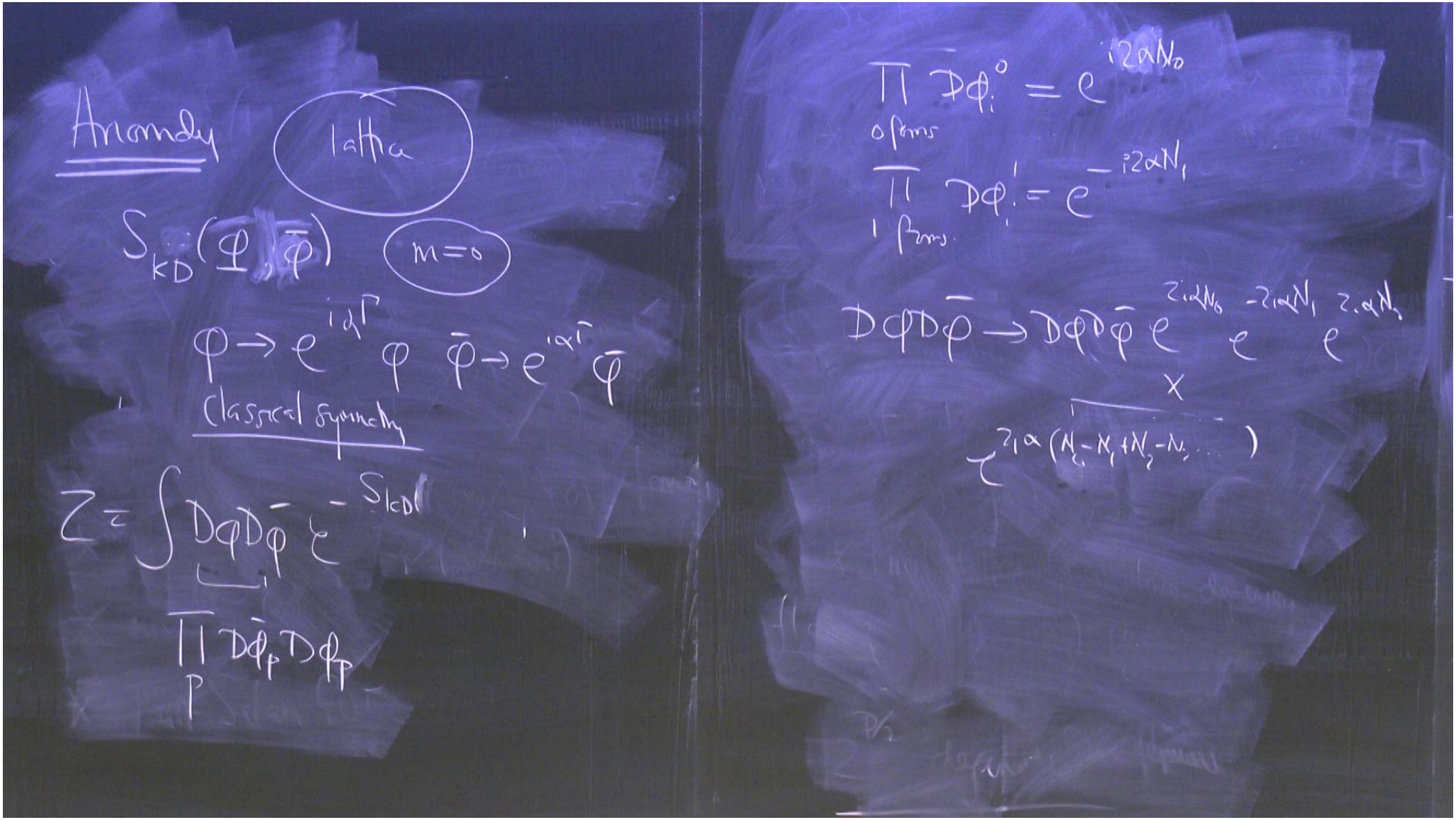
Title: Anomalies and symmetric mass generation for staggered fermions â€“ Talk 2

