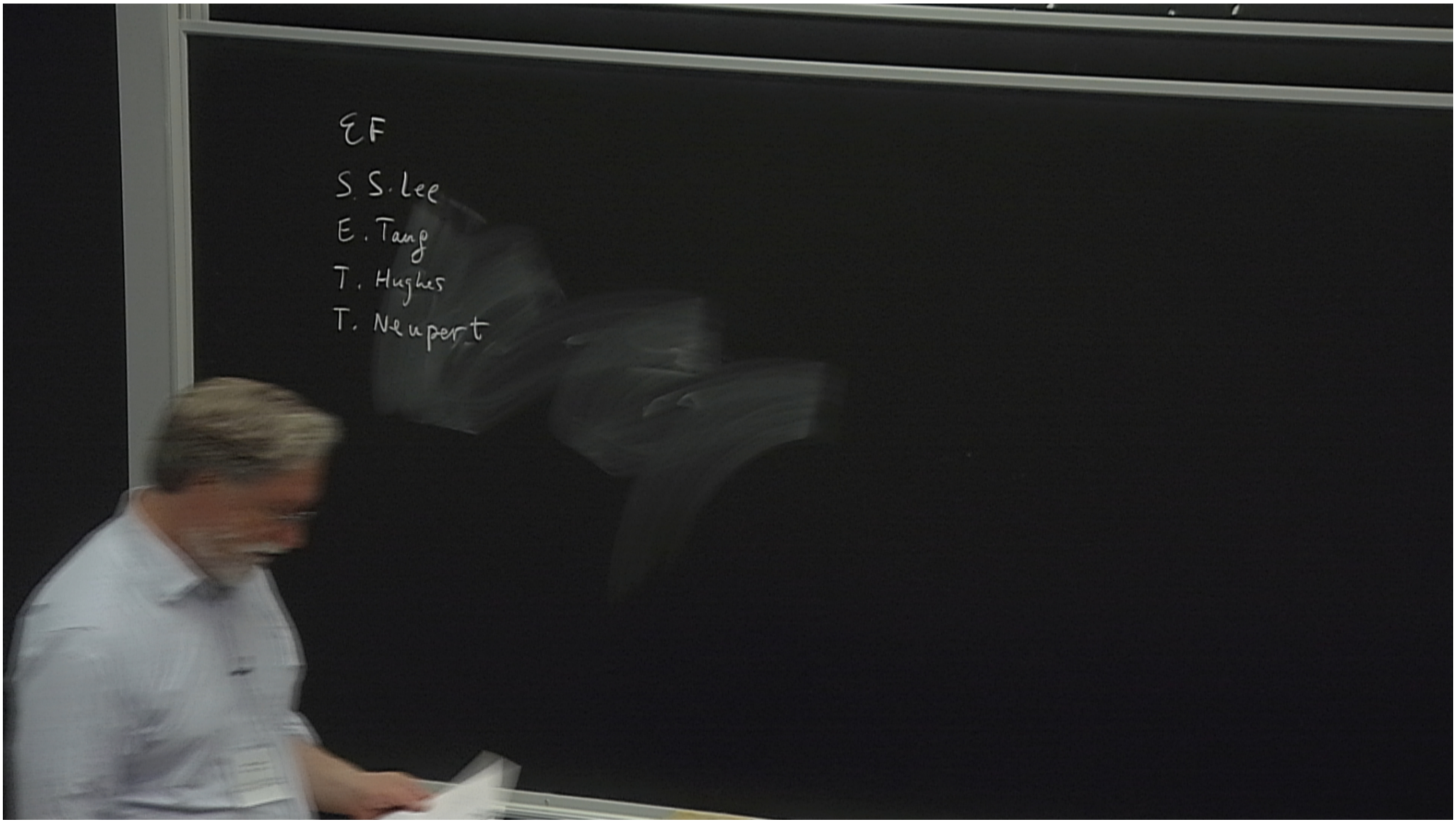
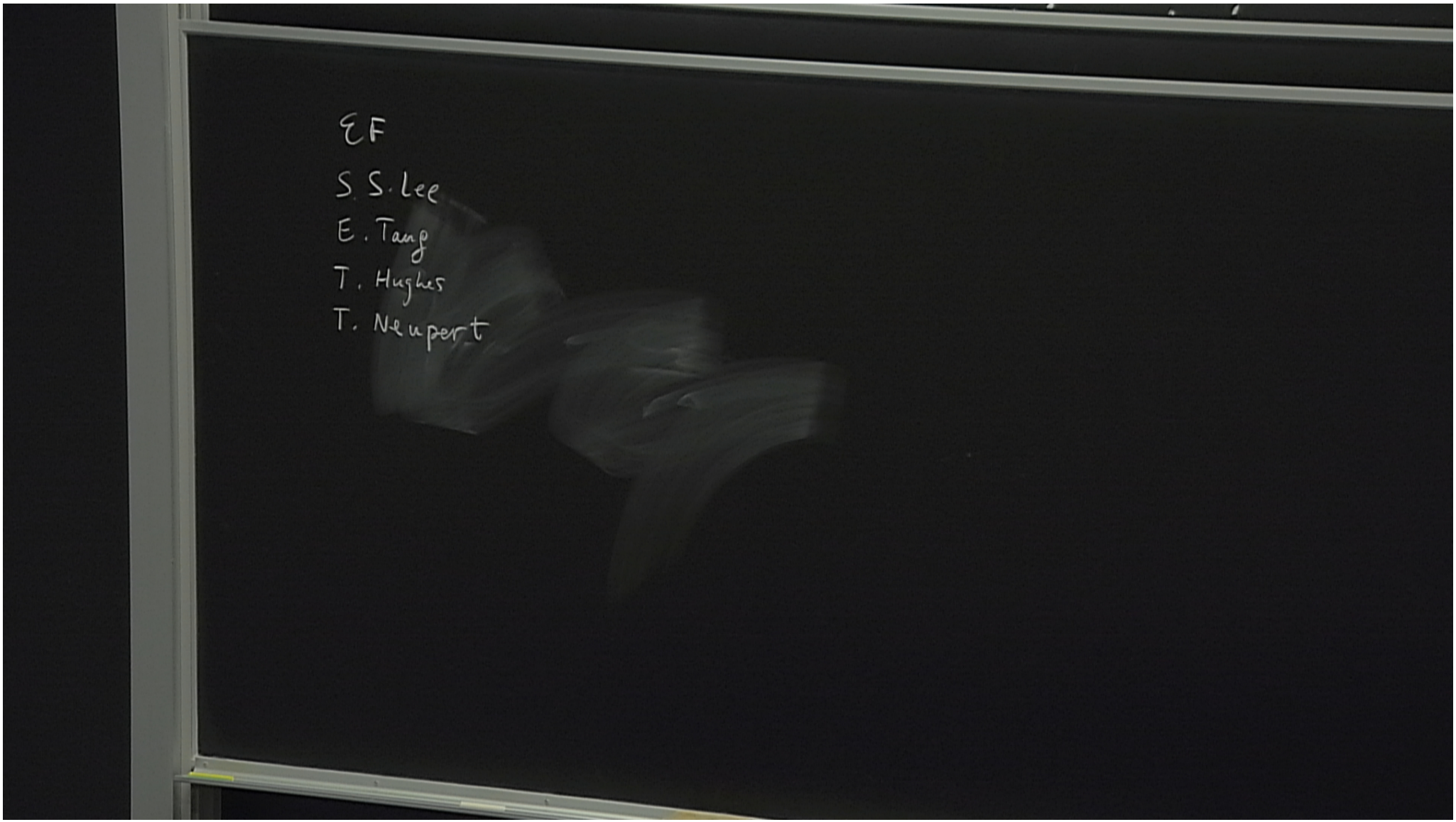
Title: Discussion

