915)
Malamut

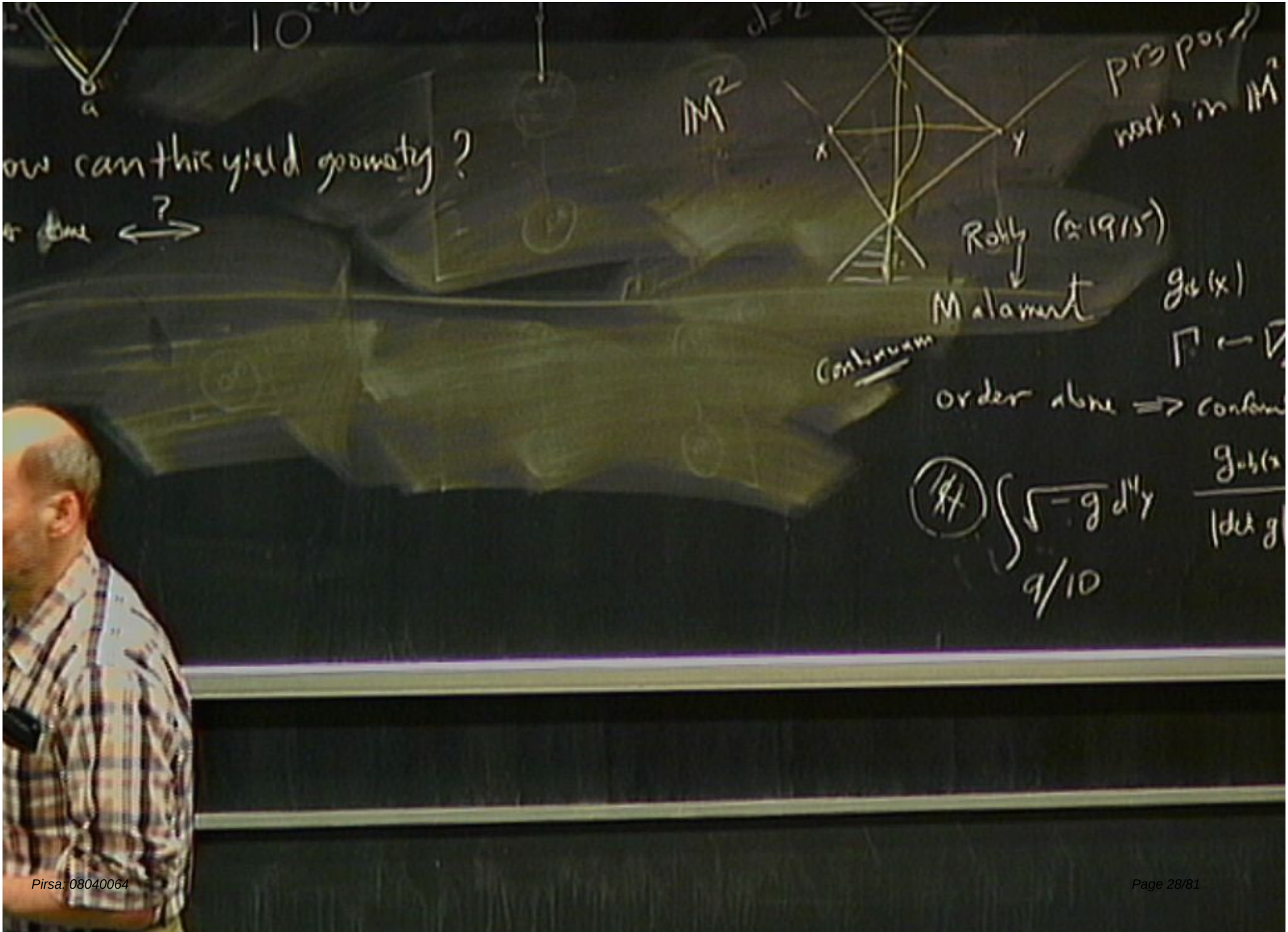

How can this yield geometry ?
Rothy (c.1975)
Malamut
order alone

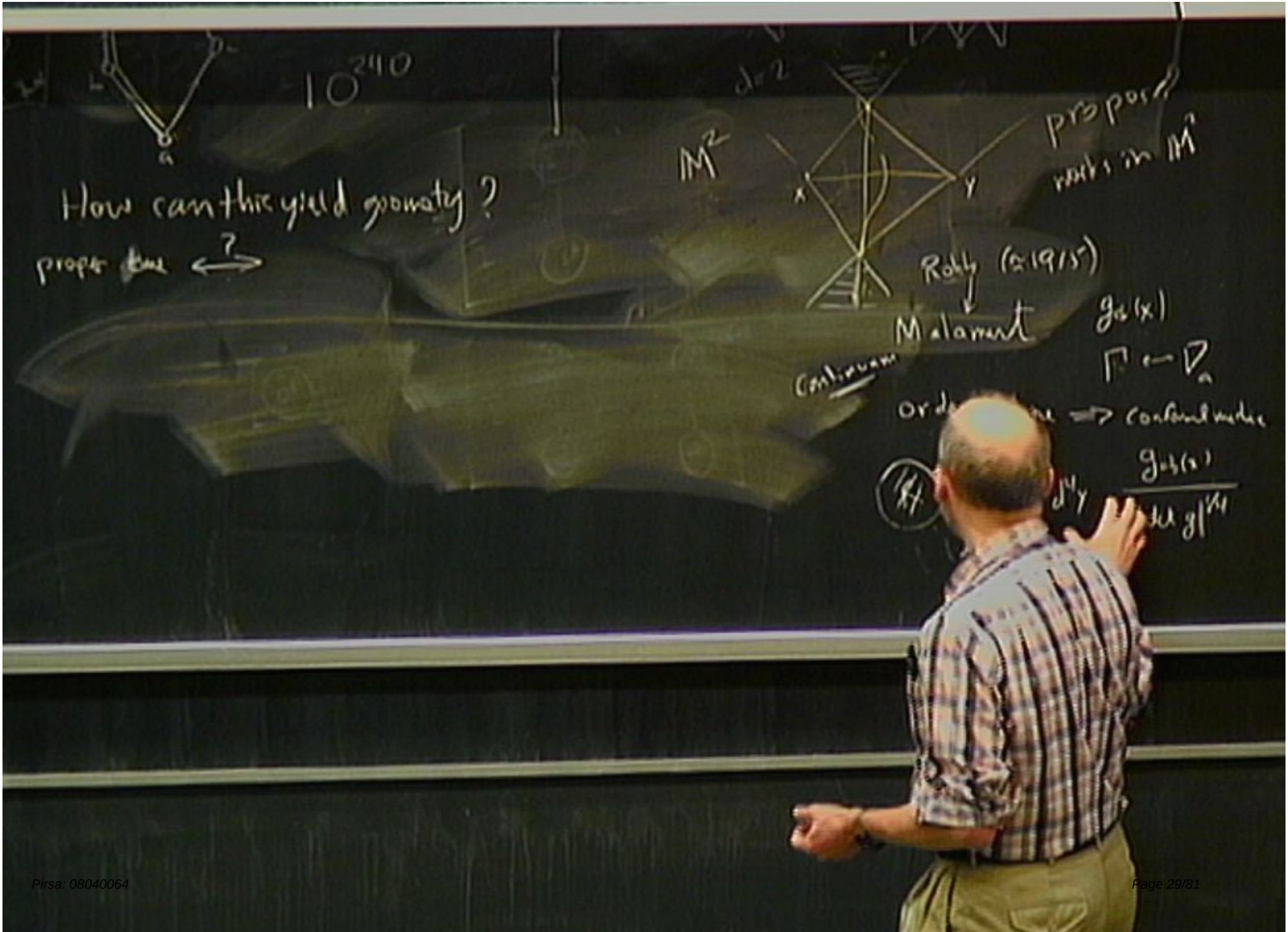

How can this yield geometry ?
Rothy (c. 1915)
Malamut
order alone

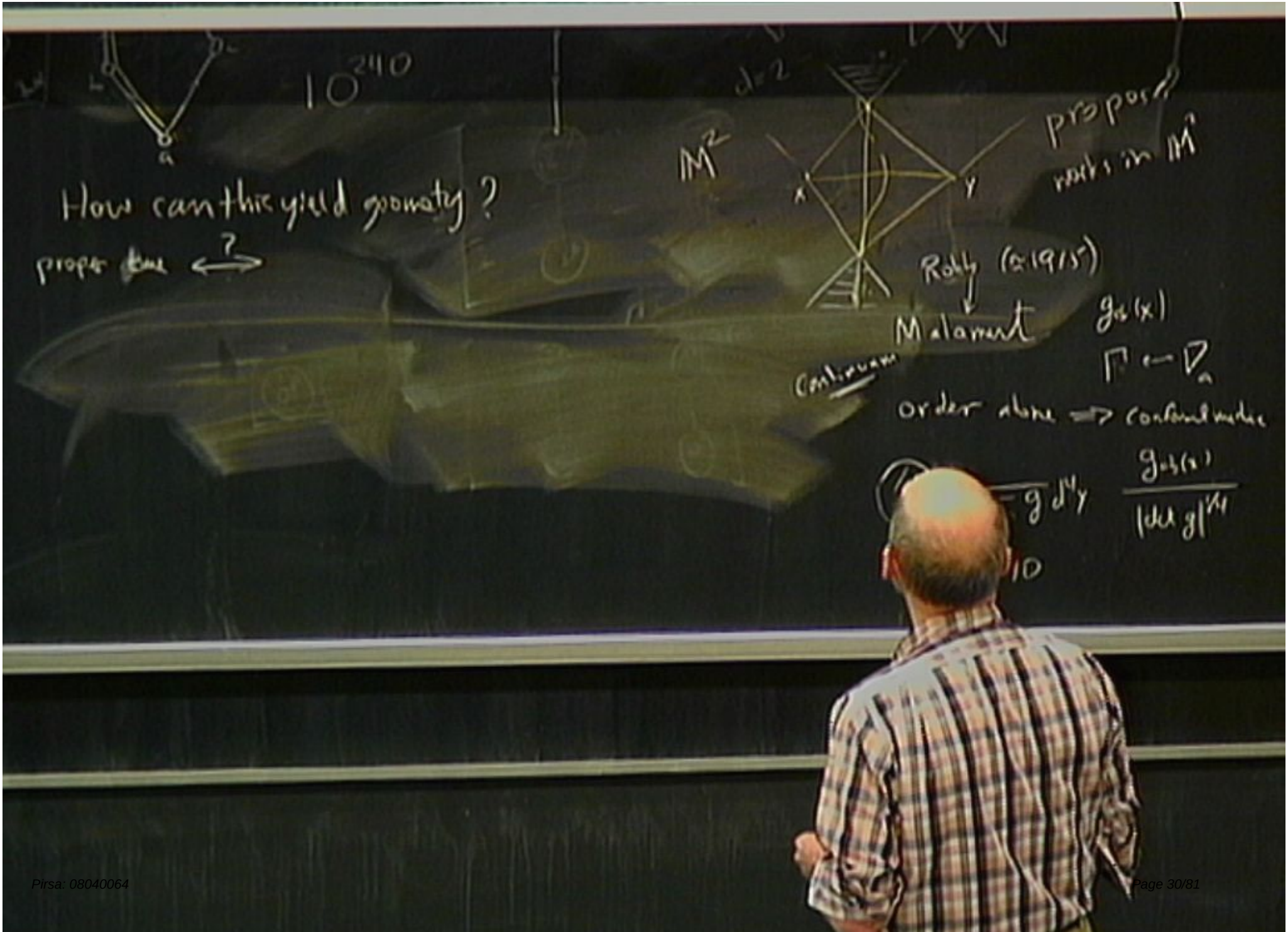

How can this yield geometry ?
proper ?
M^2
Rolly (c.1915)
Malament
order alone

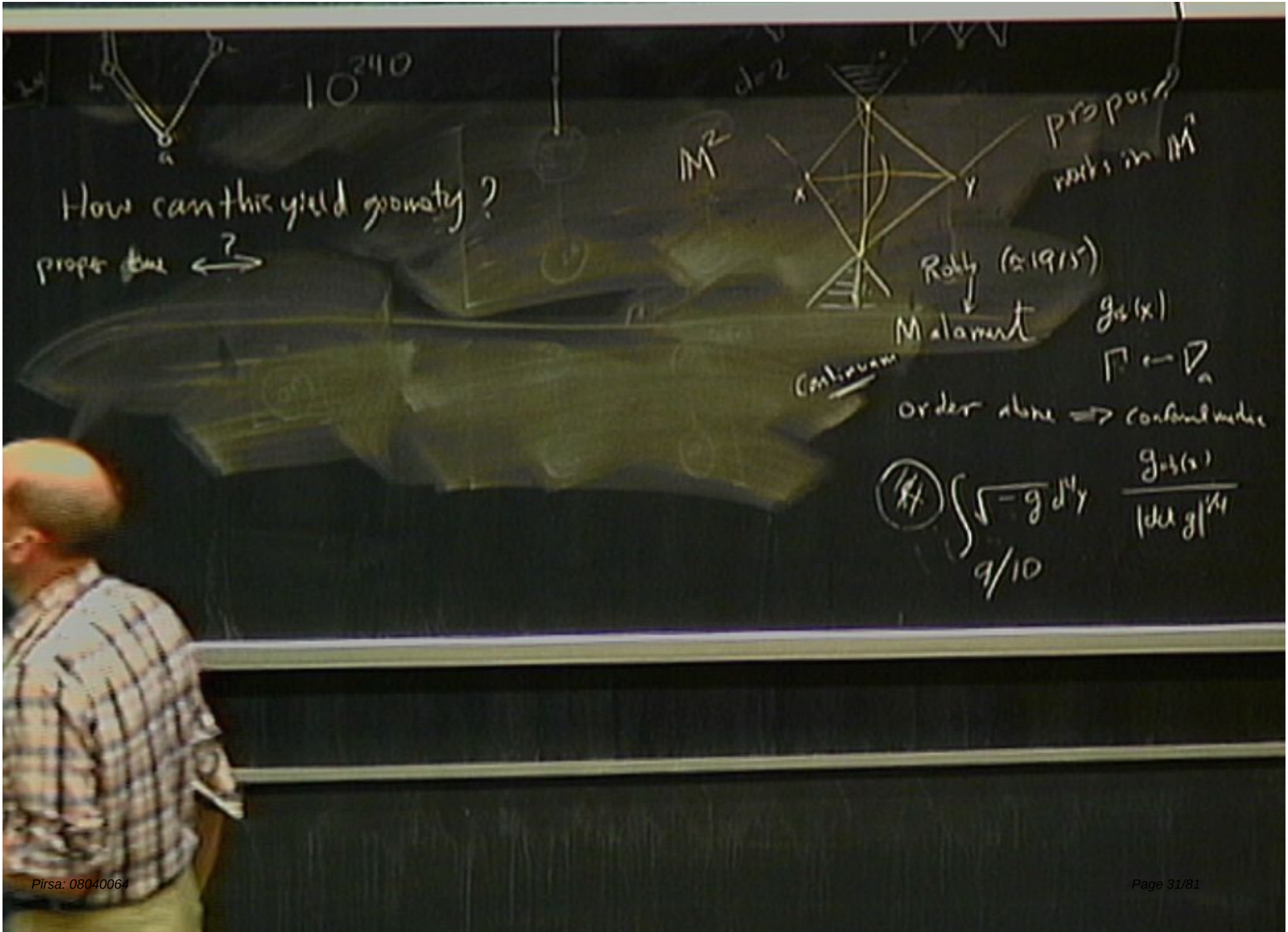

How can this yield geometry ?
proper ?
M^2
Regge (~1915)
Minimal
Continuum
order alone ⇒ confinement
9/10

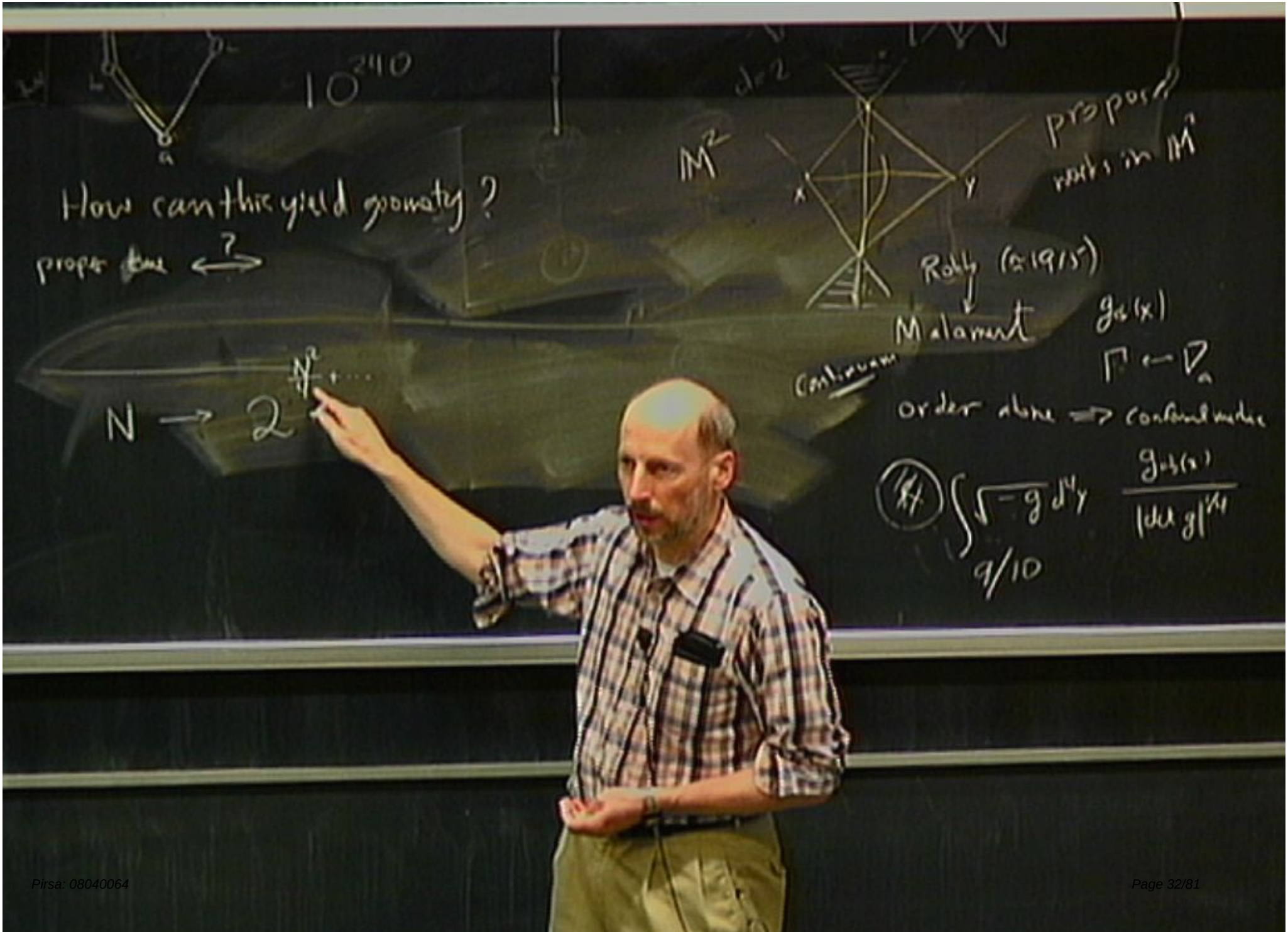

Causets
discreteness: cure ∞'s, "explains matter" (− + + +)
order + number = geometry
def Causet
elt's x, y ...
x < y
x precedes
x ancestor
transitive x<y<z ⇒
acyclic ⇐ x ≠
Part-finite
y
x
x < z
y < z
z
x
y
D(A, B)
Lorentzian
4-geometry
6 ancestors

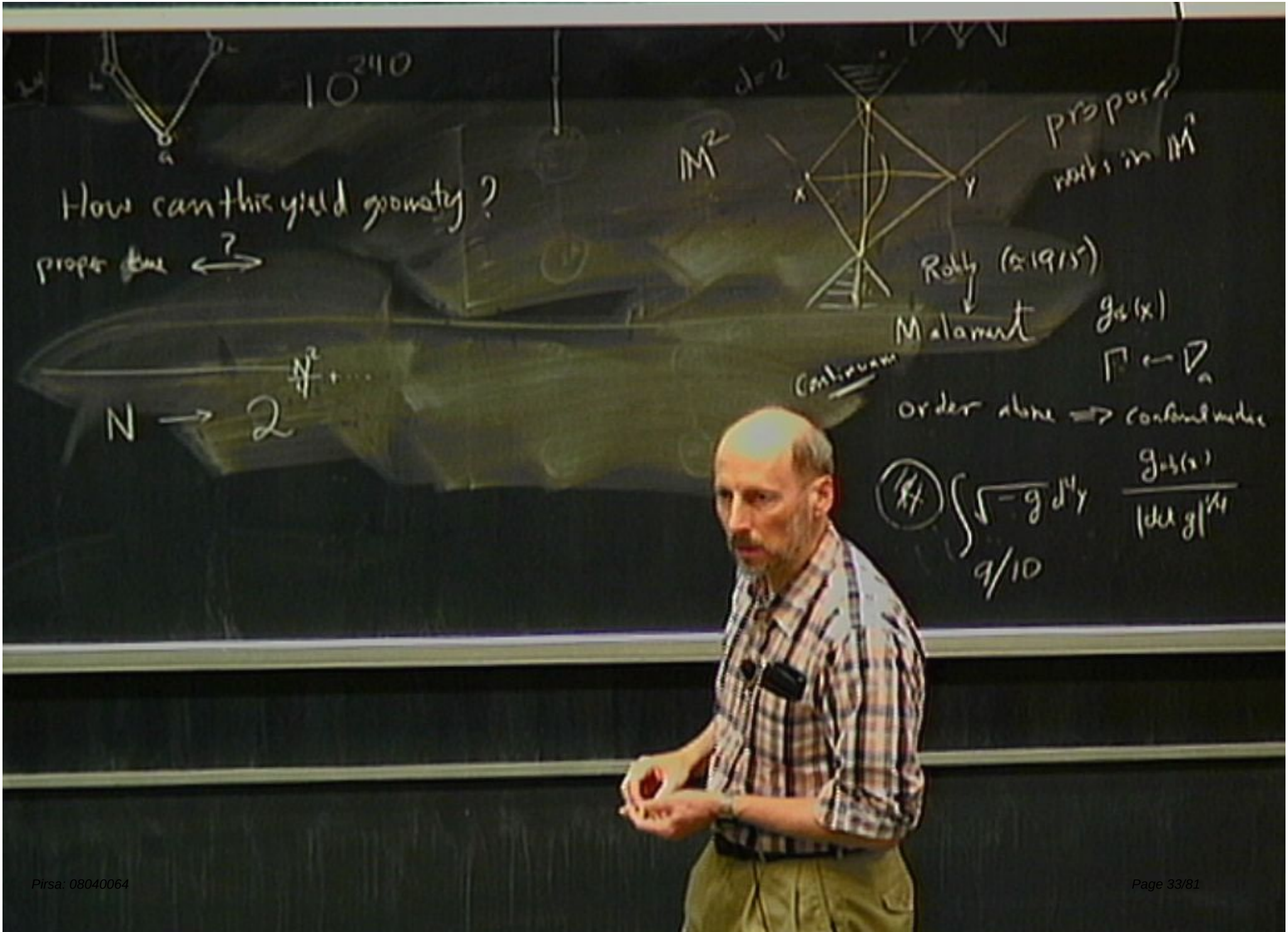

How can this yield geometry ?
M^2
Regge (~1915)
Continuum
order alone
9/10

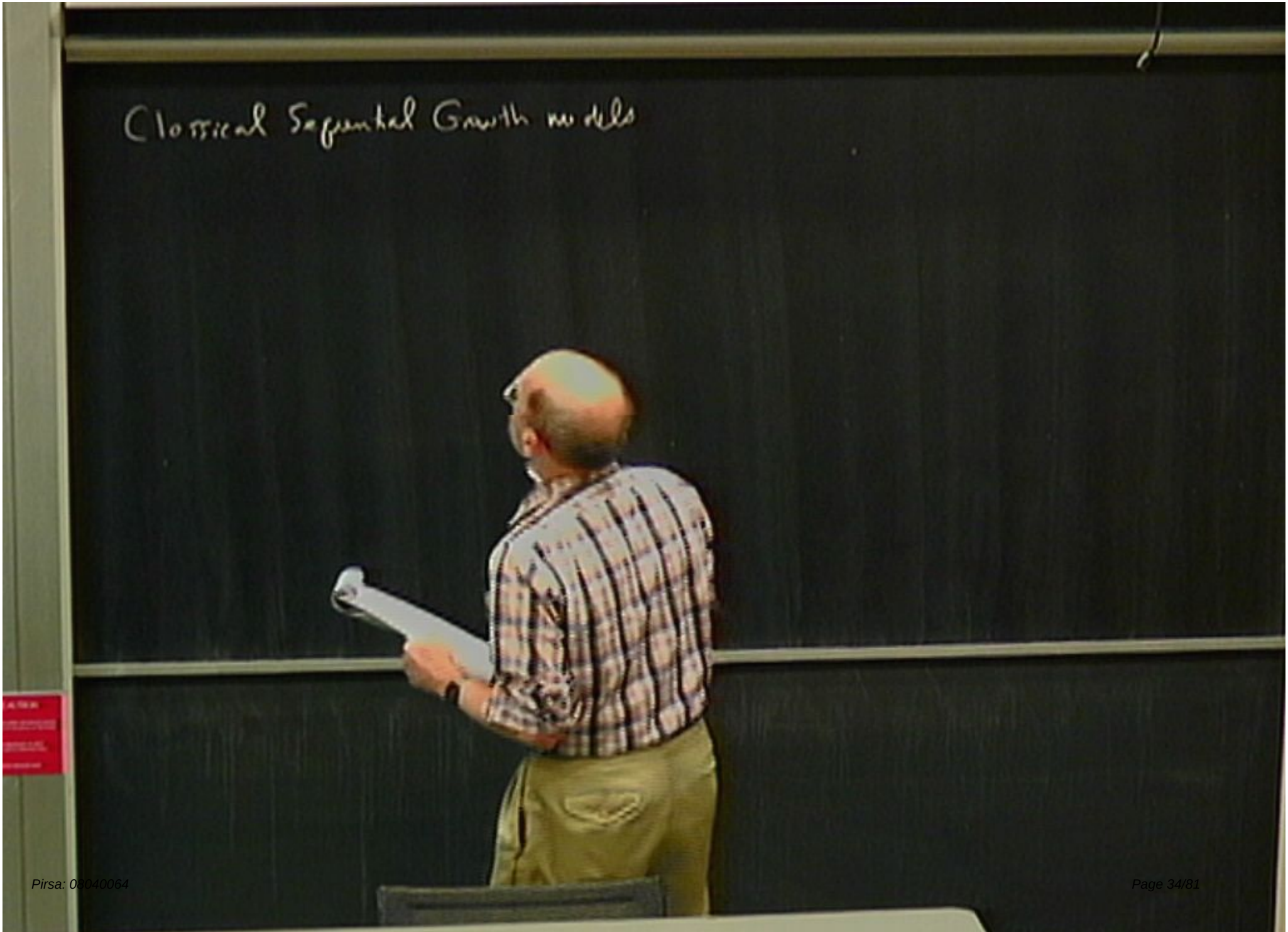

10^{240}
d=2
M^2
How can this yield geometry?
proper time
Regge (c.1915)
Minkowski
$g_{ab}(x)$
$\Gamma \leftarrow D_a$
$\frac{g_{ab}(x)}{\int d^4y \sqrt{g}\, g^{ab}}$

