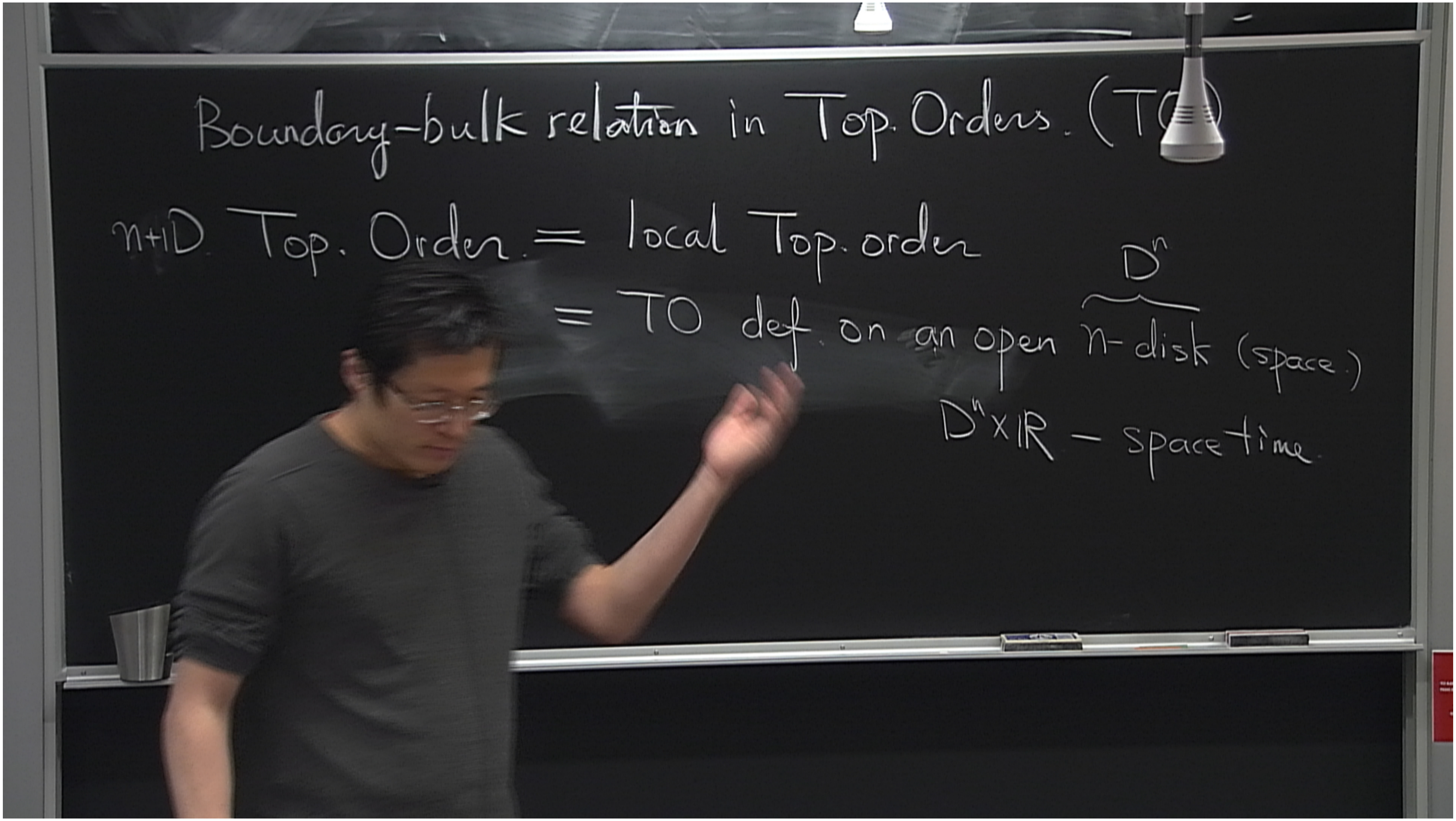
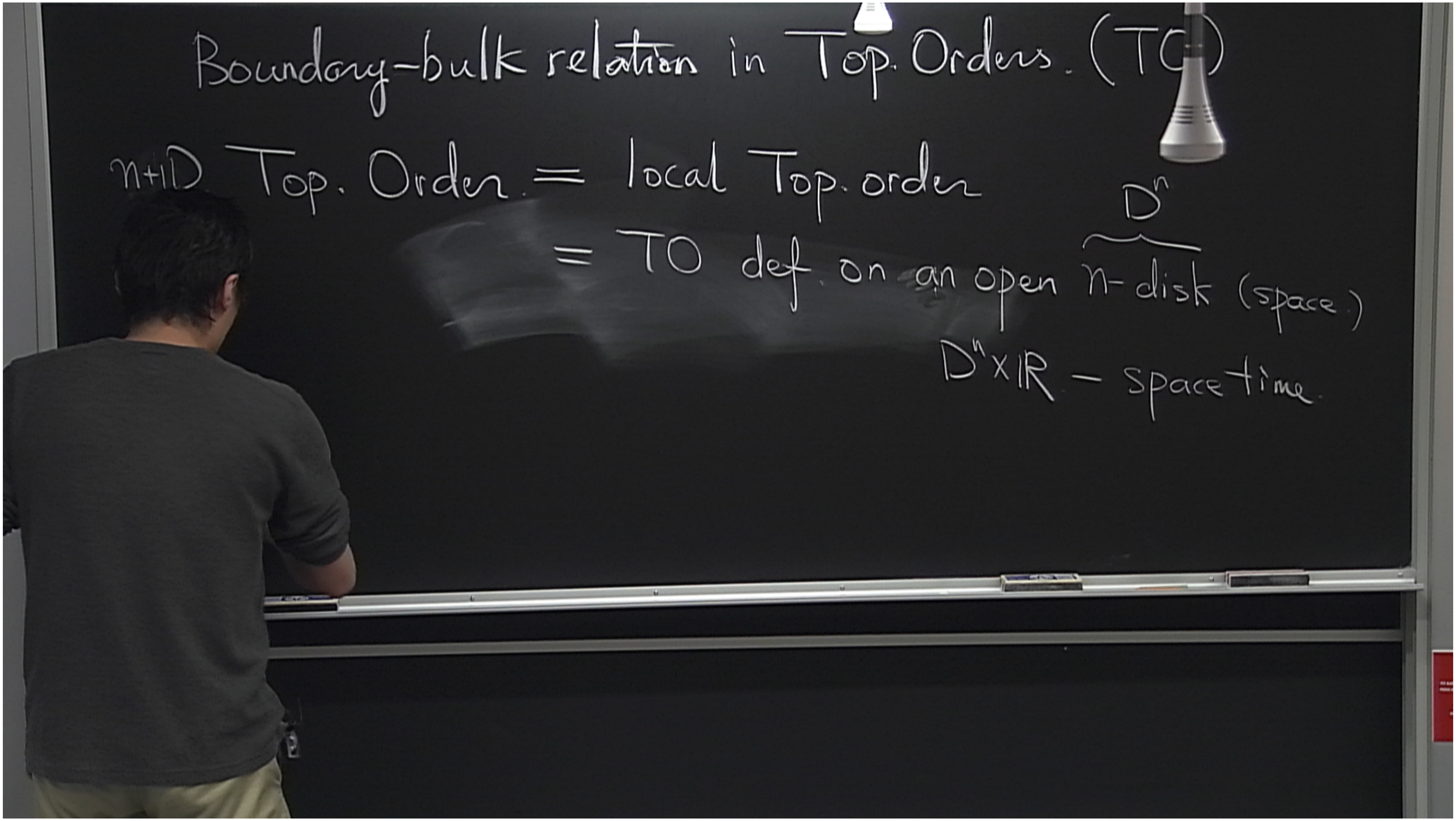
Title: TBA

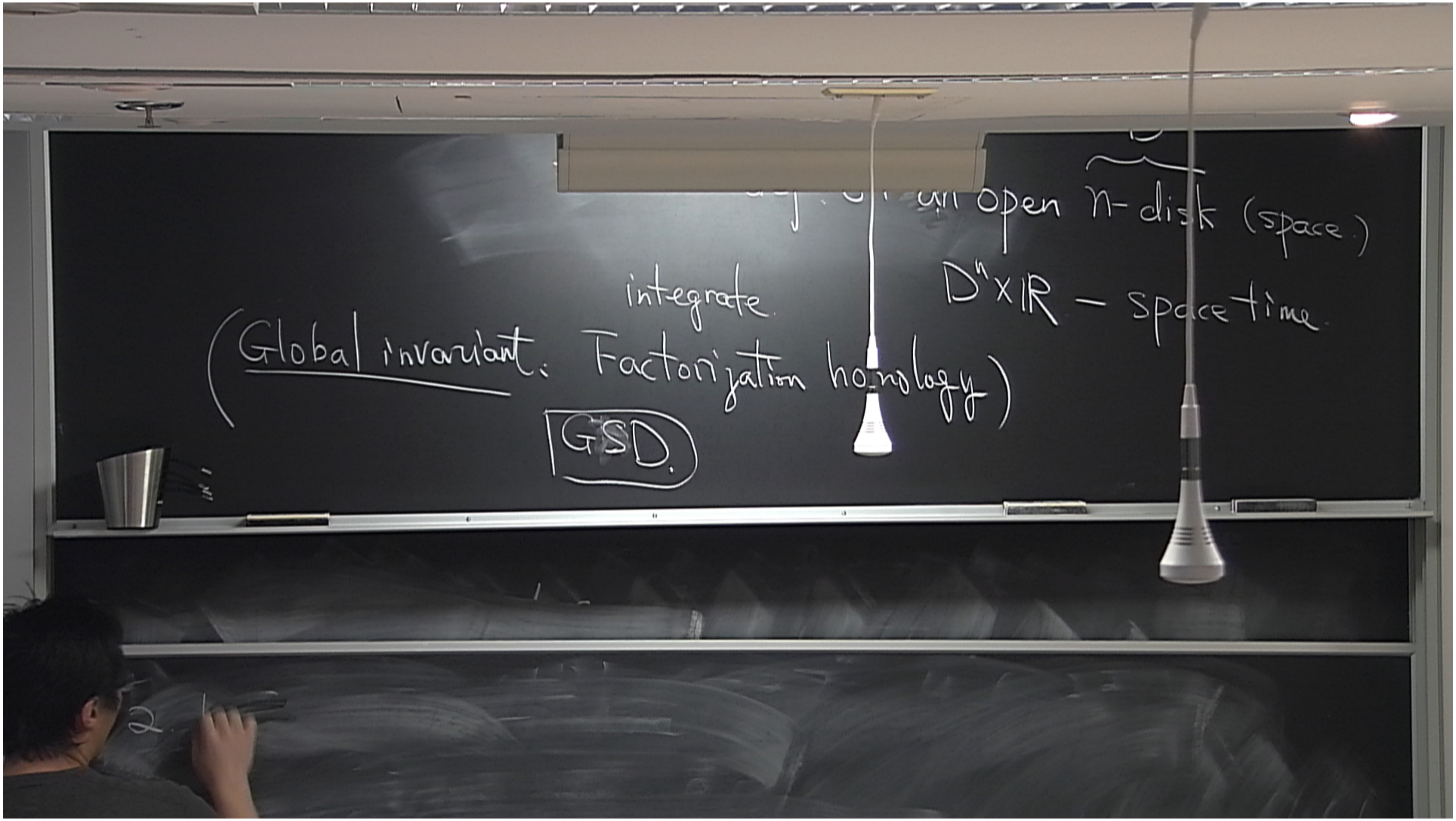
Date: Mar 10, 2016 03:30 PM

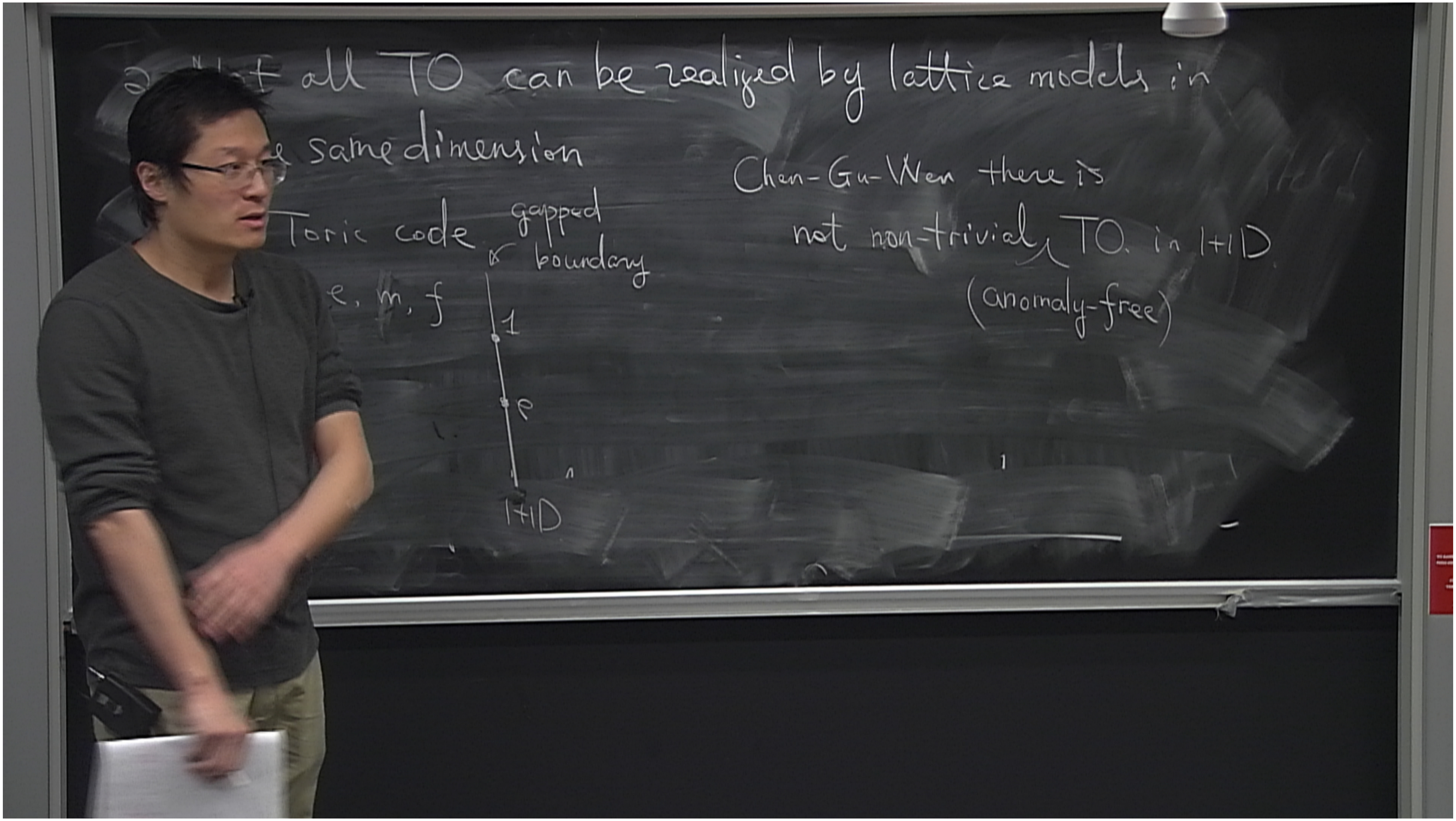
URL: http://pirsa.org/16030126

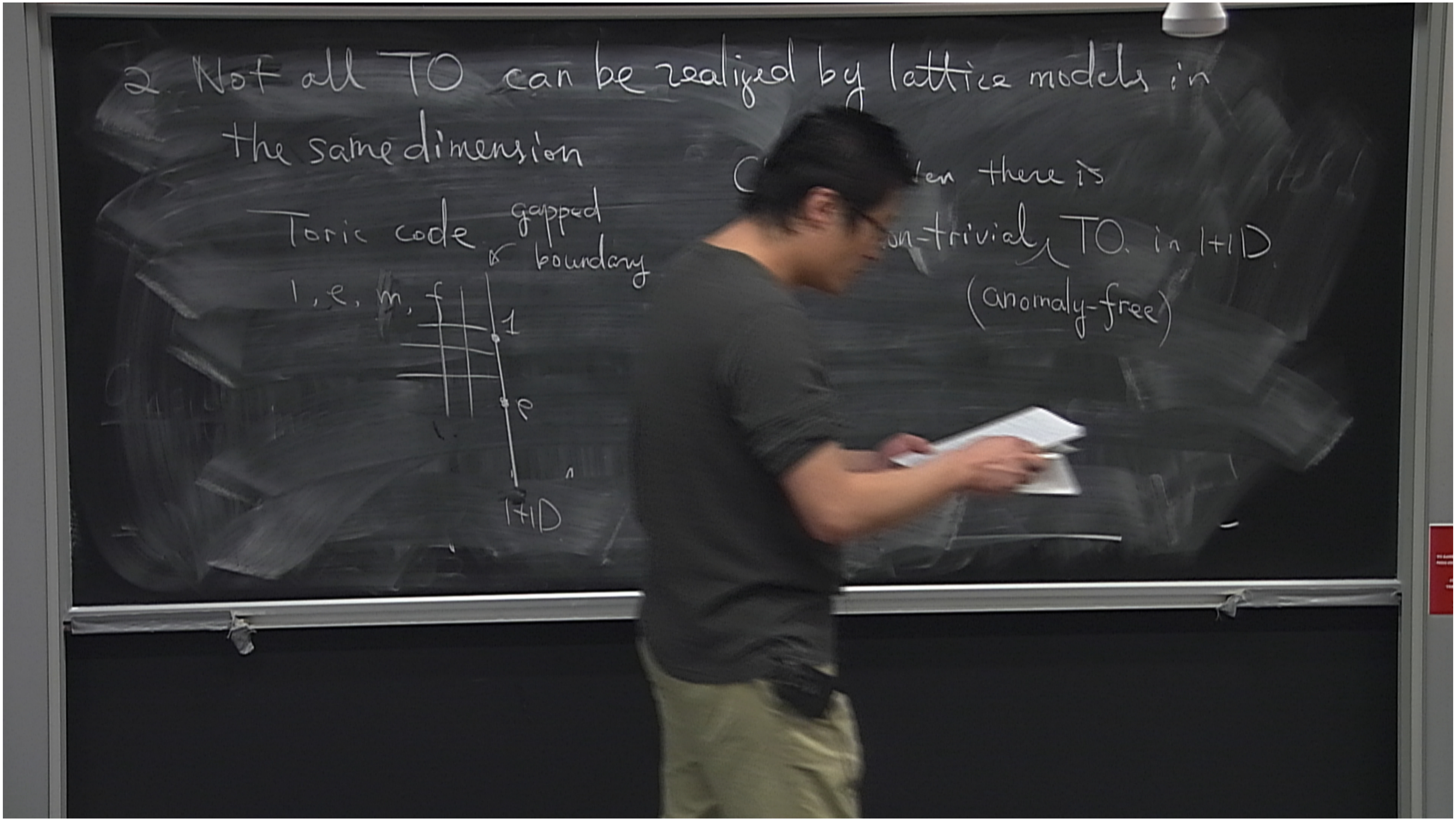
Abstract:

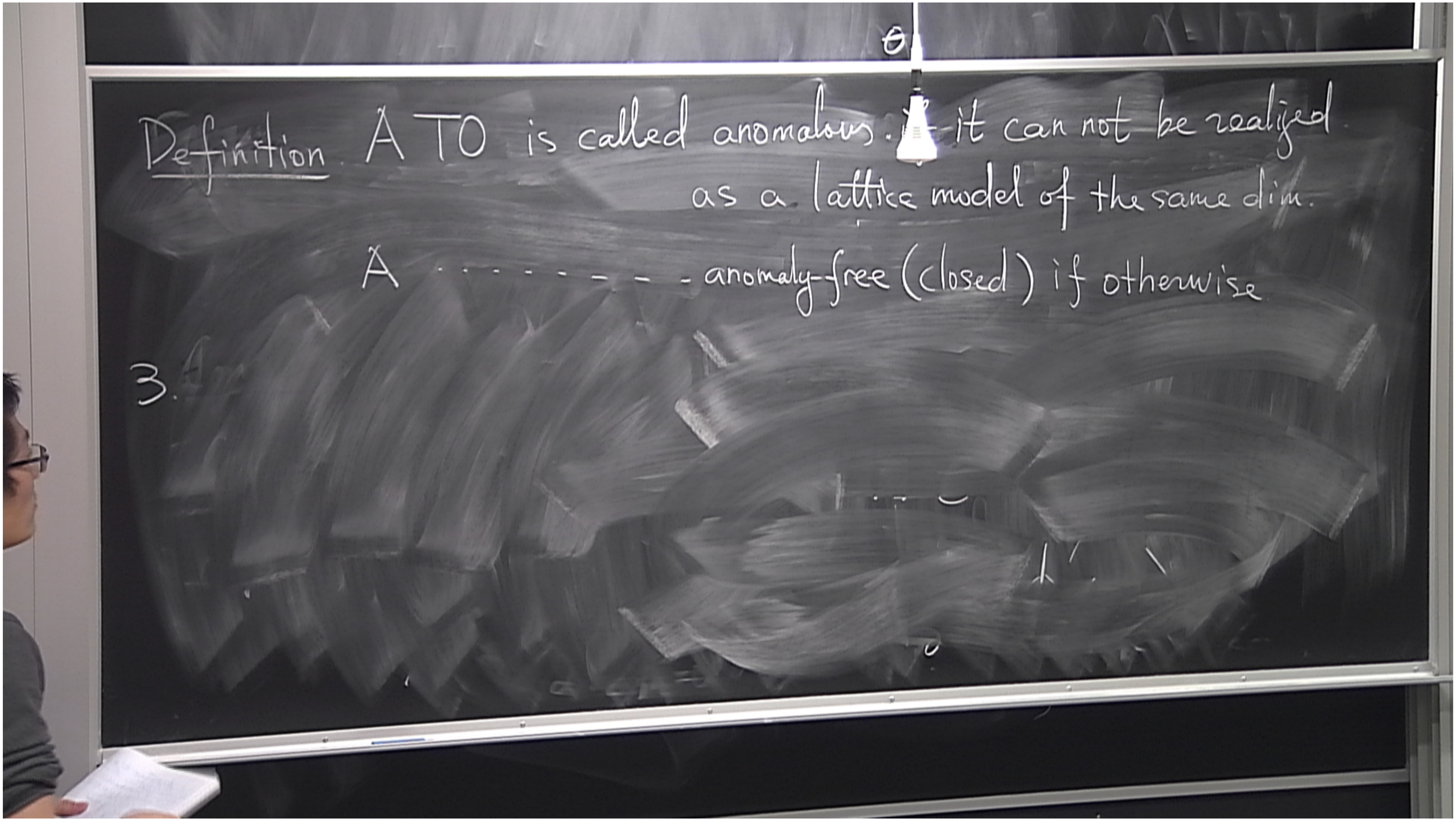

Boundary-bulk relation in Top. Orders. (T
n+1D Top. Order = local Top. order
D^n
= TO def. on an open n-disk (space)
$D^n \times \mathbb{R}$ – space time

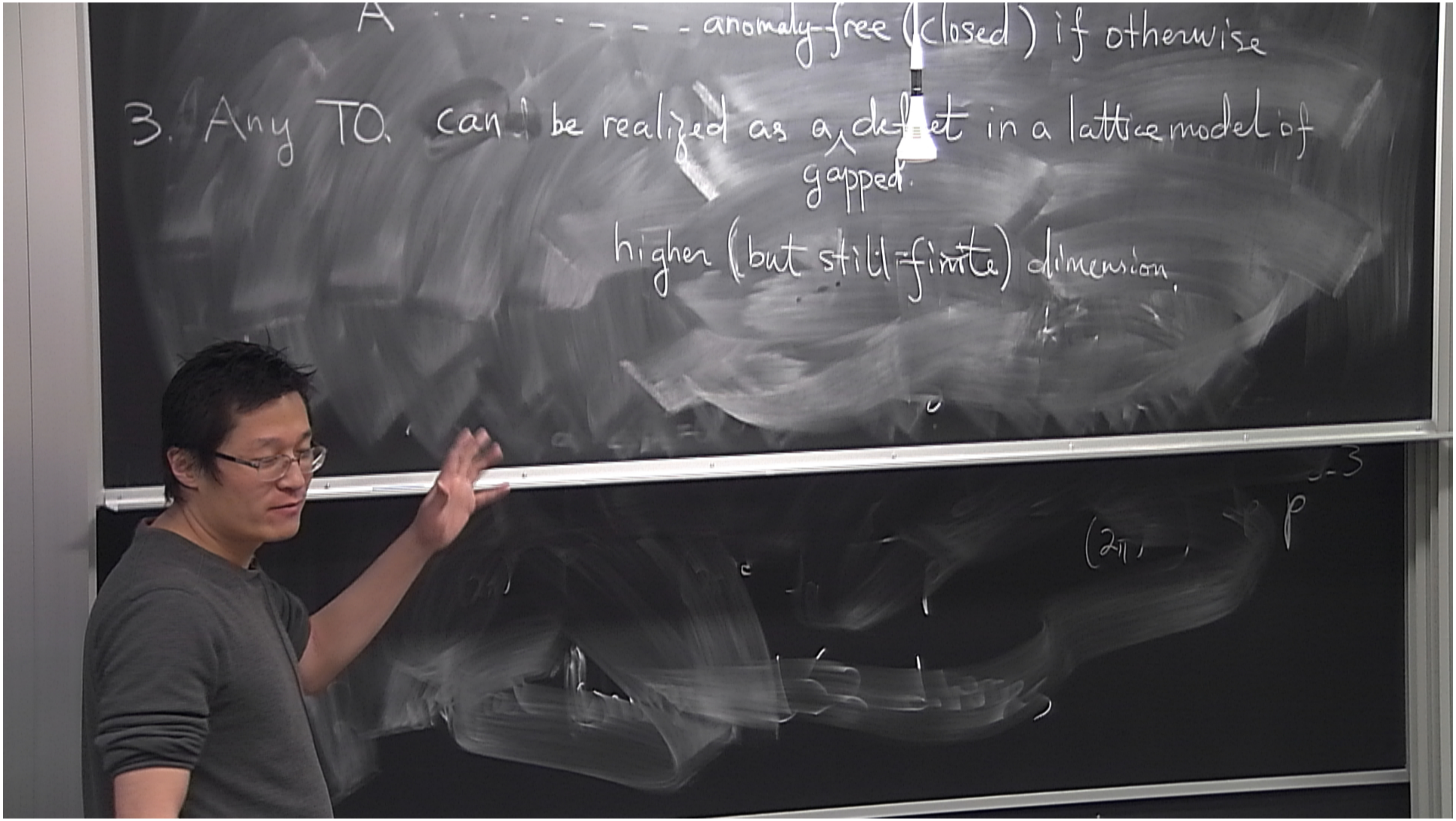

Boundary-bulk relation in Top. Orders. (TO)
n+1D Top. Order = local Top. order
D^n
= TO def. on an open n-disk (space)
$D^n \times \mathbb{R}$ – spacetime

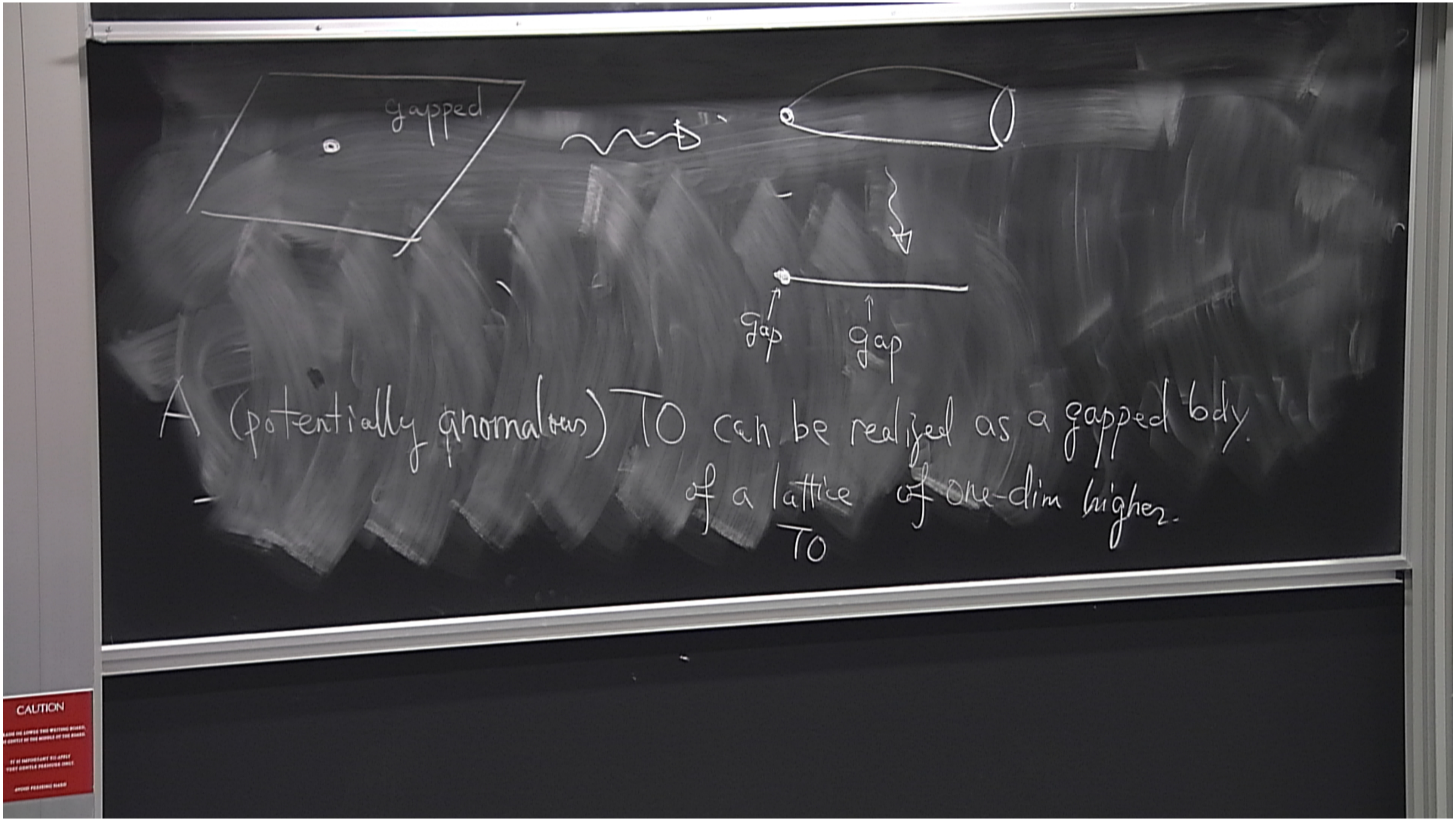

open n-disk (space)
integrate
D^n × ℝ – spacetime
(Global invariant: Factorization homology)
GSD.

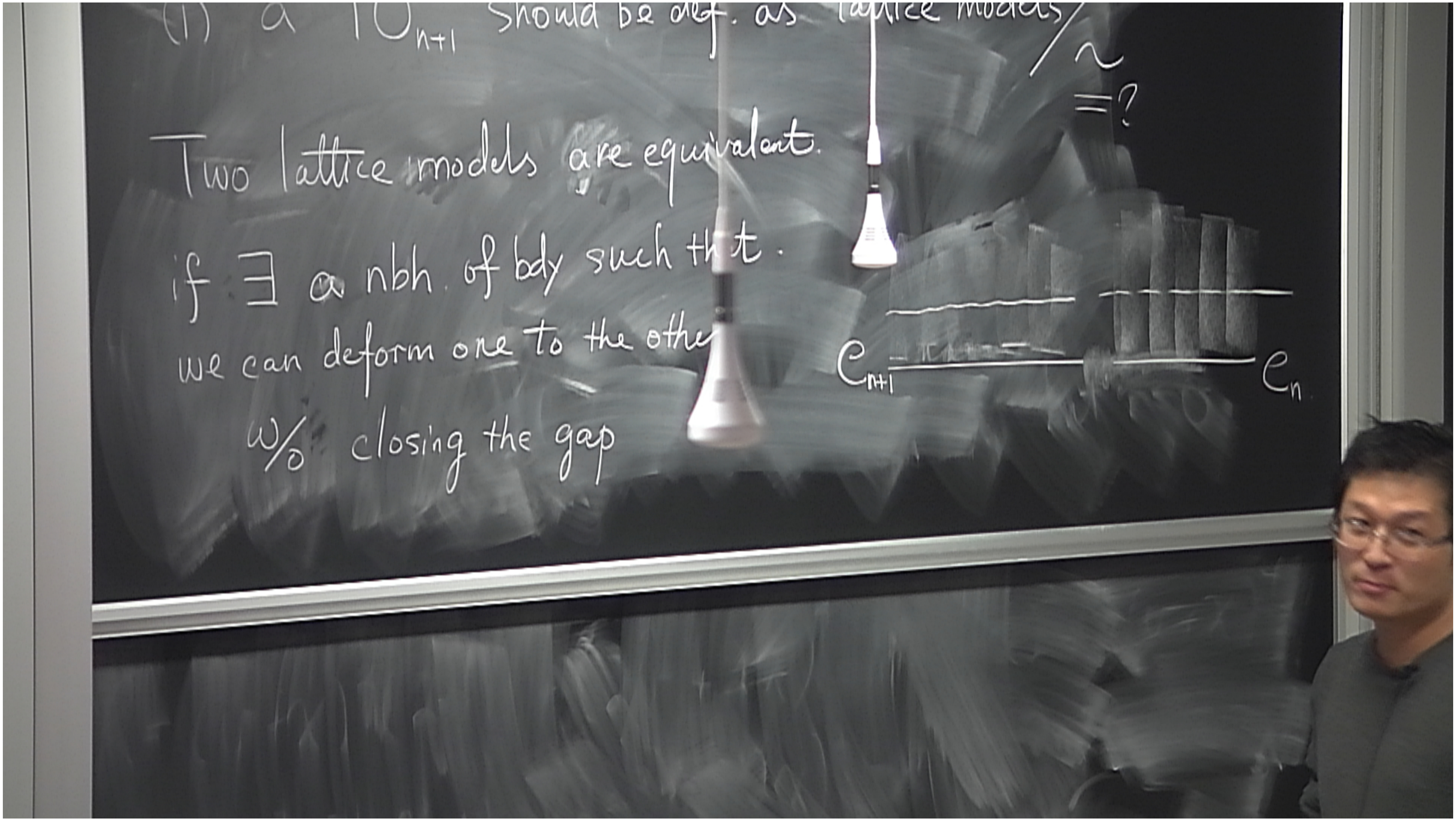

all TO can be realized by lattice models in
same dimension
Toric code
gapped
boundary
e, m, f
1
e
1+1D
Chen-Gu-Wen there is
not non-trivial TO in 1+1D
(anomaly-free)

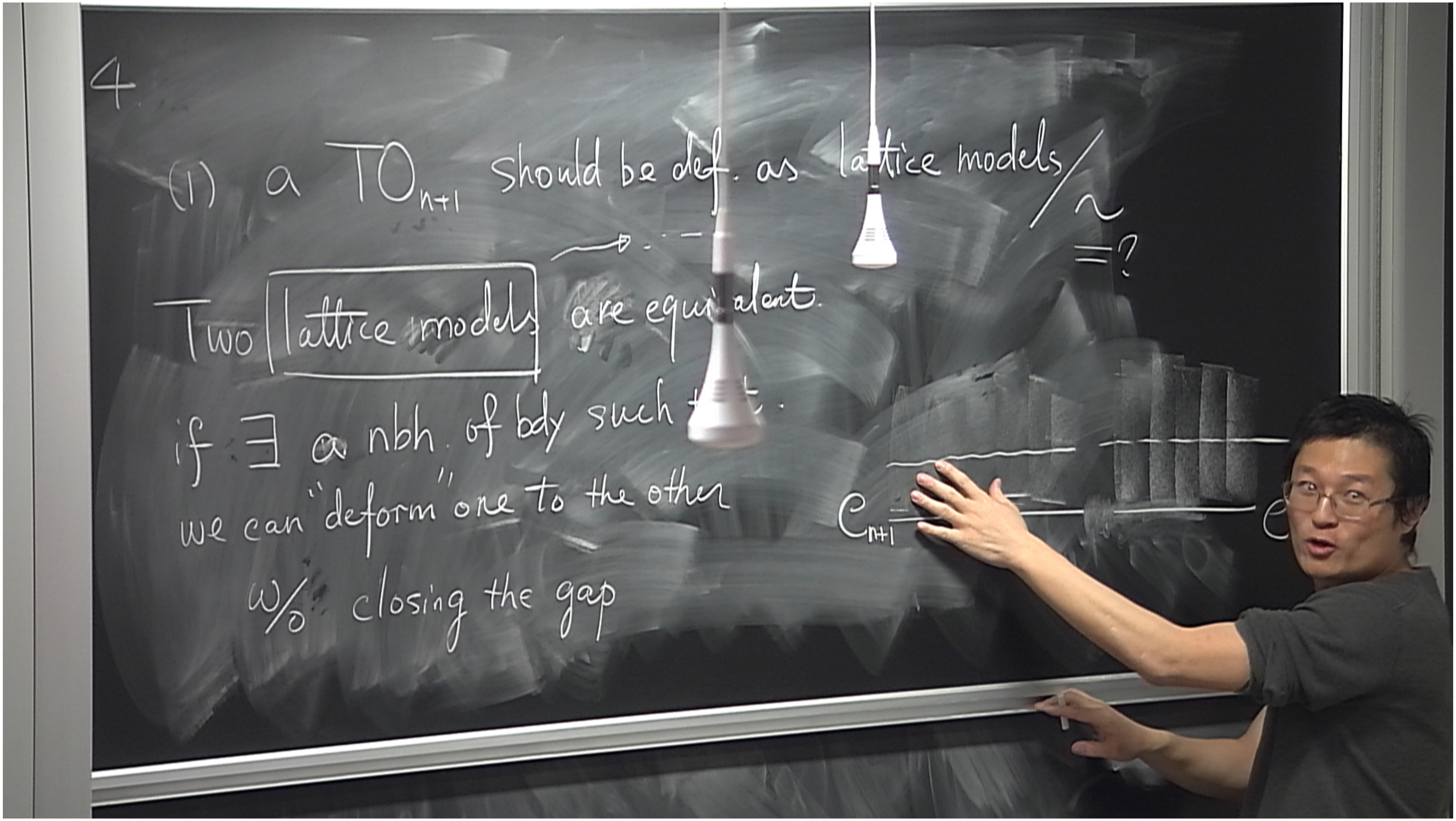

2. Not all TO can be realized by lattice models in
the same dimension
Toric code
gapped boundary
1, e, m, f
1
e
1+1D
there is
on-trivial TO in 1+1D
(anomaly-free)

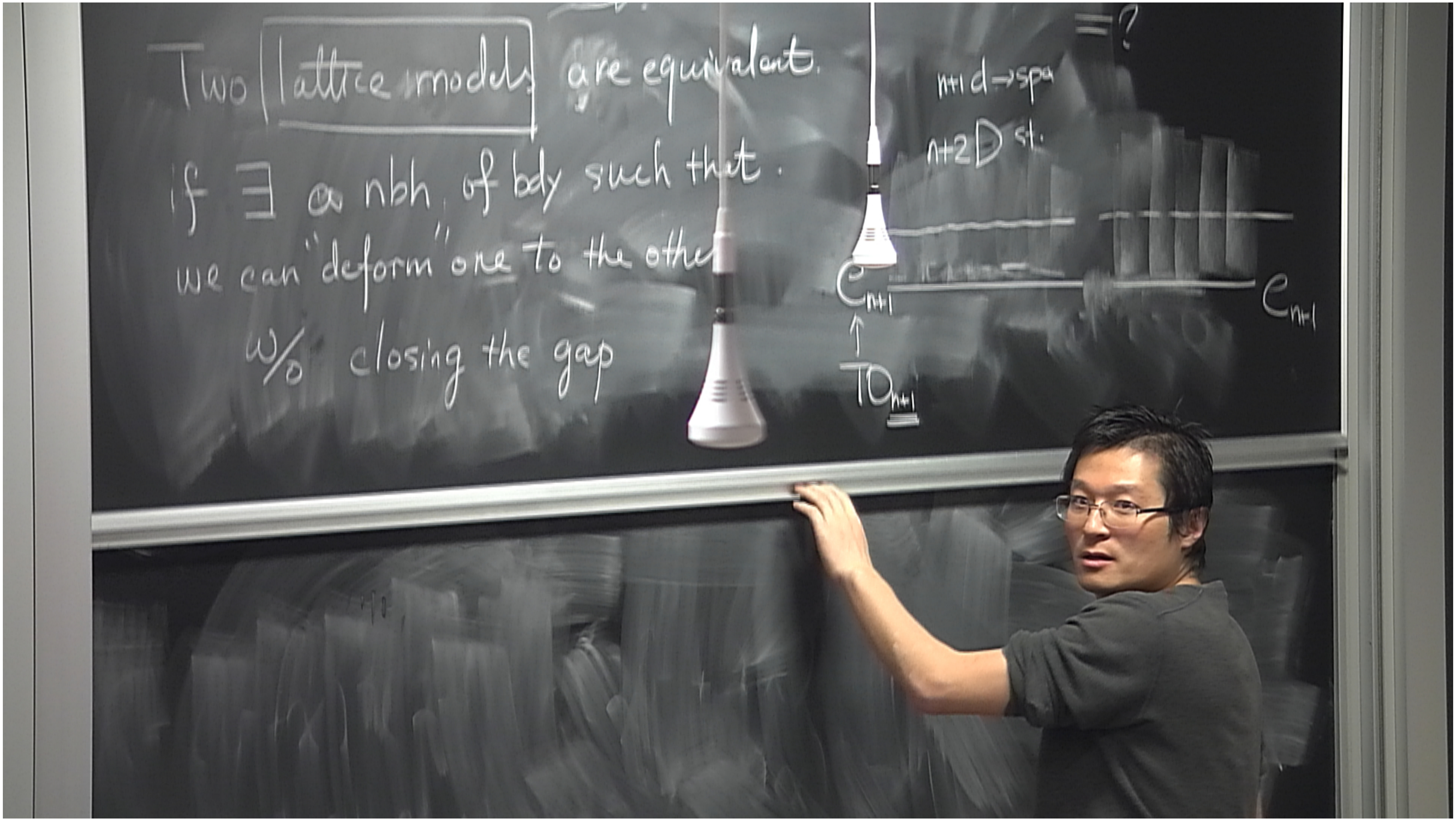

Definition. A TO is called anomalous if it can not be realized
as a lattice model of the same dim.
A - - - - - - - - anomaly-free (closed) if otherwise
3.