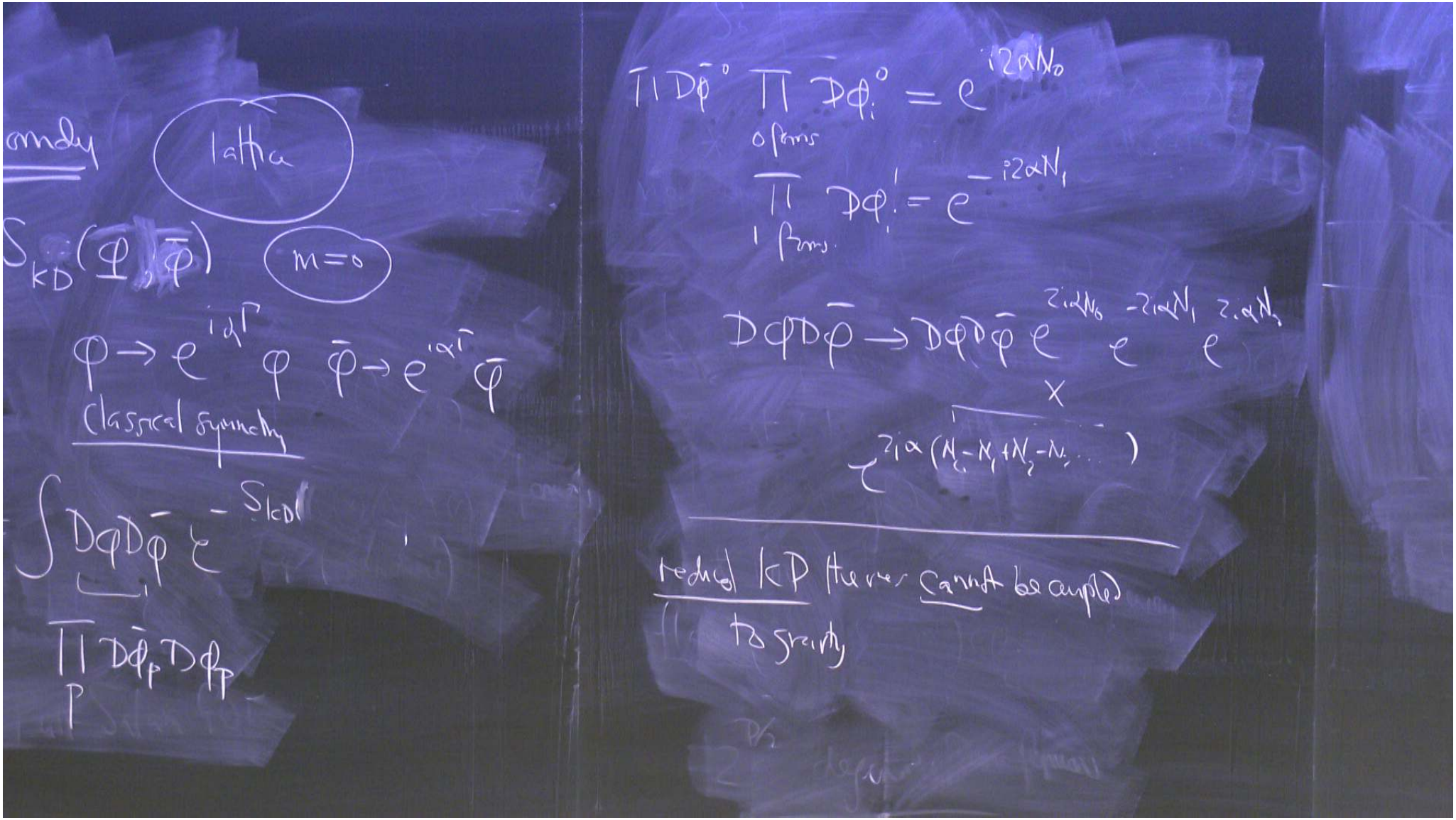
Speakers: Simon Catterall

Collection: Quantum Criticality: Gauge Fields and Matter

Date: May 20, 2022 - 10:15 AM

URL: https://pirsa.org/22050049


Anomaly
lattice
$S_{kD}(\psi,\bar{\psi})$
$m=0$
$\psi \to e^{i\alpha\Gamma}\psi \quad \bar{\psi} \to e^{i\alpha\Gamma}\bar{\psi}$
classical symmetry
$Z = \int D\psi D\bar{\psi}\, e^{-S_{kD}}$
$\prod_P D\psi_P D\bar{\psi}_P$
$\prod_{0\,\text{forms}} D\psi_i^0 = e^{i2\alpha N_0}$
$\prod_{1\,\text{forms}} D\psi_i^1 = e^{-i2\alpha N_1}$
$D\psi D\bar{\psi} \to D\psi D\bar{\psi}\, e^{2i\alpha N_0} e^{-2i\alpha N_1} e^{2i\alpha N_2} \times e^{2i\alpha(N_3 - N_2 + N_1 - N_0 \ldots)}$


Lattice
$S_{KD}(\varphi, \bar{\varphi})$
$m=0$
$\varphi \to e^{i\alpha\Gamma}\varphi \quad \bar{\varphi} \to e^{i\alpha\Gamma}\bar{\varphi}$
Classical symmetry
$\int D\varphi D\bar{\varphi}\, e^{-S_{KD}}$
$\prod_P D\bar{\varphi}_P D\varphi_P$
$\prod D\bar{\varphi}^0 \prod_{0 \text{ zeros}} D\varphi_i^0 = e^{i2\alpha N_0}$
$\prod_{1 \text{ zeros}} D\varphi_i^1 = e^{-i2\alpha N_1}$
$D\varphi D\bar{\varphi} \to D\varphi D\bar{\varphi}\, e^{2i\alpha N_0} e^{-2i\alpha N_1} e^{2i\alpha N_2}$
$\times$
$e^{2i\alpha(N_2 - N_1 + N_2 - N_3 \ldots)}$
reduced KD theories cannot be coupled
to gravity