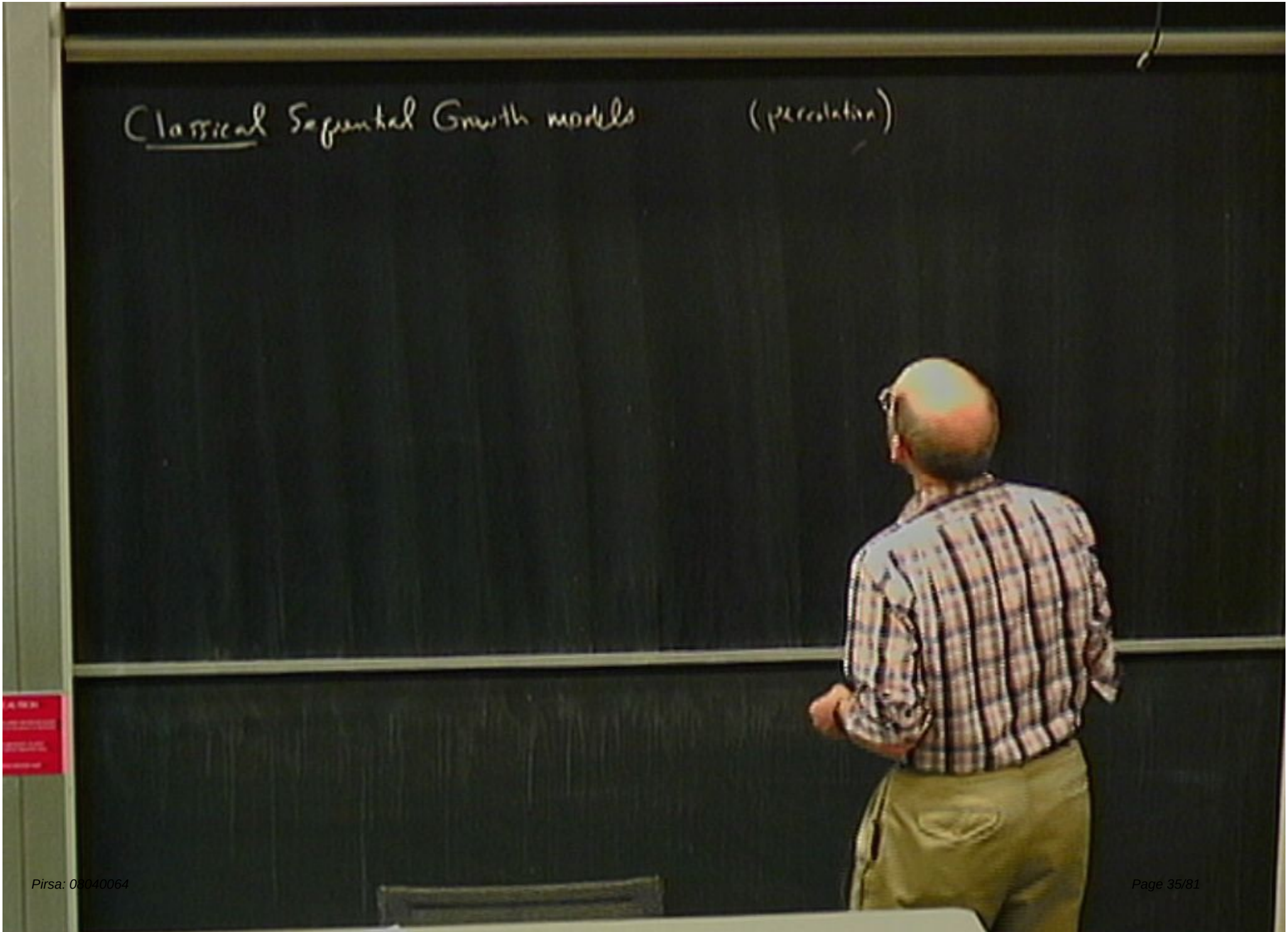

How can this yield geometry ?
proper time
Riddy (c. 1915)
Malament
order alone

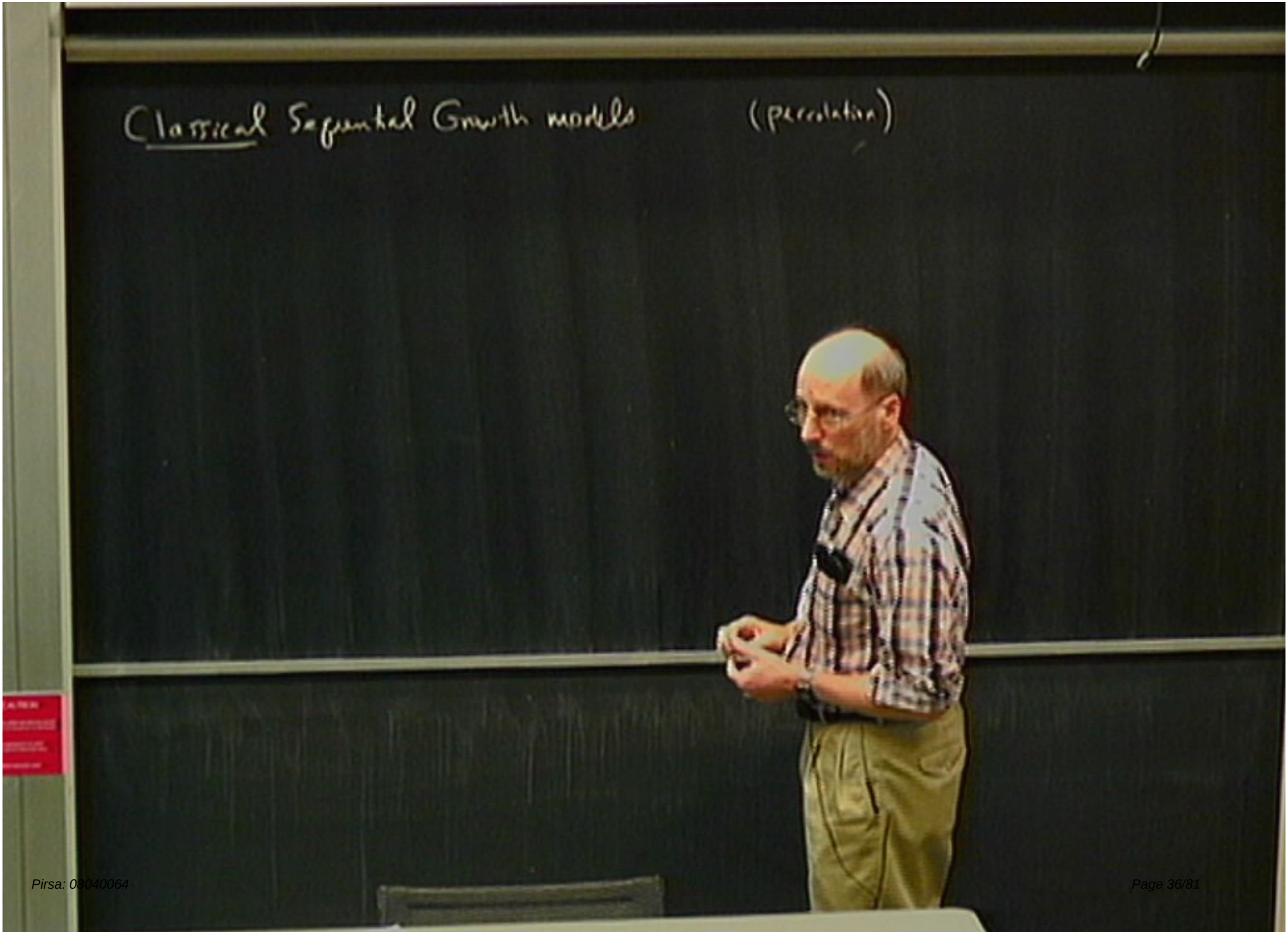

How can this yield geometry?
proper dist ⟷ ?
10^{240}
d=2
M^2
proper
reals in M^2
Rolly (≈1915)
Minimum
Continuum
$g_{ab}(x)$
$\Gamma \leftarrow D_a$
order alone ⇒ conformal modes
$\int \sqrt{-g}\, d^4y \quad \frac{g_{ab}(x)}{|dd\, g|^{1/4}}$
9/10

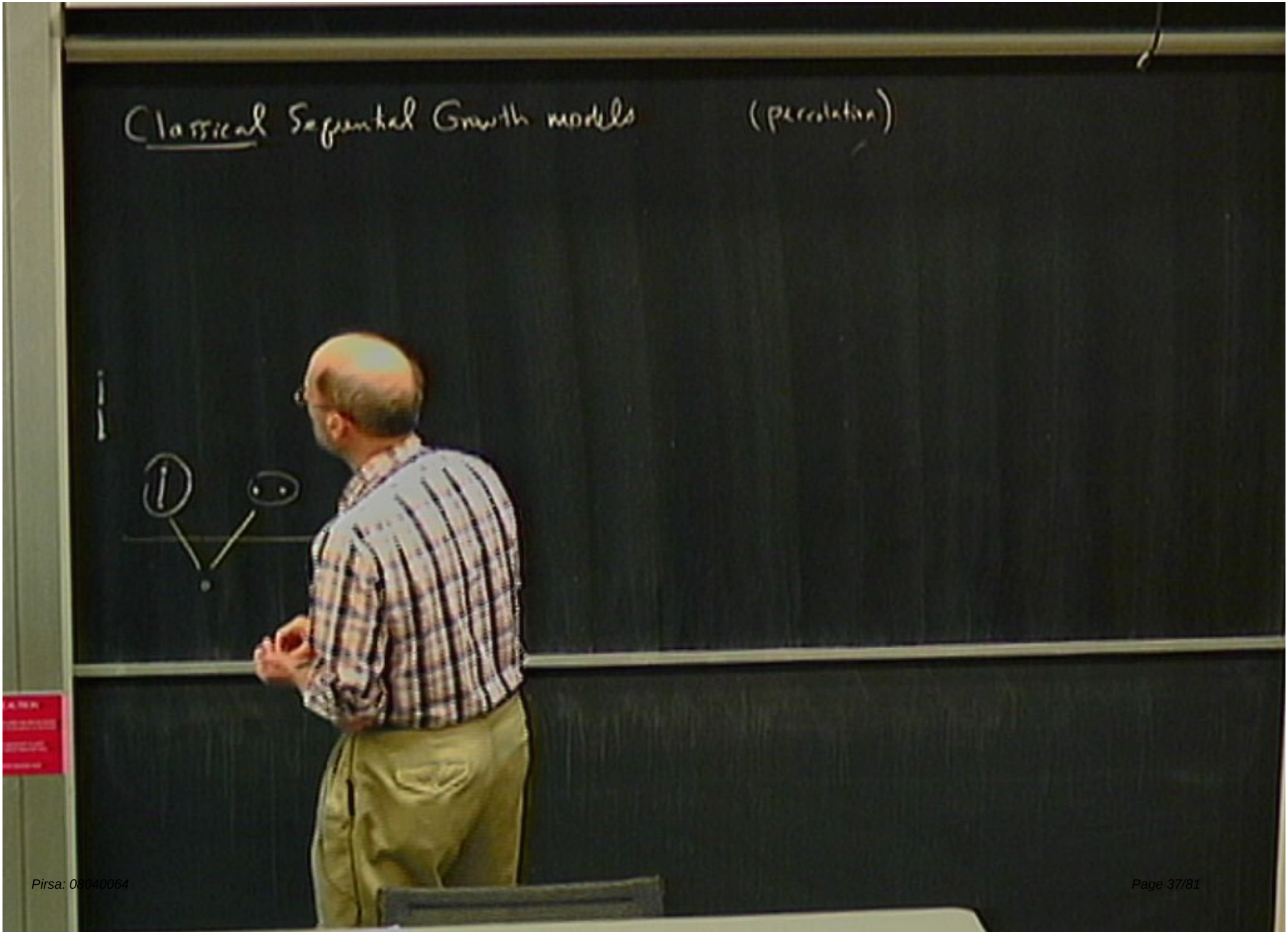

How can this yield geometry ?
proper time ?
Rolly (c. 1915)
Malament
order alone ⇒ conformal metric
9/10

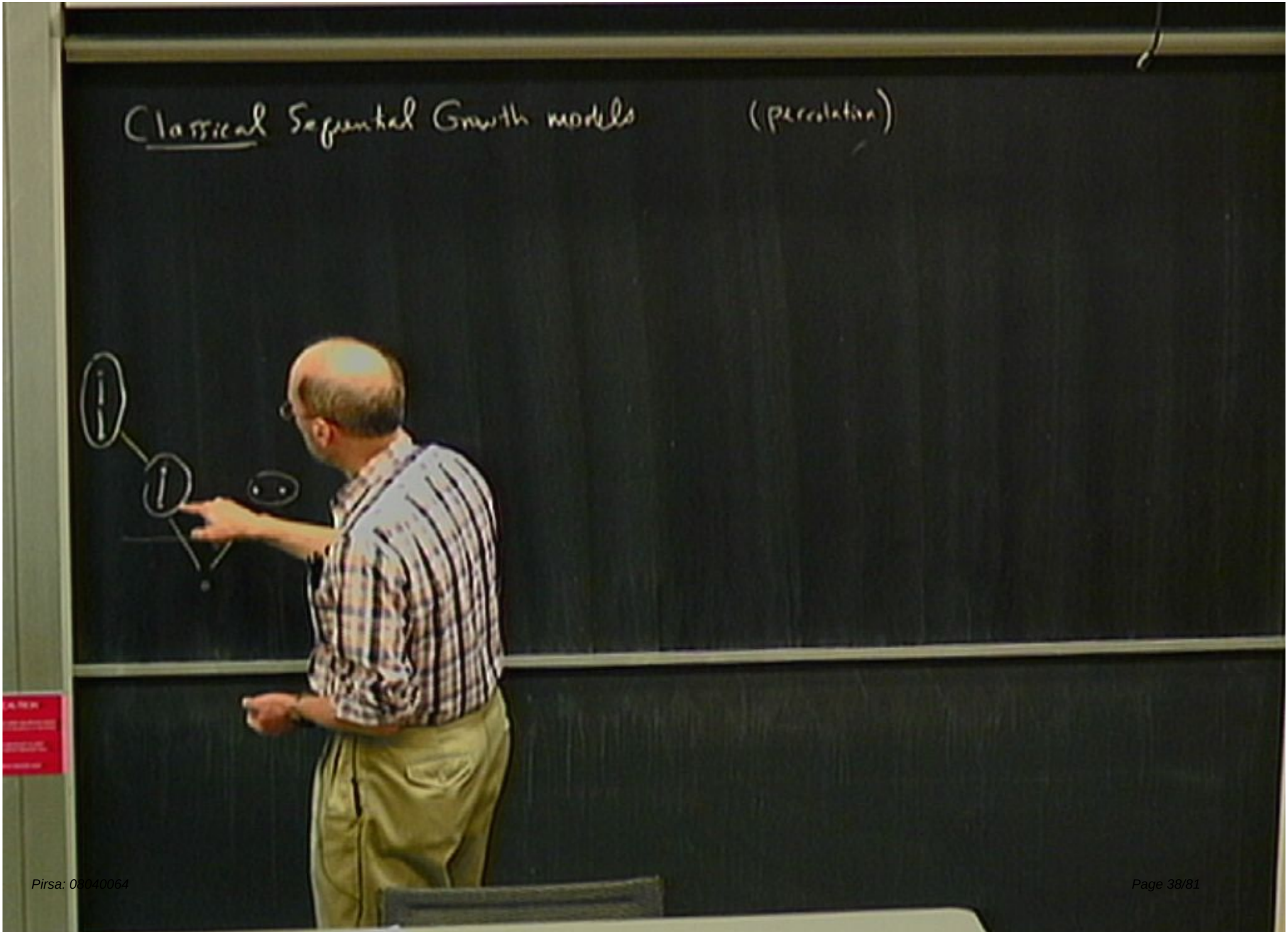

How can this yield geometry?
Reddy (c. 1915)
Malament
order alone ⇒ conformal modes
9/10

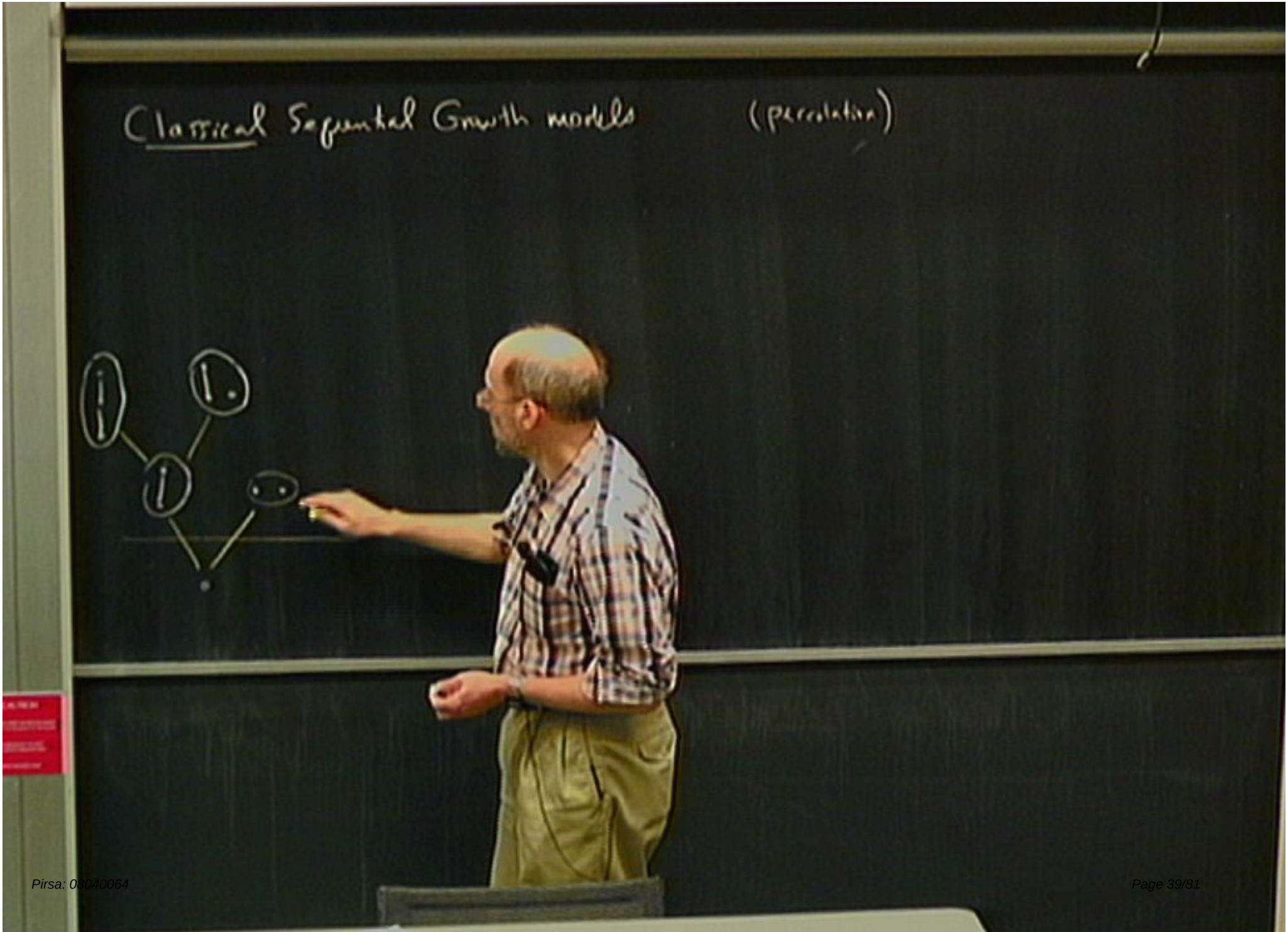

Classical Segmental Growth models

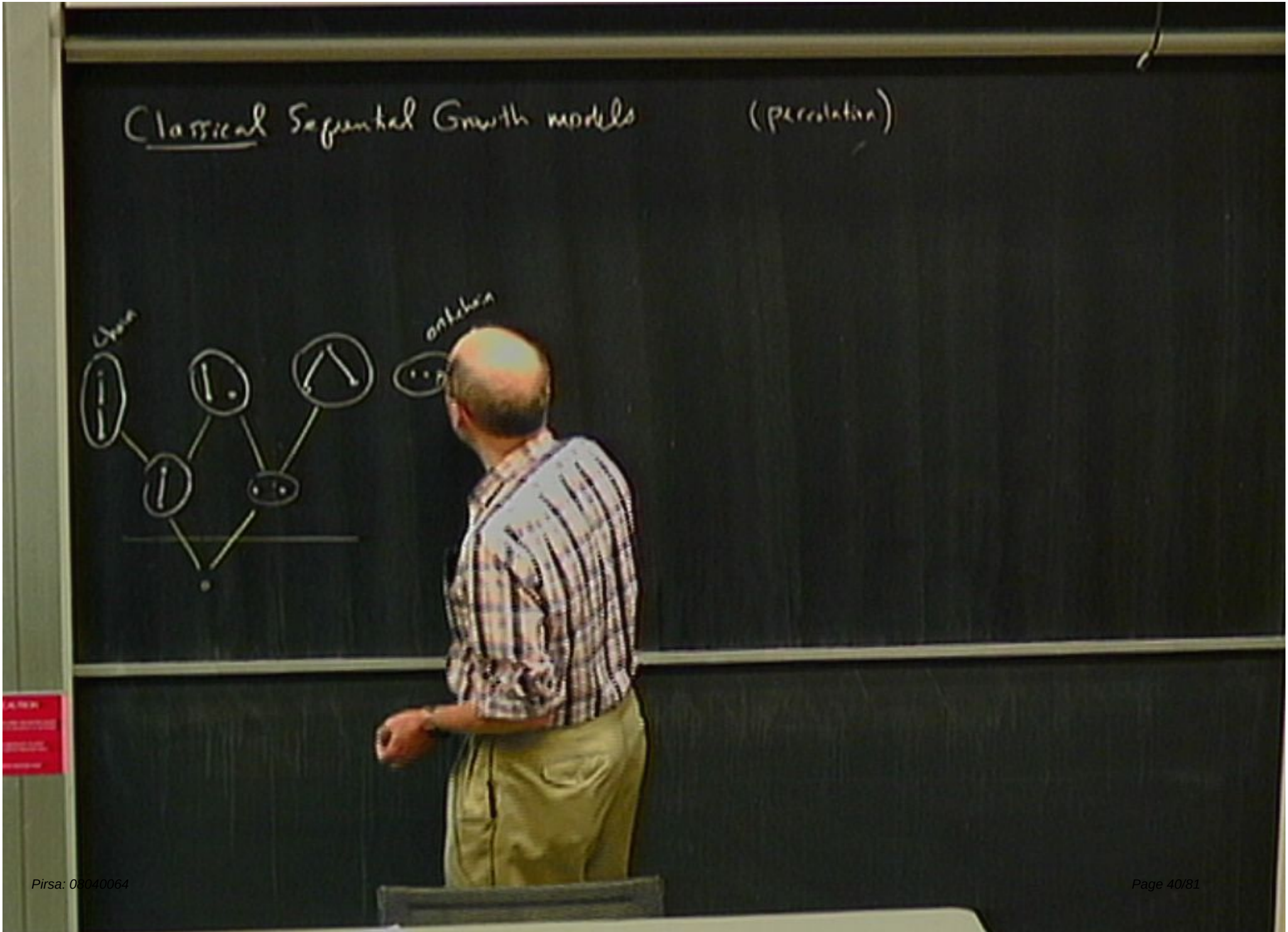

Classical Sequential Growth models
(percolation)