Date: Nov 07, 2013 05:00 PM

URL: http://pirsa.org/13110075

Abstract:


EF
S. S. Lee
E. Tang
T. Hughes
T. Neupert


EF
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R_{xx}

- Macrejko, Hsu, Zhang, Kivelson, Sondhi
- Mulligan, Nayak, Kachru

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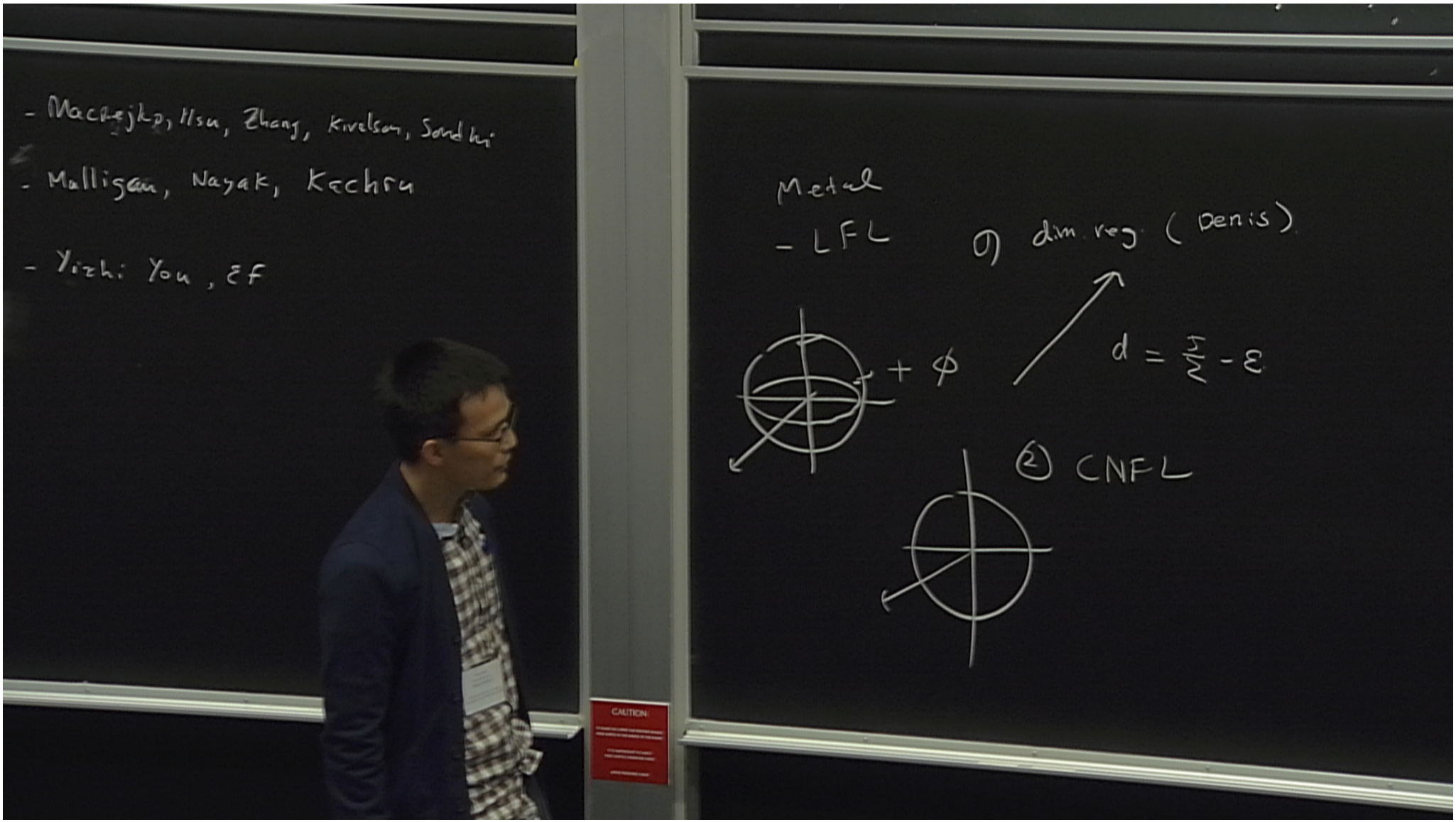
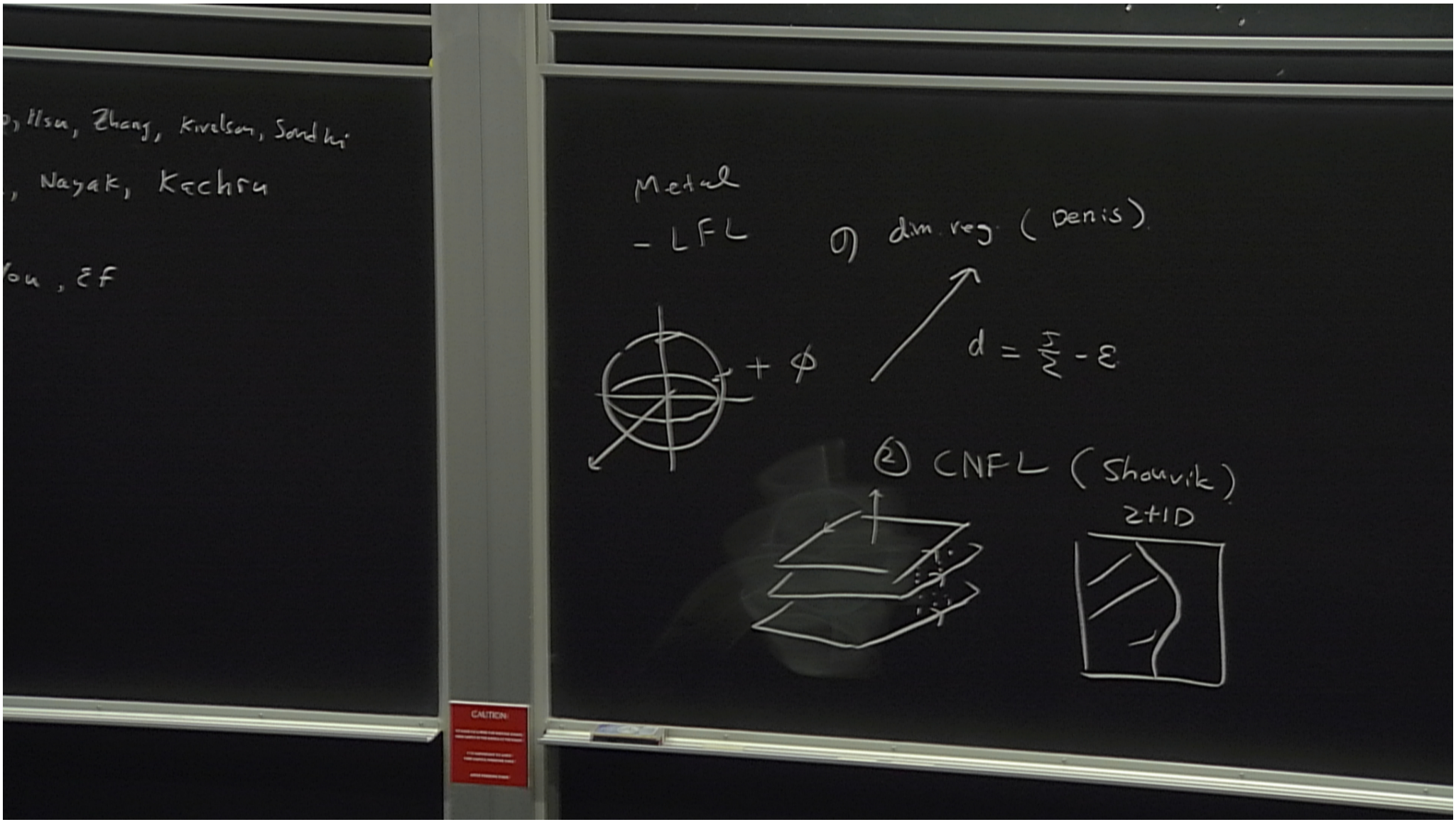
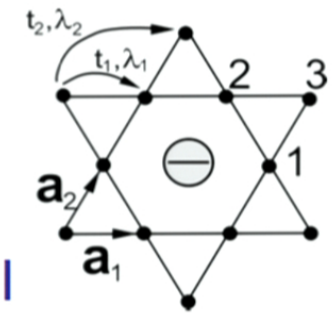
- Maciejko, Hsu, Zhang, Kivelson, Sondhi
- Mulligan, Nayak, Kachru
- Yizhi You, EF