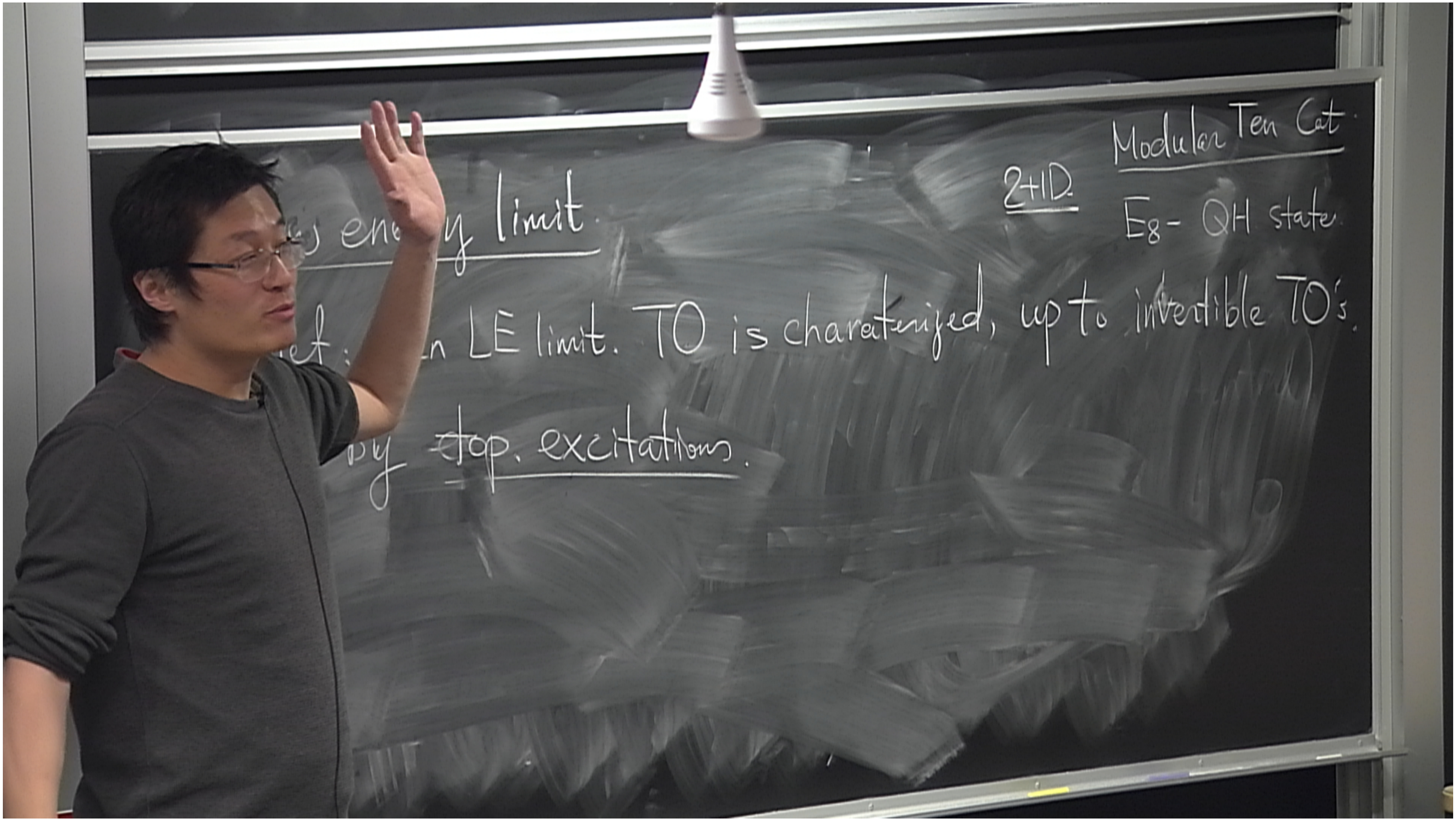

A - - - anomaly-free (closed) if otherwise
3. Any TO. can be realized as a d et in a lattice model of
gapped
higher (but still finite) dimension.

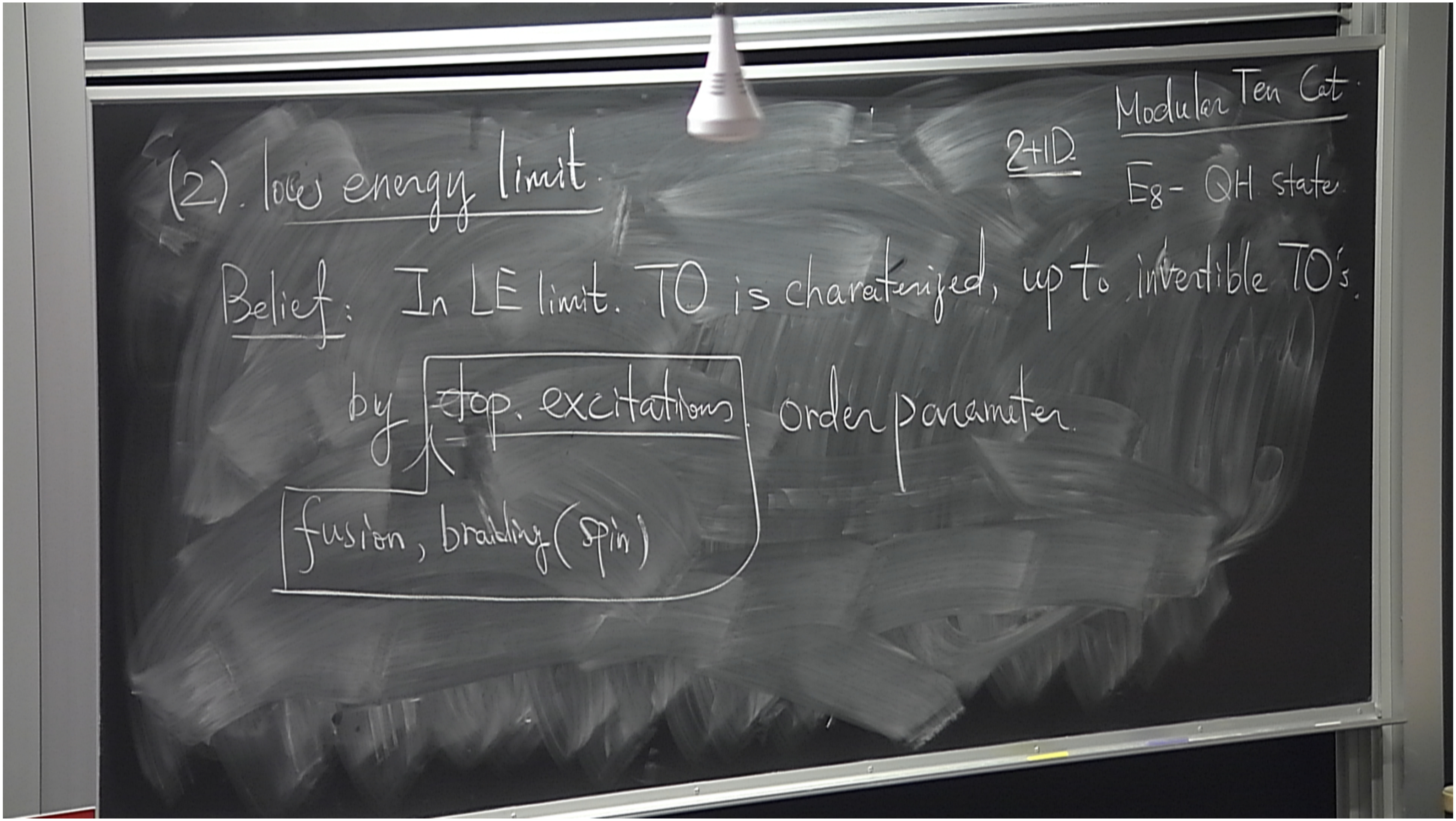

gapped
gap
gap
A (potentially anomalous) TO can be realized as a gapped bdy.
of a lattice TO of one-dim higher.
CAUTION

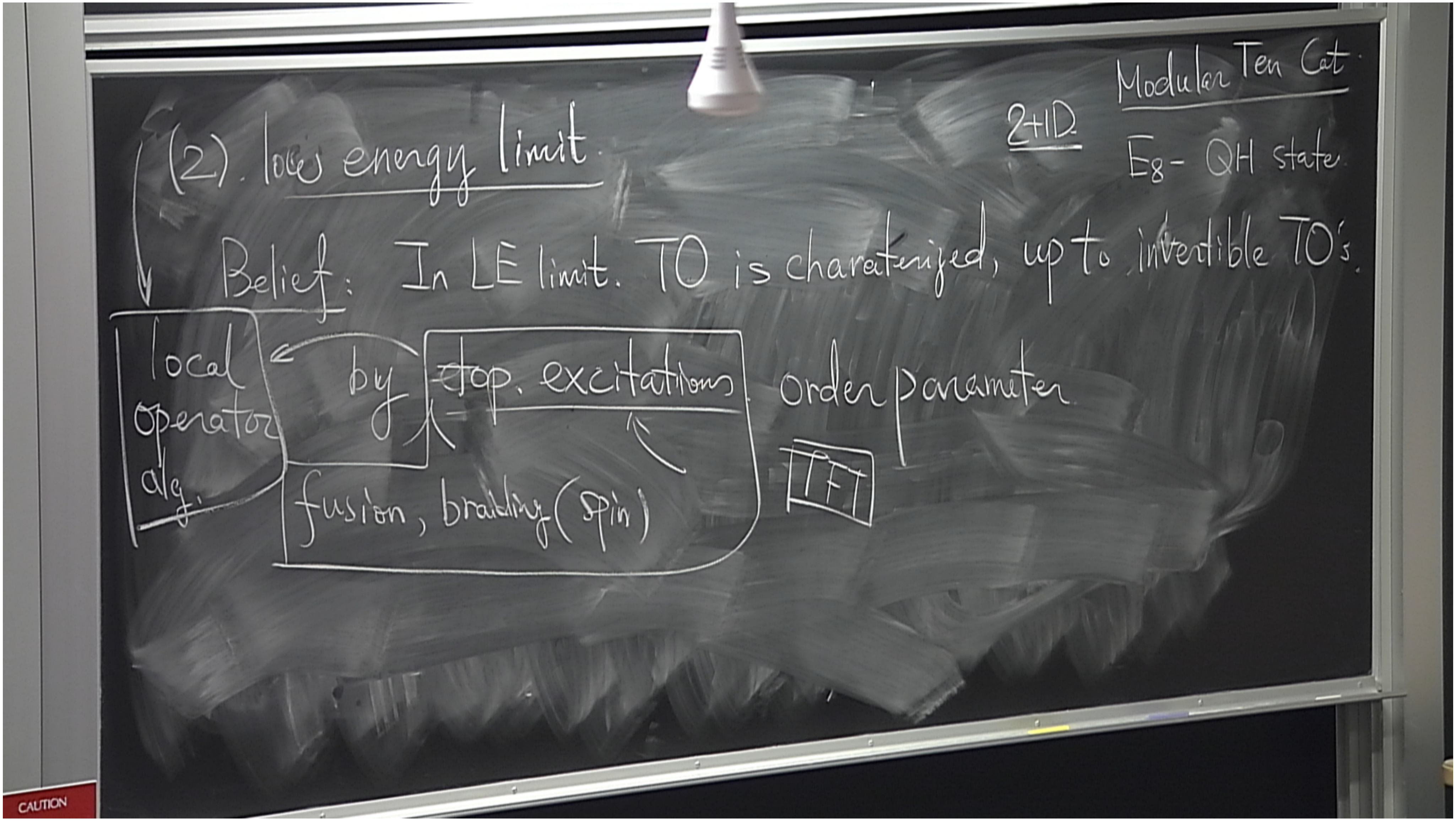

(I) a TO_{n+1} should be def. as lattice models/~
=?
Two lattice models are equivalent.
if ∃ a nbh. of bdy such that.
we can deform one to the other
w/o closing the gap
e_{n+1}
e_n

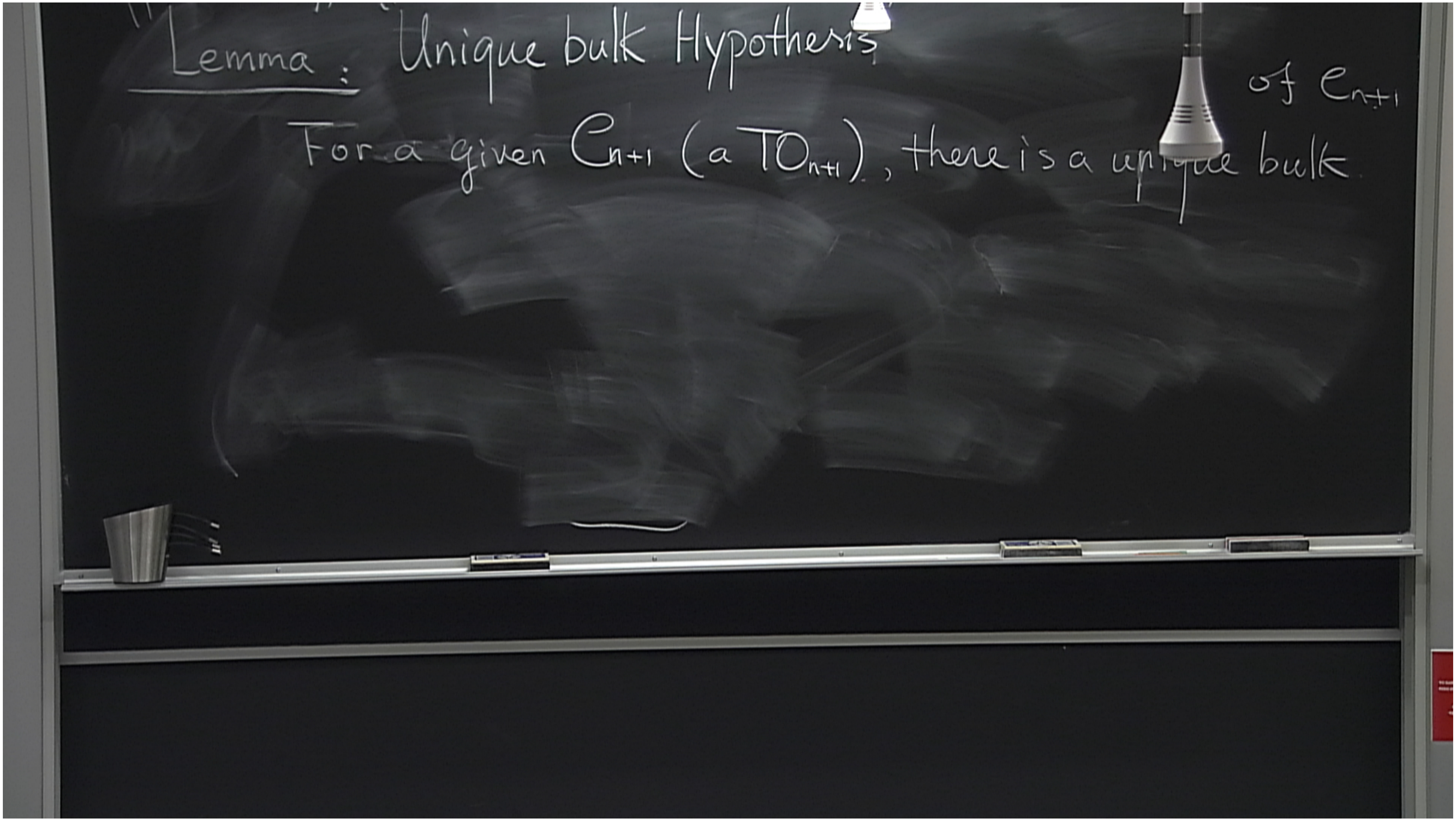

4.
(1) a TO n+1 should be def. as lattice models / ~
=?
Two lattice models are equi alent.
if ∃ a nbh. of bdy such
we can "deform" one to the other
w/o closing the gap
C n+1
C