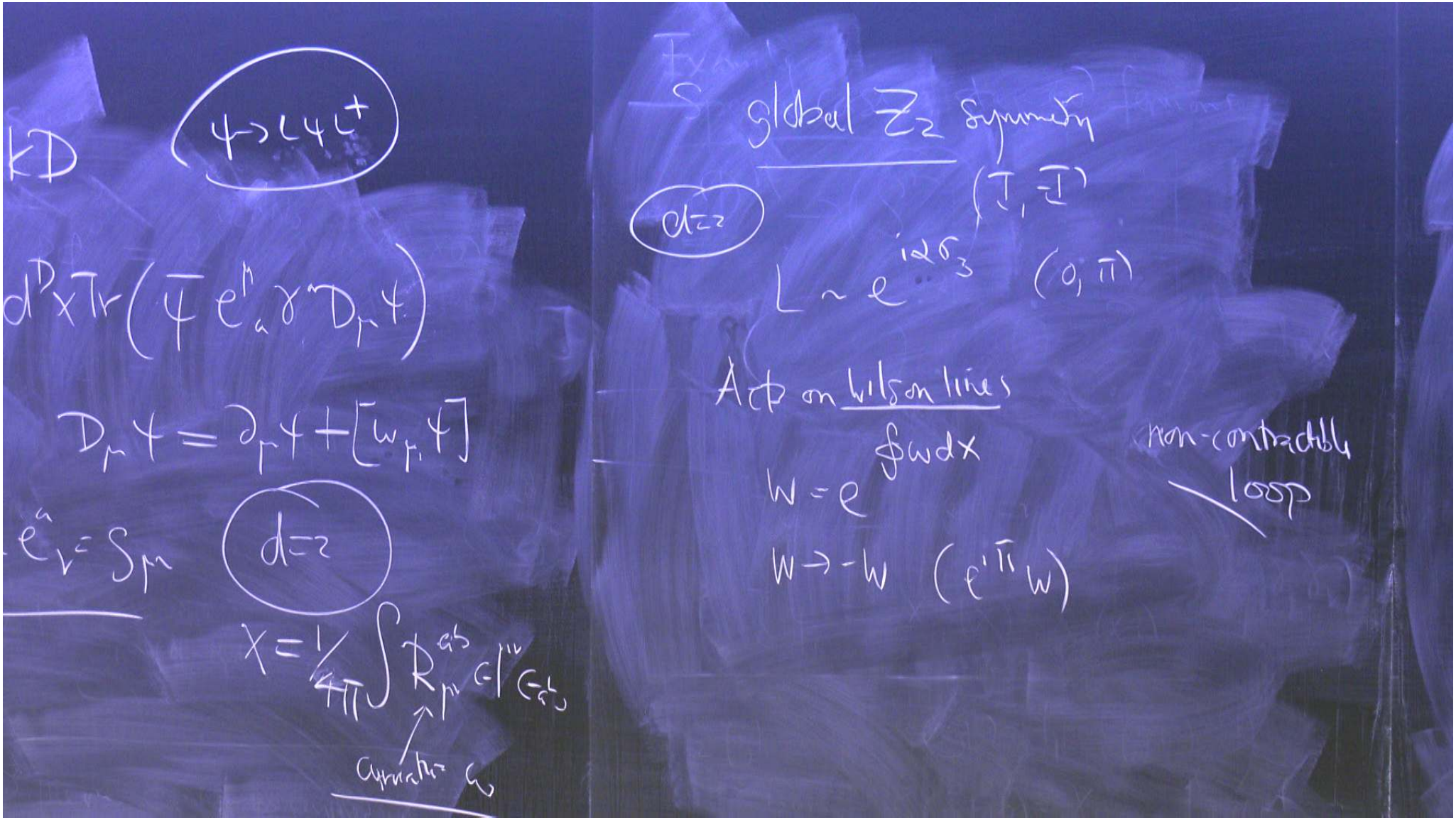
$$\prod_{0 \text{ zeros}} D\phi_i^0 \; \prod_{1 \text{ zeros}} D\phi_i^1 = e^{i2\alpha N_0} \; e^{-i2\alpha N_1}$$

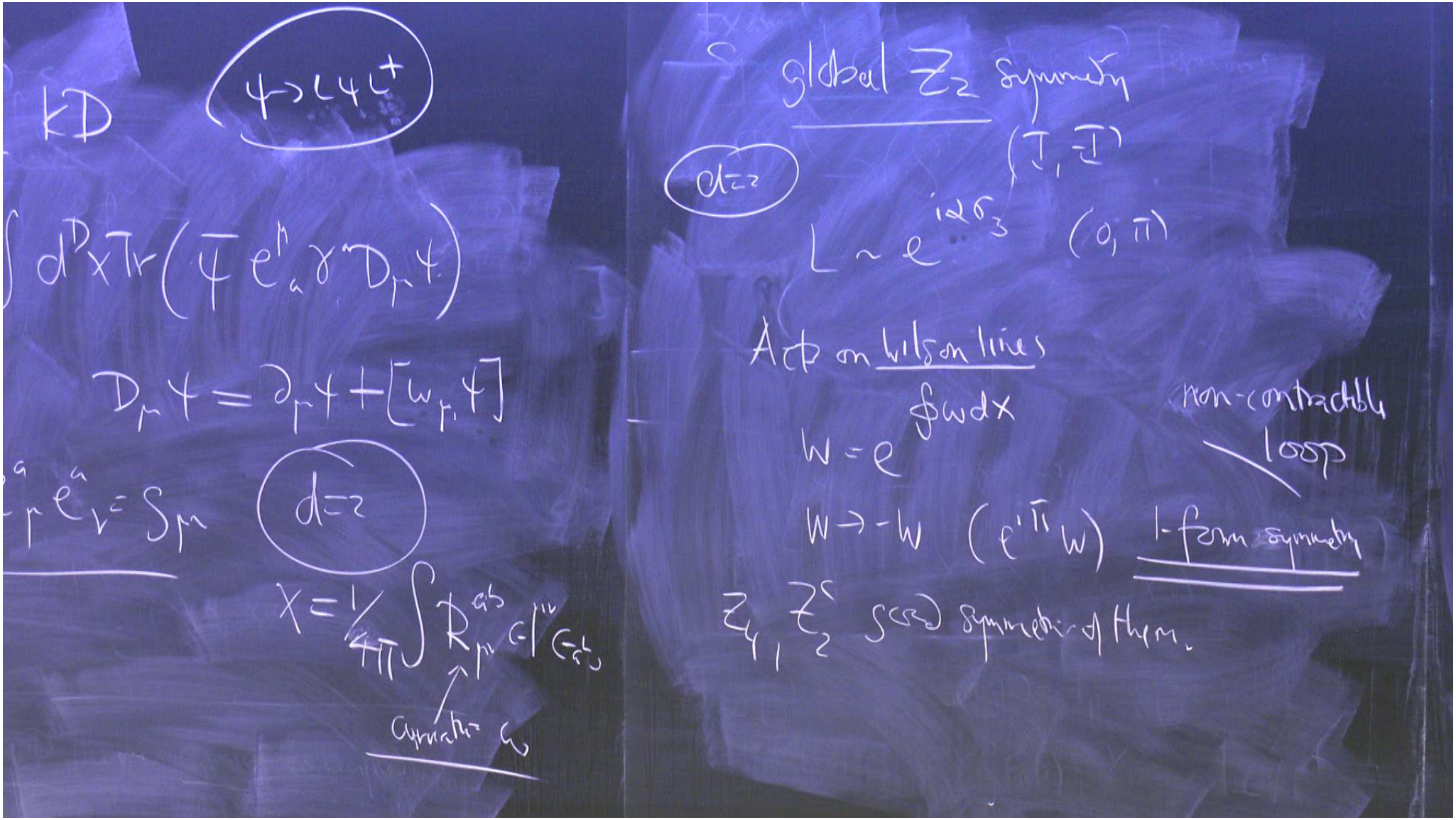
$$D\phi D\bar{\phi} \to D\phi^0 \bar{\phi} \; e^{2i\alpha N_0} \; e^{-2i\alpha N_1} \; e^{2i\alpha N_2} \times e^{2i\alpha(N_2 - N_1 + N_2 - N_1 \ldots)}$$