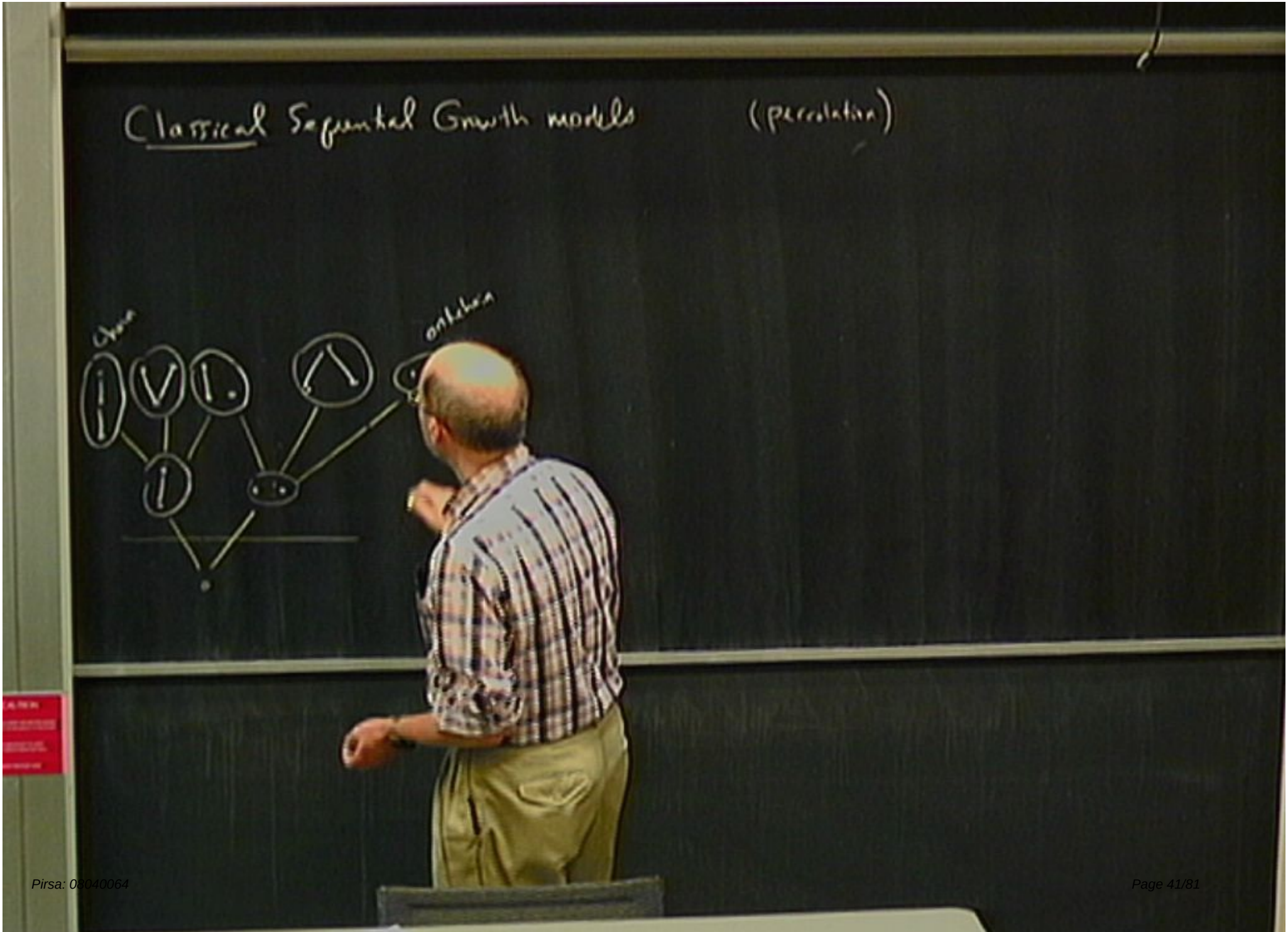

Classical Sequential Growth models
(percolation)

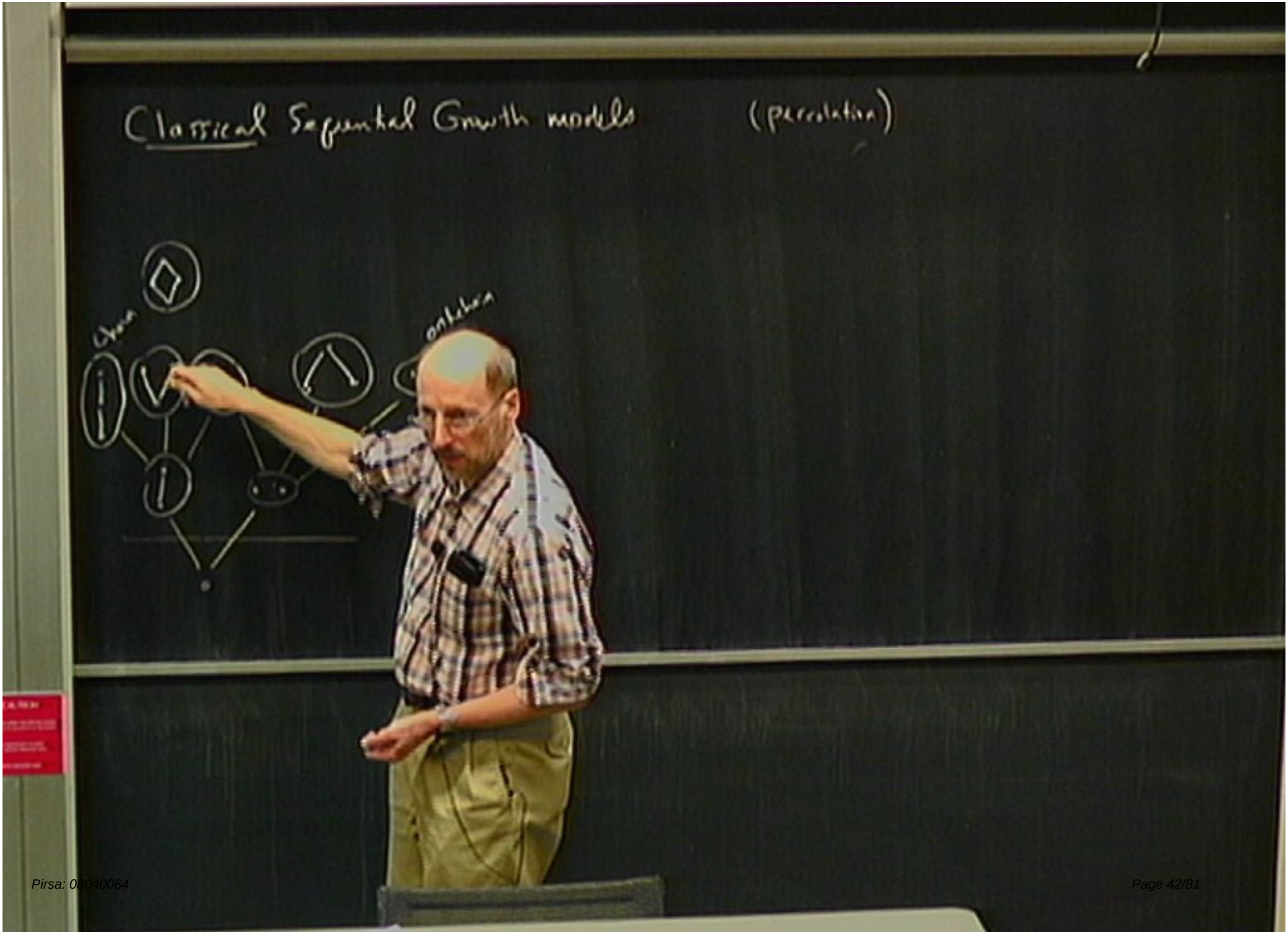

Classical Sequential Growth models
(percolation)

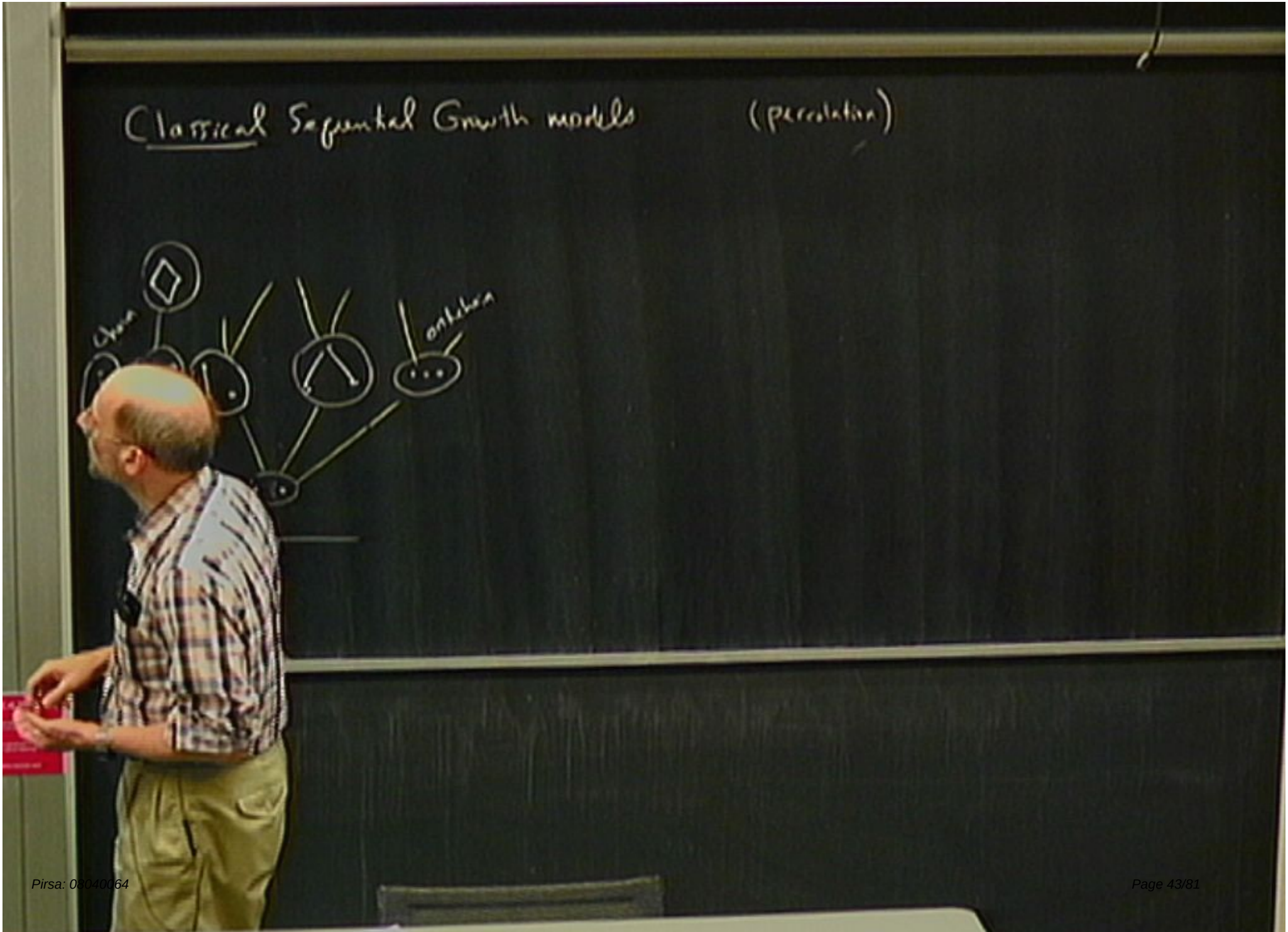

Classical Sequential Growth models
(percolation)

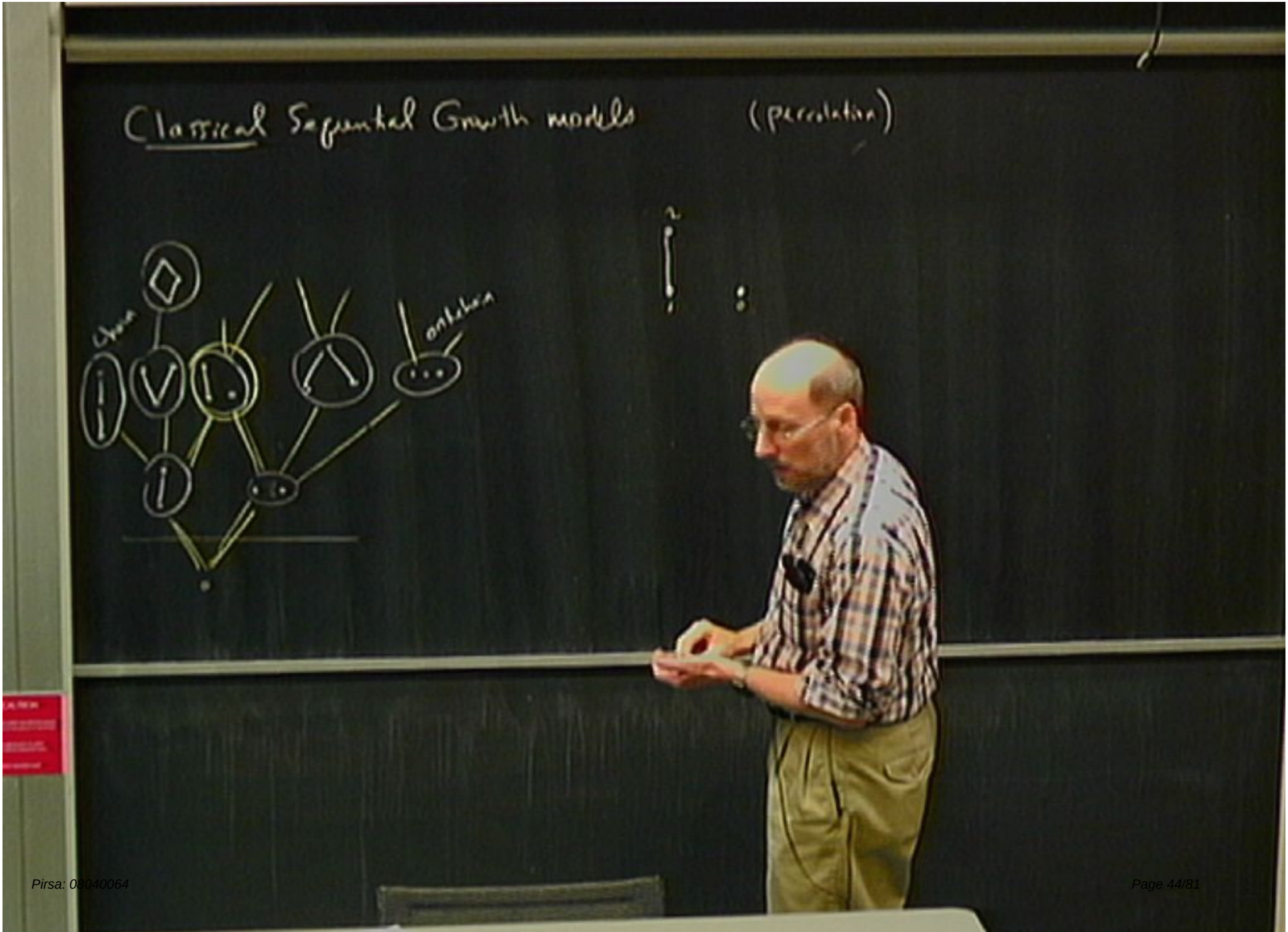

Classical Sequential Growth models
(percolation)

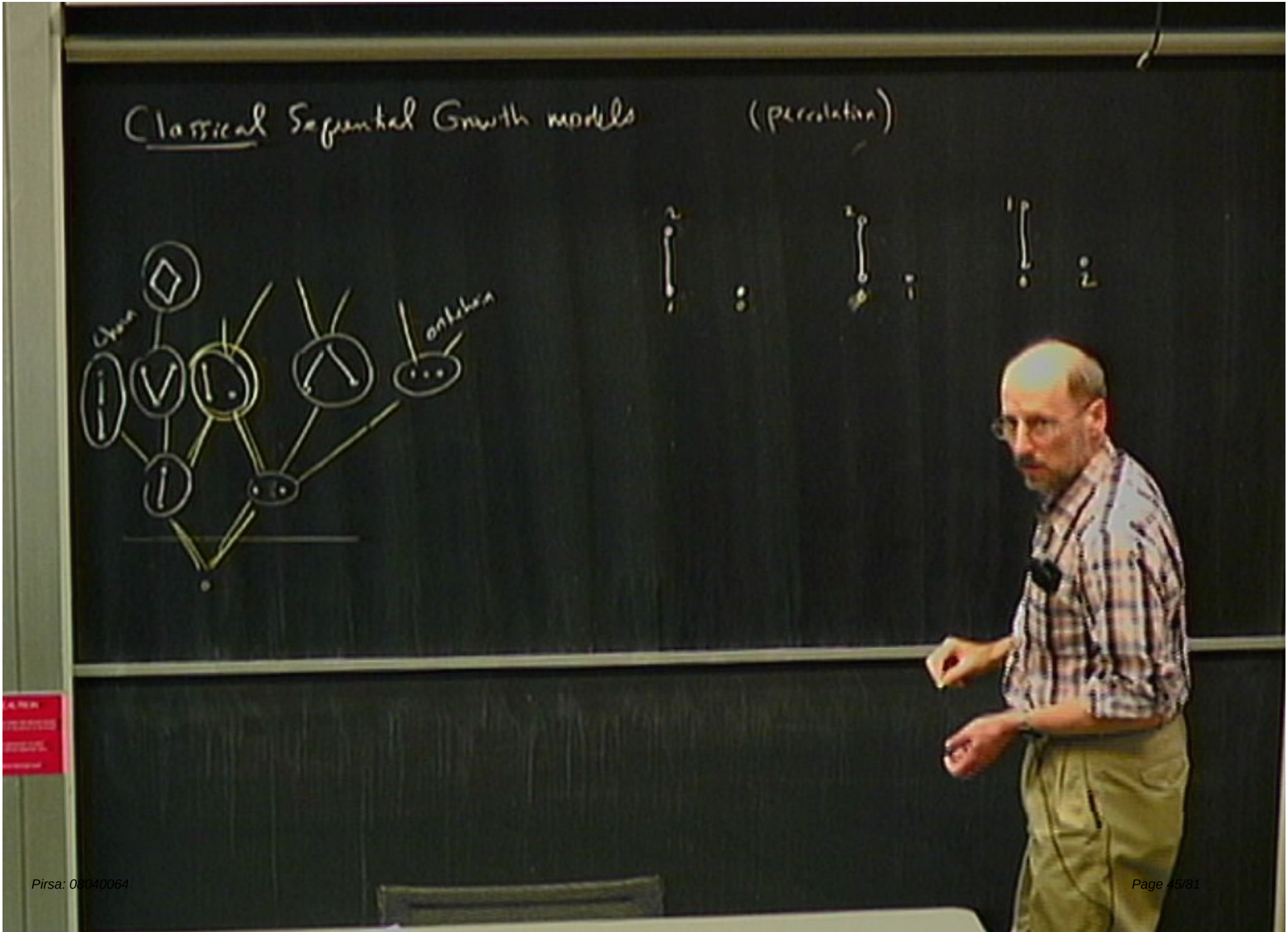

Classical Sequential Growth models
(percolation)

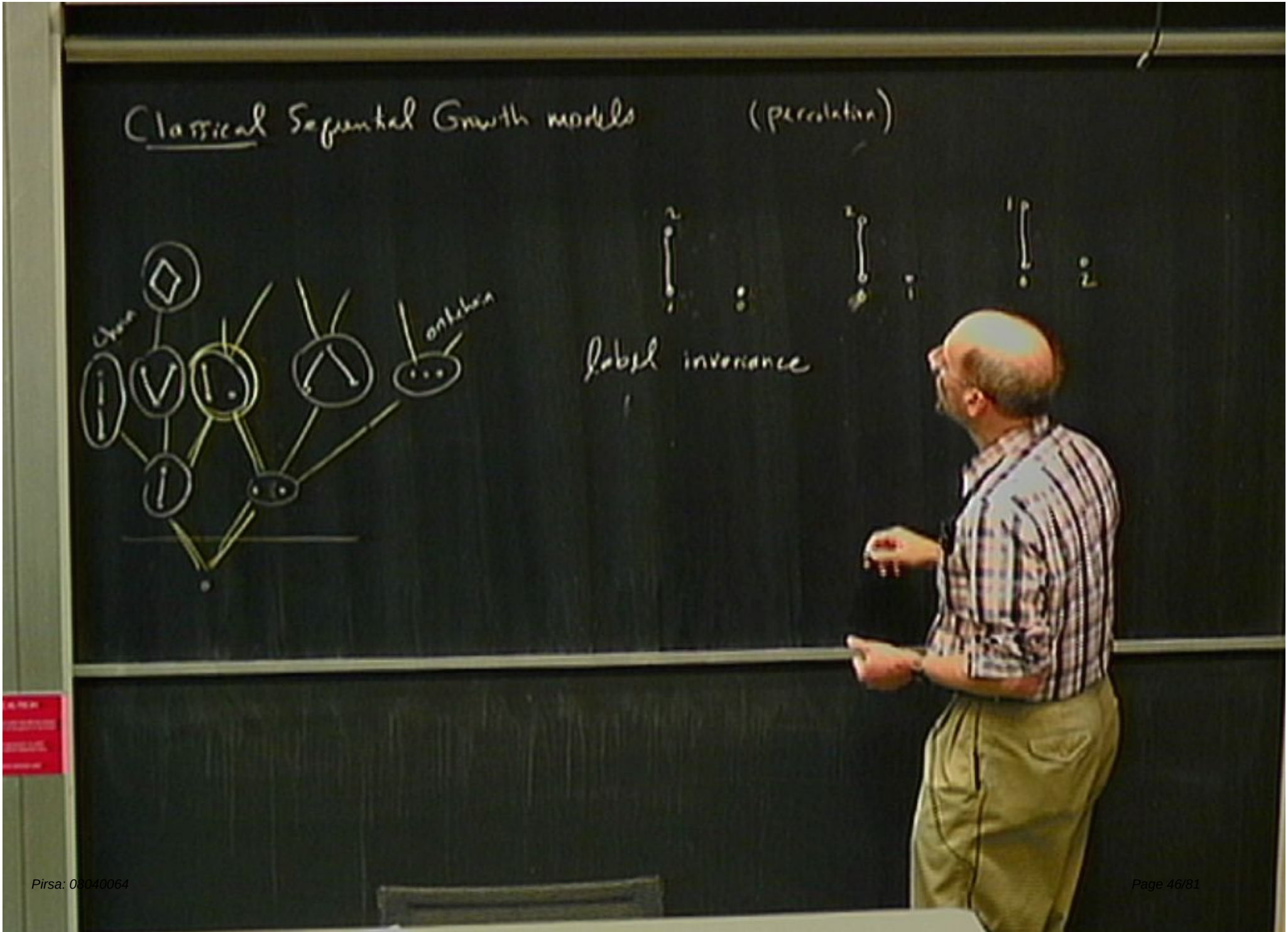

Classical Sequential Growth models
(percolation)