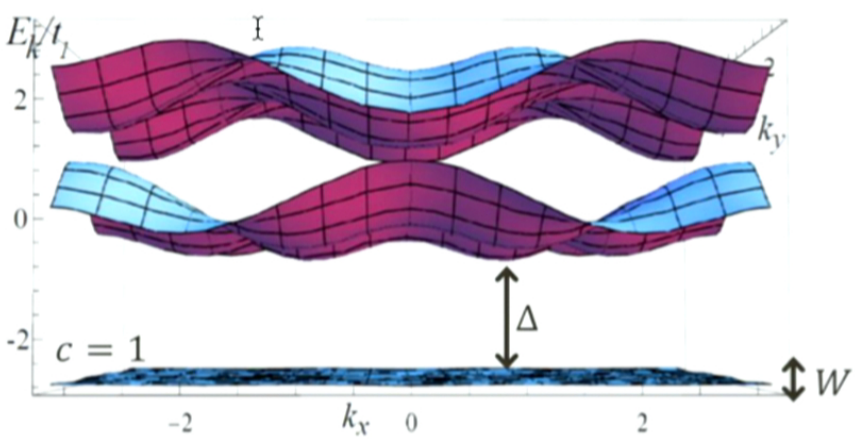

- Mackejko, Hsu, Zhang, Kivelson, Sondhi
- Mulligan, Nayak, Kachru
- Yizhi You, EF
Metal
- LFL
dim. reg. (Denis)
+ ϕ
d = 4/2 - ε
② CNFL


Hsu, Zhang, Kivelson, Sondhi
Nayak, Kechru
EF
Metal
- LFL
dim. reg. (Denis)
+ φ
d = 5/2 - ε
② CNFL (Shouvik)
2+1D

FQH State on Lattice System



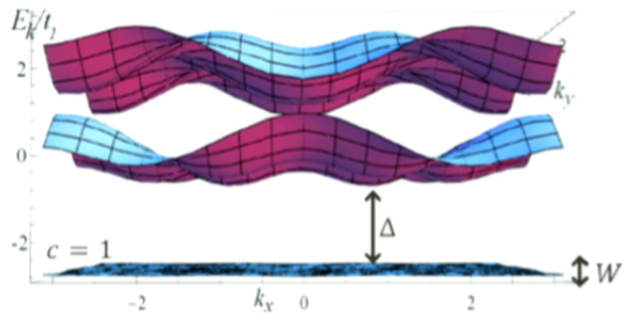
- Previously: kagome lattice
  - Bandgap $\Delta \gg$ bandwidth W
  - Chern number $c = 1$; break time-reversal
  - Fractional quantum Hall state e.g. at $\upsilon = 1/3$
    - *Tang et al '11, Neupert et al '11, Sun et al '11, Sheng et al '11 etc*



- Dope away from $\upsilon = 1/3$?