reduced KP theories cannot be coupled to gravity

$\mathbb{P}^n \to S^n$

$\chi = 2$ $\quad U(1) \to Z_4$


kD
ψ → Lψ L†
∫d^D x Tr(ψ̄ e^μ_a γ^a D_μ ψ)
D_μ ψ = ∂_μ ψ + [ω_μ, ψ]
e^a_μ = δ_μ^a
d=2
χ = 1/4π ∫ R^ab_μν ε^μν ε_ab
curvature
global Z_2 symmetry
d=2
L ~ e^{iασ_3}
(I, −I)
(0, π)
Act on Wilson lines
W = e^{∮ω dx}
W → −W (e^{iπ} W)
non-contractible loop


kD
$\psi \to U \psi U^\dagger$
$\int d^D x \, \mathrm{Tr}\left(\bar{\psi} e^a_\mu \gamma^\mu D_\mu \psi\right)$
$D_\mu \psi = \partial_\mu \psi + [\omega_\mu, \psi]$
$e^a_\mu e^a_\nu = g_{\mu\nu}$
$d=2$
$\chi = \frac{1}{4\pi} \int R^{ab}_{\mu\nu} \epsilon^{\mu\nu} \epsilon^{ab}$
curvature
global Z_2 symmetry
$d=2$
$(\bar{\psi}, -\bar{\psi})$
$L \sim e^{i\alpha\sigma_3}$
$(0, \pi)$
Act on Wilson lines
$W = e^{\oint \omega dx}$
non-contractible loop
$W \to -W$ $(e^{i\pi} W)$
1-form symmetry
Z_4, Z_2 SSB symmetries of them.

$d^D x \, \mathrm{Tr}\left(\bar{\psi} e^{\mu}_{a} \gamma^{a} D_{\mu} \psi\right)$

$D_\mu \psi = \partial_\mu \psi + [\omega_\mu, \psi]$

$e^{a}_{\mu} = S_\mu$

$d=2$

$\chi = \frac{1}{4\pi} \int R^{ab}_{\mu\nu} \, d^2\sigma \, \epsilon_{ab}$

Curvature

$d=2$

$L \sim e^{i 2\theta_3}$ $(0, \pi)$

Act on Wilson lines

$W = e^{\oint \omega dx}$

non-contractible loop

$W \to -W$ $(e^{i\pi} W)$ 1-form symmetry

$\mathbb{Z}_2, \mathbb{Z}_2$ SSB symmetries of Hyp.

Invisible sanpion $\mathbb{Z}_2$

↳ 't Hooft

$d^D x \, \mathrm{Tr}\left(\bar{\psi} e^{\mu}_a \gamma^a D_\mu \psi\right)$

$D_\mu \psi = \partial_\mu \psi + [\omega_\mu, \psi]$

$e^a_\mu = S_\mu$ (d=2)

$\chi = \frac{1}{4\pi} \int R^{ab}_{\mu\nu} \epsilon^{\mu\nu}$

Curvature

(d=2)