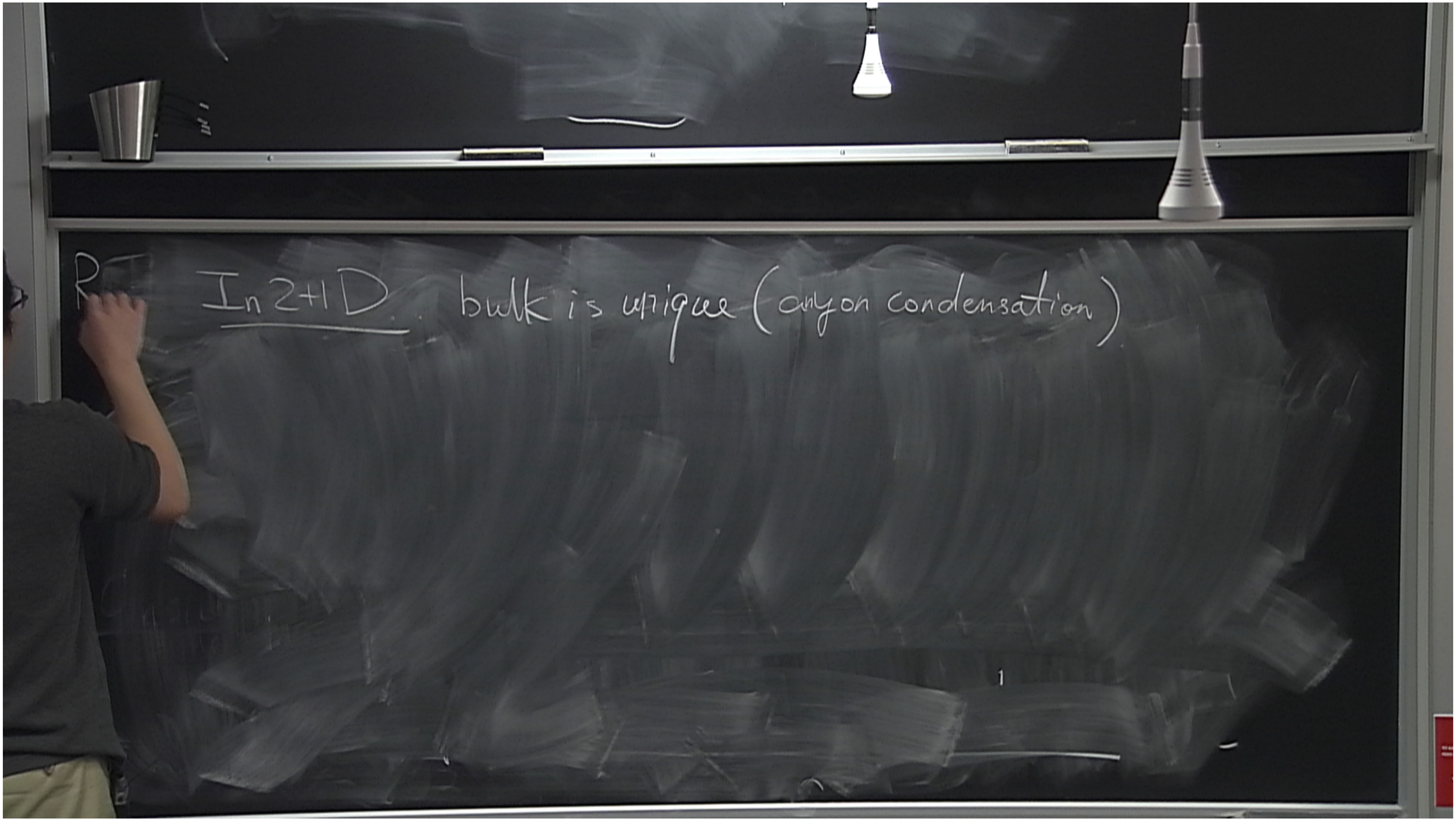

Two lattice models are equivalent.
if ∃ a nbh. of bdy such that.
we can "deform" one to the other
w/o closing the gap
=?
n+1 d → spa
n+2 D st.
C_{n+1}
TO_{n+1}
C_{n+1}

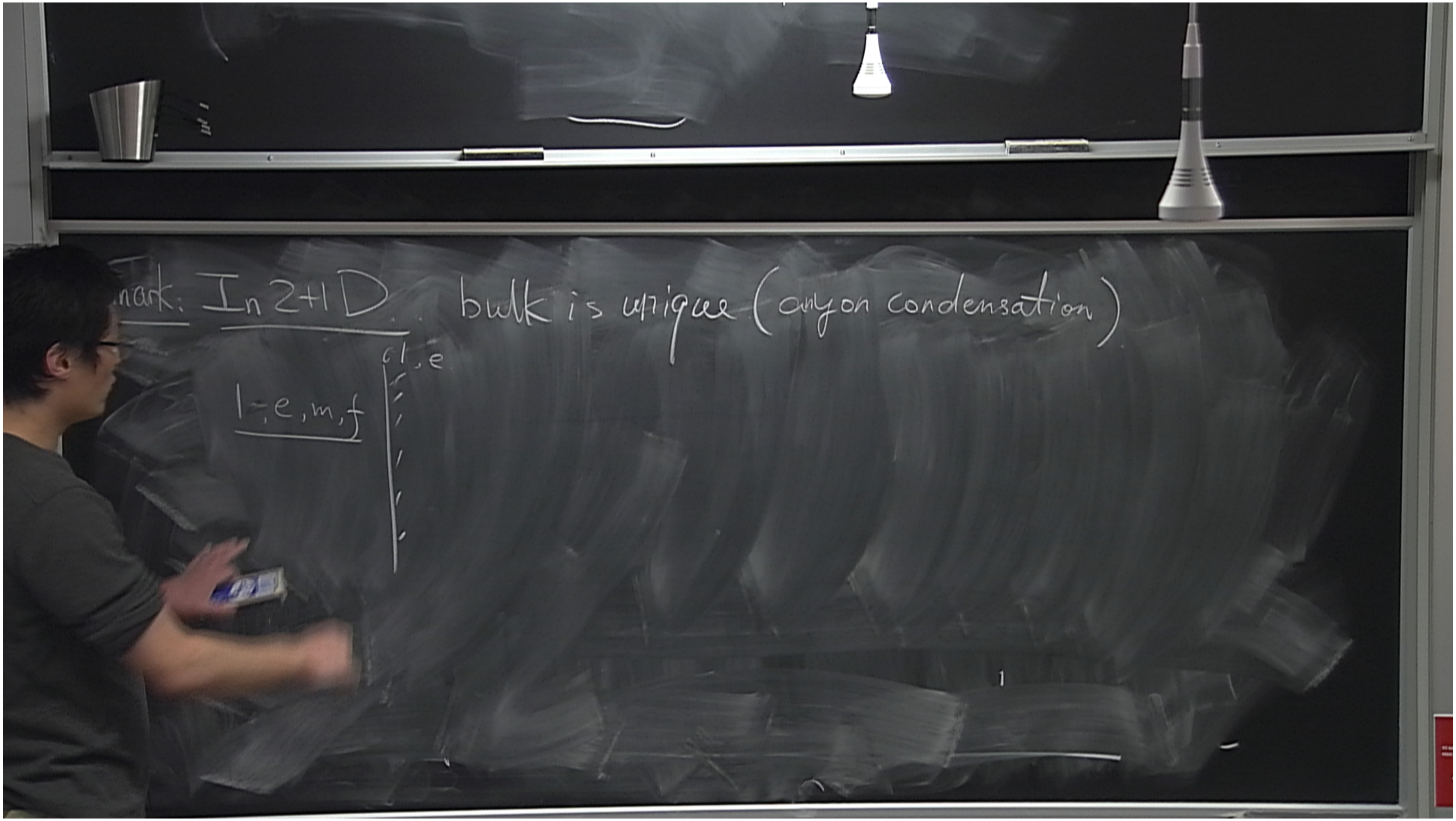

Modular Ten Cat
2+1D
E8 - QH state
limit
LE limit. TO is charaterized, up to invertible TO's
top. excitations

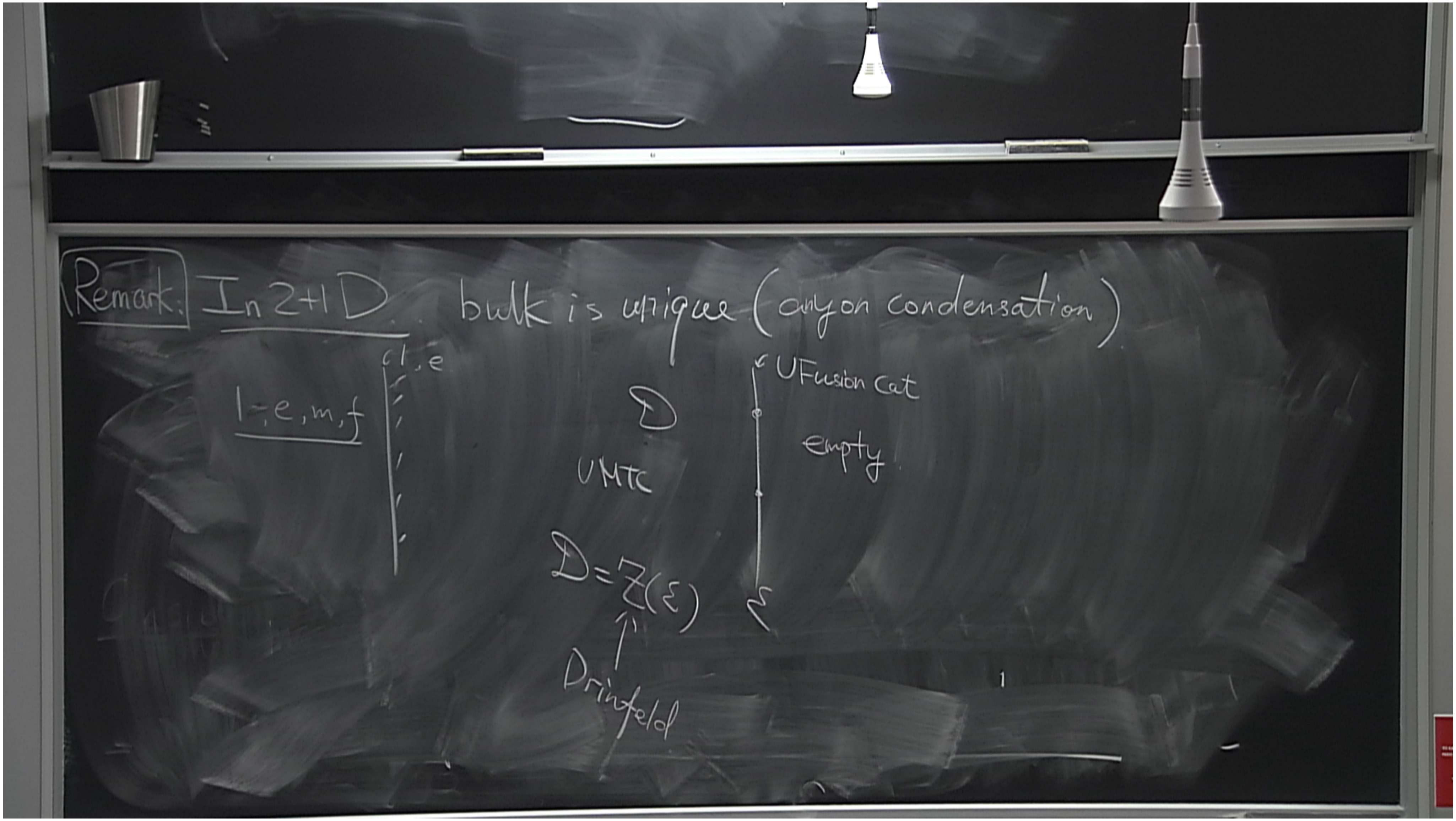

(2). low energy limit
2+1D.
Modular Ten Cat.
E8 - QH state
Belief: In LE limit. TO is charaterized, up to invertible TO's.
by top. excitations
order parameter
fusion, braiding (spin)

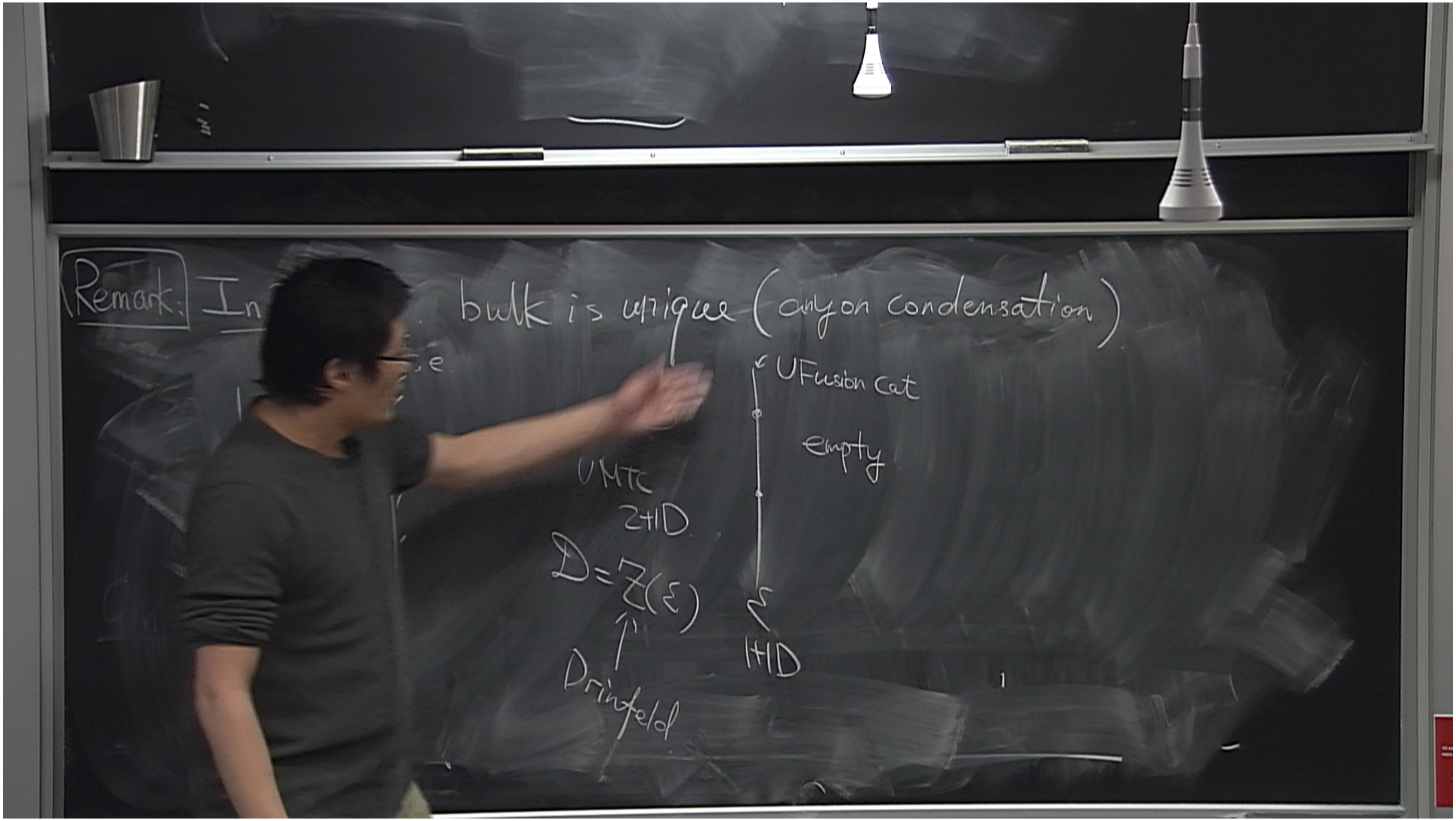

(2). low energy limit.
2+1D
Modular Ten Cat.
E8 - QH state
Belief: In LE limit. TO is characterized, up to invertible TO's.
local operator alg.
by
top. excitations
fusion, braiding (spin)
order parameter
TFT

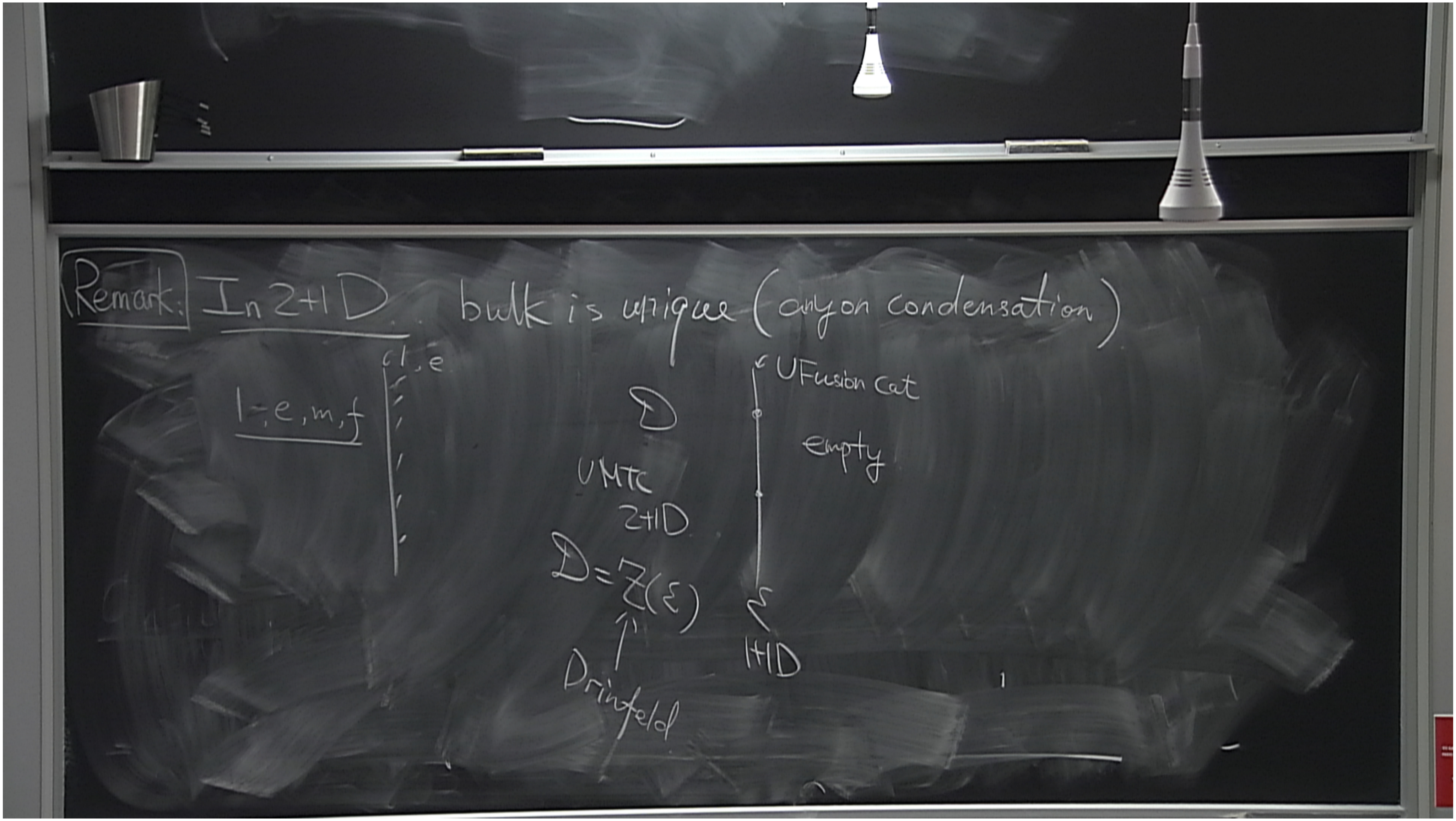

Lemma: Unique bulk Hypothesis
For a given C_{n+1} (a TO_{n+1}), there is a unique bulk
of e_{n+1}