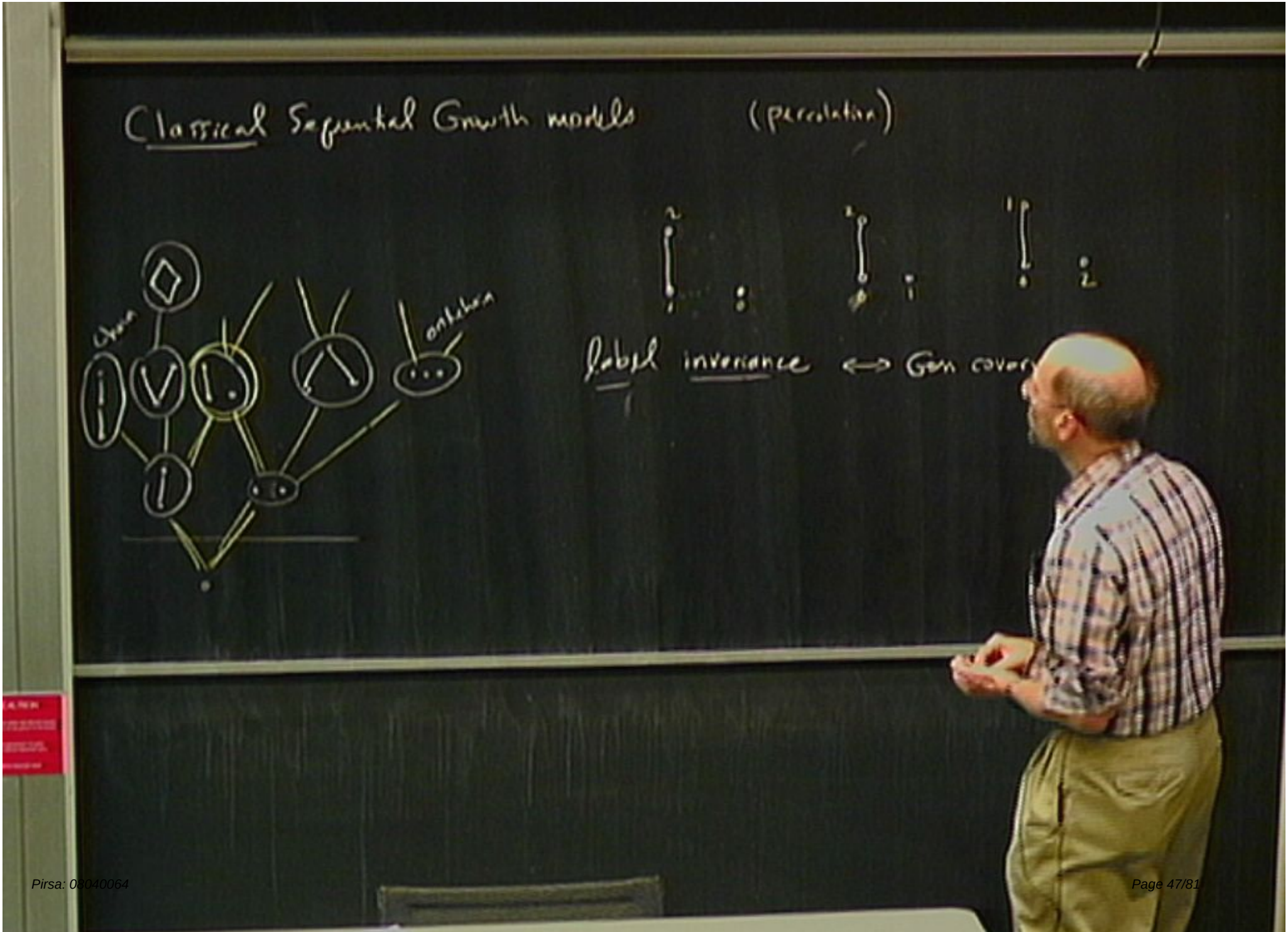

Classical Sequential Growth models
(percolation)


Classical Sequential Growth models
(percolation)


Classical Sequential Growth models
(percolation)


Classical Sequential Growth models
(percolation)

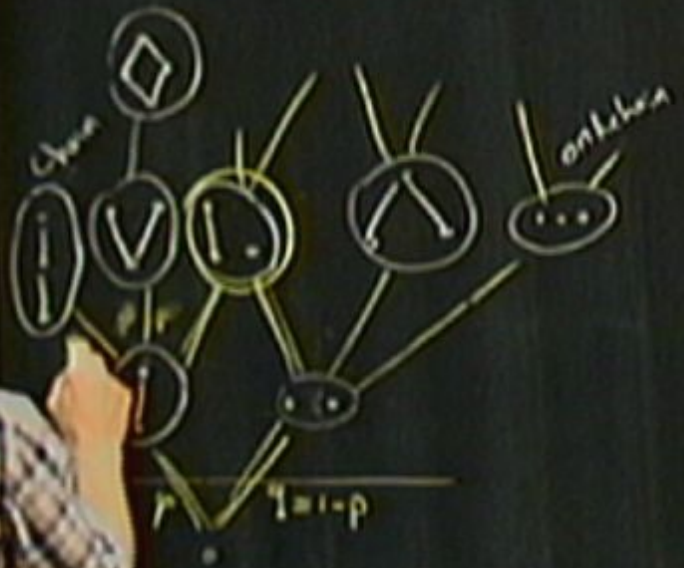

Classical Sequential Growth models (percolation)
label invariance


Classical Sequential Growth models (percolation)
label invariance ↔ Gen cover

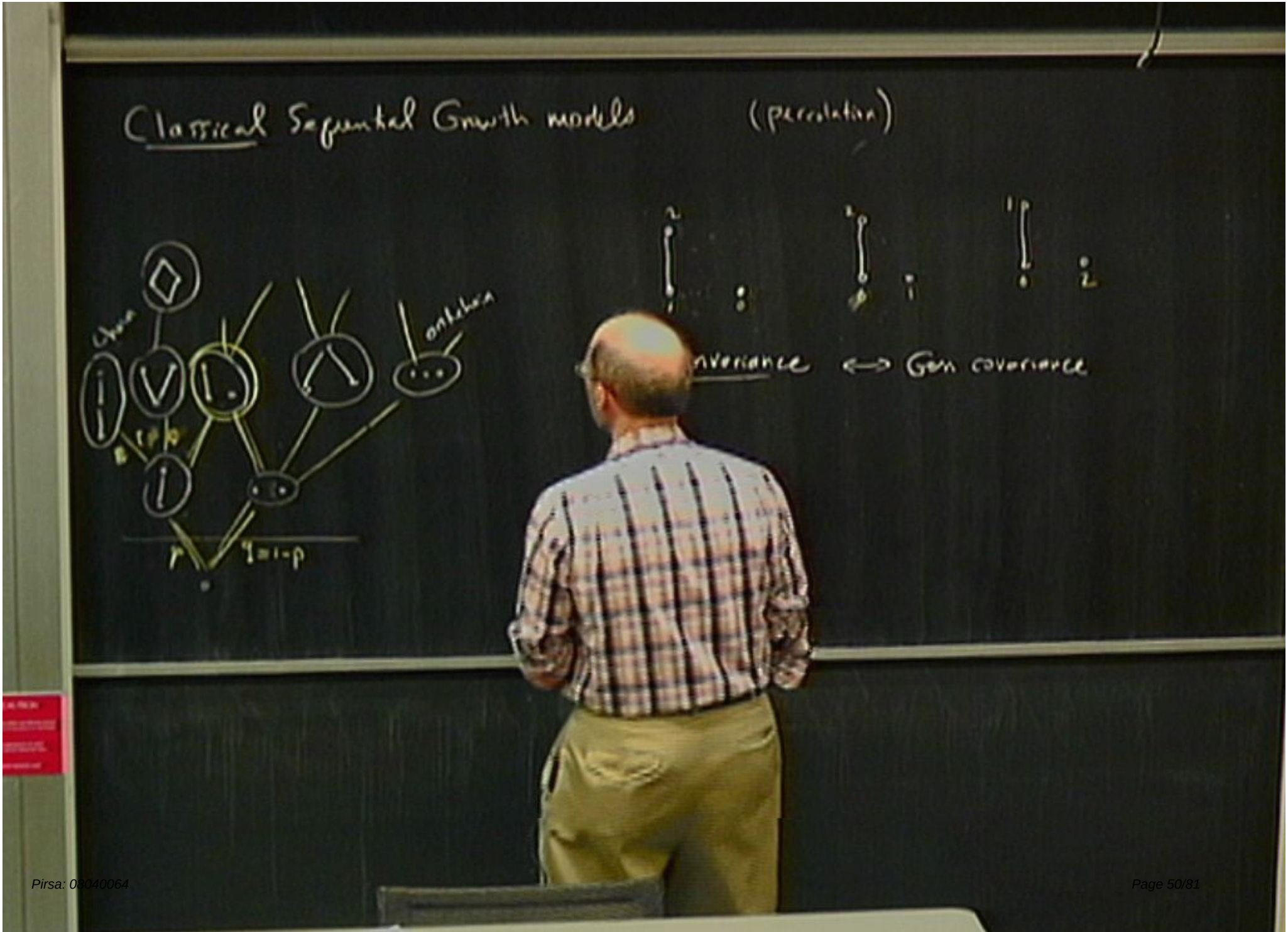
Classical Sequential Growth models (percolation)

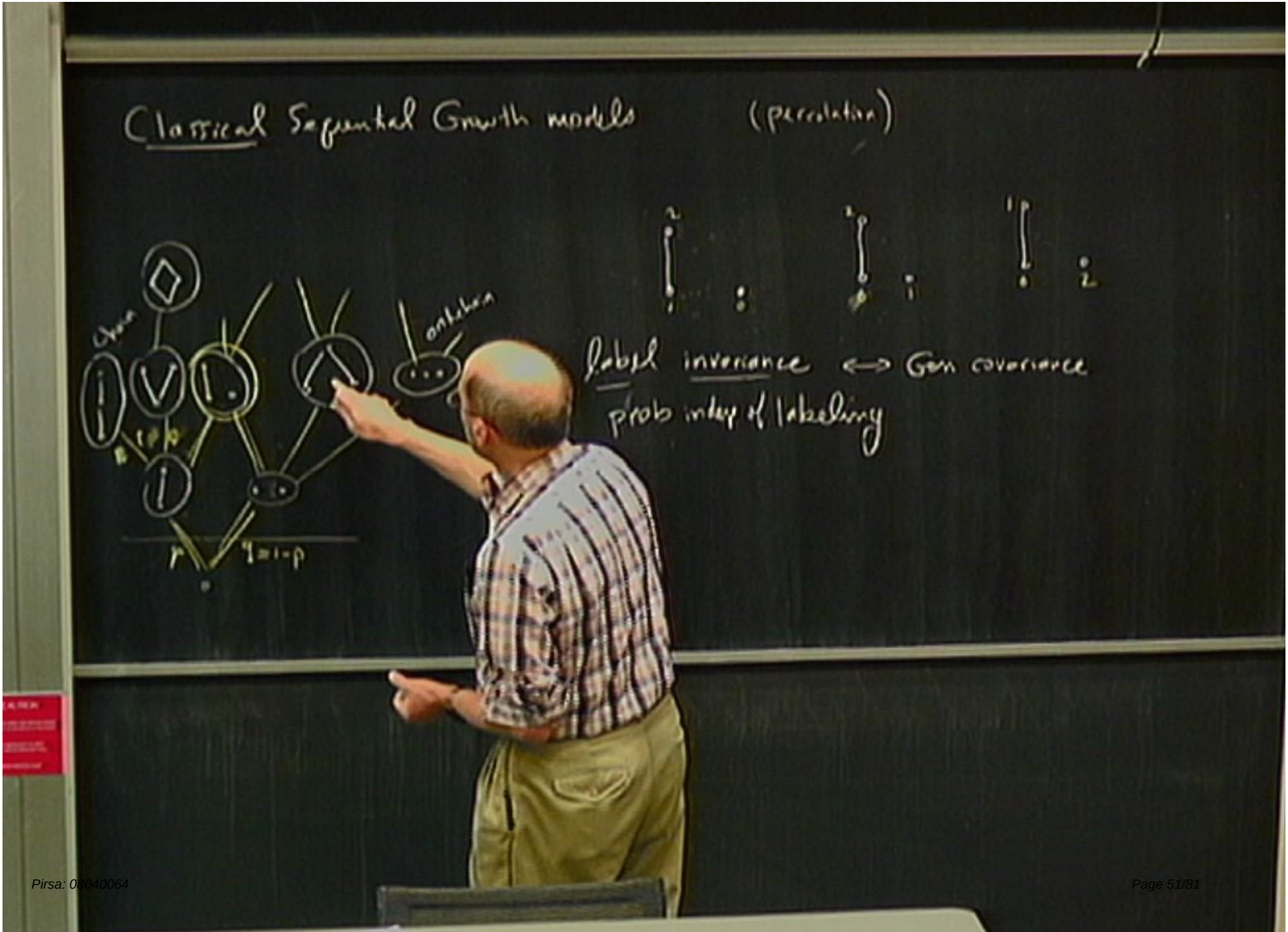
labeled invariance ↔ Gen covariance

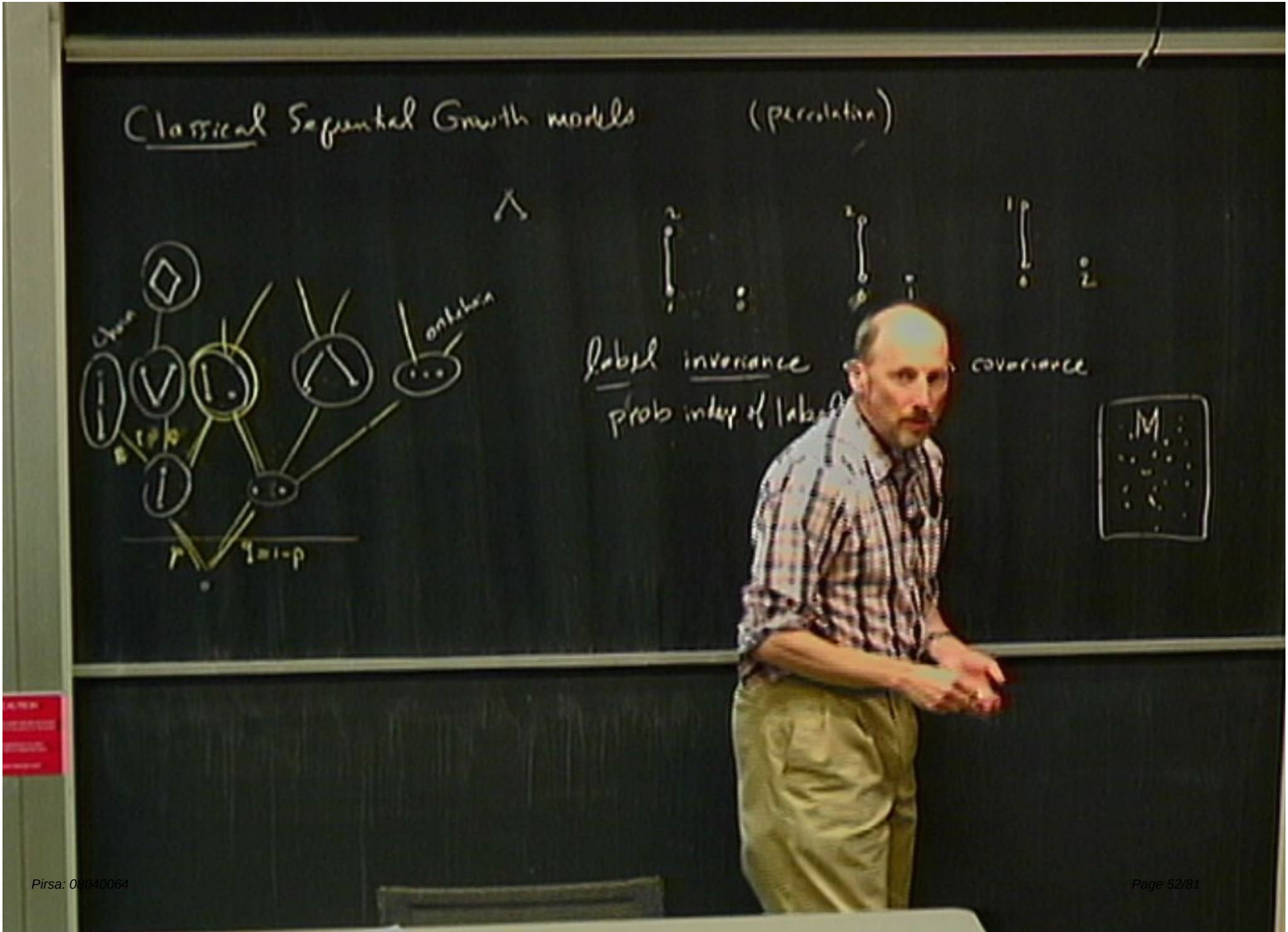
Classical Sequential Growth models (percolation)