$L \sim e^{i 2\pi \sigma_3}$ $(0, \pi)$

Act on Wilson lines

$W = e^{\oint \omega dx}$

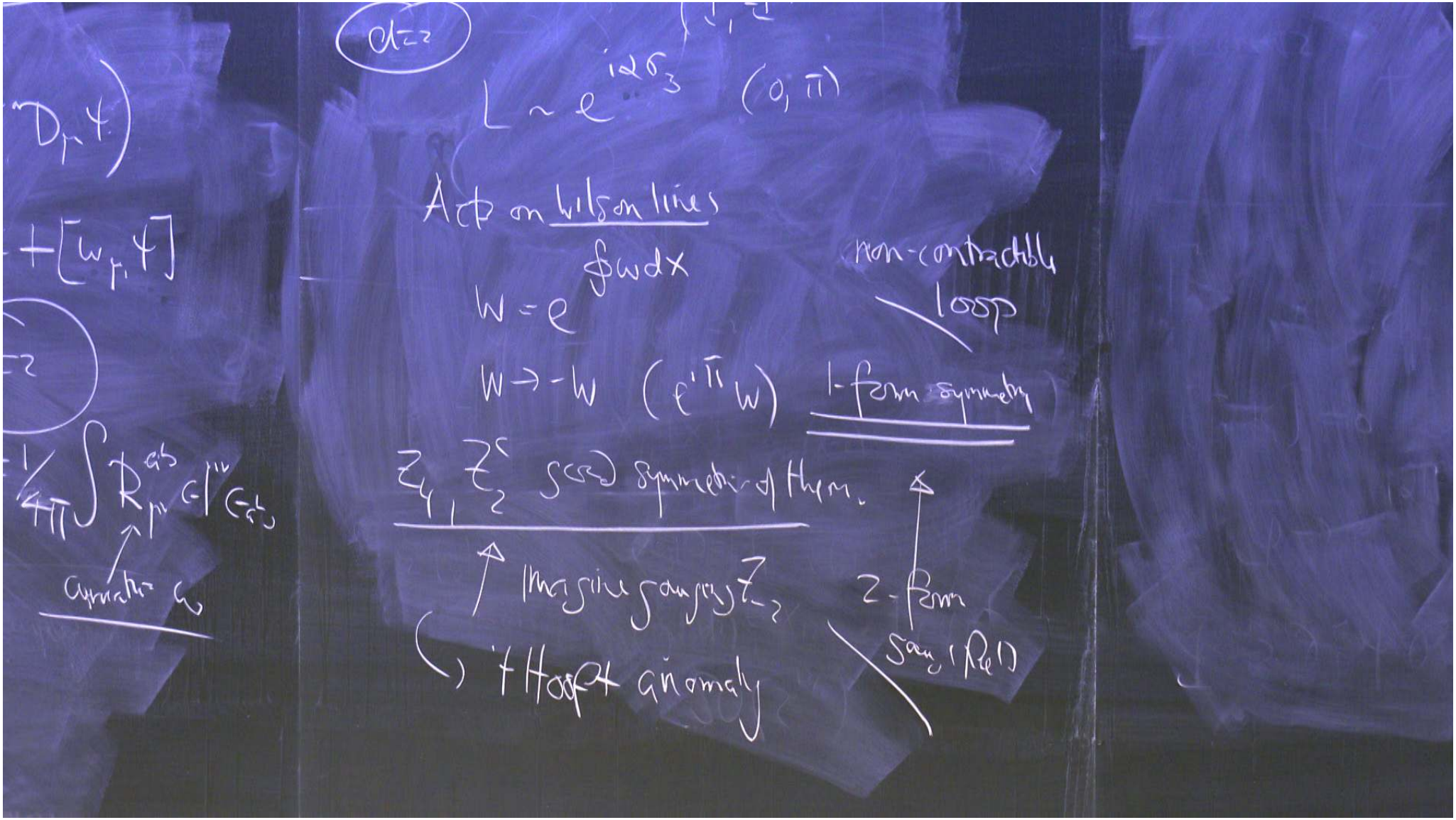
non-contractible loop

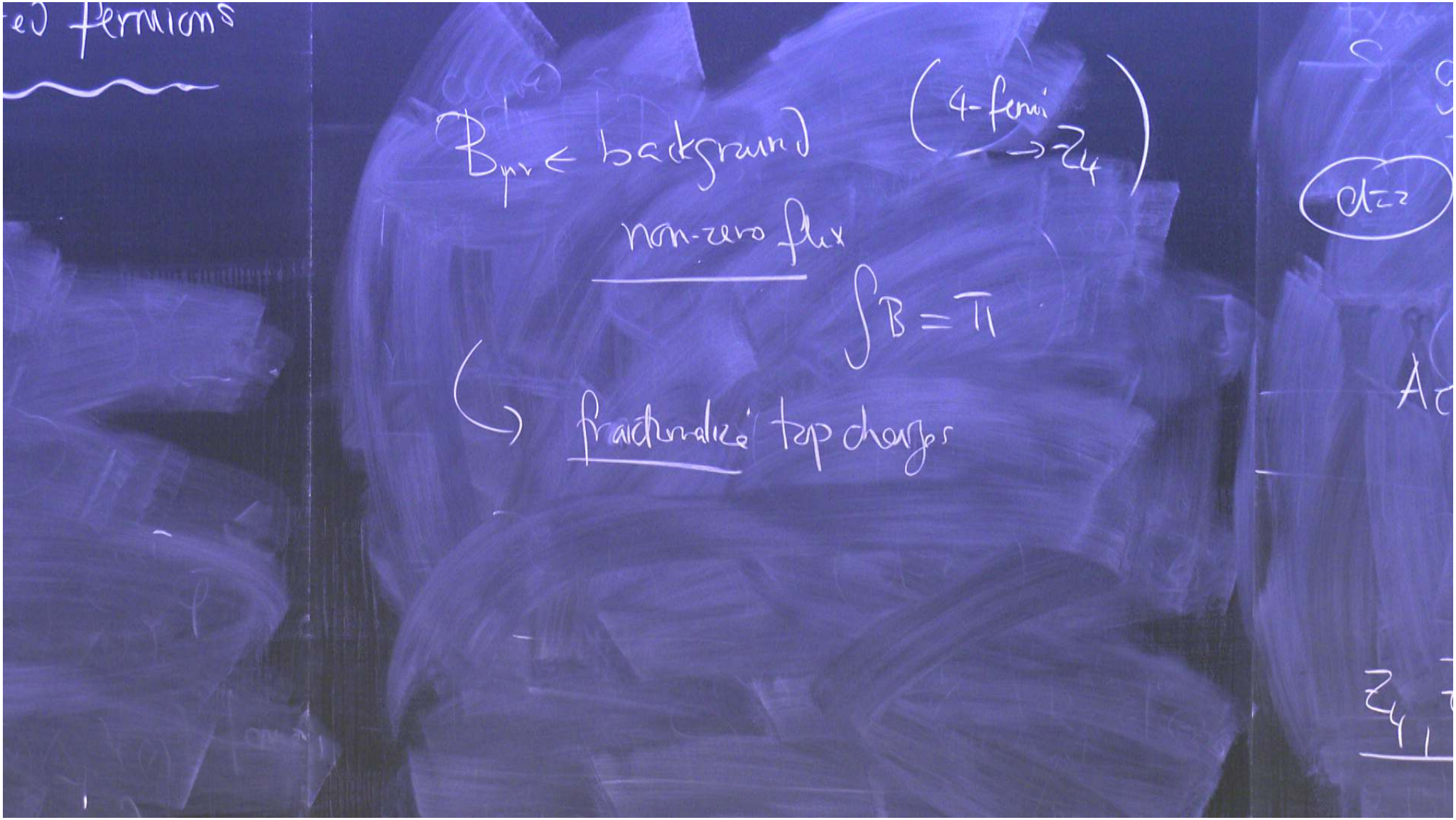
$W \to -W$ $(e^{i\pi} W)$ 1-form symmetry