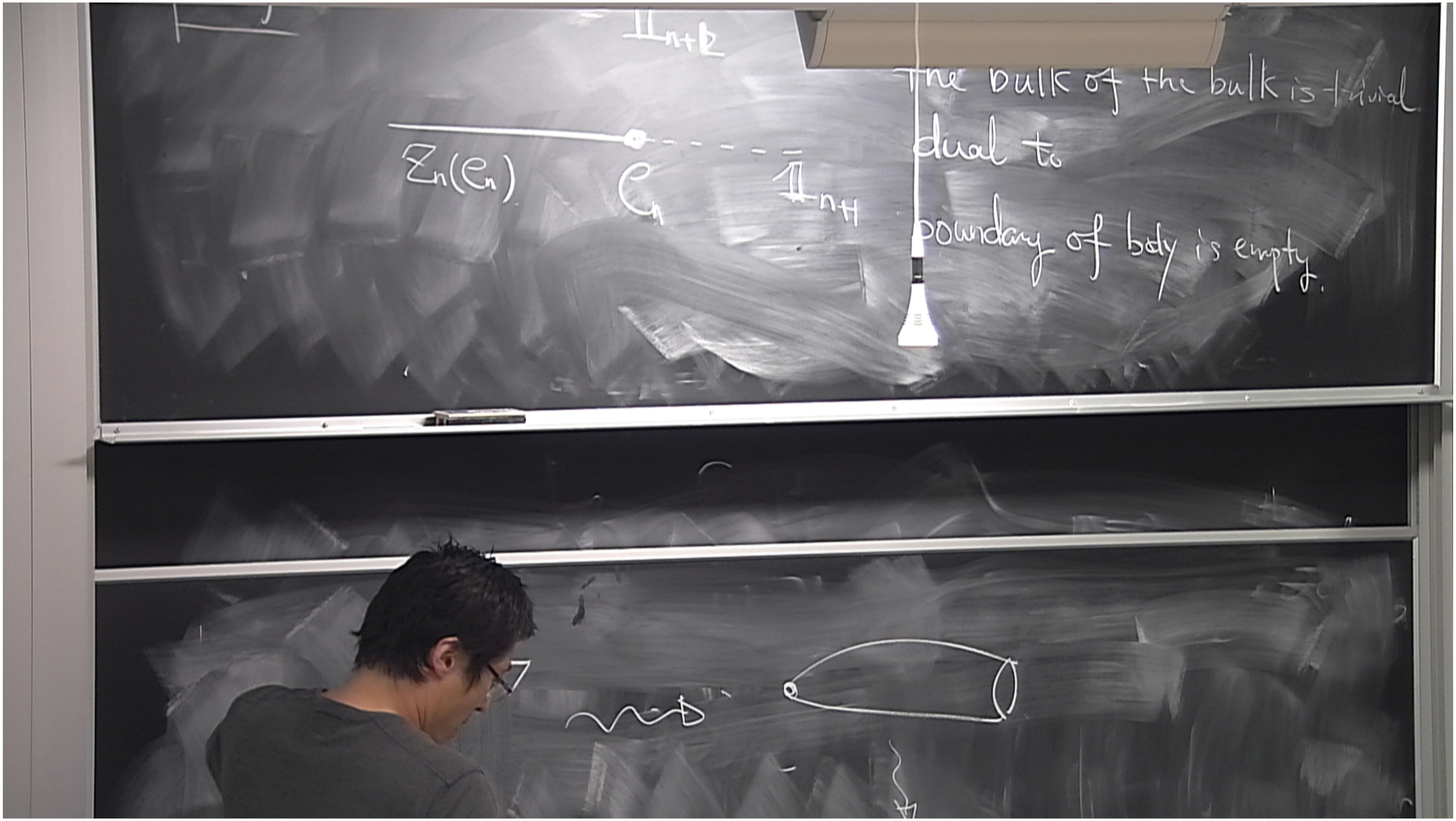

In 2+1D: bulk is unique (anyon condensation)

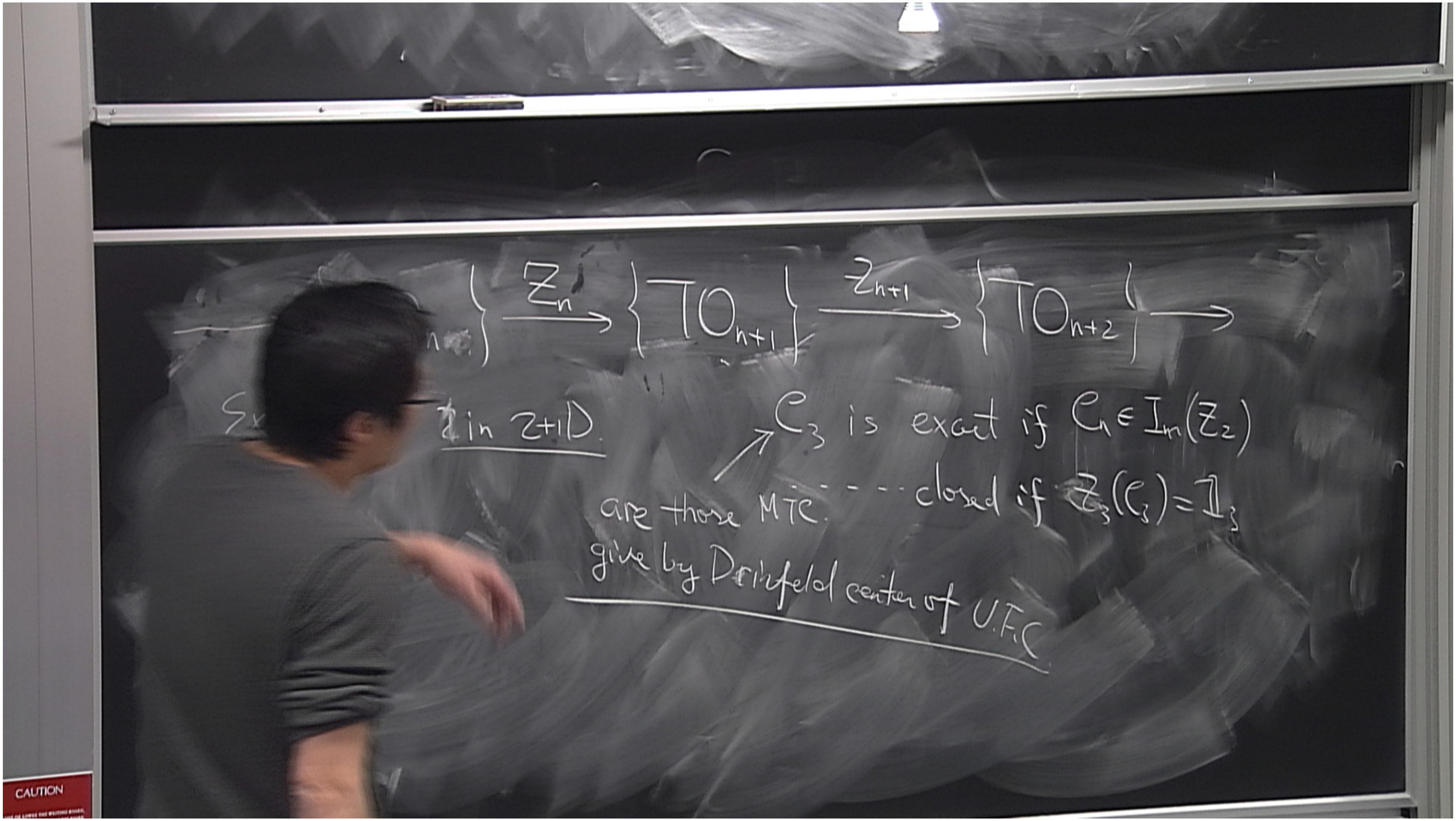

mark: In 2+1 D. bulk is unique (anyon condensation)
1, e
1, e, m, f

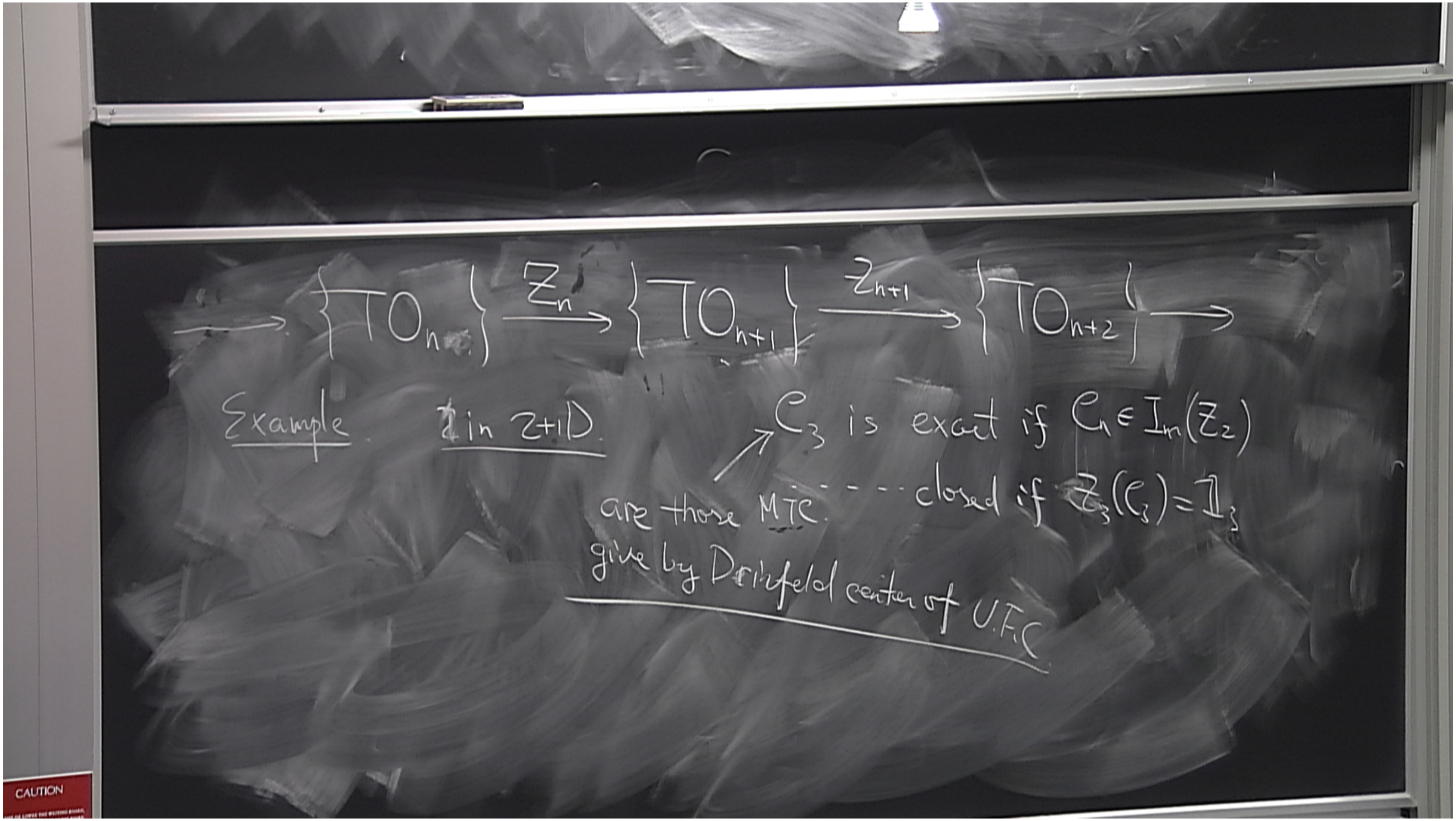

Remark: In 2+1 D bulk is unique (anyon condensation)
1, e, m, f
cl, e
UFusion cat
D
empty
UMTC
D = Z(ε)
Drinfeld
ε

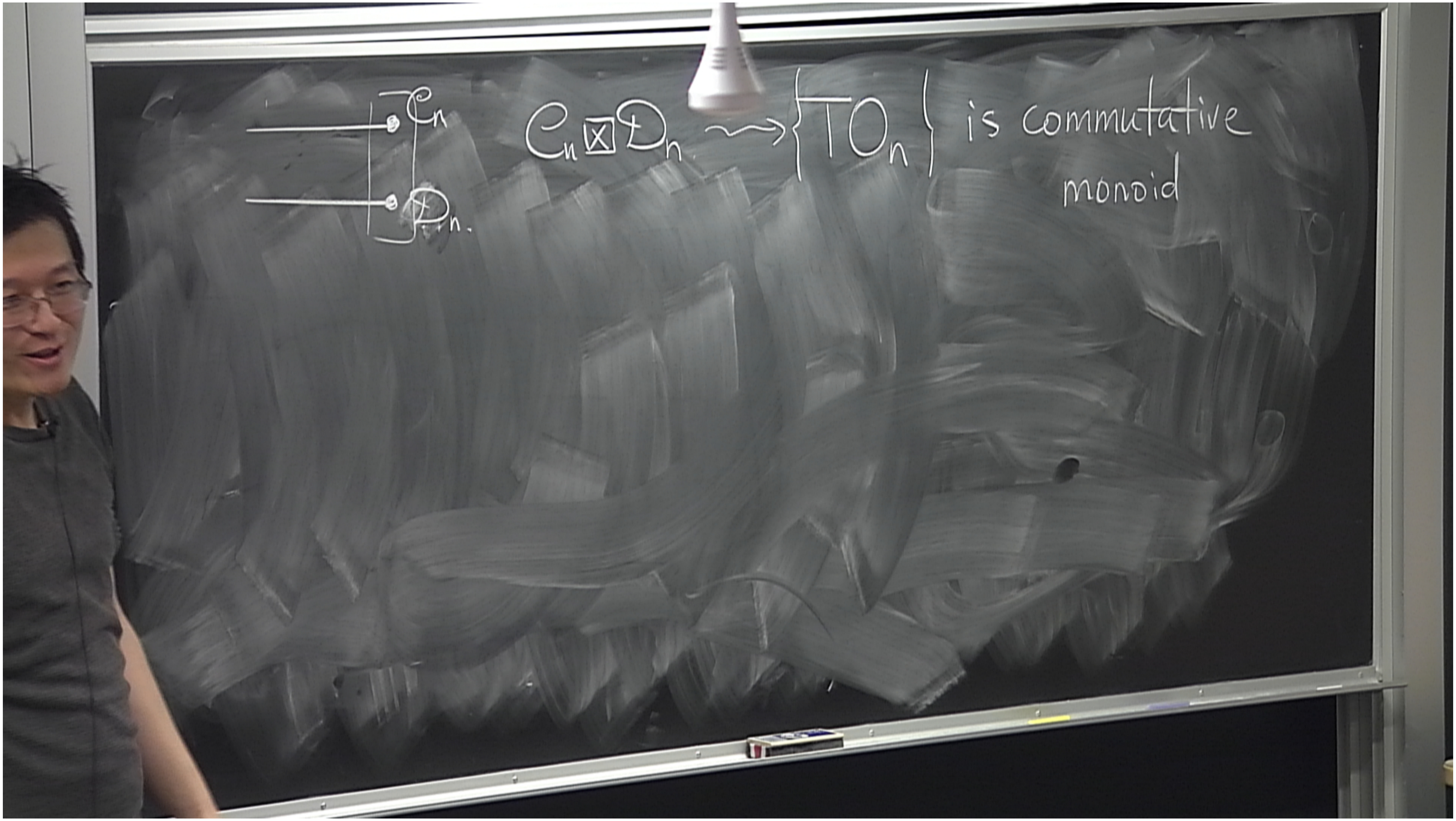

Remark: In
bulk is unique (anyon condensation)
UFusion cat
empty
UMTC
2+1D
D = Z(E)
Drinfeld
1+1D


Remark: In 2+1 D bulk is unique (anyon condensation)
1, e, m, f
1, e
D
UMTC
2+1D
D = Z(ε)
Drinfeld
UFusion cat
empty
ε
1+1D

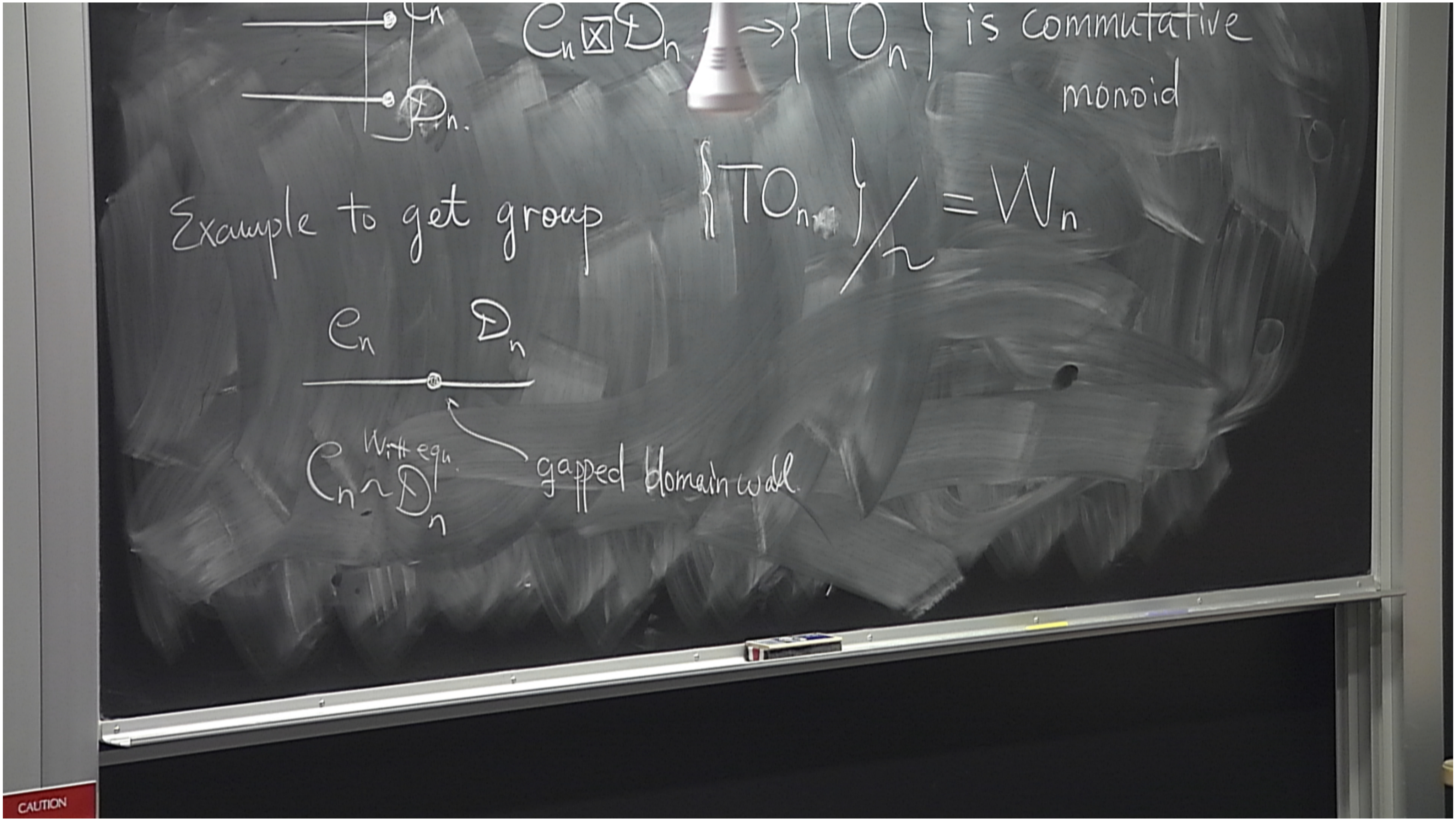

The bulk of the bulk is trivial
dual to
boundary of bdy is empty.
Zn(Cn)
Cn
1n+1
1n+2


Z_n
{TO_{n+1}}
Z_{n+1}
{TO_{n+2}}
in Z+1D
C_3 is exact if C_1 ∈ Im(Z_2)
closed if Z_3(C_3) = 1_3
are those MTC
give by Drinfeld center of U.F.C
CAUTION