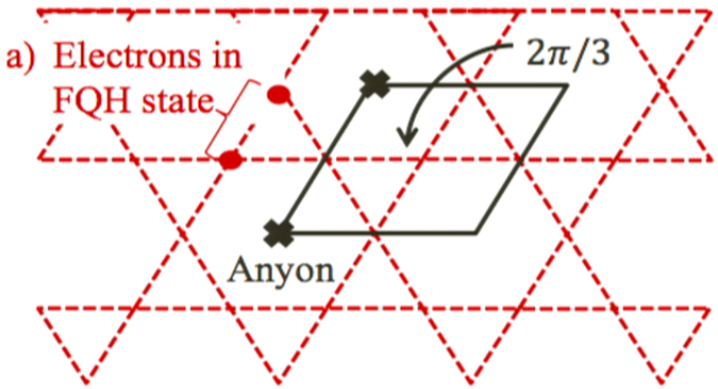
Upon Doping: Anyon gas

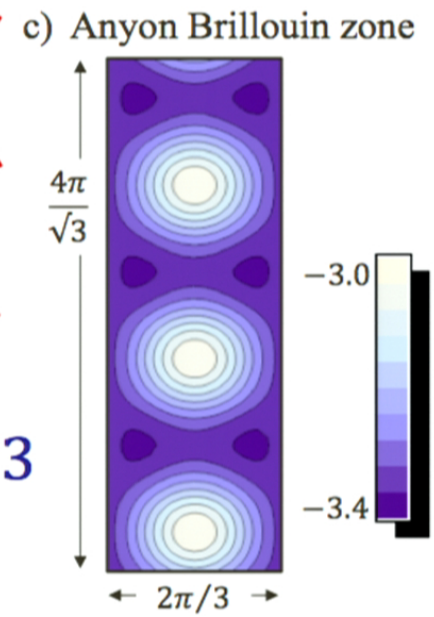
- Excitations of the FQH state are anyons
- Underlying lattice could access new regime
  - Finite anyon mass
  - Governed by typical electron hopping ~Δ



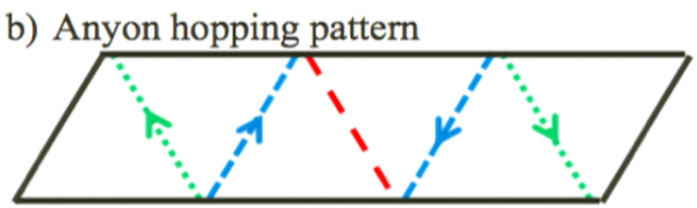
- *Anyon kinetic energy can dominate their interaction energy*

Properties of Anyon Gas



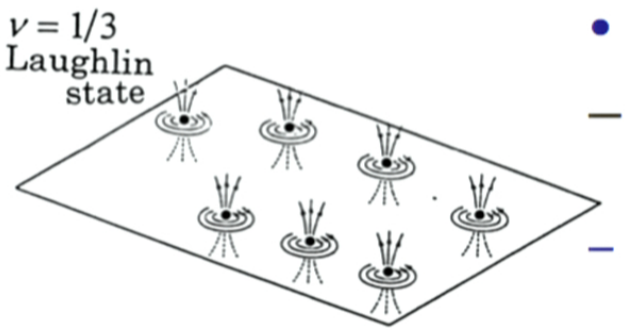


- $\upsilon = 1/3$ anyons see $2\pi/3$ flux per unit cell



– Six band minima: six anyons species

Ground State of Anyon Fluid?

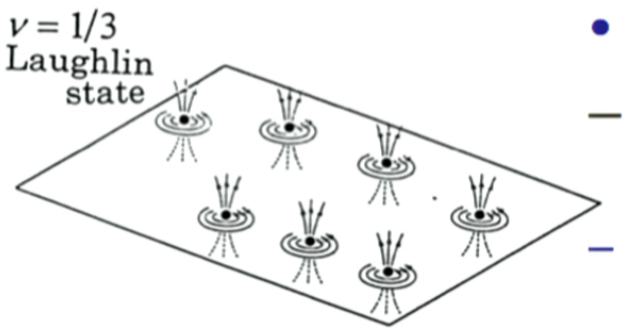


- Composite fermion approach
  - Anyon = Flux + Composite fermion
  - Girvin & McDonald '87, Zhang et. al '89, Read '89 (bosons), Jain '89 (fermions)

- Mean-field: flux smeared as background field

- Fermions in constant magnetic field?
  - Compressible states or quantum Hall states (QHS)

Ground State of Anyon Fluid?



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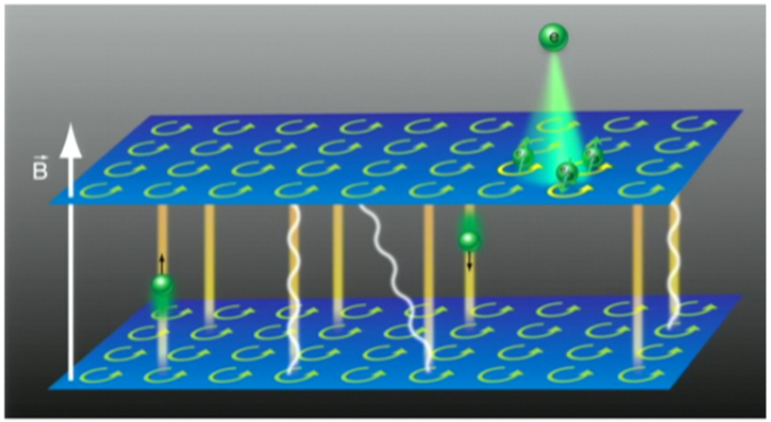
Three Bilayer Halperin States

- Anyon = Flux + Composite fermion
  - Six anyons → six fermions
  - $\theta = \pi/3$ stat angle → $\nu = 3/2$ filling fraction



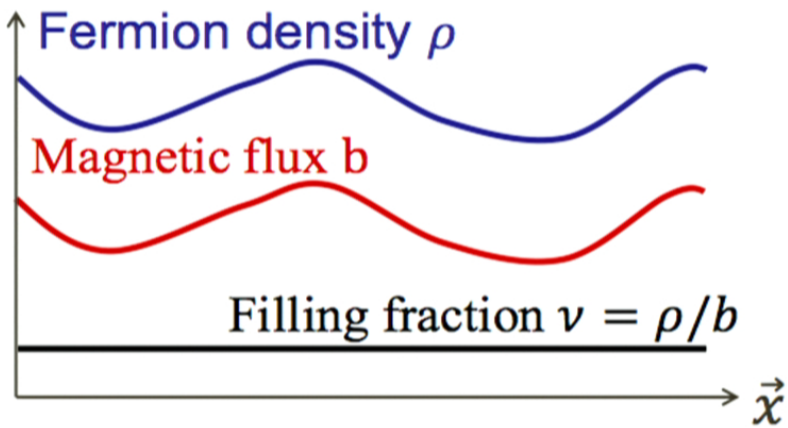
- Three $\nu = 1/2$ bilayer Halperin states

WHAT IS THIS MEAN-FIELD QHS?