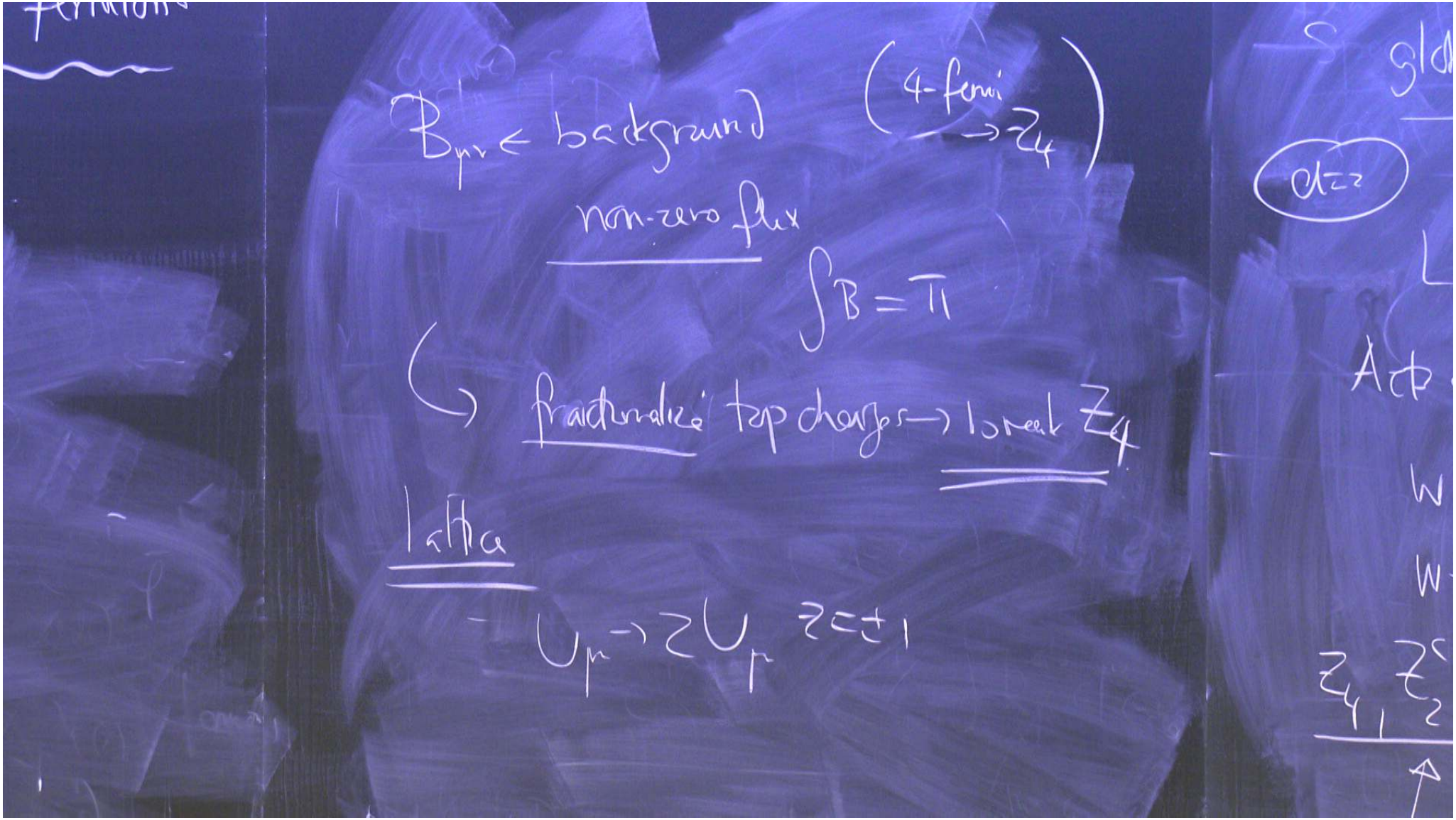
$\mathbb{Z}_2, \mathbb{Z}_2^c$ 0(1) symmetries of them.