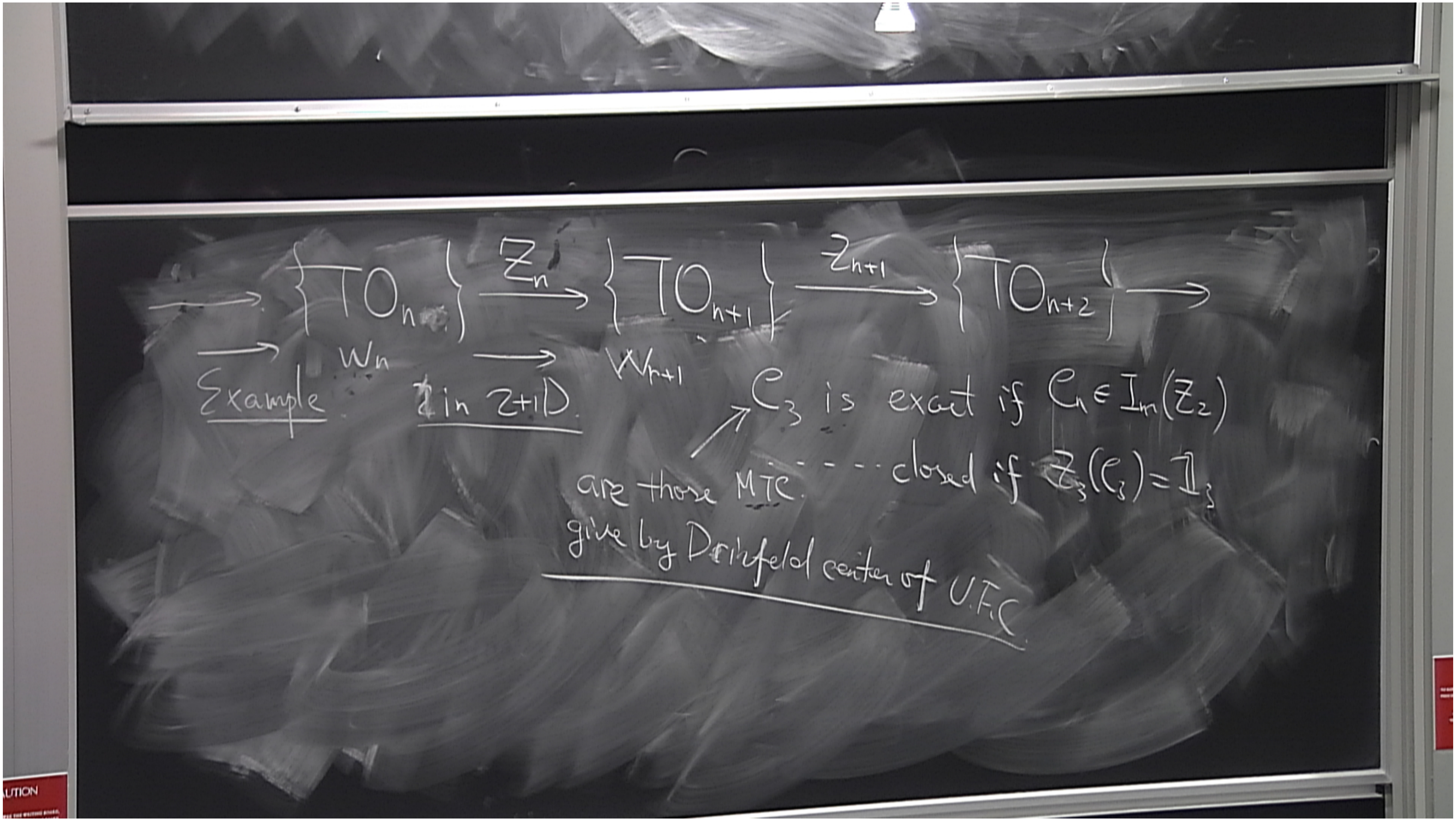

→ {TO_n} —Z_n→ {TO_{n+1}} —Z_{n+1}→ {TO_{n+2}} →
Example
in 2+1D
C_3 is exact if C_1 ∈ Im(Z_2)
closed if Z_3(C_3) = 1_3
are those MTC
give by Drinfeld center of U.F.C
CAUTION

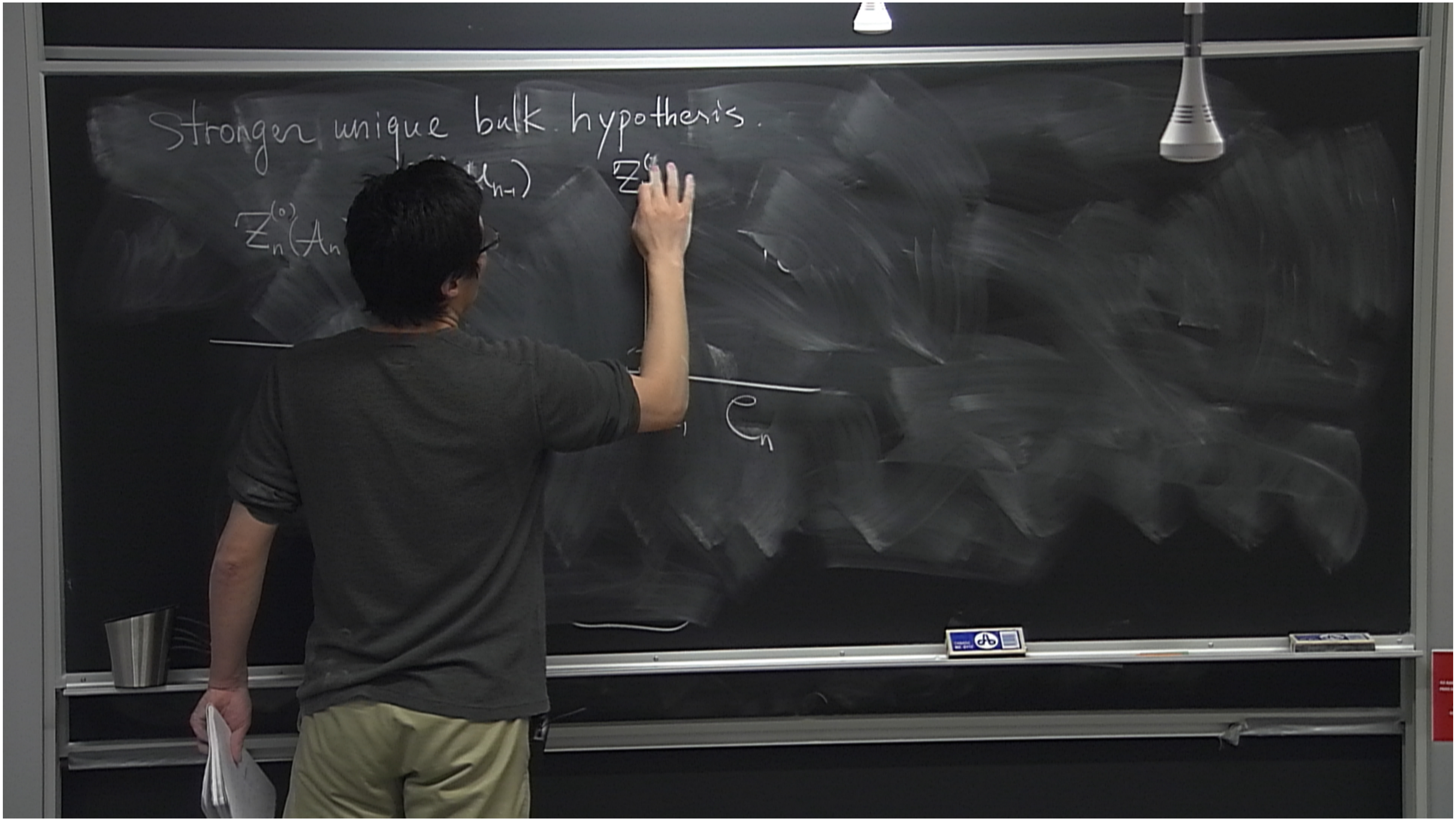


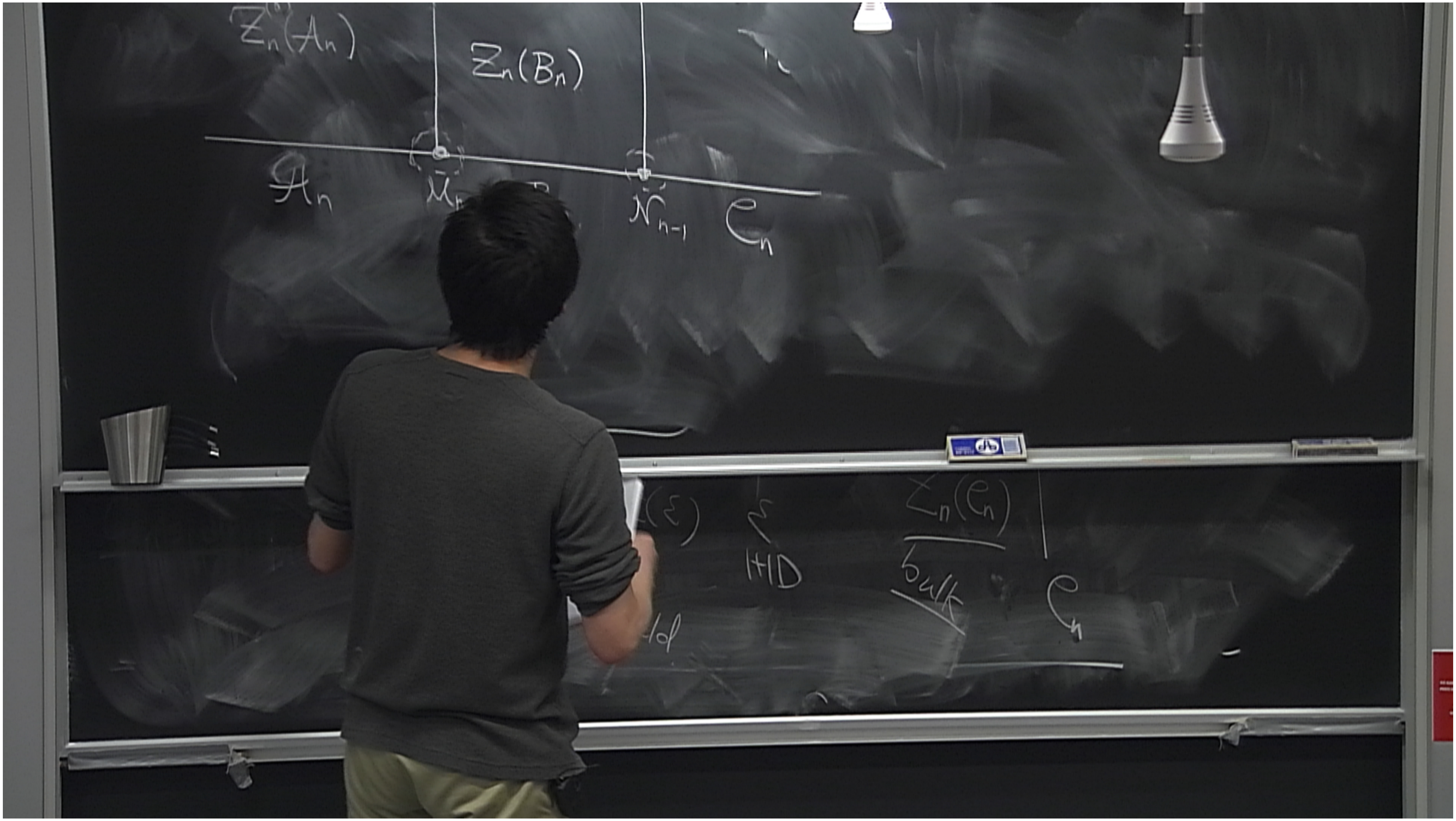
Cn
Dn.
Cn ⊠ Dn ⇝ {TOn} is commutative monoid



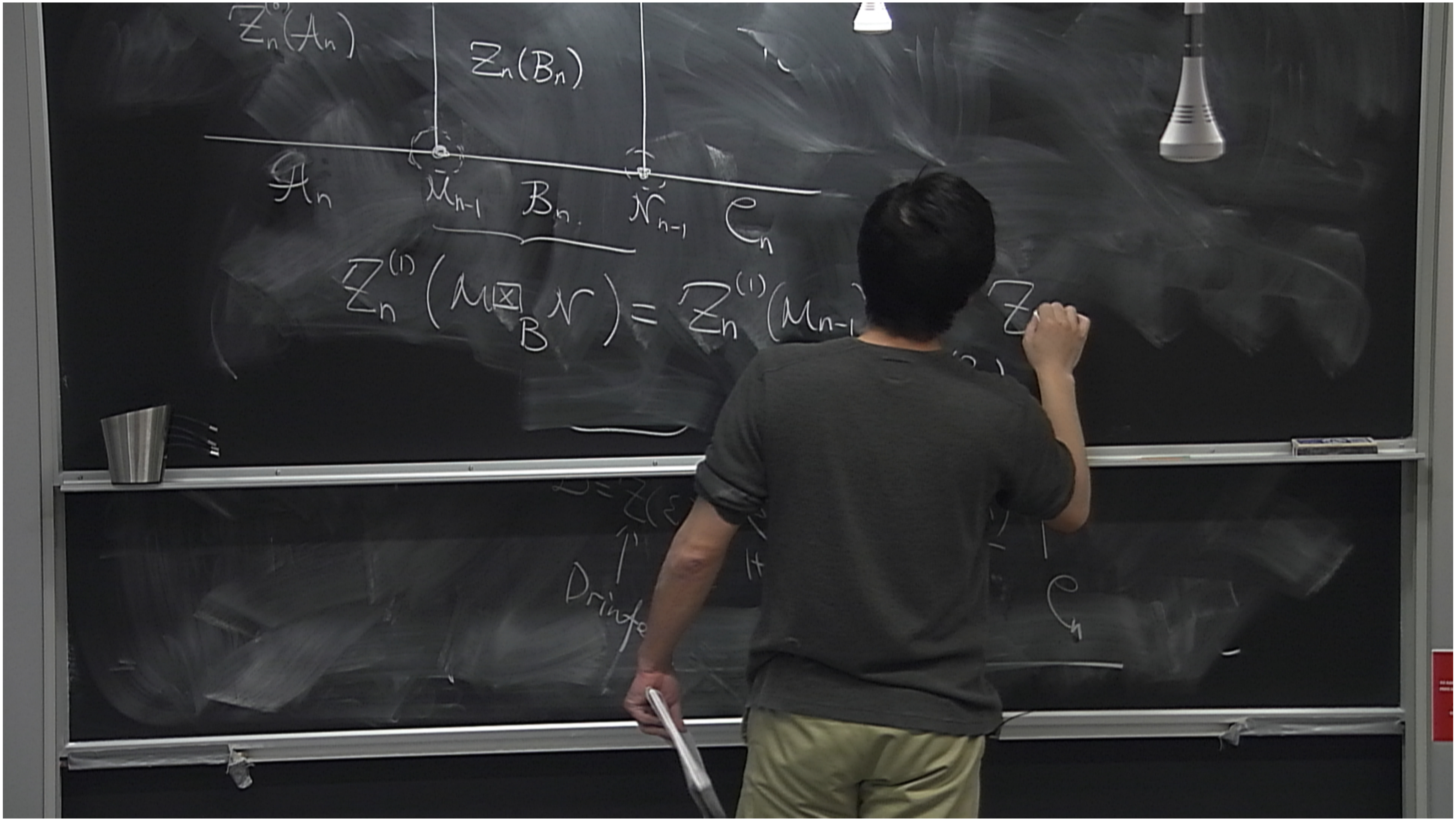
Cn ⊠ Dn → {TOn} is commutative monoid
Example to get group
{TOn}/~ = Wn
Cn
Dn
gapped domain wall
With equ.
Cn ~ Dn

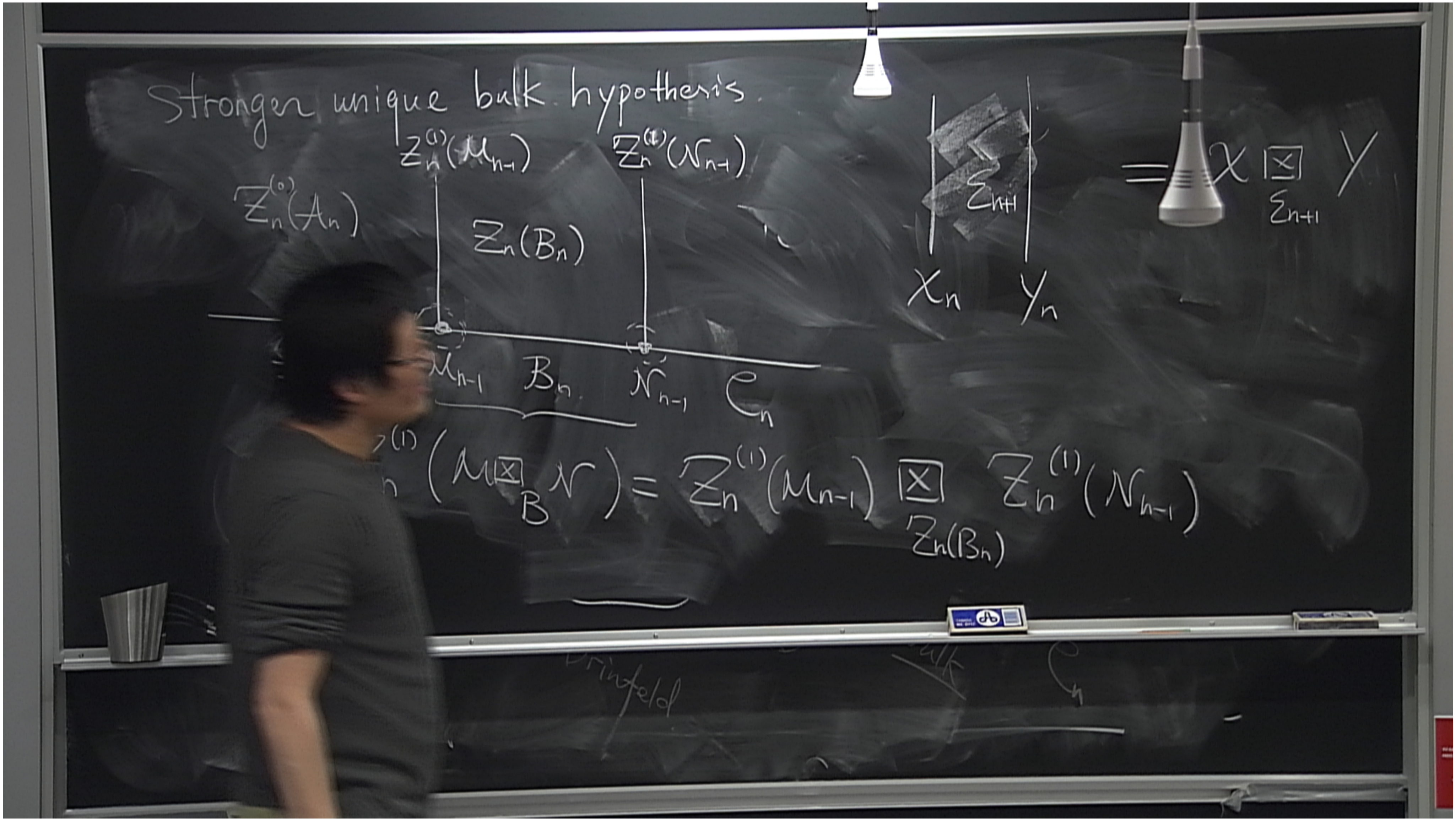

→ {TO_n} Z_n → {TO_n+1} Z_n+1 → {TO_n+2} →
→ W_n → W_n+1
Example: Z in 2+1D.
C_3 is exact if C_1 ∈ Im(Z_2)
closed if Z_3(C_3) = 1_3
are those MTC
give by Drinfeld center of U.F.C

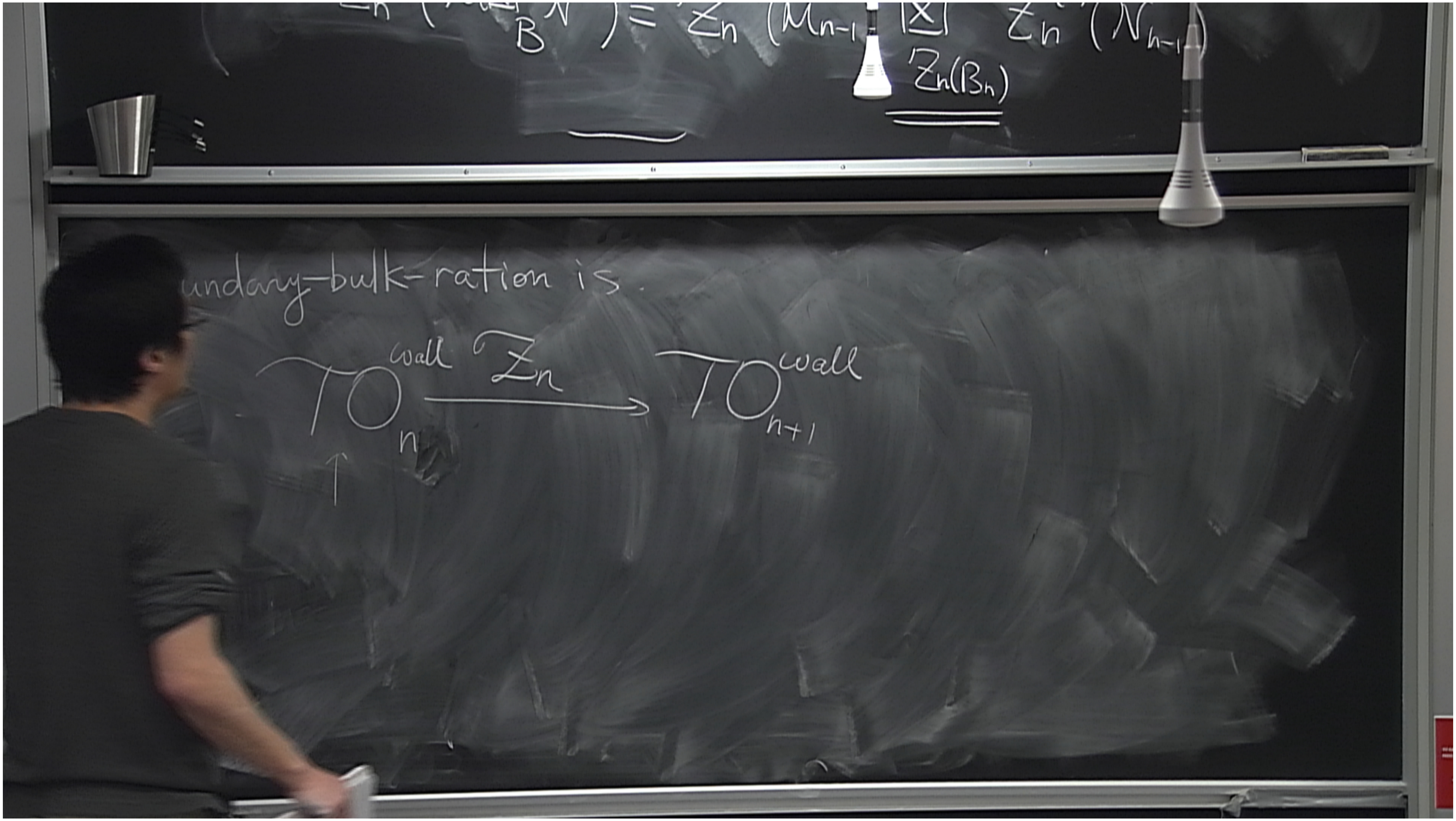

Stronger unique bulk hypothesis.