- Mean-field fermionic QHS
  - ⇒ Anyon superfluid (electron superfluid)
  - – Laughlin '88, Fetter et. al '89, Chen et. al '89

- Superfluid: density mode as only gapless mode Wen & Zee '99

- With fluctuations?
  - – Filling ν constant
  - – QHS locally stable



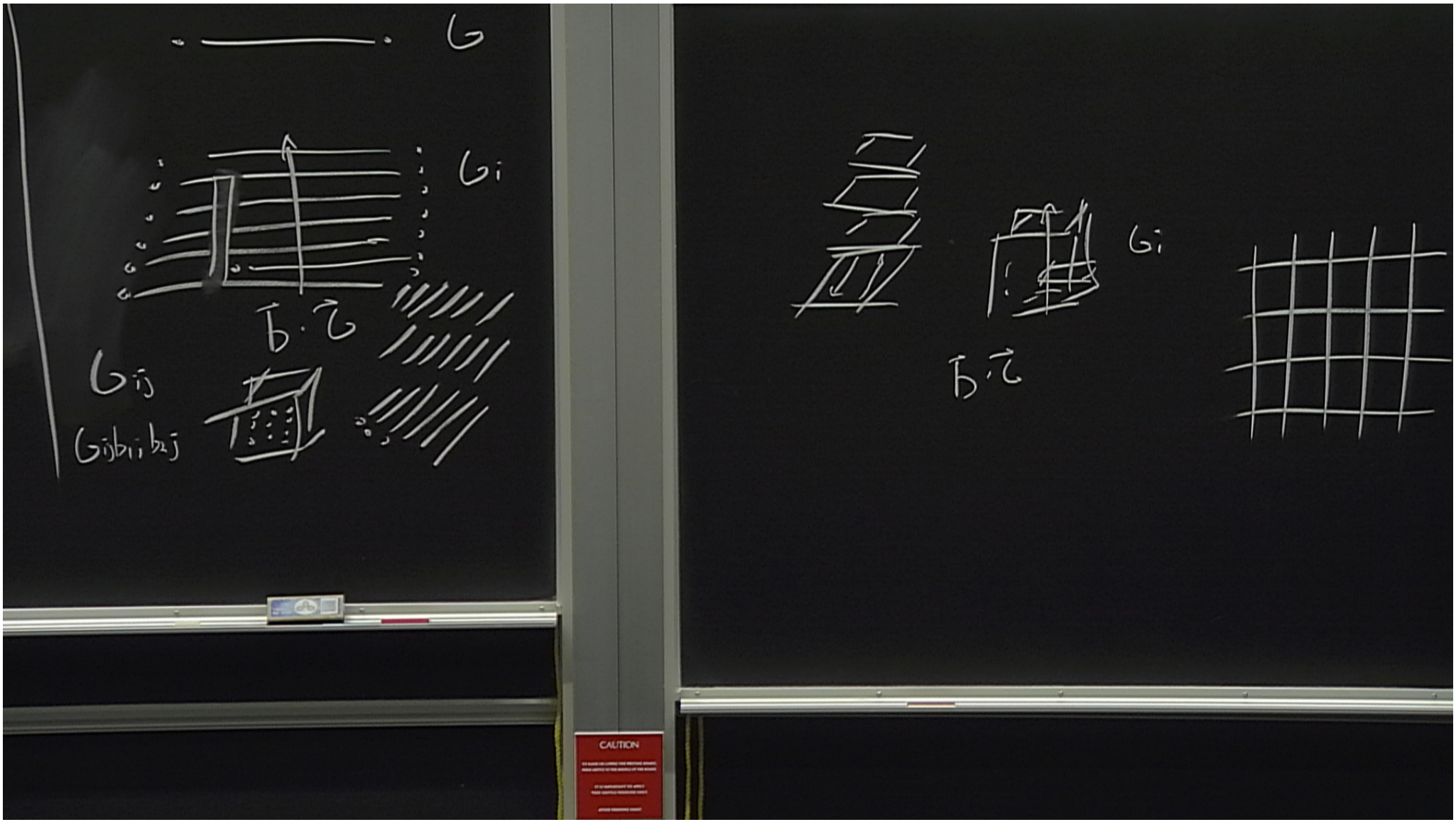
Intrinsic Topological Order

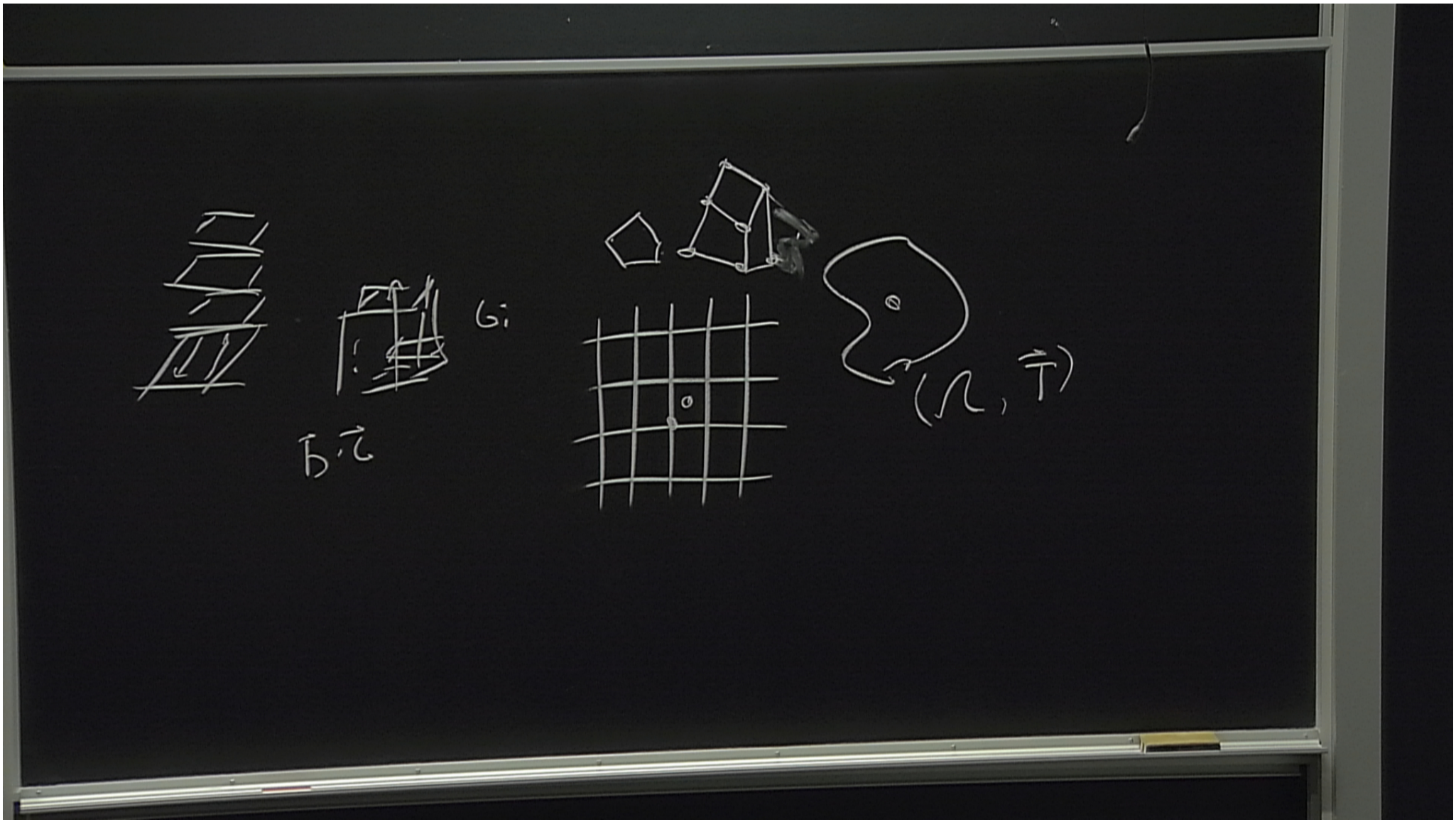
- Gapless mode has flux quantization $hc/2e$
  - BCS-like electron pair condensation
  - Other clearly non-BCS properties