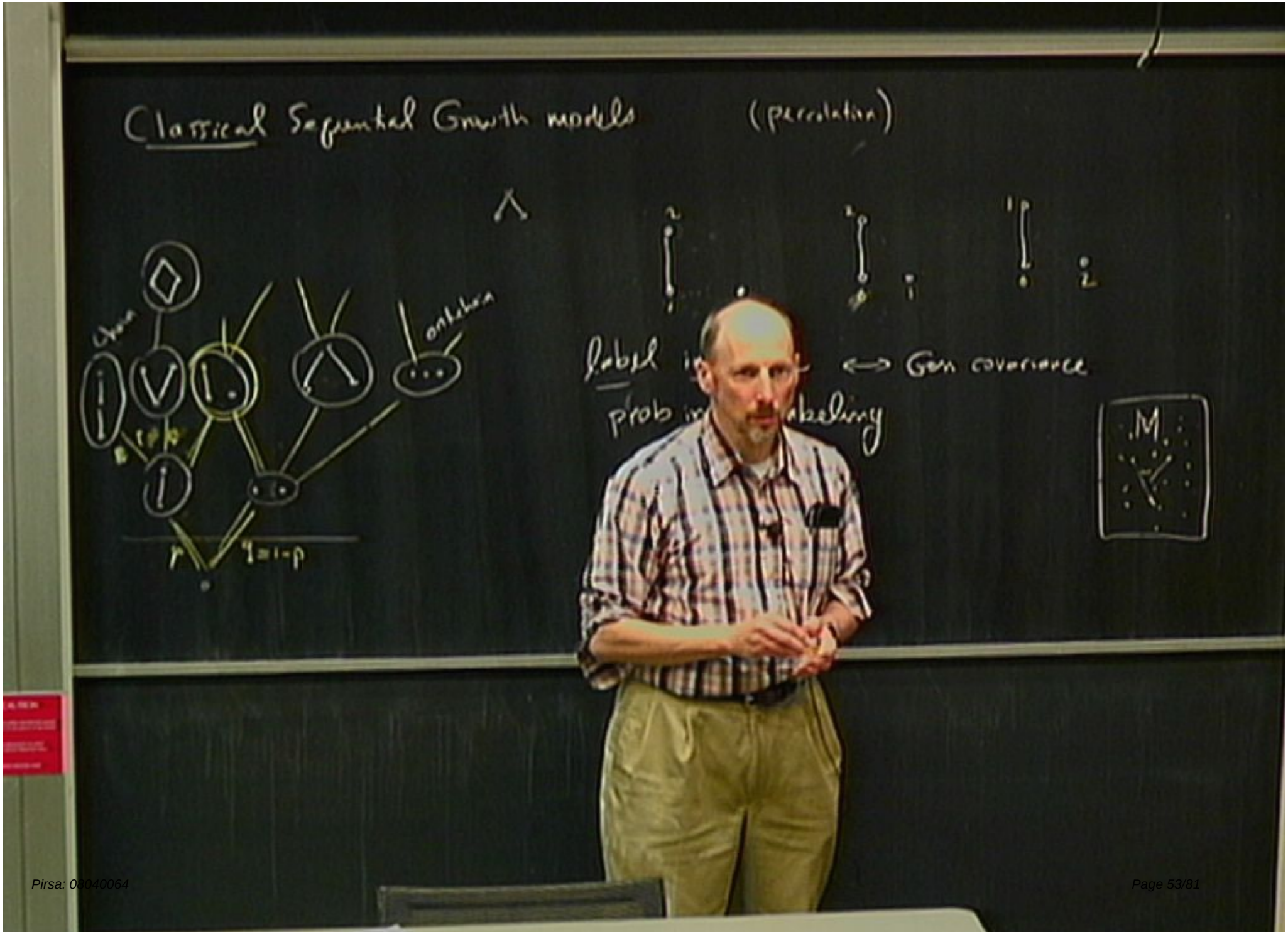


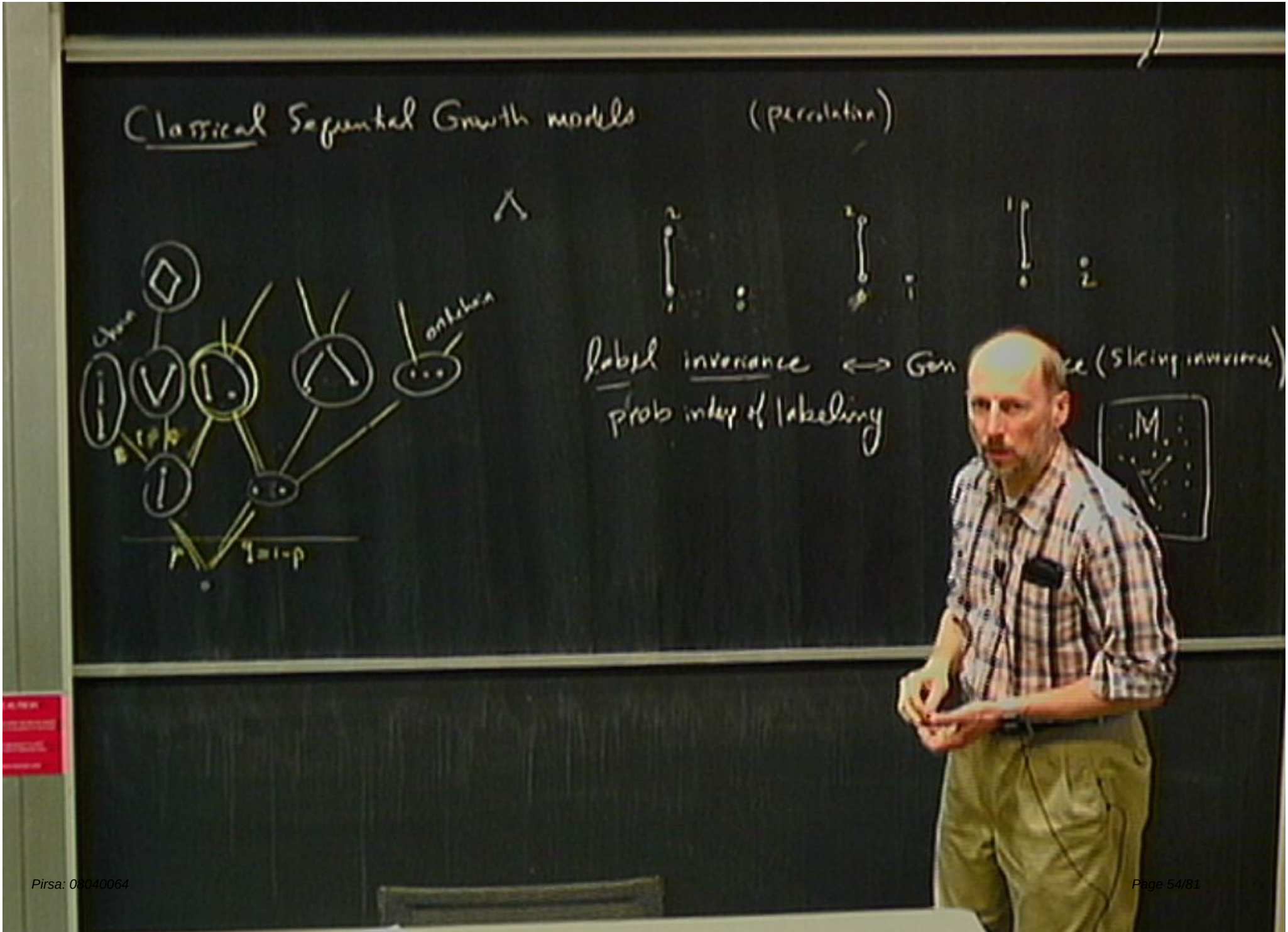
label invariance ↔ Gen covariance

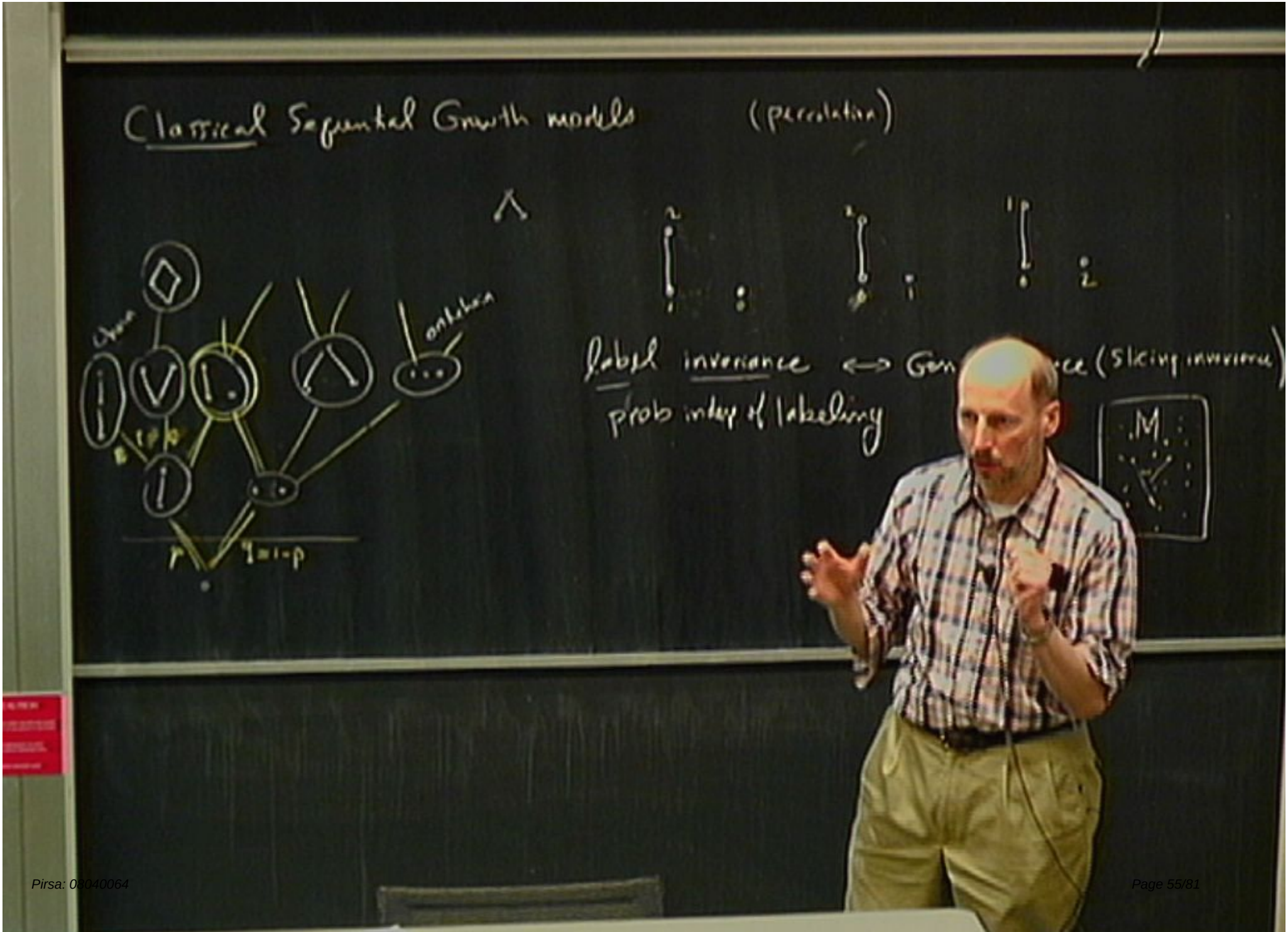

Classical Sequential Growth models (percolation)
Gen covariance

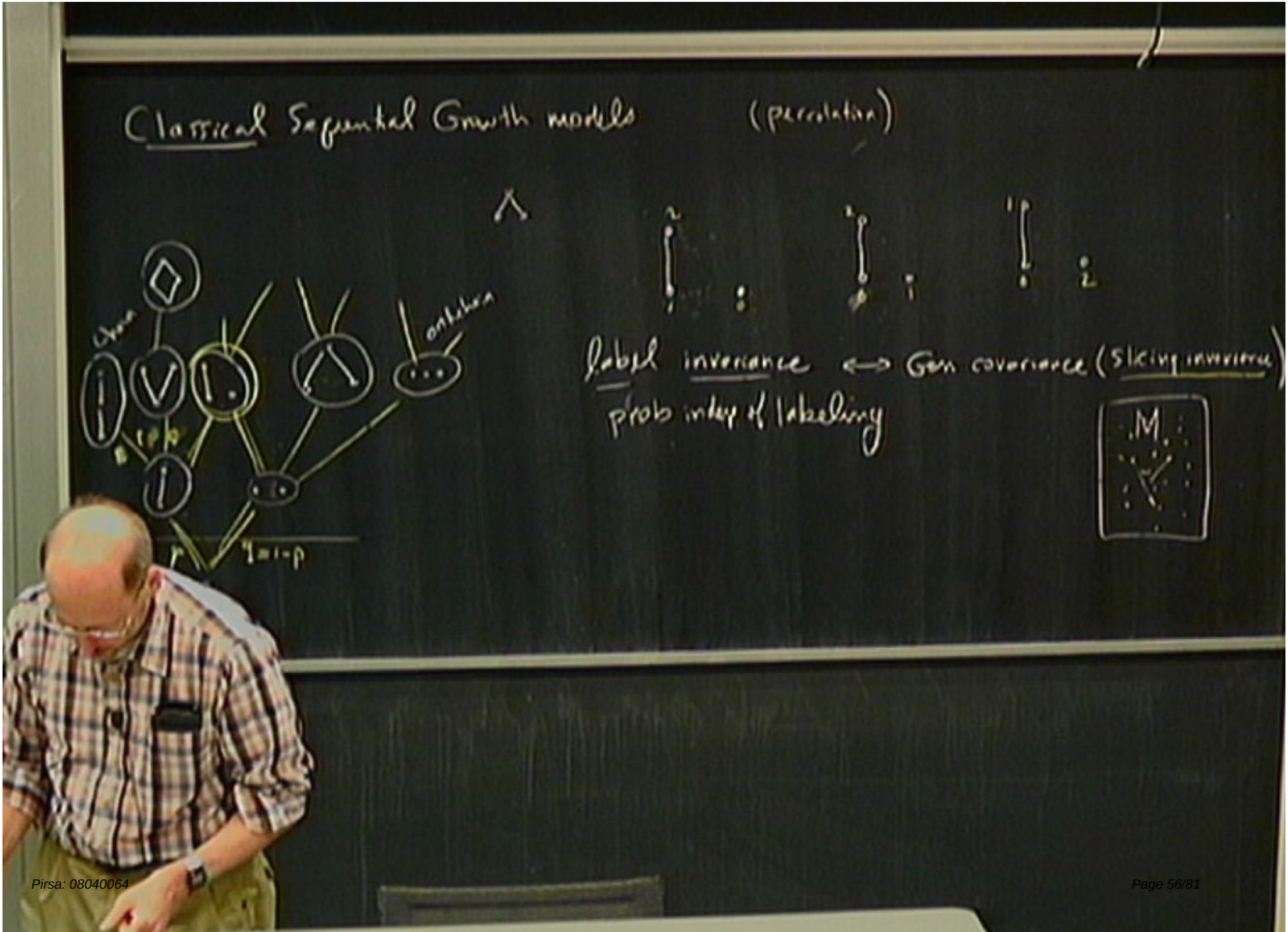

Classical Sequential Growth models (percolation)
label invariance ↔ Gen covariance
prob indep of labeling

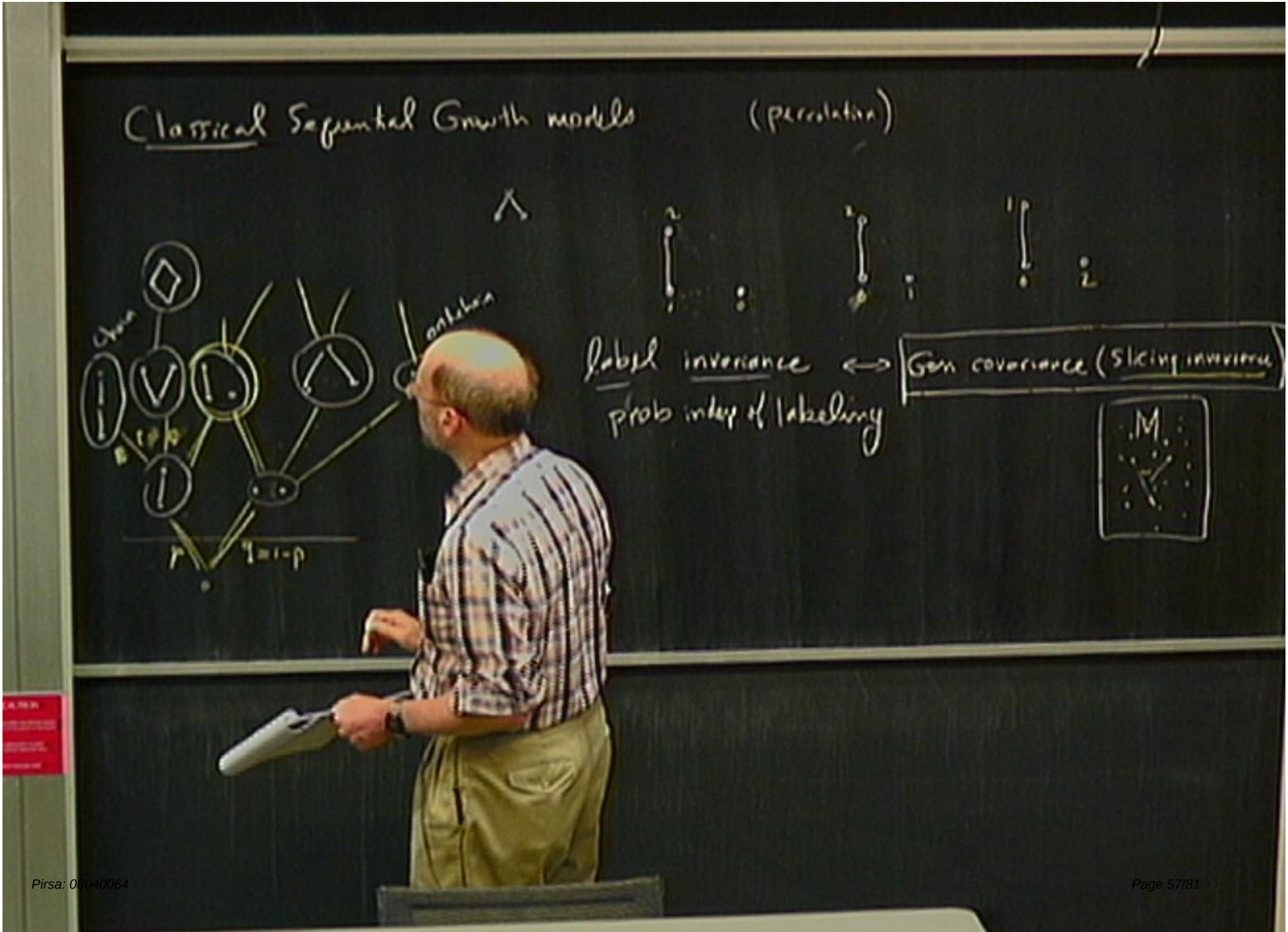

Classical Sequential Growth models
(percolation)
label invariance
covariance
prob indep of label
M

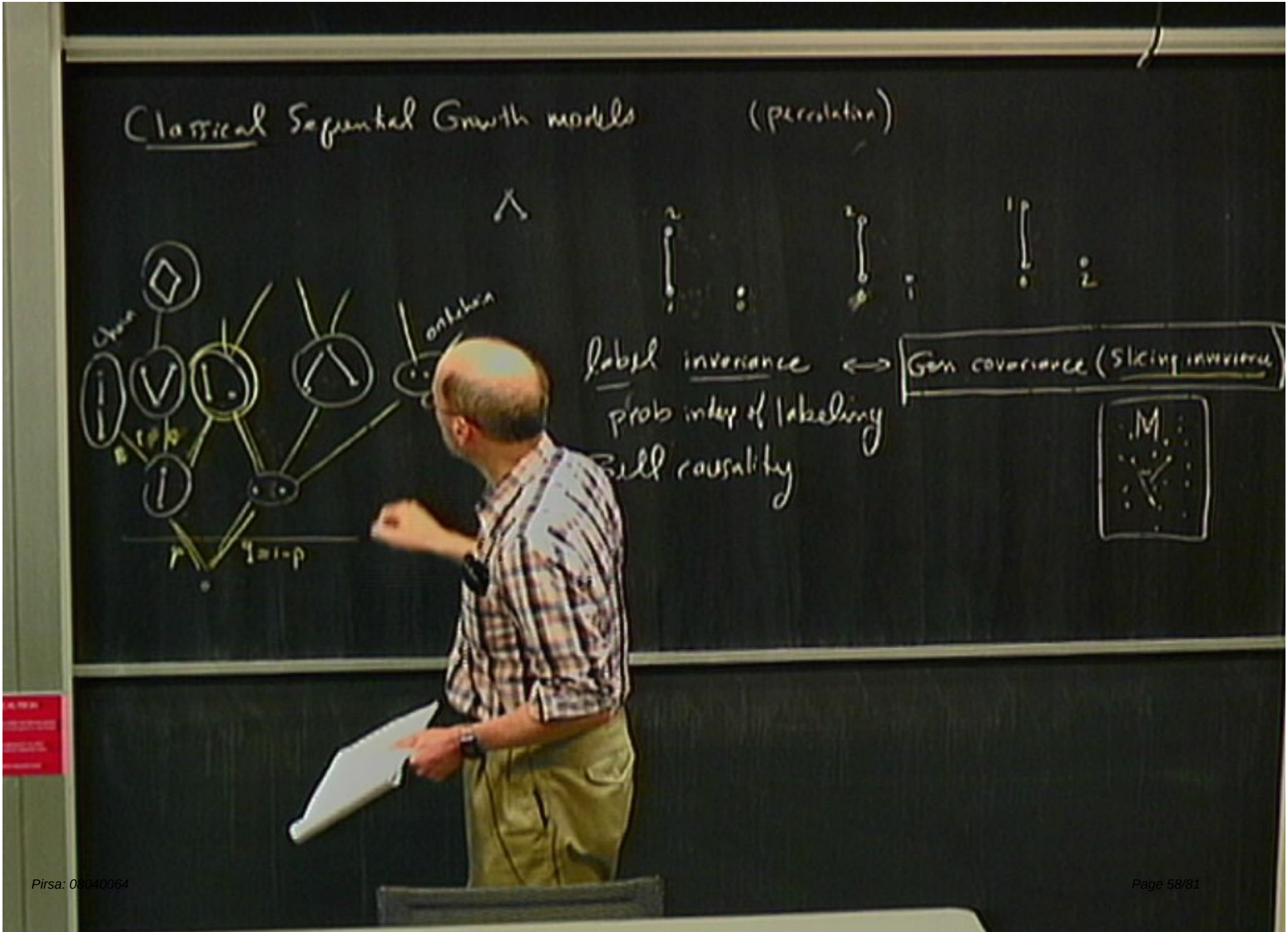

Classical Sequential Growth models (percolation)
labels
Gen covariance
M

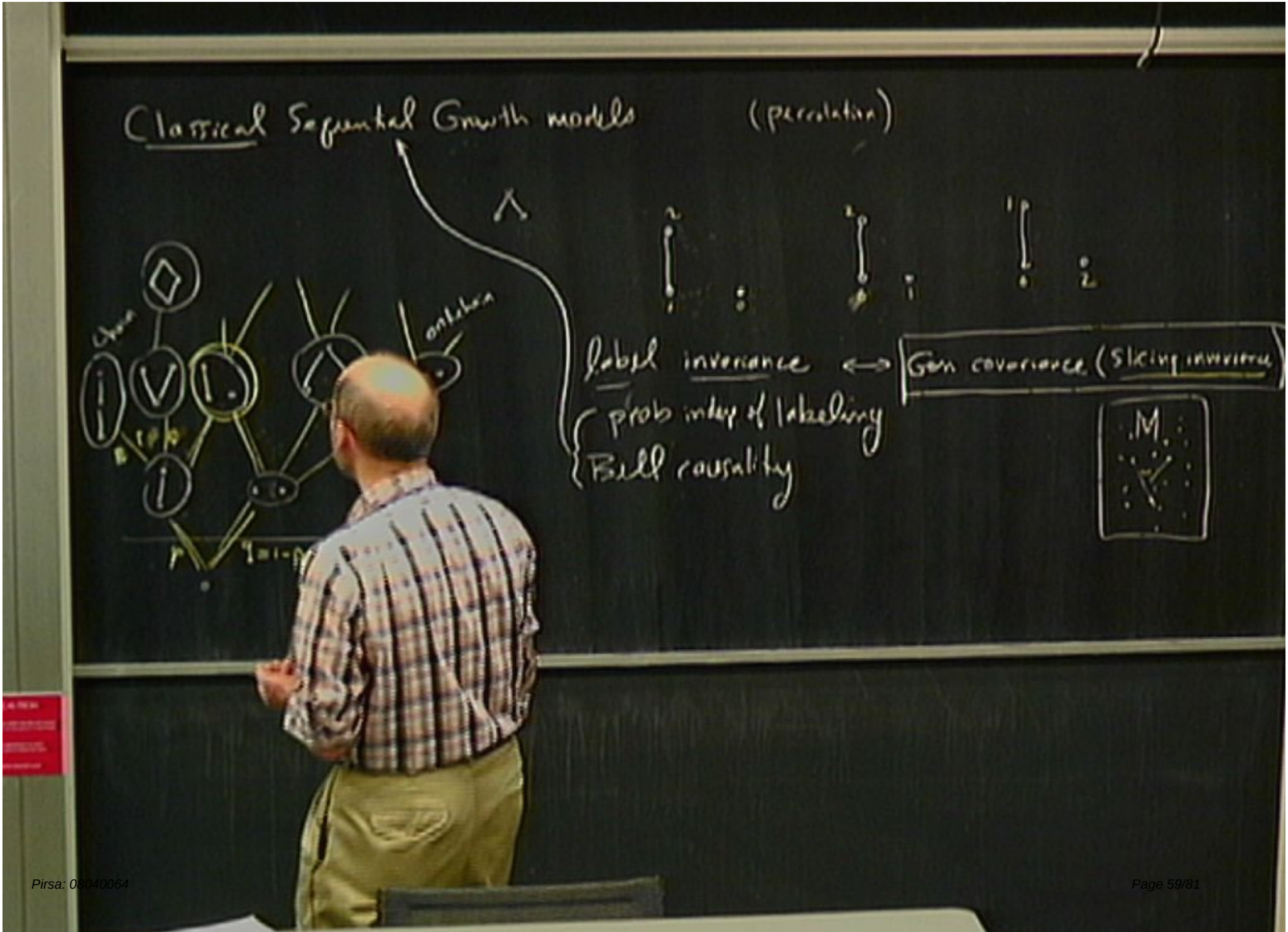

Classical Sequential Growth models
(percolation)
label invariance
prob indep of labeling
M
p
1-p

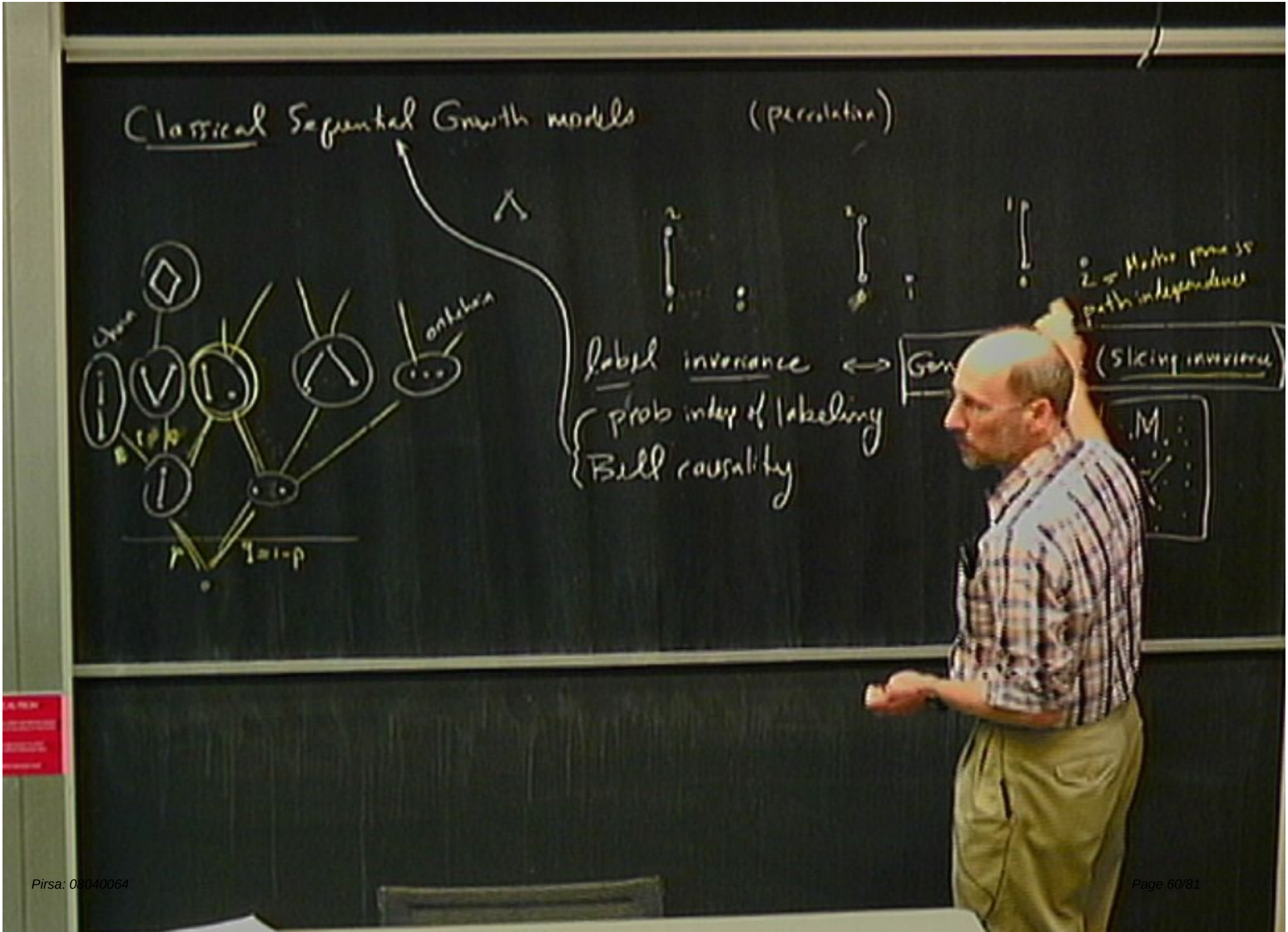

Classical Sequential Growth models
(percolation)
label invariance
prob indep of labeling
M