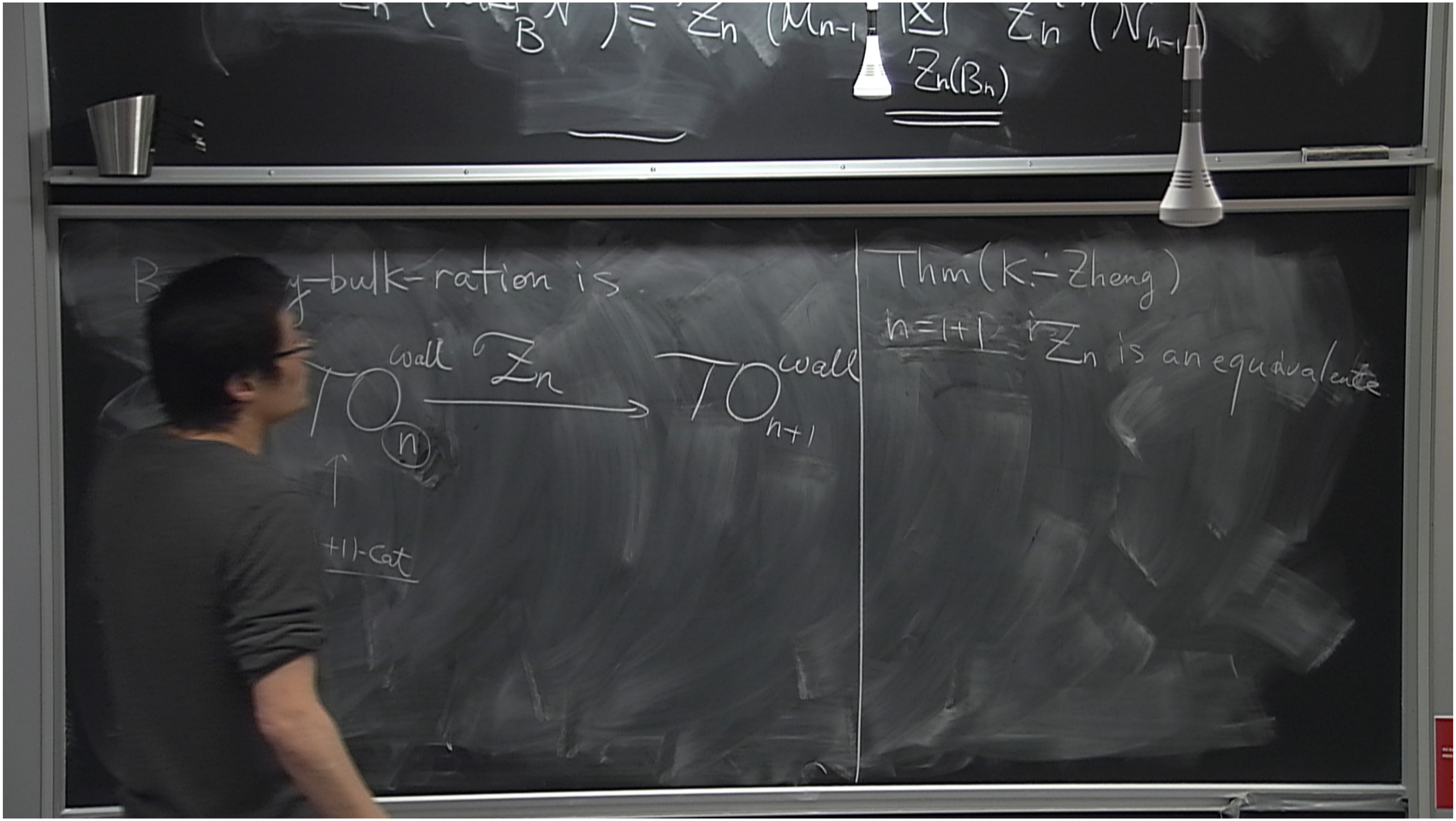


$Z_n(\mathcal{A}_n)$
$Z_n(B_n)$
$\mathcal{A}_n$
$\mathcal{N}_{n-1}$
$\mathcal{C}_n$
$Z_n(\mathcal{C}_n)$
bulk
1+1D

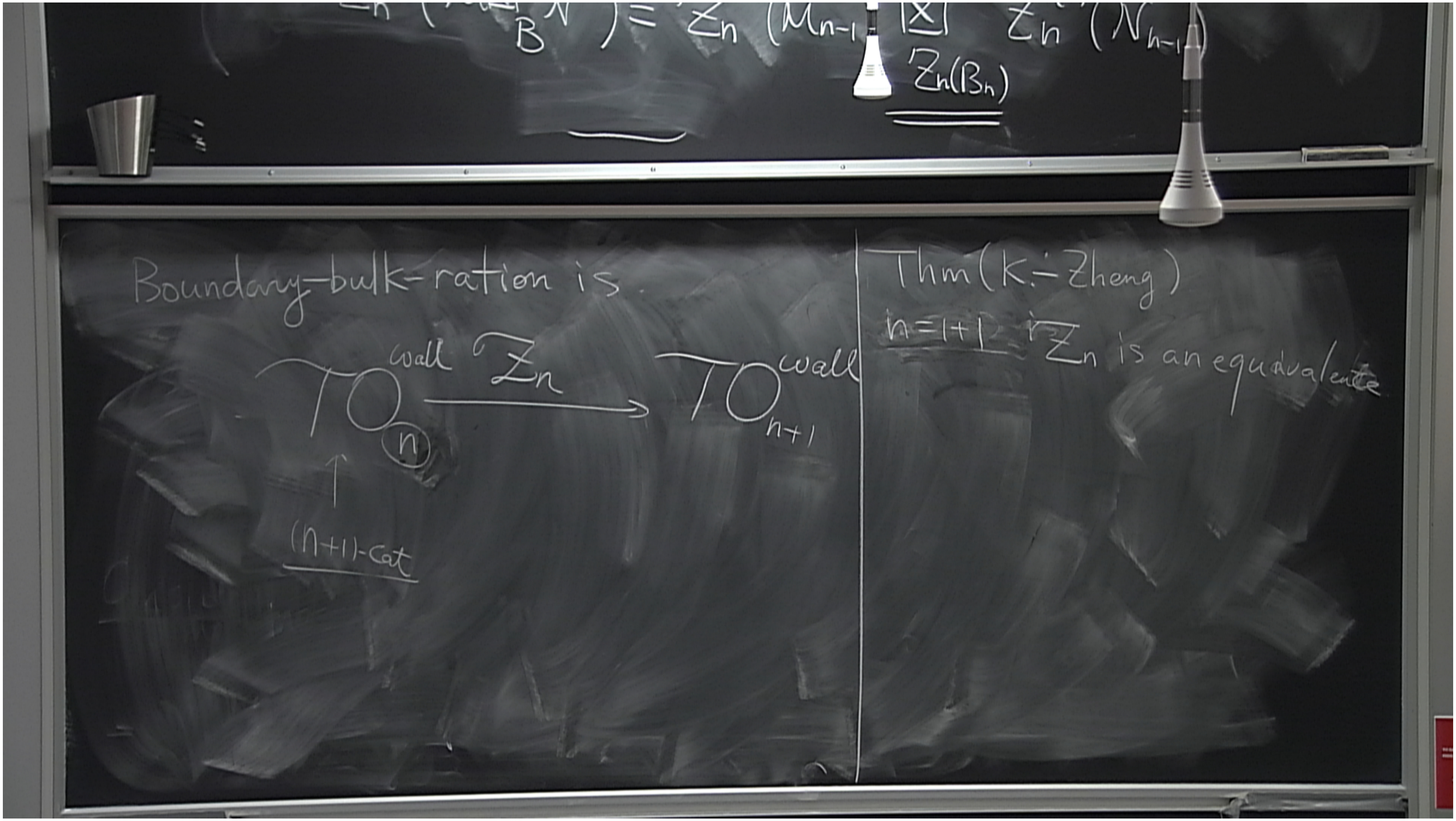

$Z_n(B_n)$
$\mathcal{A}_n$ $\mathcal{M}_{n-1}$ $\mathcal{B}_n$ $\mathcal{N}_{n-1}$ $\mathcal{C}_n$
$Z_n^{(1)}(\mathcal{M} \boxtimes_{\mathcal{B}} \mathcal{N}) = Z_n^{(1)}(\mathcal{M}_{n-1}$

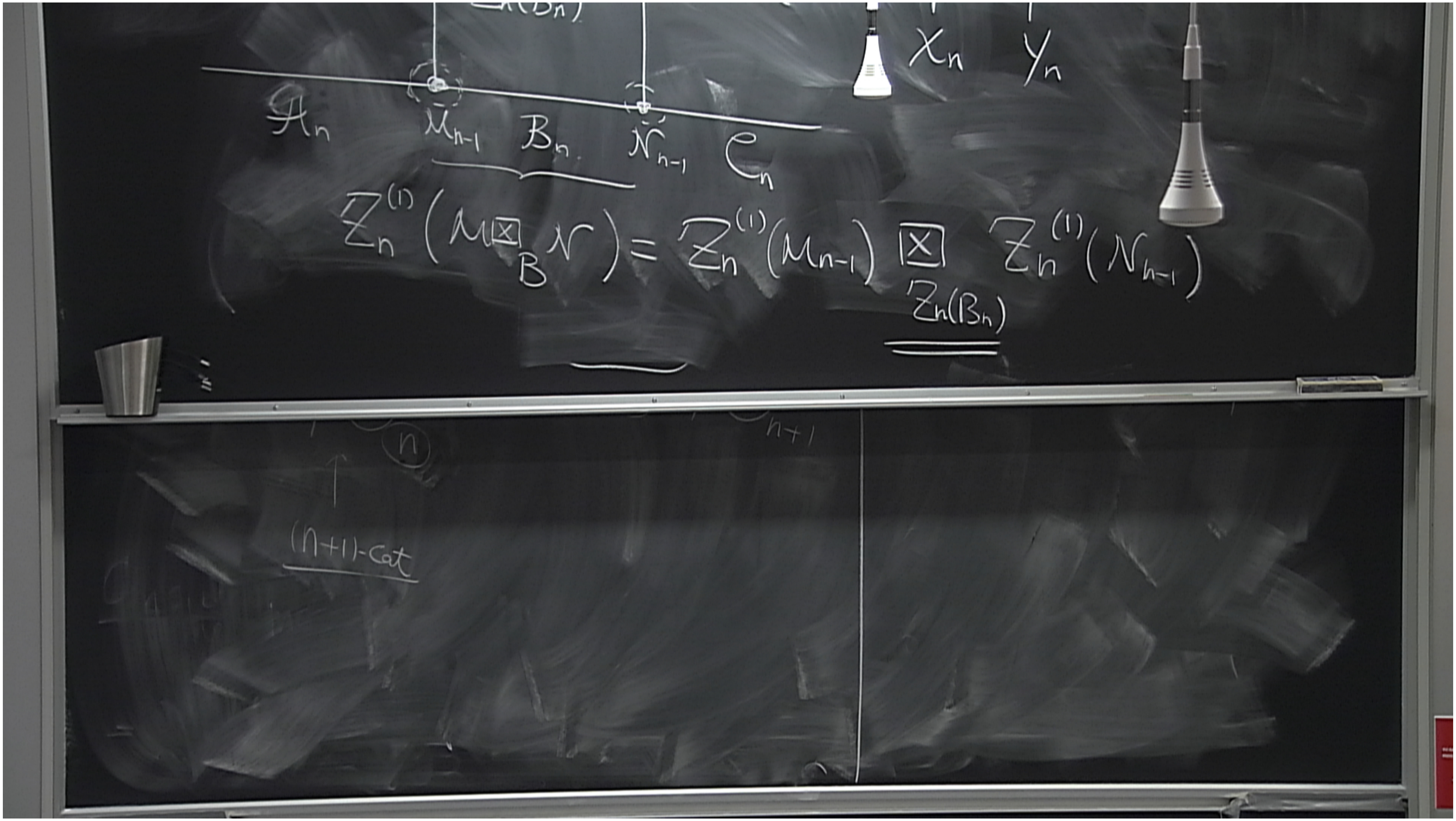

Stronger unique bulk hypothesis.
Z_n^(1)(M_n-1)
Z_n^(1)(N_n-1)
Z_n^(0)(A_n)
Z_n(B_n)
E_n+1
X_n
Y_n
= X ⊠ Y
E_n+1
M_n-1 B_n N_n-1 C_n
(M ⊠_B N) = Z_n^(1)(M_n-1) ⊠ Z_n^(1)(N_n-1)
Z_n(B_n)