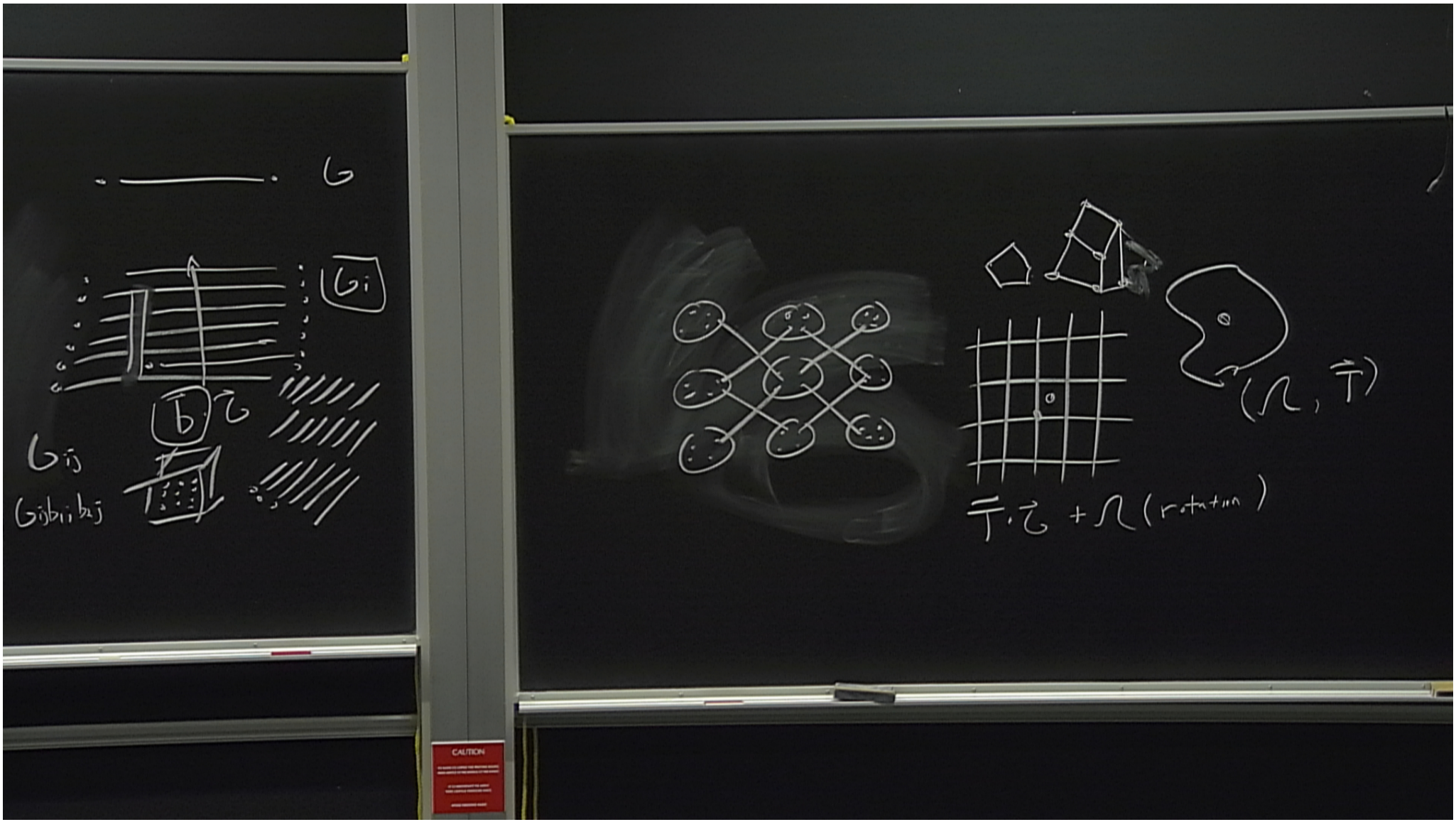
- Gapped quasiparticles
  - Fractionalized statistics (topologically non-trivial)
  - Unique non-trivial particles have four generators
  - Satisfy $(\mathbb{Z}_2)^2$ group algebra → 16 unique particles