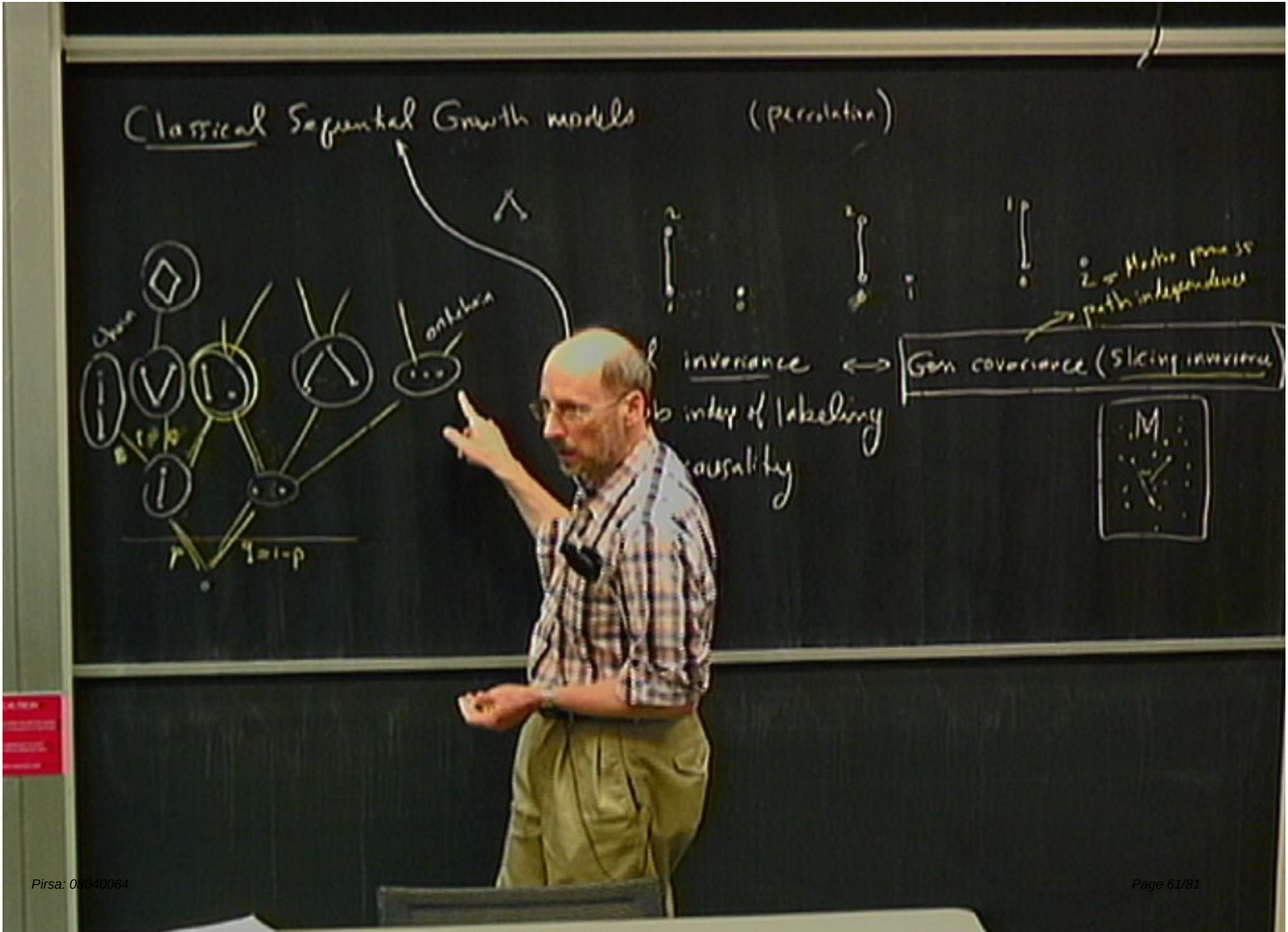

Classical Sequential Growth models (percolation)
label invariance ↔ Gen covariance (slicing invariance)
prob indep of labeling
M

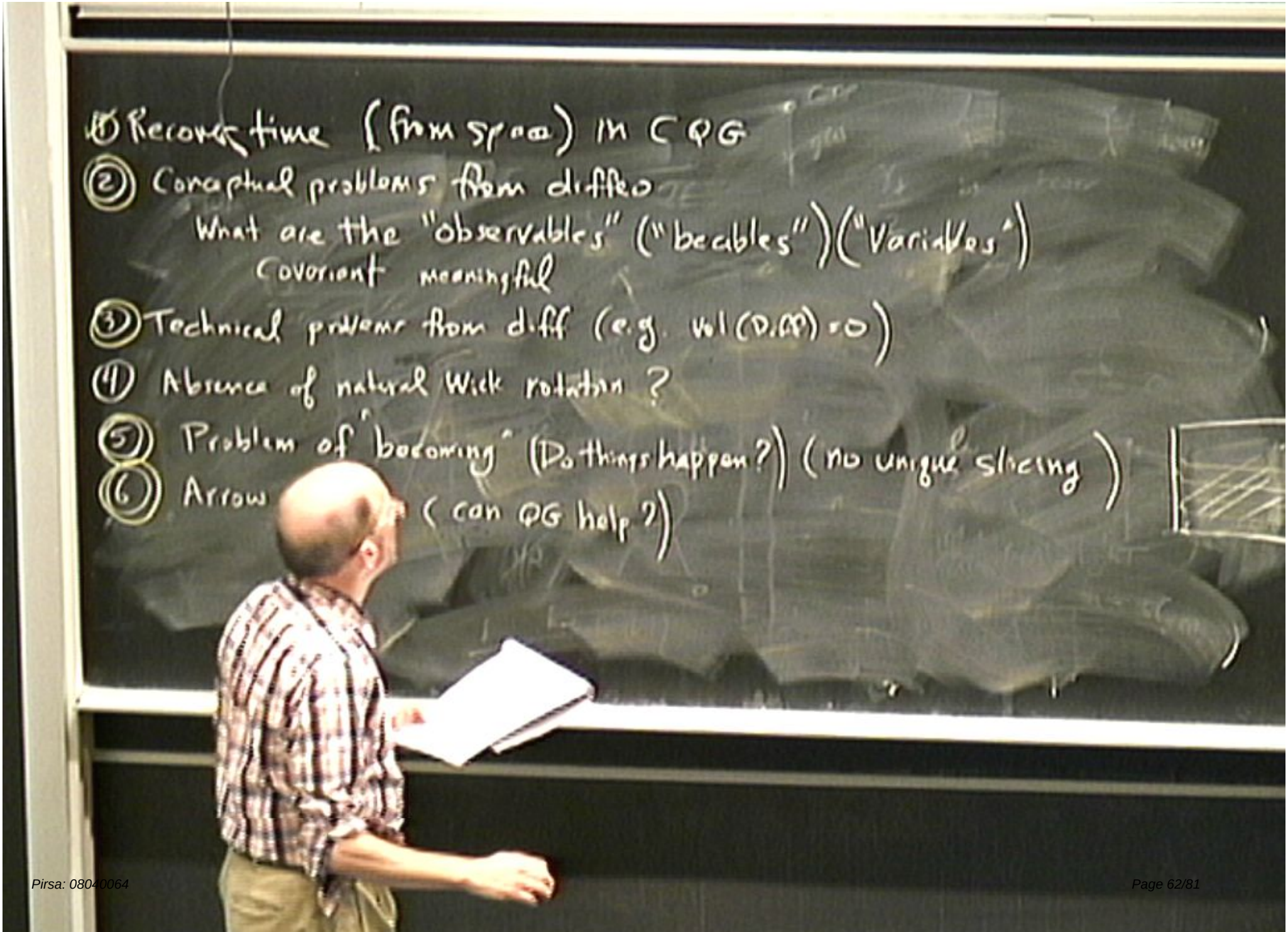

Classical Sequential Growth models (percolation)
label invariance ↔ Gen covariance (Slicing invariance)
prob indep of labeling
M

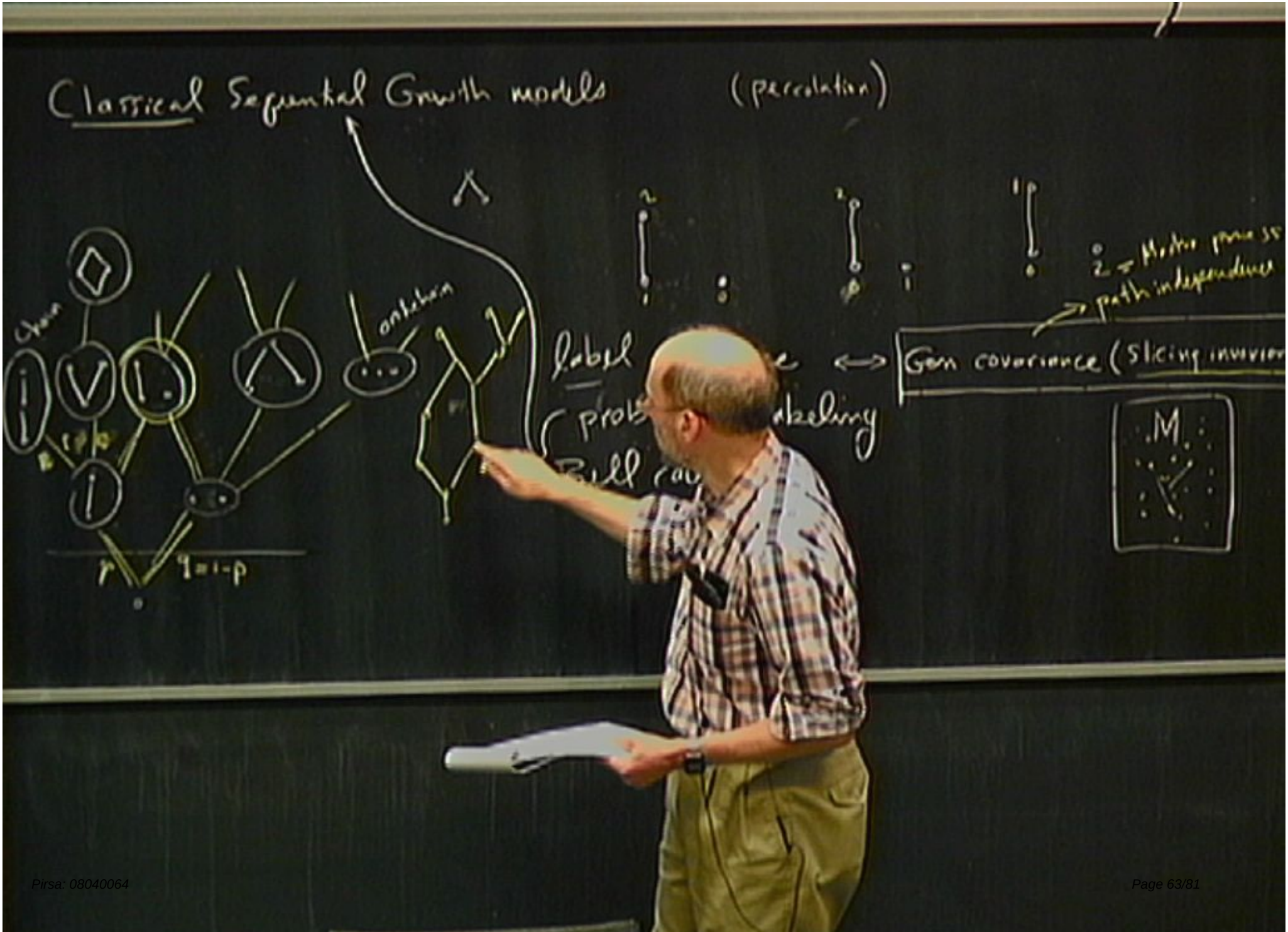

Classical Sequential Growth models (percolation)
label invariance ↔ Gen covariance (Slicing invariance)
prob indep of labeling
Full causality
M

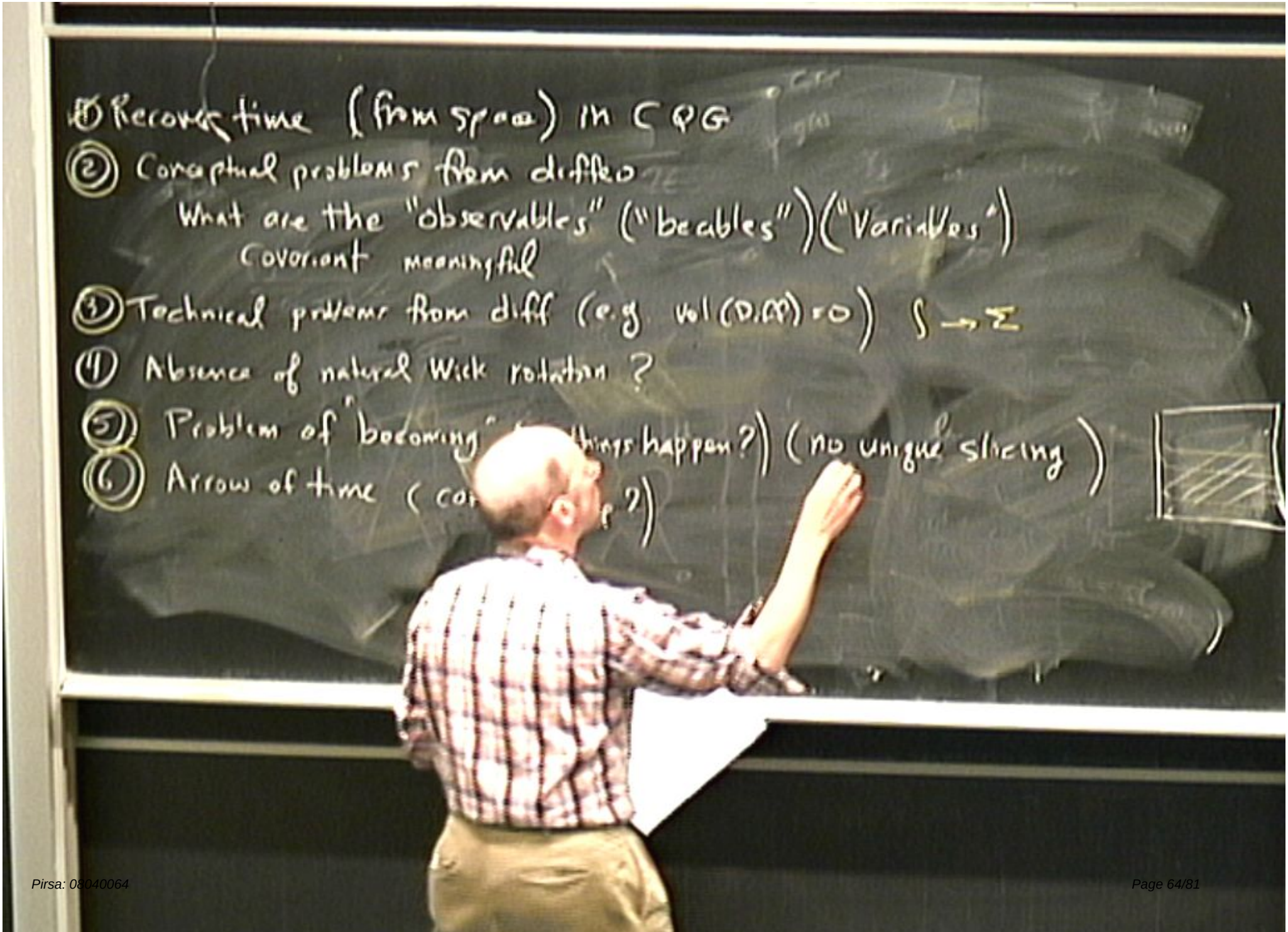

Classical Sequential Growth models
(percolation)
label invariance
prob indep of labeling
Bell causality
Gen covariance (Slicing invariance)
M

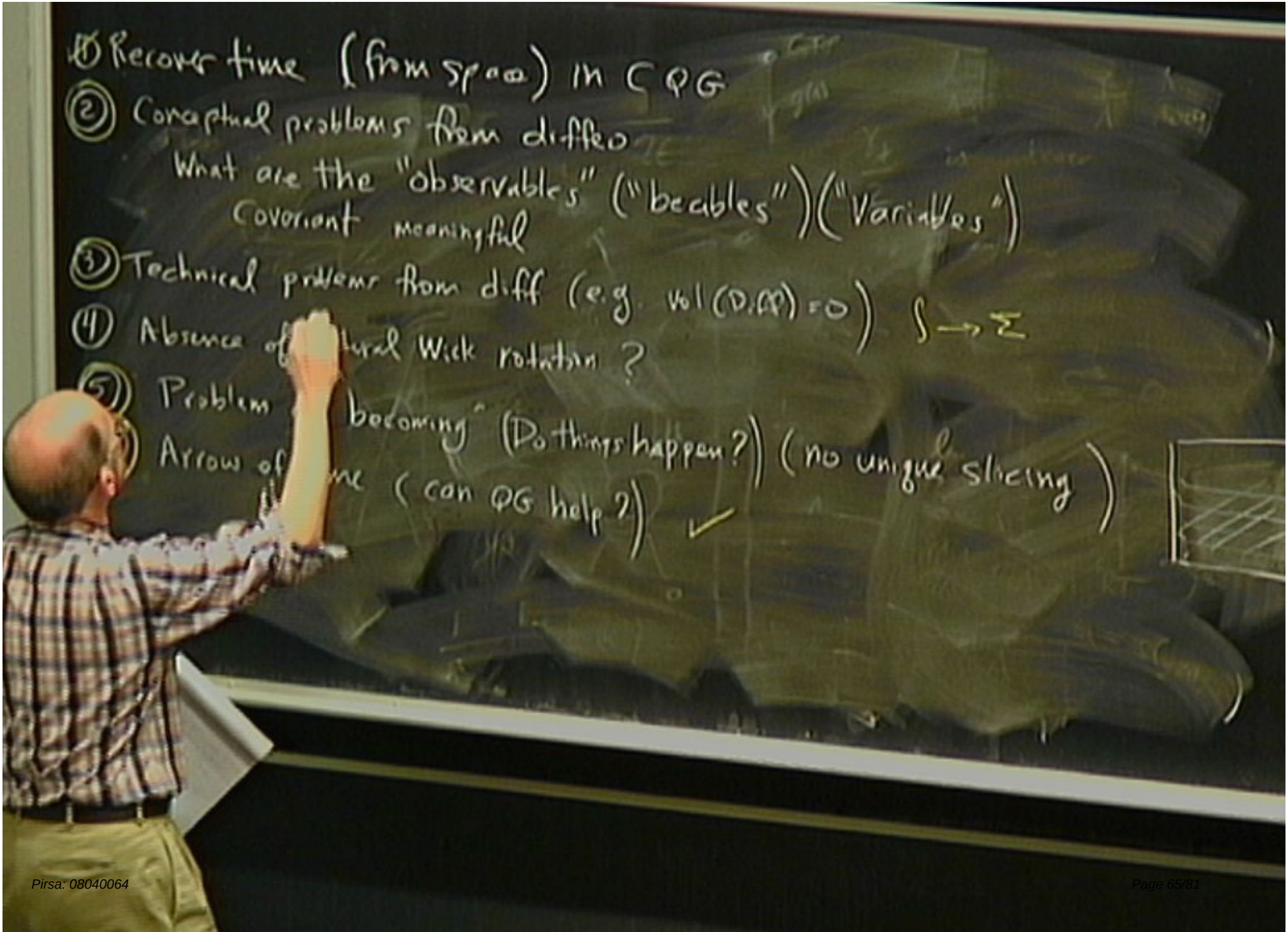

Classical Sequential Growth models
(percolation)
labels invariance
prob indep of labeling
Bell causality
(slicing invariance)
M


Classical Sequential Growth models
(percolation)
invariance
Gen covariance (Slicing invariance)
M


(1) Recovering time (from space) in CQG
(2) Conceptual problems from diffeo
What are the "observables" ("beables") ("VariaVes")
Covariant meaningful
(3) Technical problems from diff (e.g. Vol(Diff) = ∞)
(4) Absence of natural Wick rotation ?
(5) Problem of "becoming" (Do things happen?) (no unique slicing)
(6) Arrow (can QG help?)


Classical Sequential Growth models
(percolation)
Gen covariance
M
p
q=1-p


① Recover time (from space) in CQG
② Conceptual problems from diffeo
What are the "observables" ("beables") ("VariAbles")
covariant meaningful
③ Technical problems from diff (e.g. vol(D/Diff) = 0) S → Σ
④ Absence of natural Wick rotation ?
⑤ Problem of "becoming" (no unique slicing)
⑥ Arrow of time


① Recover time (from space) in CQG
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What are the "observables" ("beables") ("Variables")
Covariant meaningful
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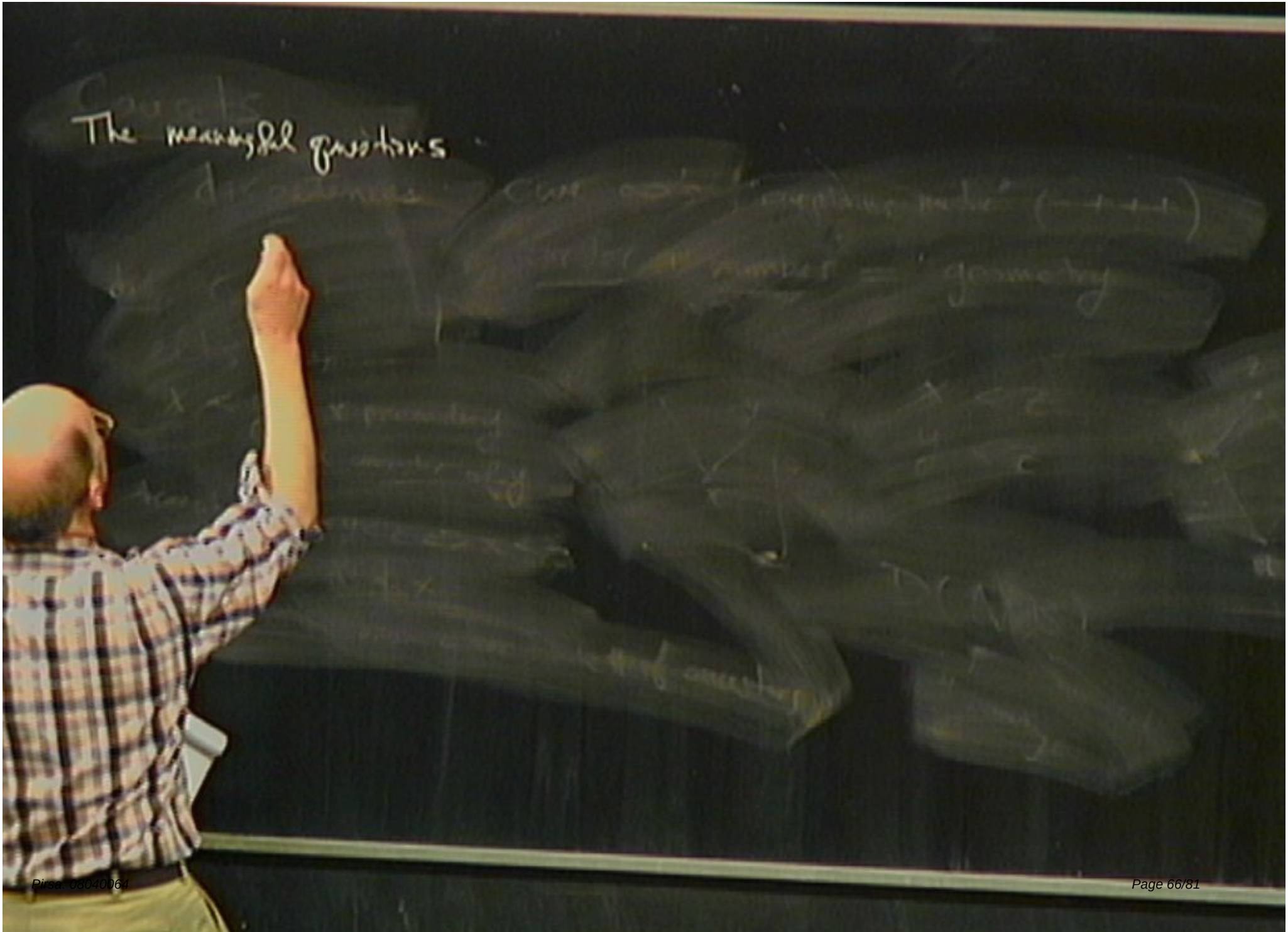
⑥ Arrow of time (can QG help?)