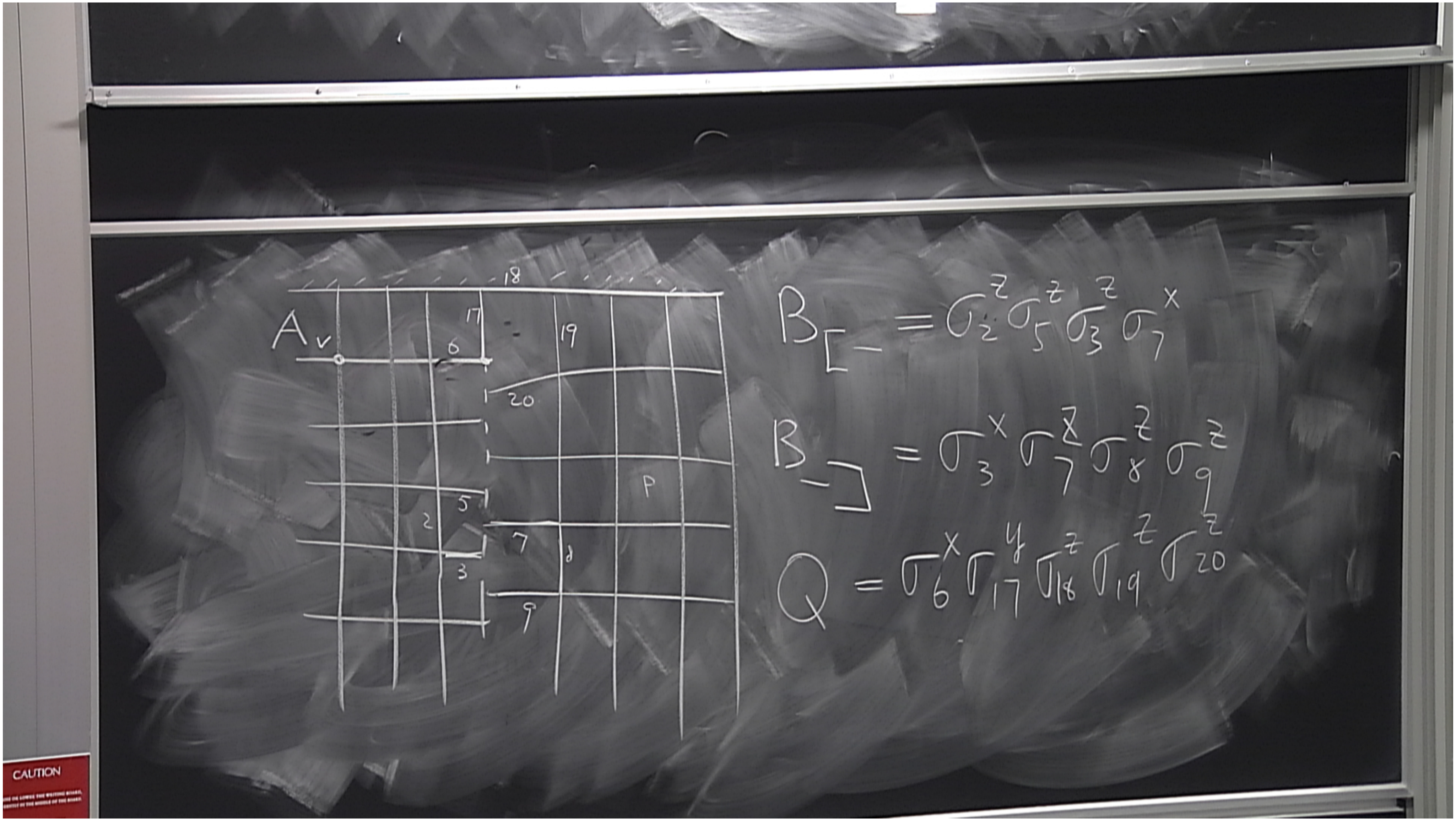

Zn(Bn)
undary-bulk-ration is
wall Zn
TO n wall
TO n+1

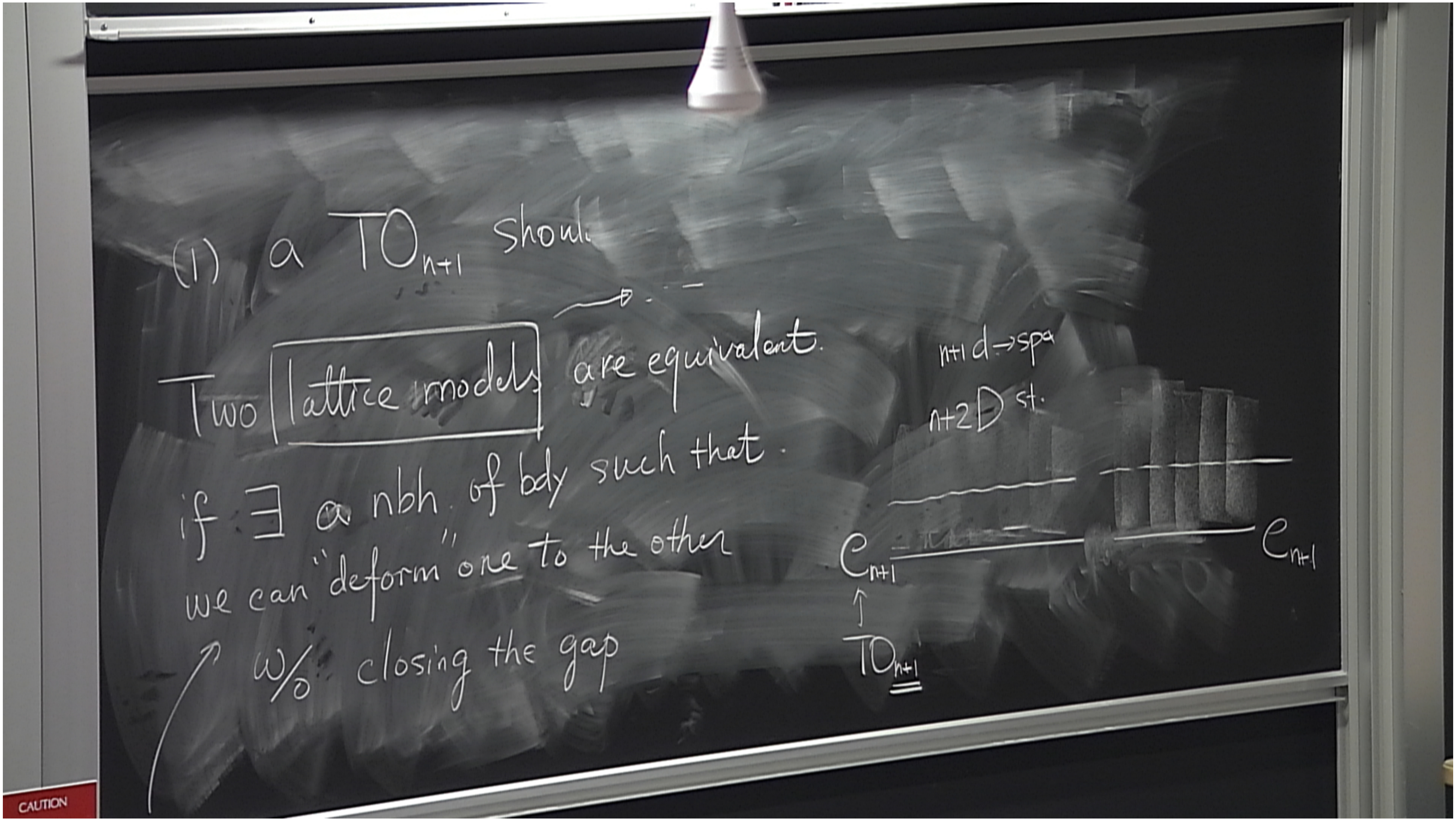


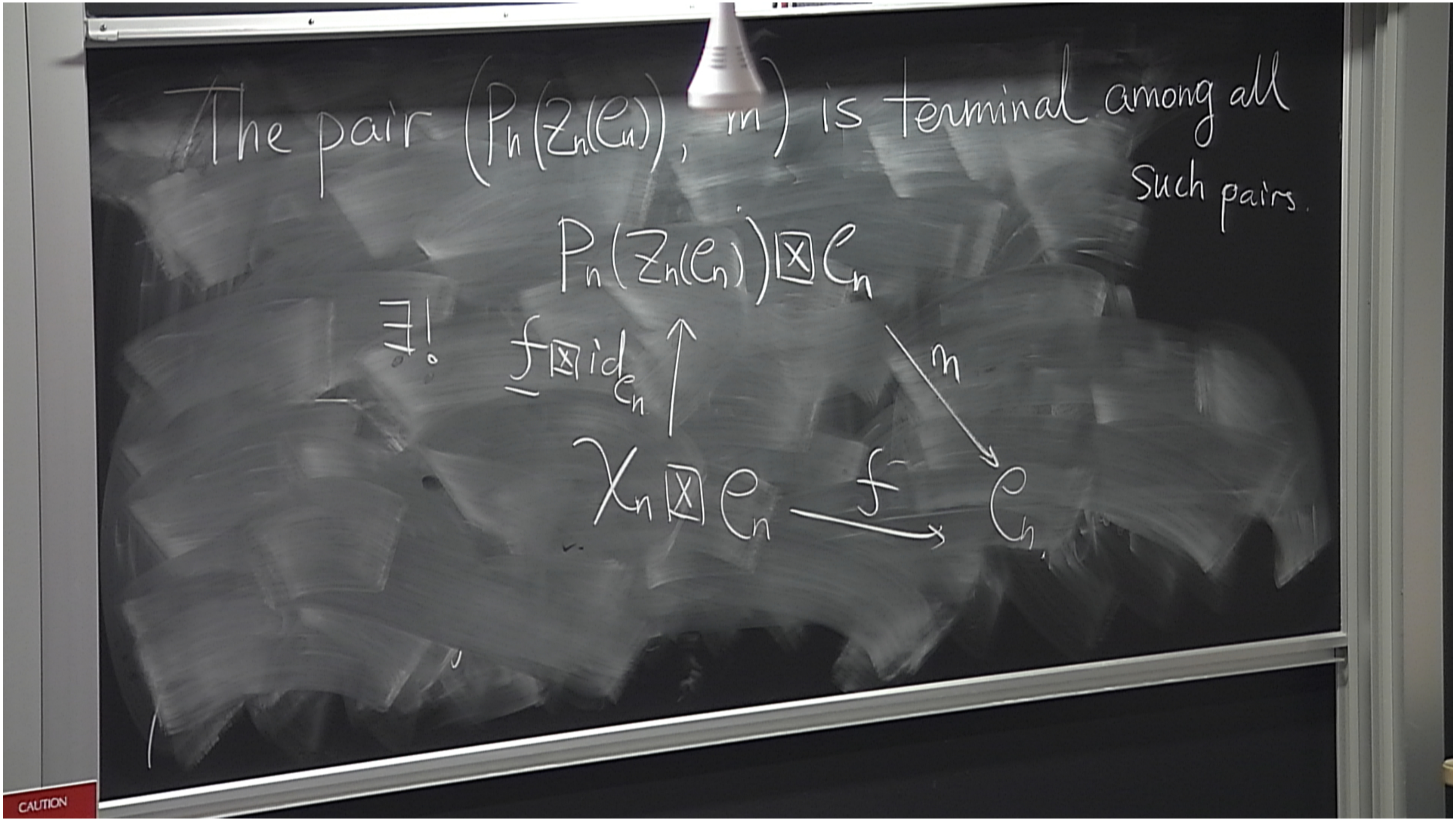
Z_n(B_n)
-bulk-ration is
wall
Z_n
TO_n
TO_{n+1}
wall
+1)-Cat
Thm(K.-Zheng)
n=1+1
Z_n is an equivalence

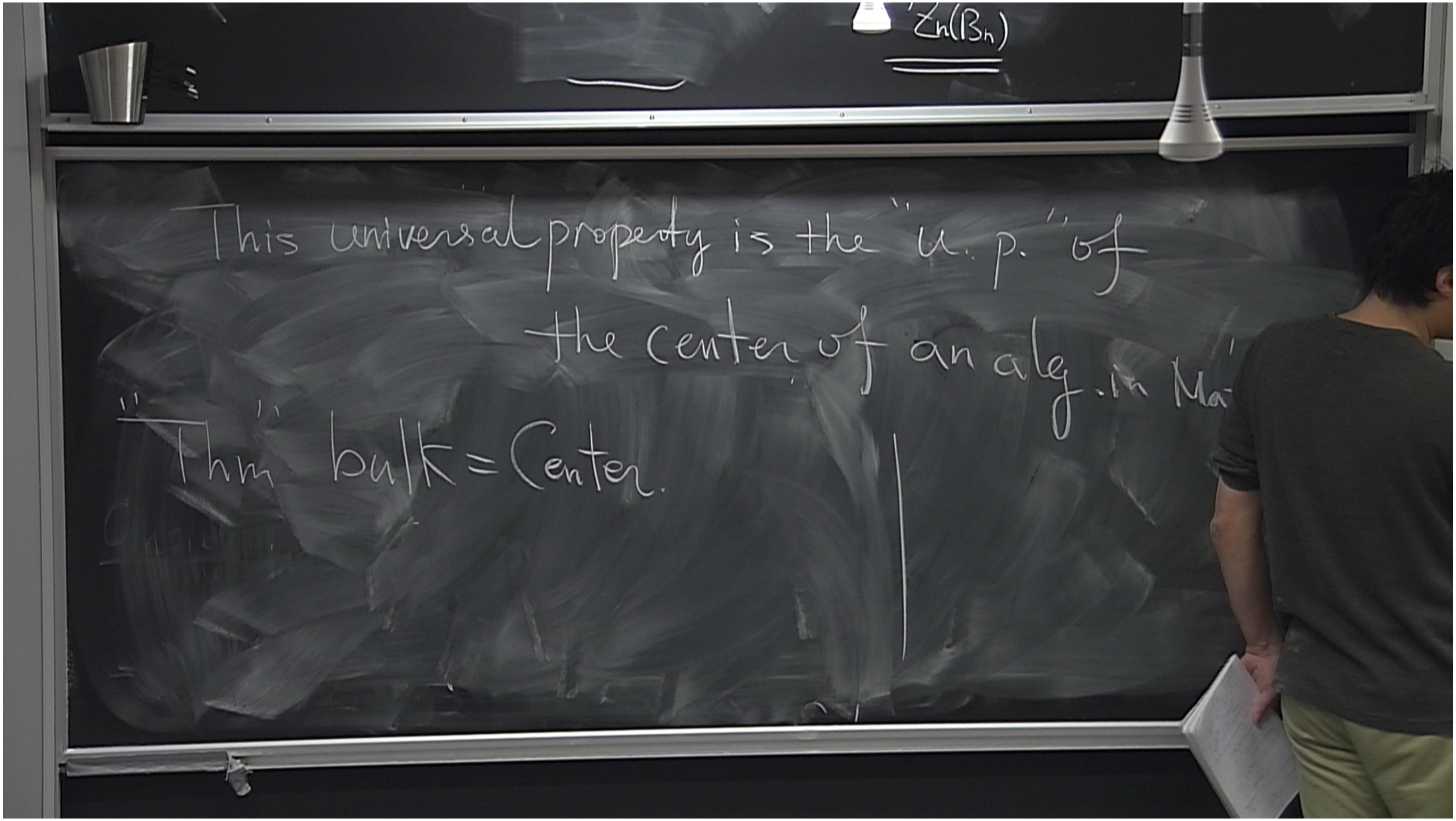

Boundary-bulk-ration is.
$TO^{wall}_{n} \xrightarrow{Z_n} TO^{wall}_{n+1}$
(n+1)-Cat
Thm (K.-Zheng)
n = 1+1 : Z_n is an equivalence

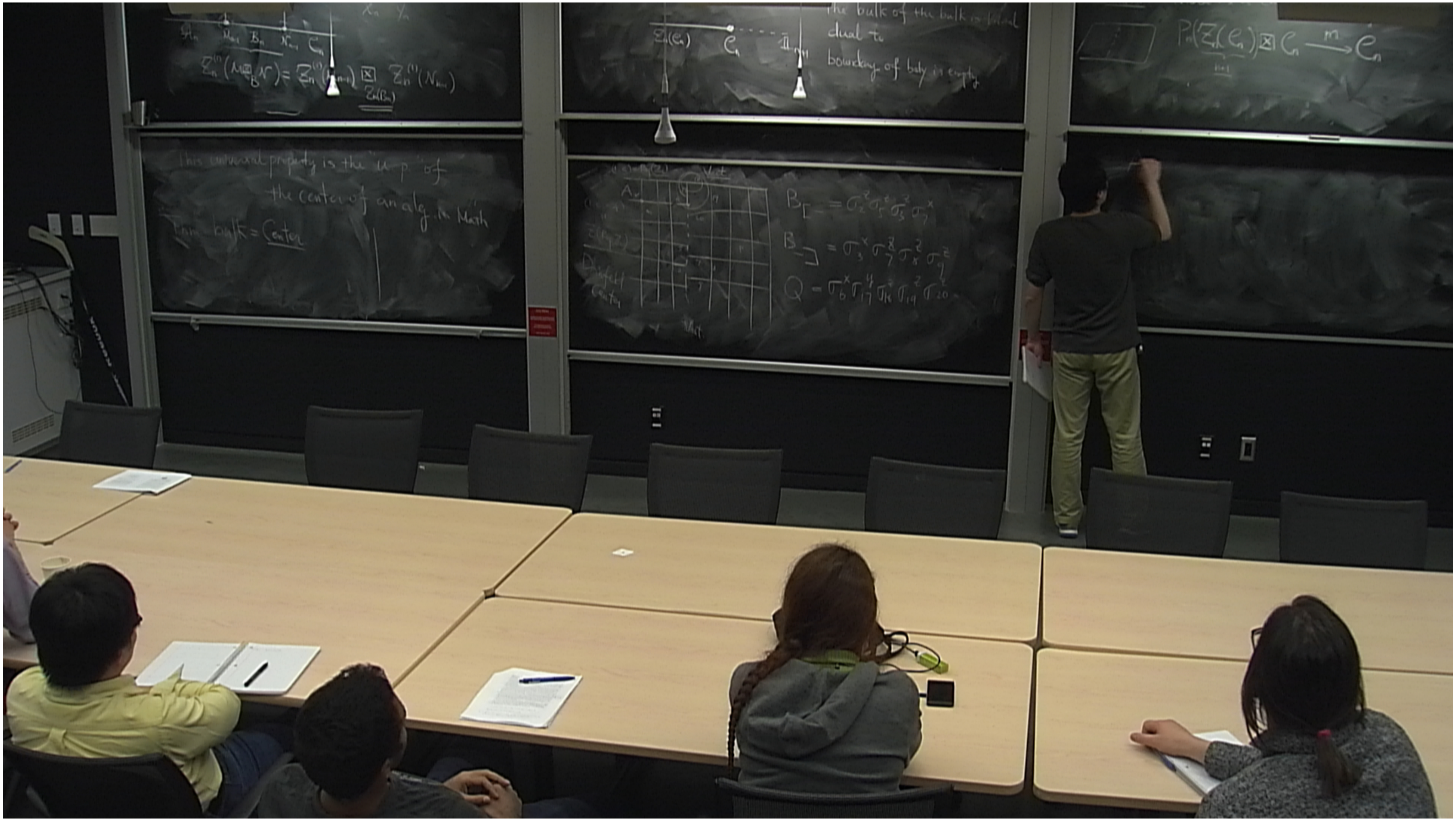

X_n Y_n
$\mathcal{A}_n$ $\mathcal{M}_{n-1}$ $\mathcal{B}_n$ $\mathcal{N}_{n-1}$ $\mathcal{C}_n$
$Z_n^{(1)}(\mathcal{M} \boxtimes_B \mathcal{N}) = Z_n^{(1)}(\mathcal{M}_{n-1}) \boxtimes_{Z_n(\mathcal{B}_n)} Z_n^{(1)}(\mathcal{N}_{n-1})$
n
$n+1$
$(n+1)$-Cat

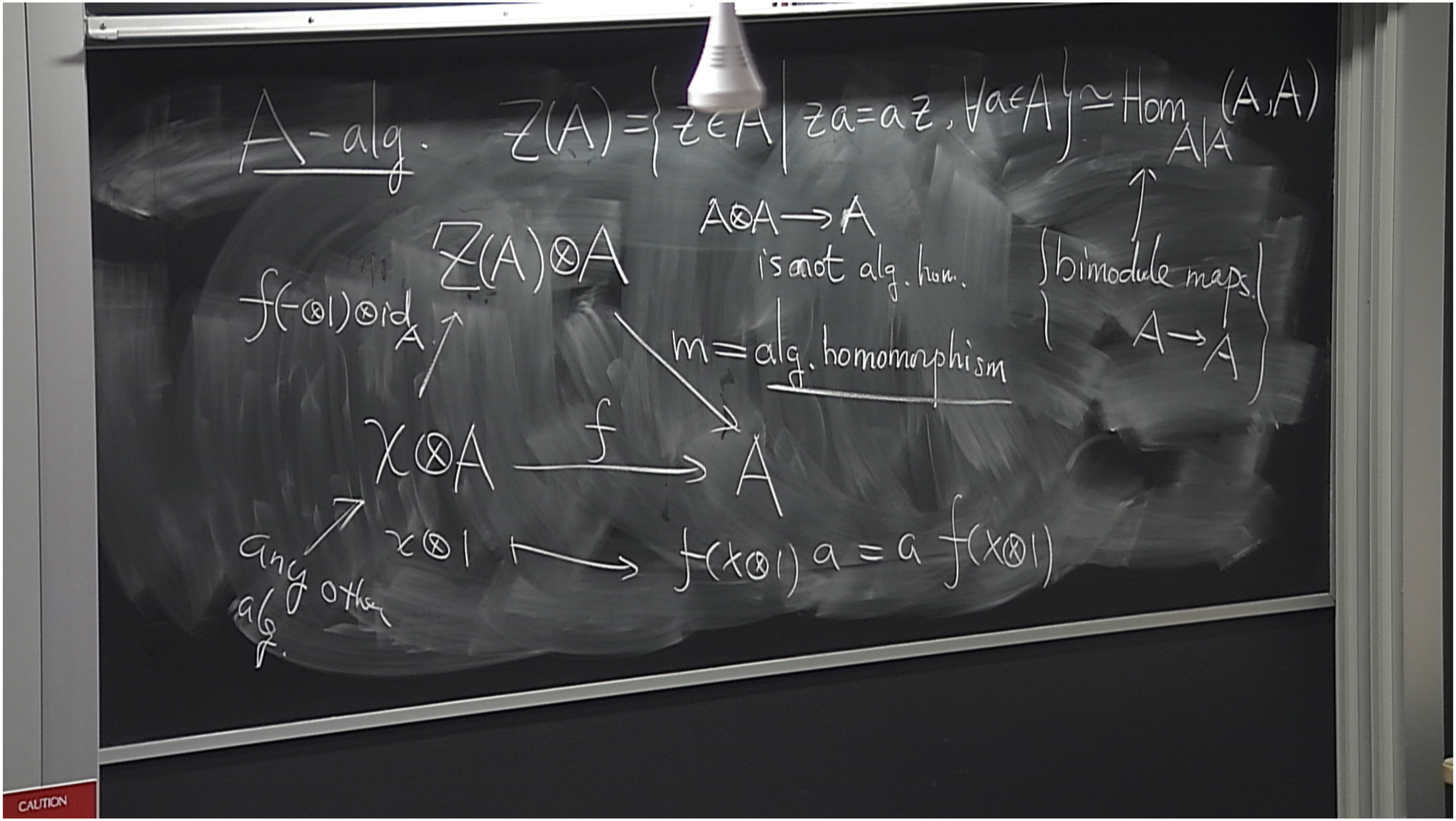

A_v
$B = \sigma_2^z \sigma_5^z \sigma_3^z \sigma_7^x$
$B = \sigma_3^x \sigma_7^z \sigma_8^z \sigma_9^z$
$Q = \sigma_6^x \sigma_{17}^y \sigma_{18}^z \sigma_{19}^z \sigma_{20}^z$
CAUTION


(1) a TO_{n+1} shoul
Two lattice models are equivalent.
if ∃ a nbh. of bdy such that
we can "deform" one to the other
w/o closing the gap
n+1 d → spa
n+2 D st.
e_{n+1}
e_{n+1}
TO_{n+1}
CAUTION


The pair $(P_n(Z_n(\mathcal{C}_n)), m)$ is terminal among all such pairs.
$P_n(Z_n(\mathcal{C}_n)) \boxtimes \mathcal{C}_n$
$\exists!\ f \boxtimes id_{\mathcal{C}_n}$
m
$X_n \boxtimes \mathcal{C}_n$
f
$\mathcal{C}_n$


Zn(Bn)
This universal property is the "u.p." of
the center of an alg. in
"Thm" bulk = Center.


bulk of the bulk is trivial
dual to
boundary of bdy is empty
This universal property is the u.p. of
the center of an alg. in Math
Bulk = Center


A-alg.
Z(A) = {z ∈ A | za = az, ∀a ∈ A} ≃ Hom_{A|A}(A,A)
A⊗A → A
is not alg. hom.
Z(A)⊗A
{bimodule maps A → A}
f(-⊗1)⊗id_A
m = alg. homomorphism
X⊗A → A
f
any other alg.
x⊗1 ↦ f(x⊗1) a = a f(x⊗1)