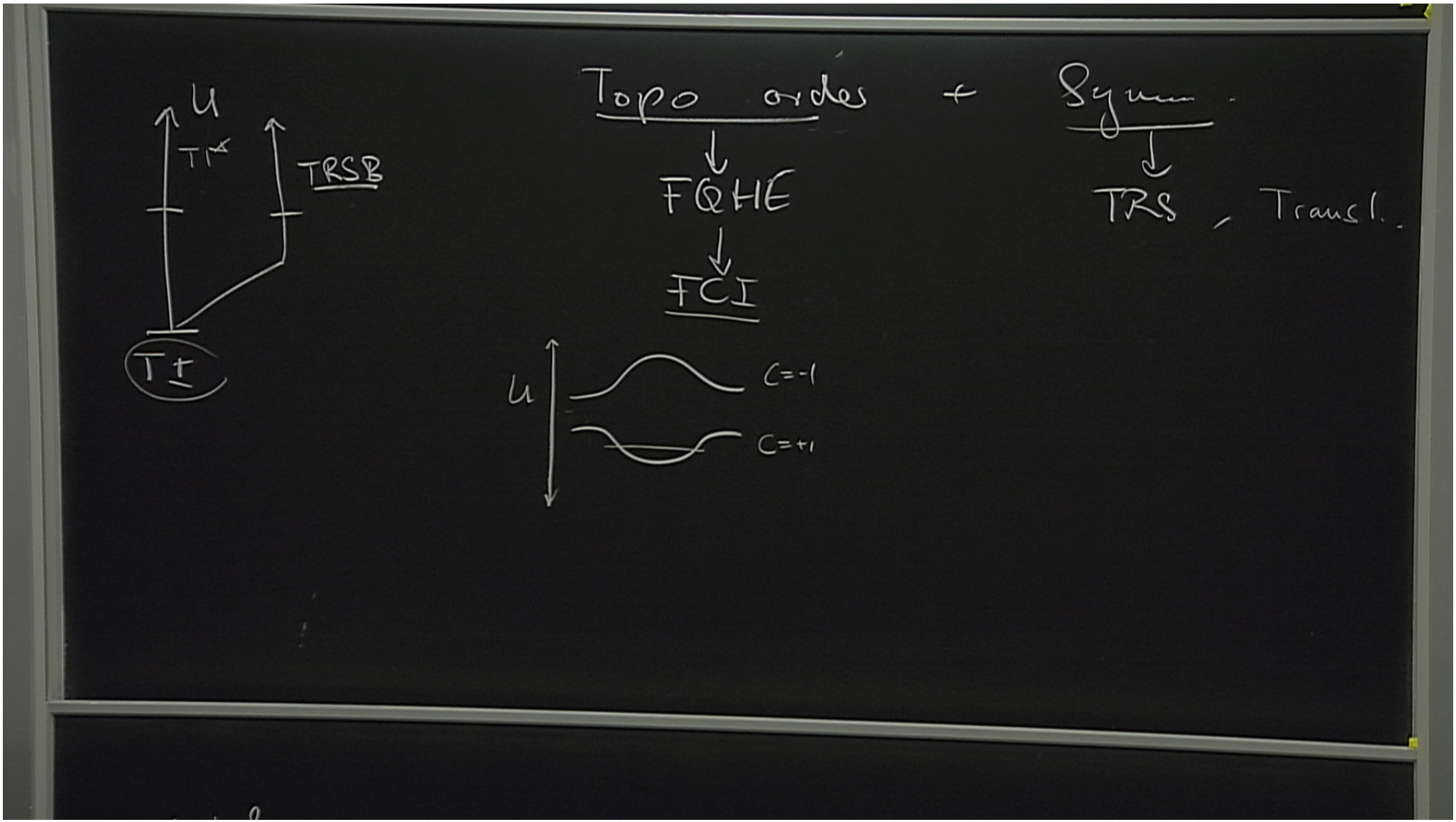
Results & Discussion

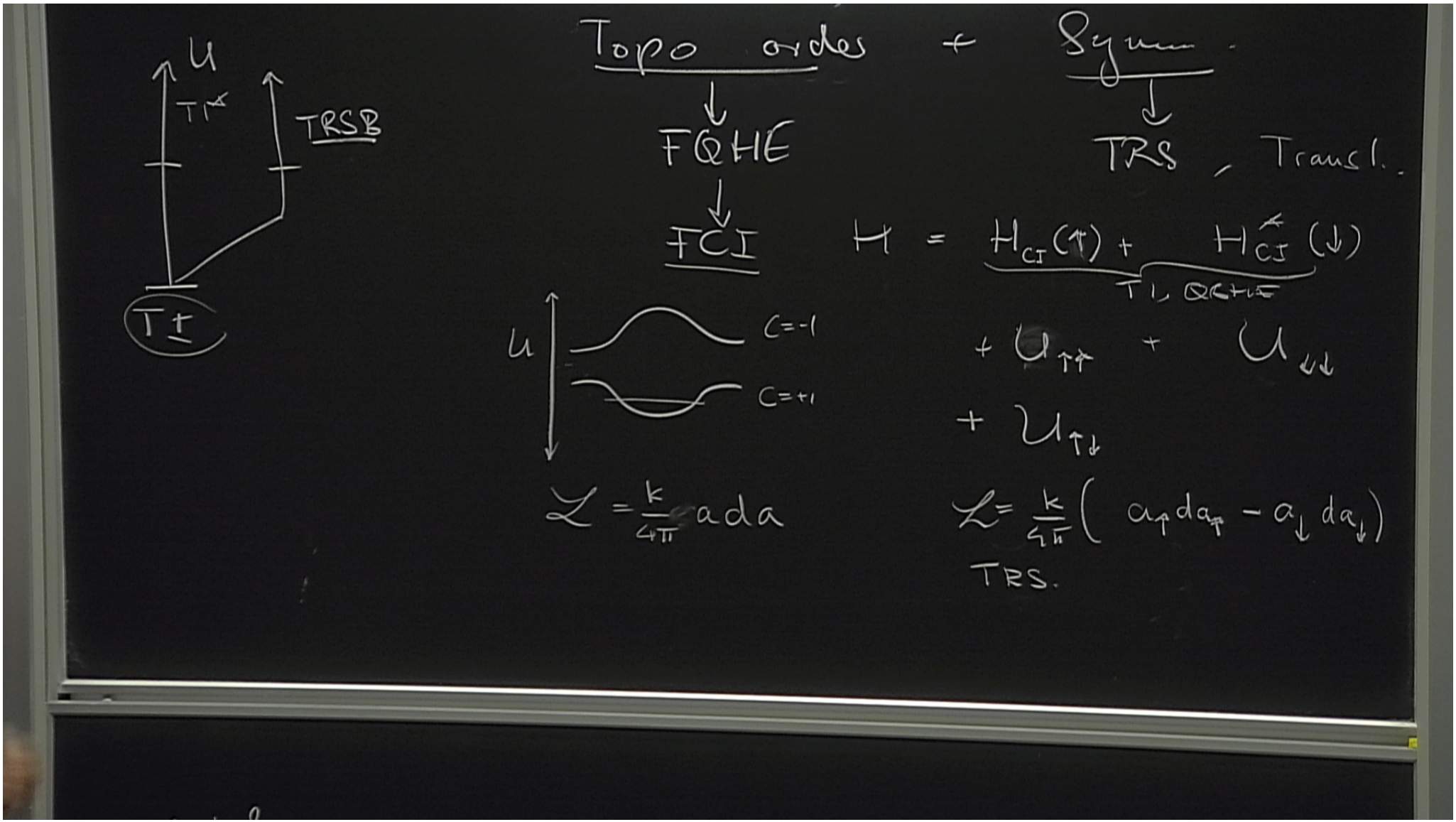
- Mechanism driven only by strong repulsion and complex hopping of electrons
  - Can obtain intrinsic topological order
  - Or a state similar to BCS-type
- Effects of underlying lattice are novel
  - Or apply periodic potential to other FQH systems like semiconductors or graphene
- Energetic comparison needed
  - Approach suggests variational electron wavefunctions