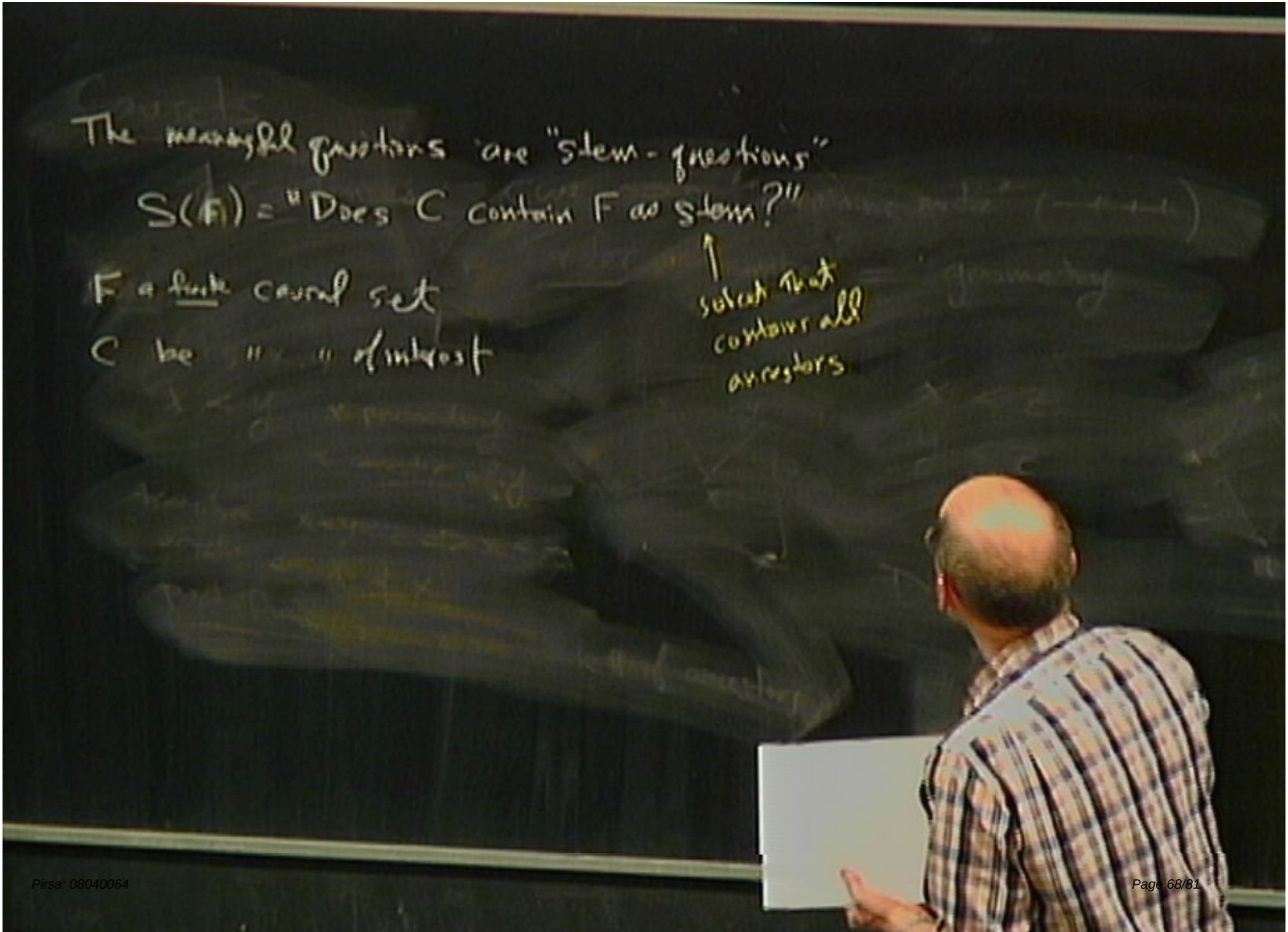

The meaningful questions

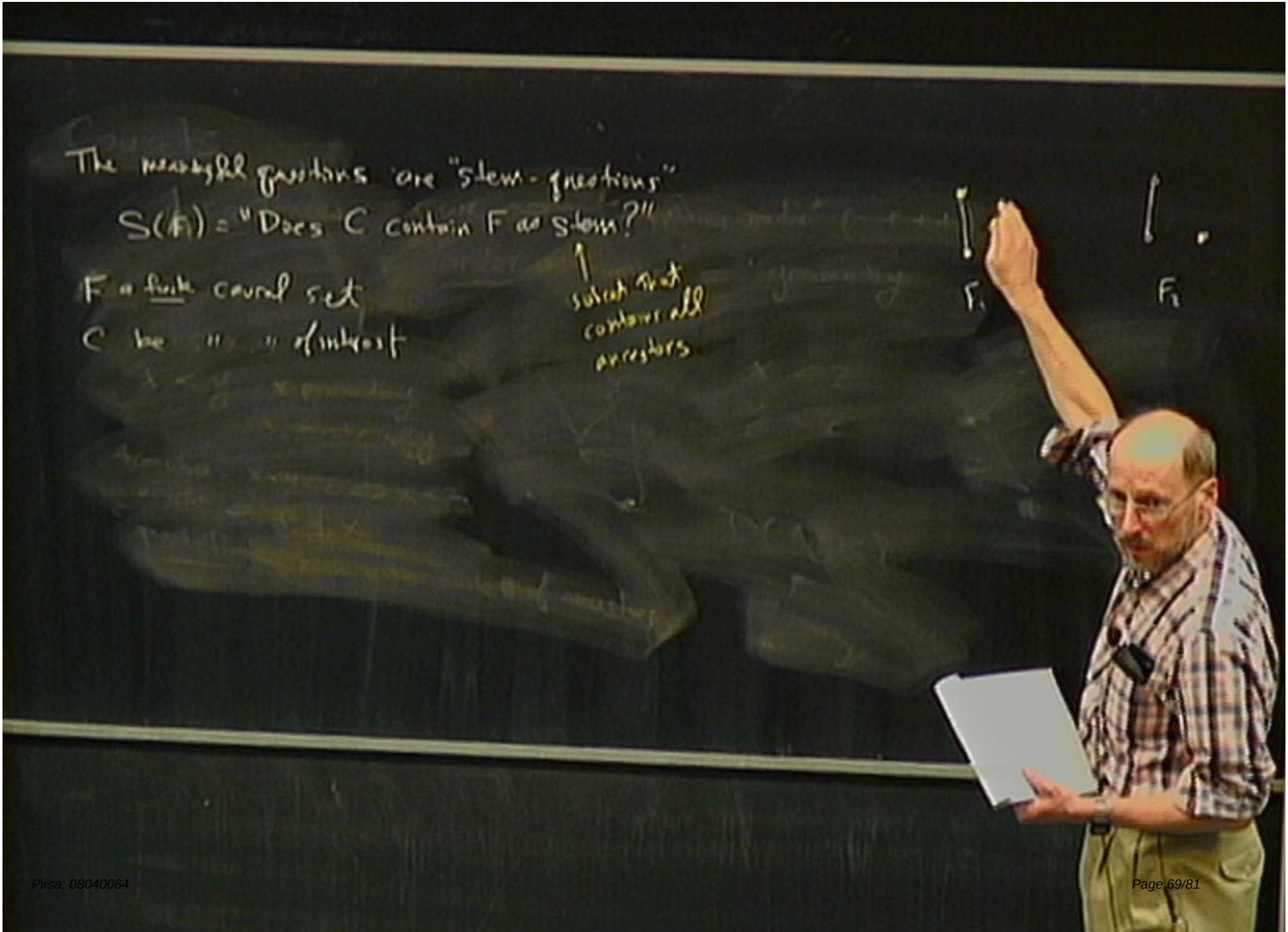
The meaningful questions are "stem-questions"

$S(F)$ = "Does C contain F as stem?"

F a finite causal set

C be " " of interest


The meaningful questions are "stem-questions"
S(F) = "Does C contain F as stem?"
F a finite causal set
C be " " of interest
select that contains all antecedents


The meaningful questions are "stem-questions"
S(F) = "Does C contain F as stem?"
F a finite causal set
C be " " of interest
subset that contains all ancestors
F1
F1

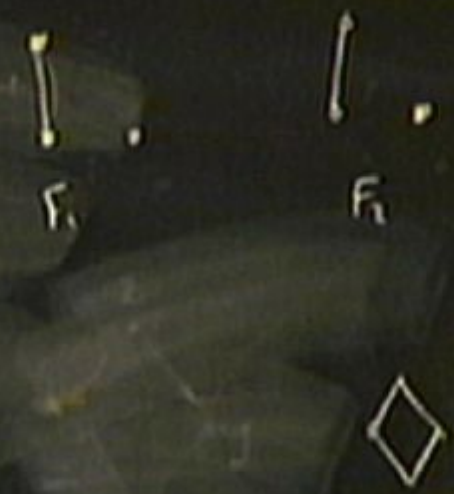
The meaningful questions are "stem-questions"

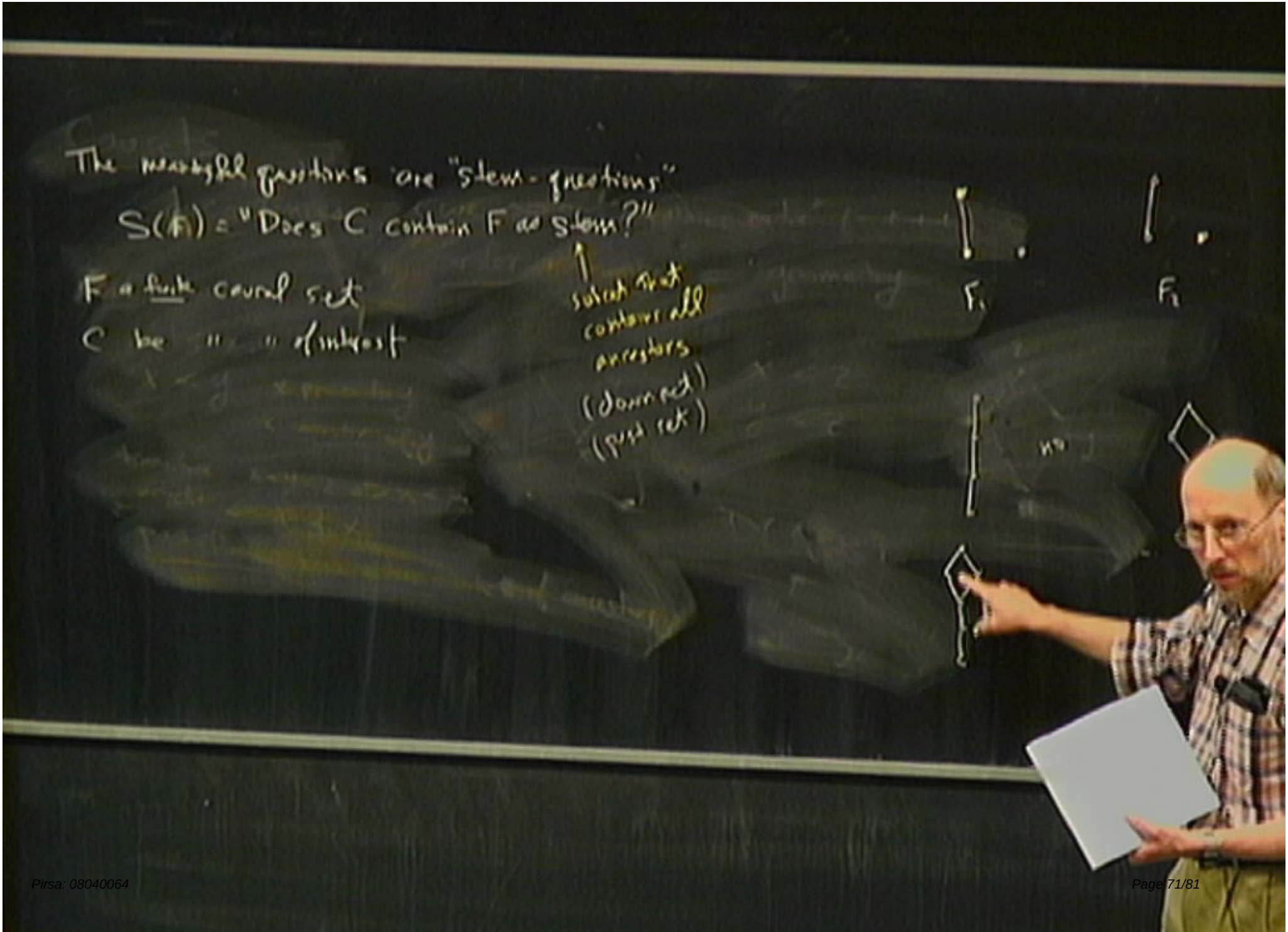
$S(F)$ = "Does C contain F as stem?"

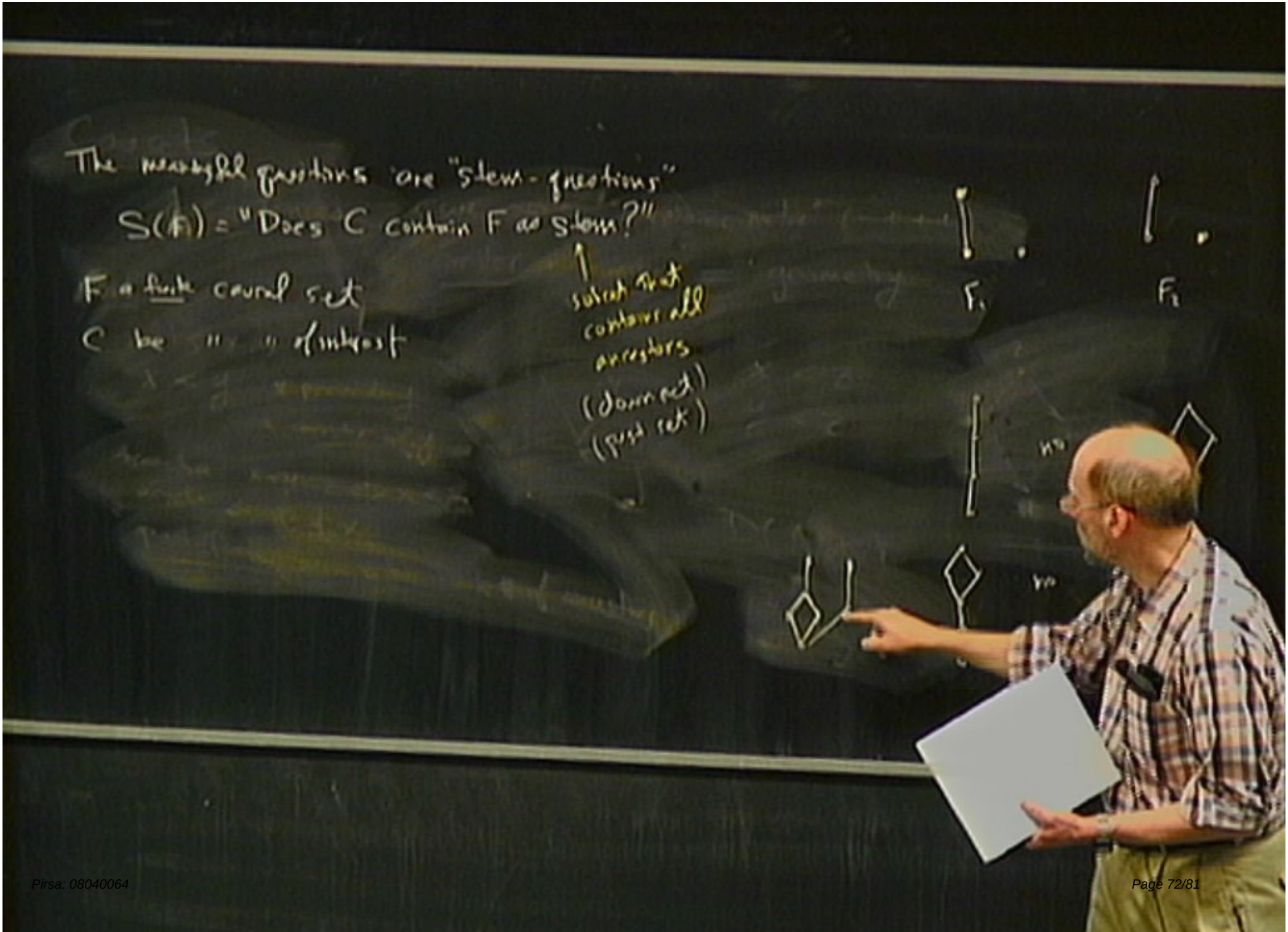
↑ subset that contains all ancestors (downset) (prefix set)

F a finite causal set

C be "..." of interest




The meaningful questions are "stem-questions"
S(F) = "Does C contain F as stem?"
F a finite causal set
C be " " of interest
subset that contains all ancestors
(down set)
(past set)
F1
F1


The meaningful questions are "stem-questions"
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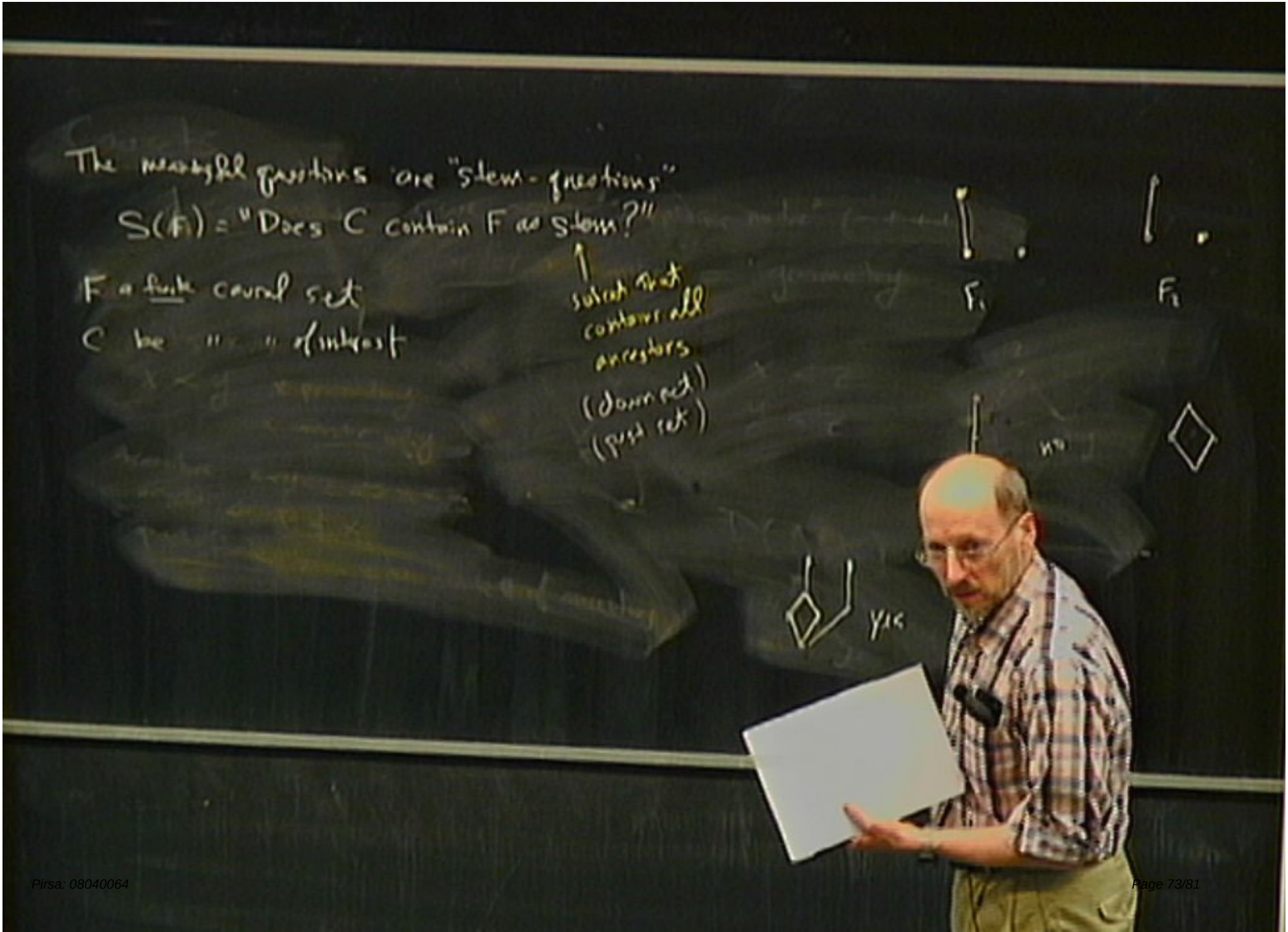
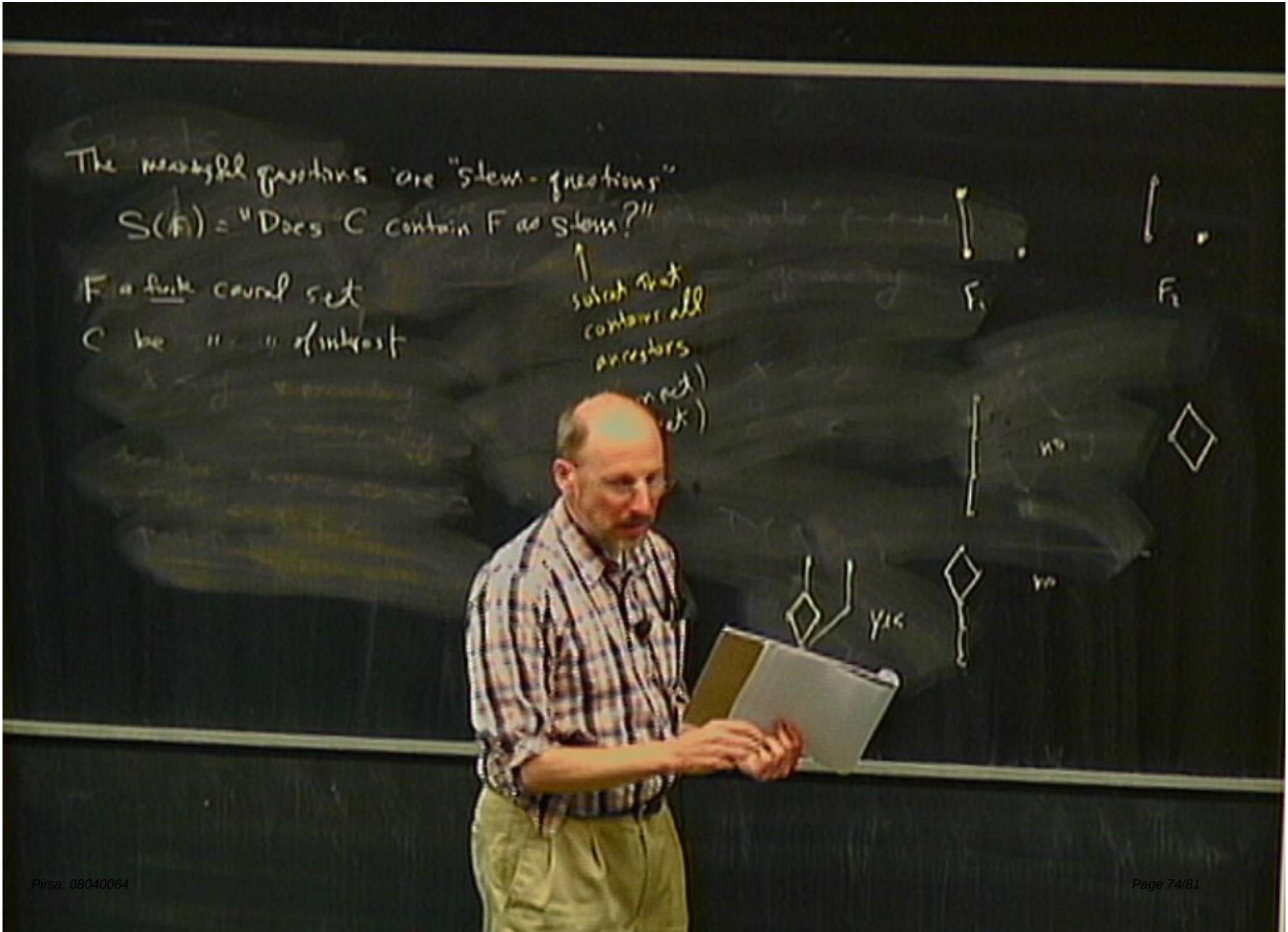
(downset)
(past set)
F1
F1


The neighborhood questions are "stem-questions"
S(F) = "Does C contain F as stem?"
F a finite causal set
C be " " of interest
subset that contains all ancestors
(downset)
(past set)
F1
F1
Y16


The meaningful questions are "stem-questions"
S(F) = "Does C contain F as stem?"
F a finite causal set
C be " " of interest
which that contains all ancestors
F1
F1
H0
Y16
Y0

The meaningful questions are "stem-questions"

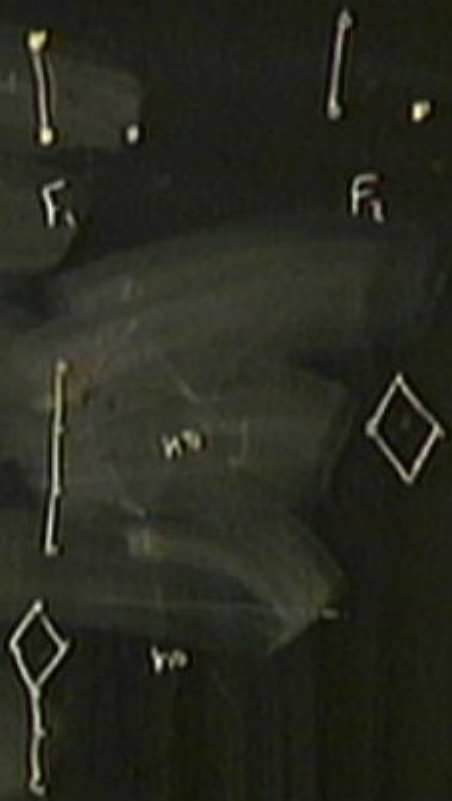
S(F) = "Does C contain F as stem?"