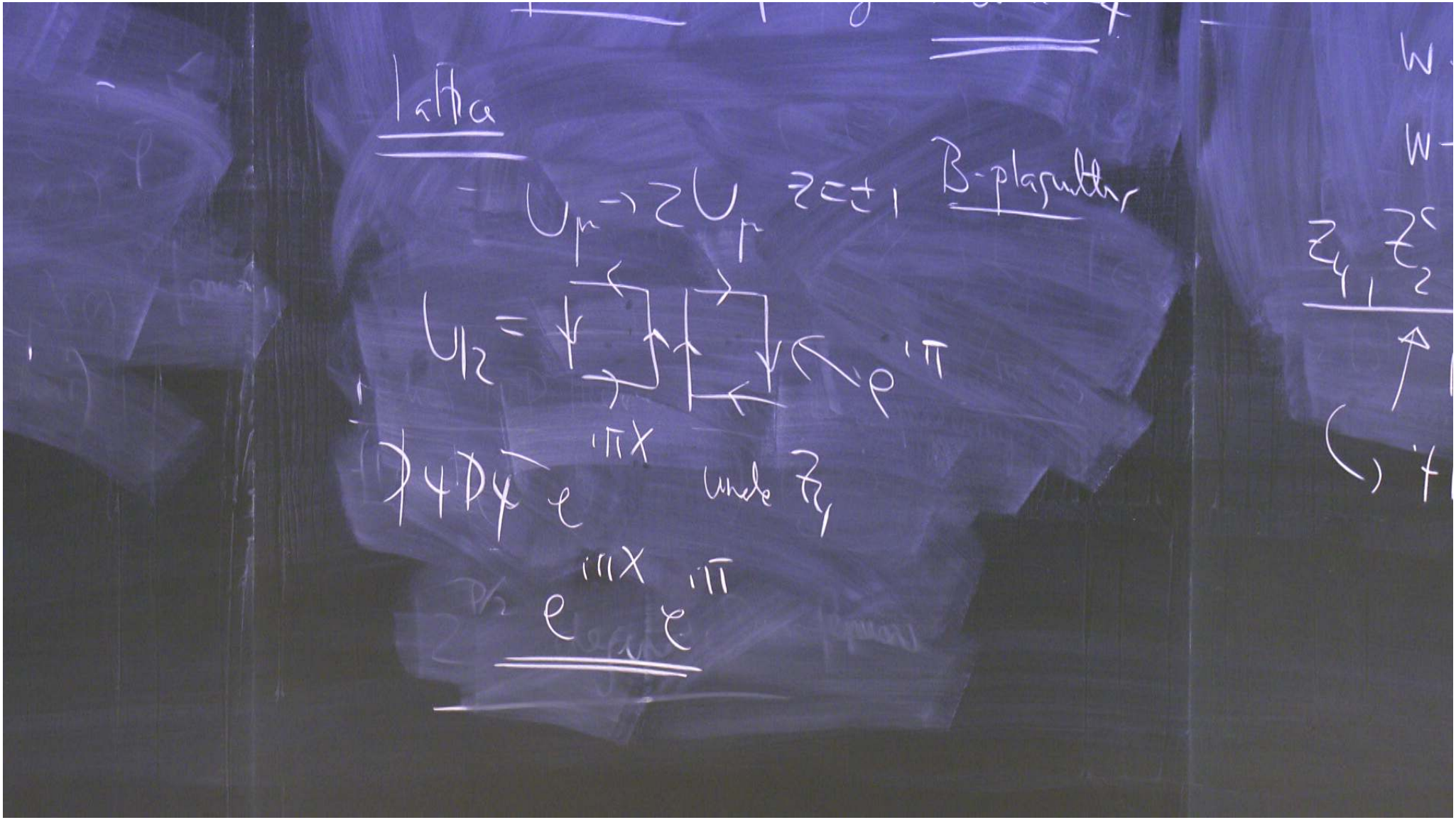
Invisible boundary $\mathbb{Z}_2$

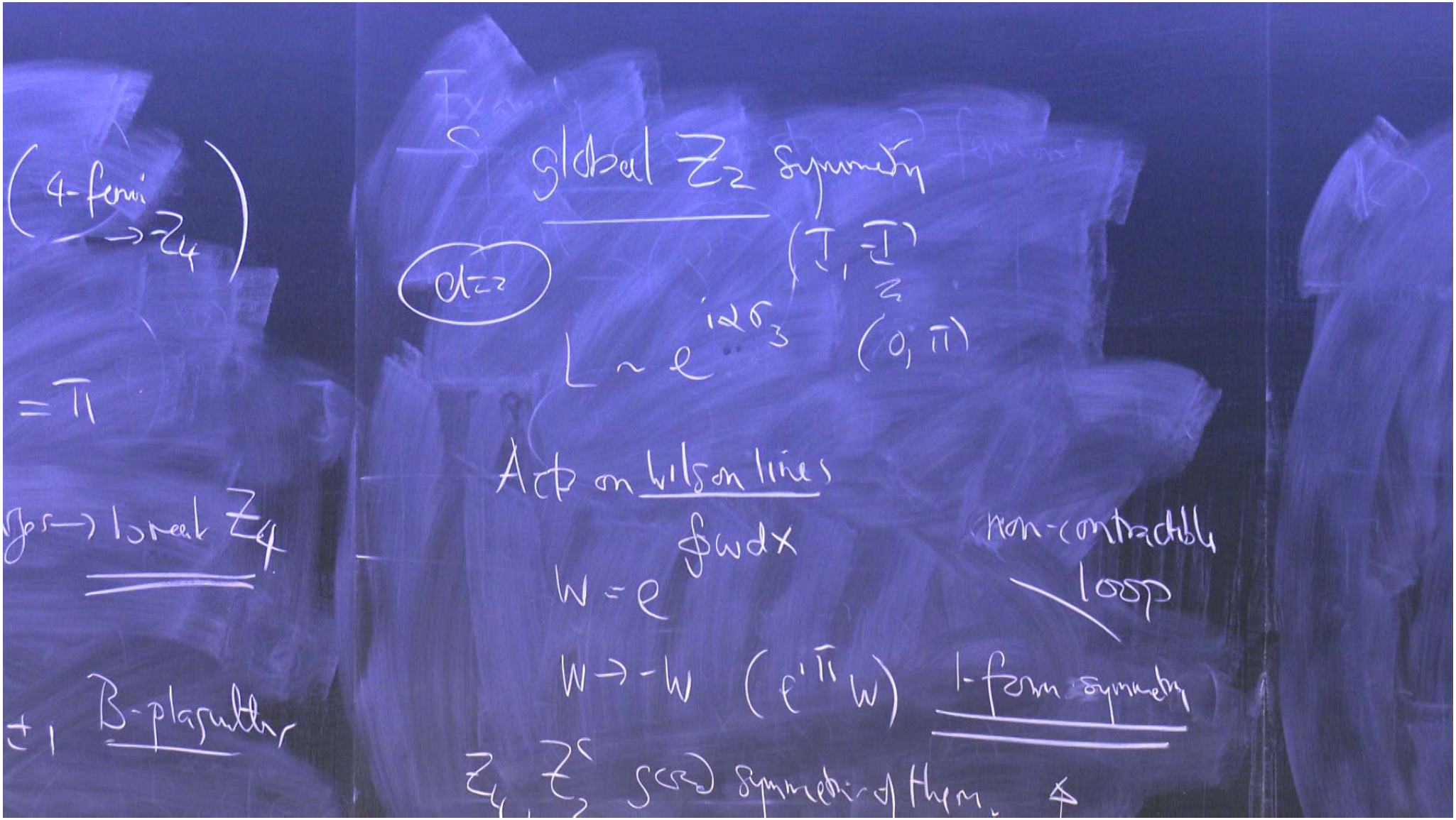
't Hooft anomaly


$L \sim e^{i2\sigma_3}$ $(0,\pi)$
Acts on Wilson lines
$W = e^{\oint w dx}$
non-contractible loop
$W \to -W$ $(e^{i\pi} W)$ 1-form symmetry
$\mathbb{Z}_4, \mathbb{Z}_2^c$ SCFT symmetries of Thm.
Invisible subgroup $\mathbb{Z}_2$
't Hooft anomaly
2-form symm (RG)
$\frac{1}{4\pi}\int R^{ab}_{\mu\nu}$
curvature


ed fermions
$B_{\mu\nu}$ ← background
(4-fermi → Z_4)
non-zero flux
$\int B = \pi$
fractionalized top charges


fermions
$B_{\mu\nu}$ ← background
(4-fermi → Z_4)
non-zero flux
$\int B = \pi$
↳ fractionalize top charges → local Z_4
Ising
$U_\mu \to z U_\mu$ $z = \pm 1$
Z_4, Z_2


Wilson
$U_\mu \to z U_\mu$ $z = \pm 1$ 1-plaquettes
$U_{12} =$
$e^{i\pi}$
$e^{i\pi x}$
$\int dx\, e^{i\pi x}$ under Z_1