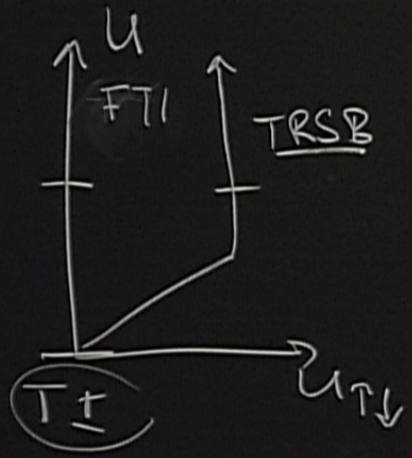

G
Gi
b·G
Gij
Gijbibj
Gi
b·G
CAUTION


G_i
$(\Omega, \vec{T})$


G
Gi
b
Gij
Gijbibj
(Ω, T)
T·b + Ω (rotation)


U
TI
TRSB
TI
Topo order + Sym.
FQHE
FCI
TRS , Transl.
U
C=-1
C=+1


U
TI*
TRSB
TI
Topo order + Sym.
FQHE
TRS, Transl.
FCI
H = H_CI(↑) + H_CI*(↓)
TI, QCHE
+ U_↑↑ + U_↓↓
+ U_↑↓
U
C=-1
C=+1
L = k/4π a da
L = k/4π (a_↑ da_↑ - a_↓ da_↓)
TRS.

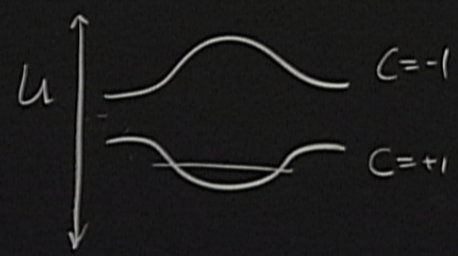


Topo order + Sym.

↓ FQHE ↓ FCI

↓ TRS, Transl.

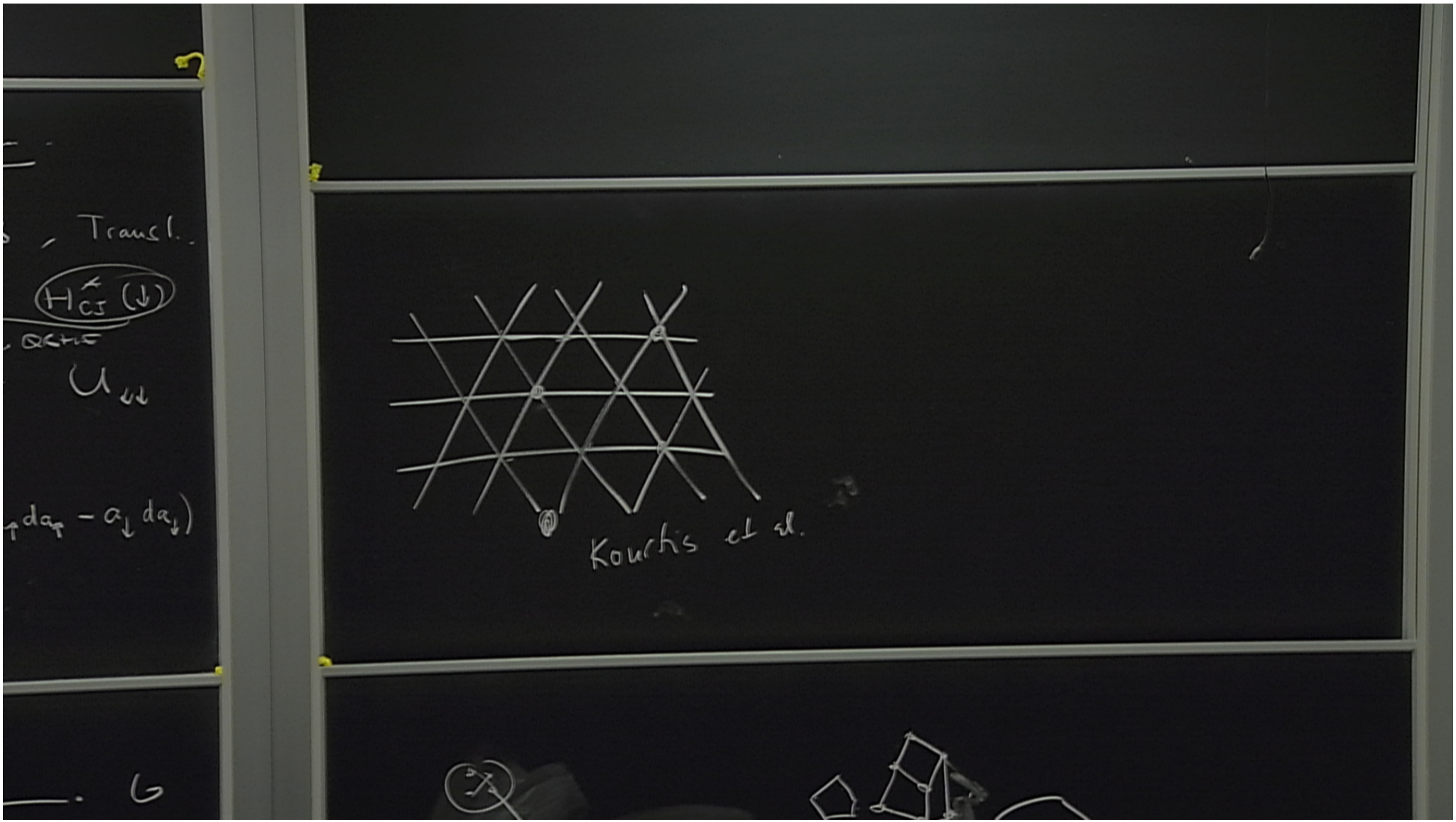
$$H = \underbrace{H_{CI}(\uparrow) + H_{CI}(\downarrow)}_{\text{TI, QAHE}} + U_{\uparrow\uparrow} + U_{\downarrow\downarrow} + U_{\uparrow\downarrow}$$



$$\mathcal{L} = \frac{k}{4\pi} a\,da$$

$$\mathcal{L} = \frac{k}{4\pi}\left(a_\uparrow da_\uparrow - a_\downarrow da_\downarrow\right)$$

TRS.


Transl.
Kourkis et al.