F a finite causal set

C be " " of interest

Every question can be expressed in terms of stem-questions using and or not

subset that contains all ancestors (Down set) (past set)



The meaningful questions are "stem-questions"

$S(F)$ = "Does C contain F as stem?"

F a finite causal set

C be "the" causal set of interest

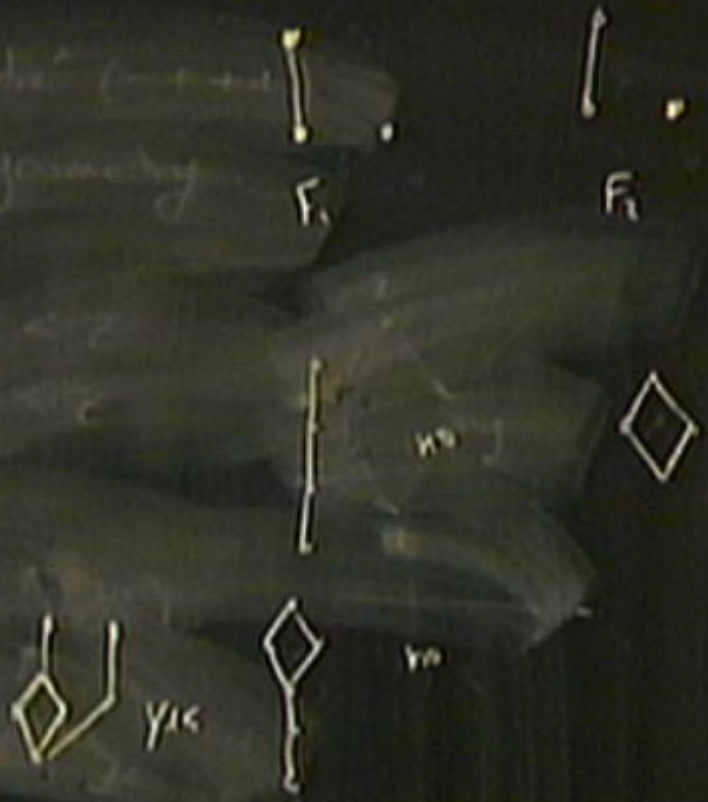
Every question can be expressed in terms of stem-questions using and or not

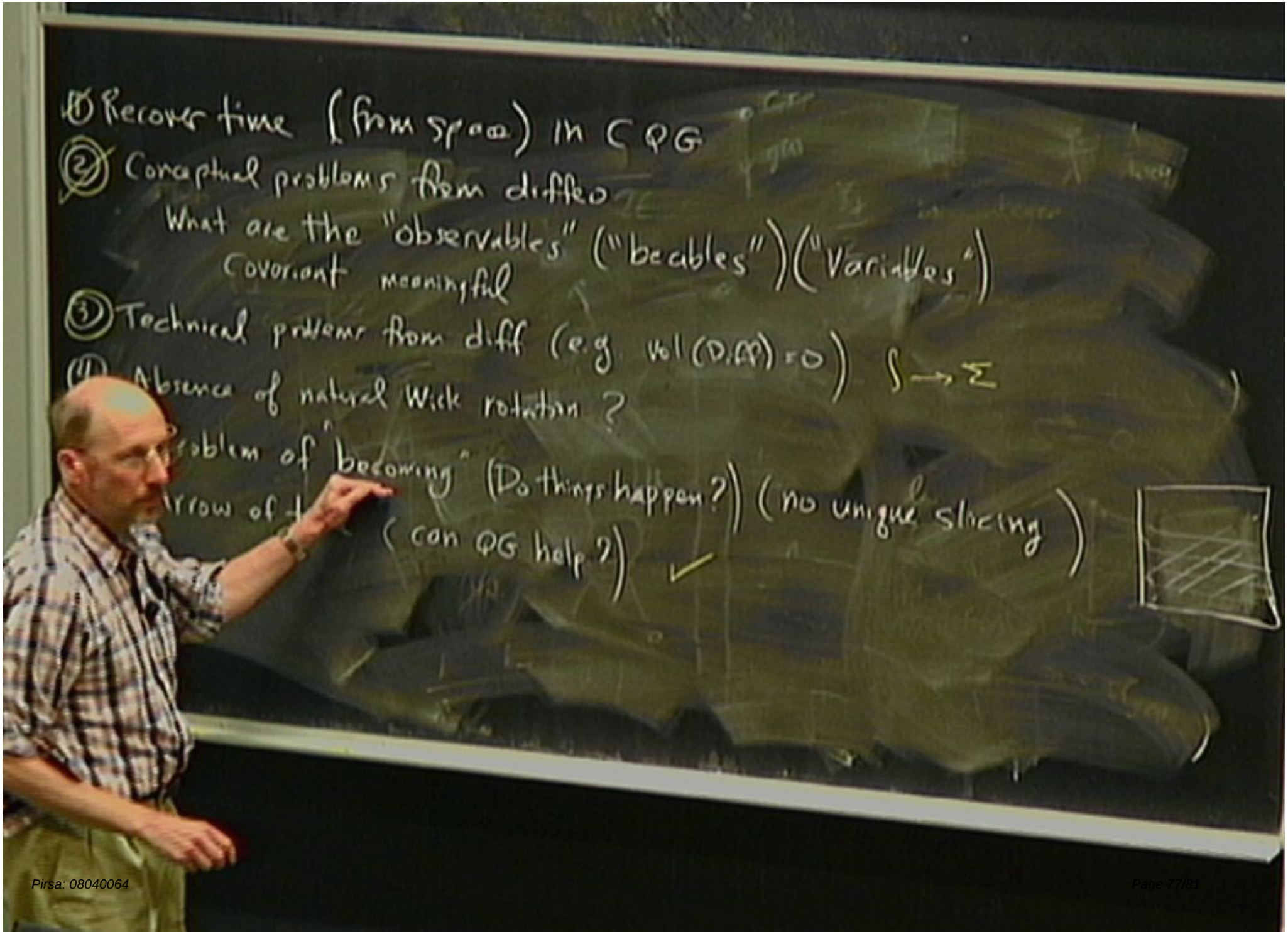
(up to sets of measure zero)

subset that contains all ancestors

(Domain)

(past set)




① Recover time (from Spacetime) in CQG
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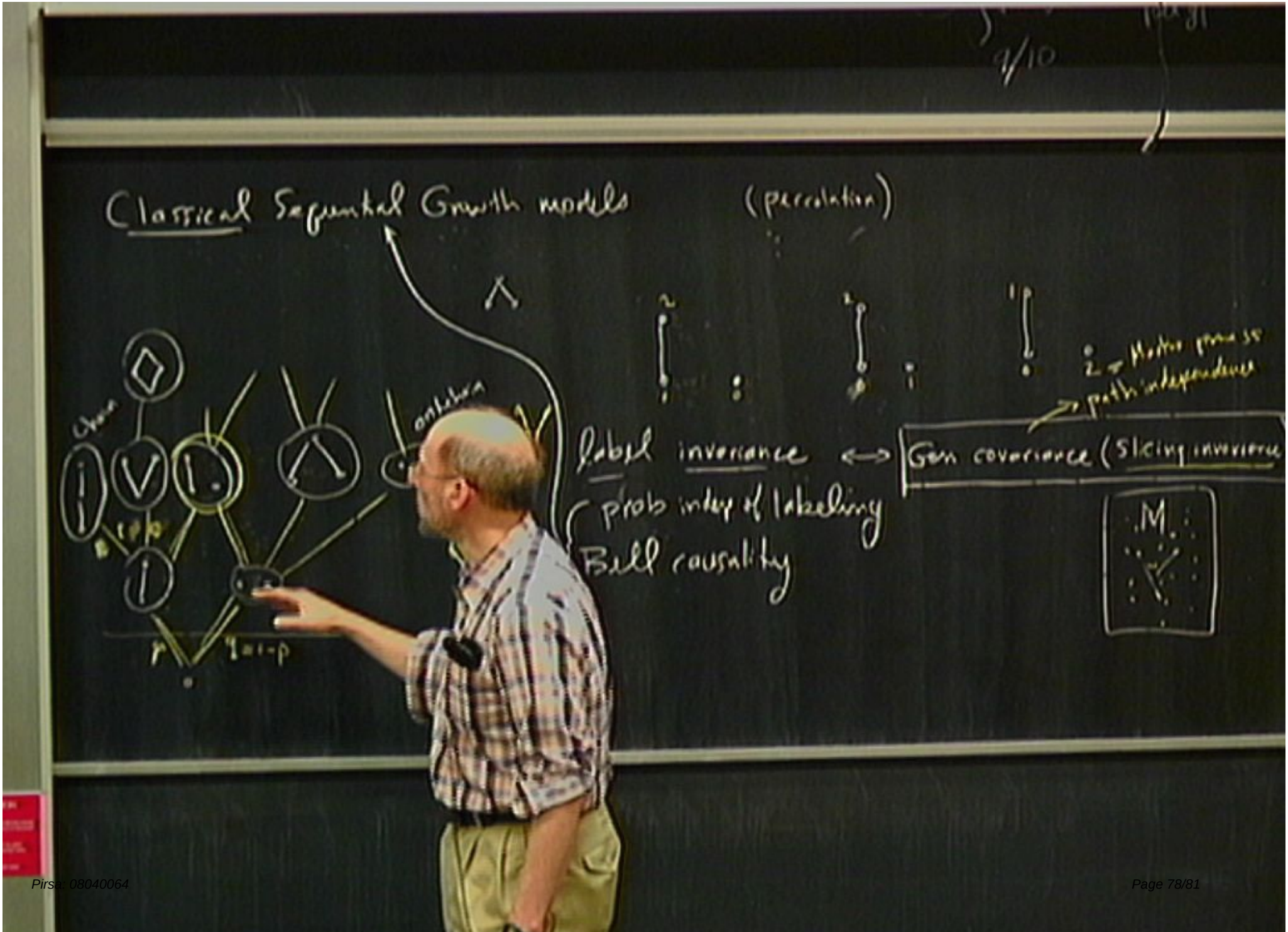
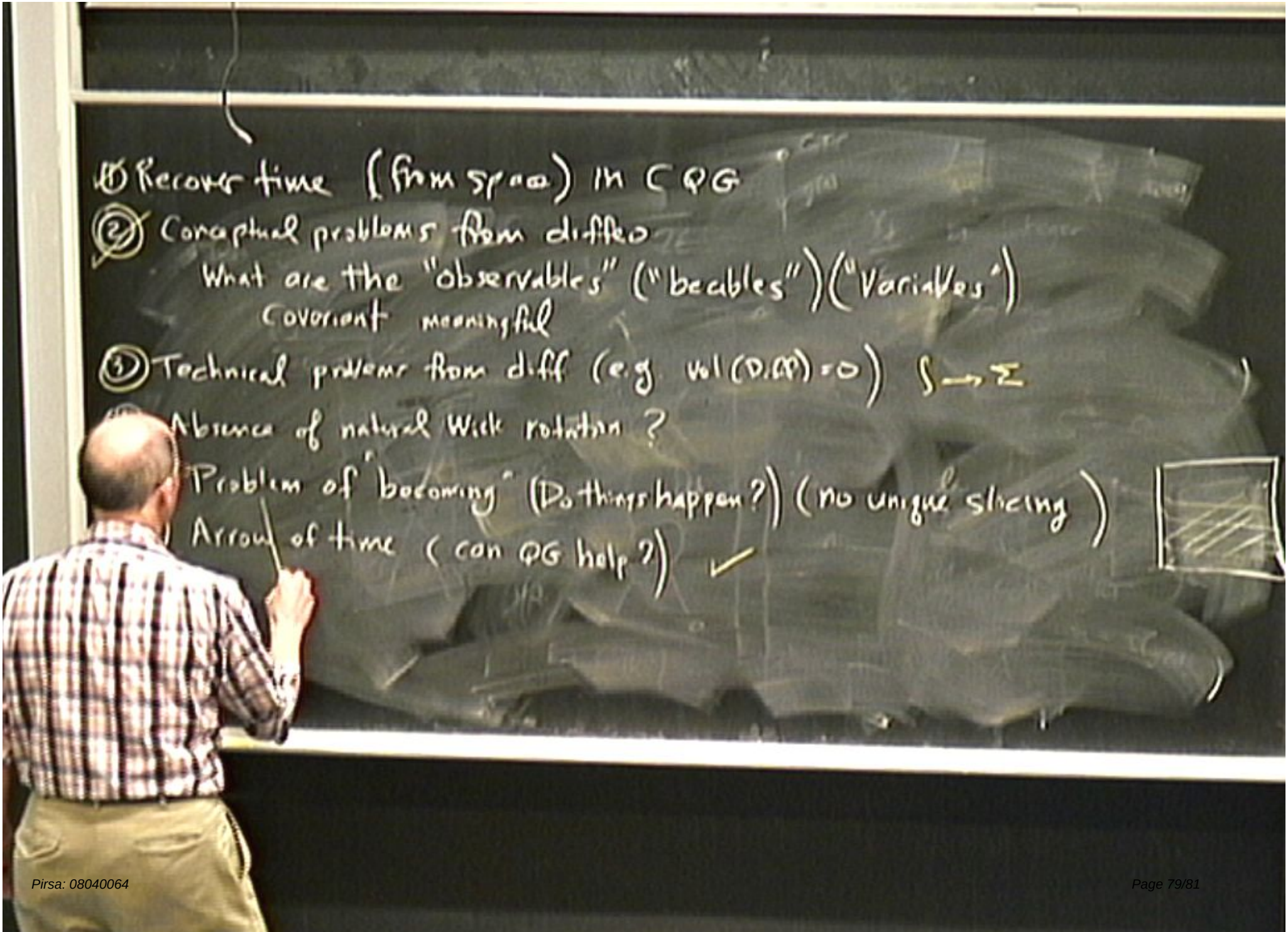

Classical Sequential Growth models
(percolation)
Label invariance
Gen covariance (Slicing invarian
prob indep of labeling
Bell causality
M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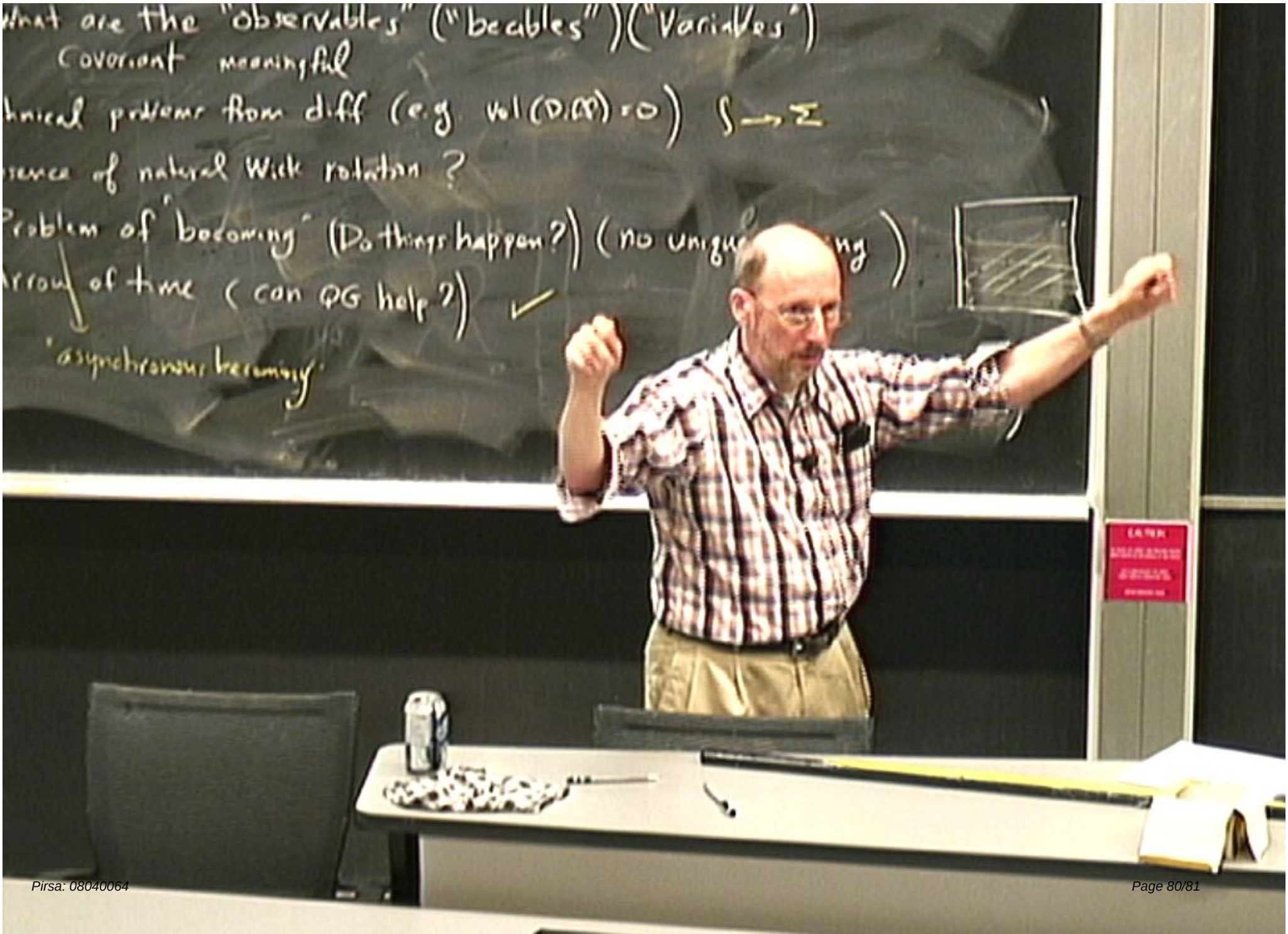
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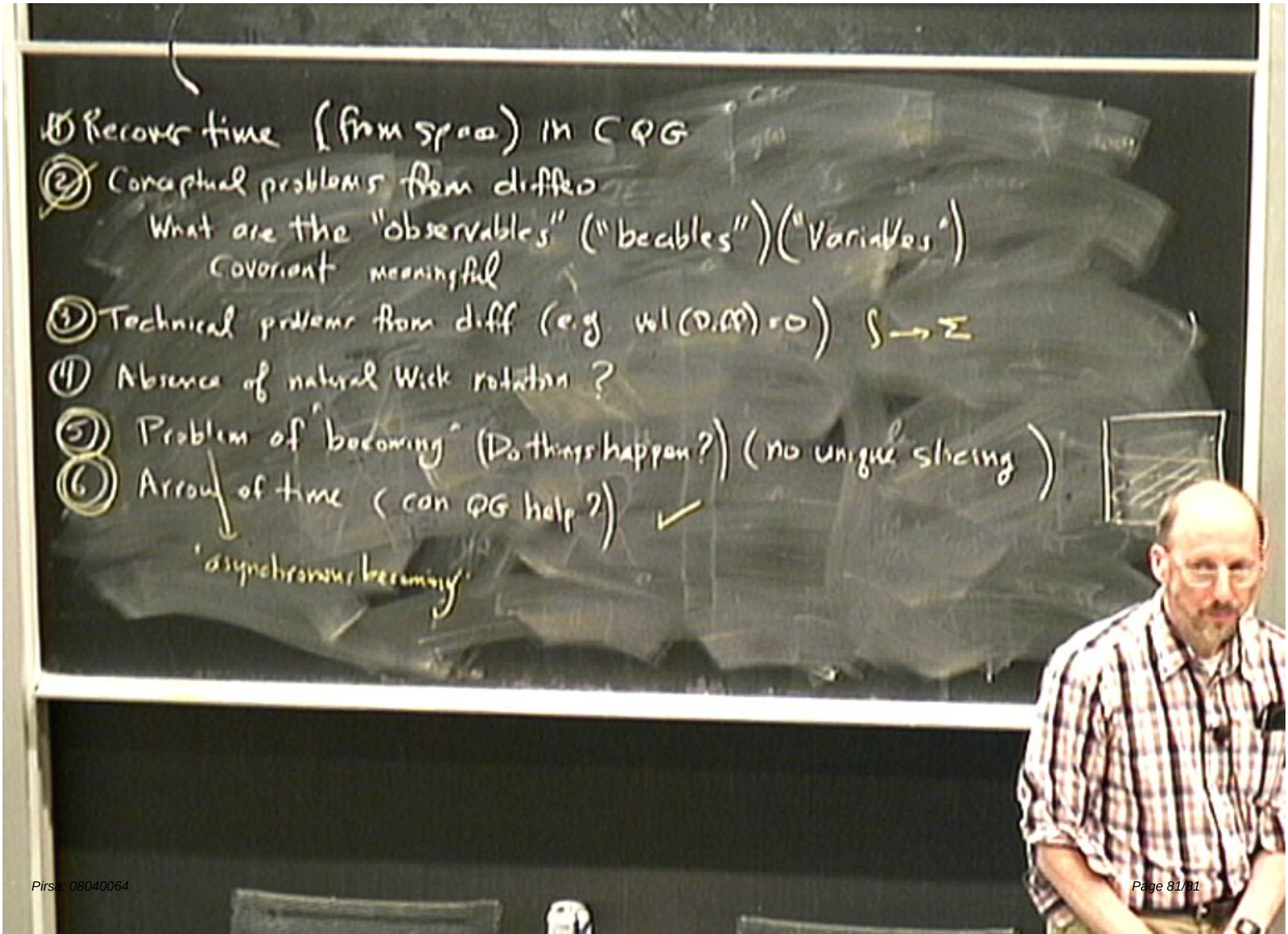
Covariant meaningful
hnical problems from diff (e.g. Vol(Diff(M)) = 0) ∫ → Σ
sence of natural Wick rotation ?
Problem of "becoming" (Do things happen?) (no uniqu ng)
Arrow of time (can QG help?)
"asynchronous hermiticity"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(6) Arrow of time (can QG help?)
'asynchronous becoming'