$e^{i\pi x}$ $e^{i\pi}$
Z_1 Z_2


(4-fermi → Z4)
= π
→ break Z4
B-plaquette
±1
global Z2 symmetry
d=2
(π, −π)
(0, π)
L ~ e^{i2σ3}
Act on Wilson lines
W = e^{∮w dx}
non-contractible loop
W → −W (e^{iπ} W)
1-form symmetry
Z4, Z2 SSB Symmetric Phase

cancel anomaly of 1

with 2 copies of 4D field

$d=2$

1 4D = 2 Dirac × 2

= 8 Majorana

$d=4$

1 4D = 4 Dirac × 2

= 16 Majorana

$B_{\mu\nu}$ ← background

non-zero flux

$\int B =$

↳ fractionalized top charges

Alpha

$U_\mu \to z U_\mu \quad z = \pm 1$

$U_2 =$

πX

4D ψ

Cancel anomaly of 1

with 2 copies of 4D field

d=2

1 4D = 2 Dirac x 2

= 8 Majorana

d=4

1 4D = 4 Dirac x 2

= 16 Majorana

$B_{\mu\nu}$ ← background

non-zero flux

$\int B =$

↳ fractionalize top charges

Laffla

$U_\mu \to z U_\mu$ $z = \pm 1$

$U_{12} =$

πx

$\int 4D\chi$ e

Under Z_2