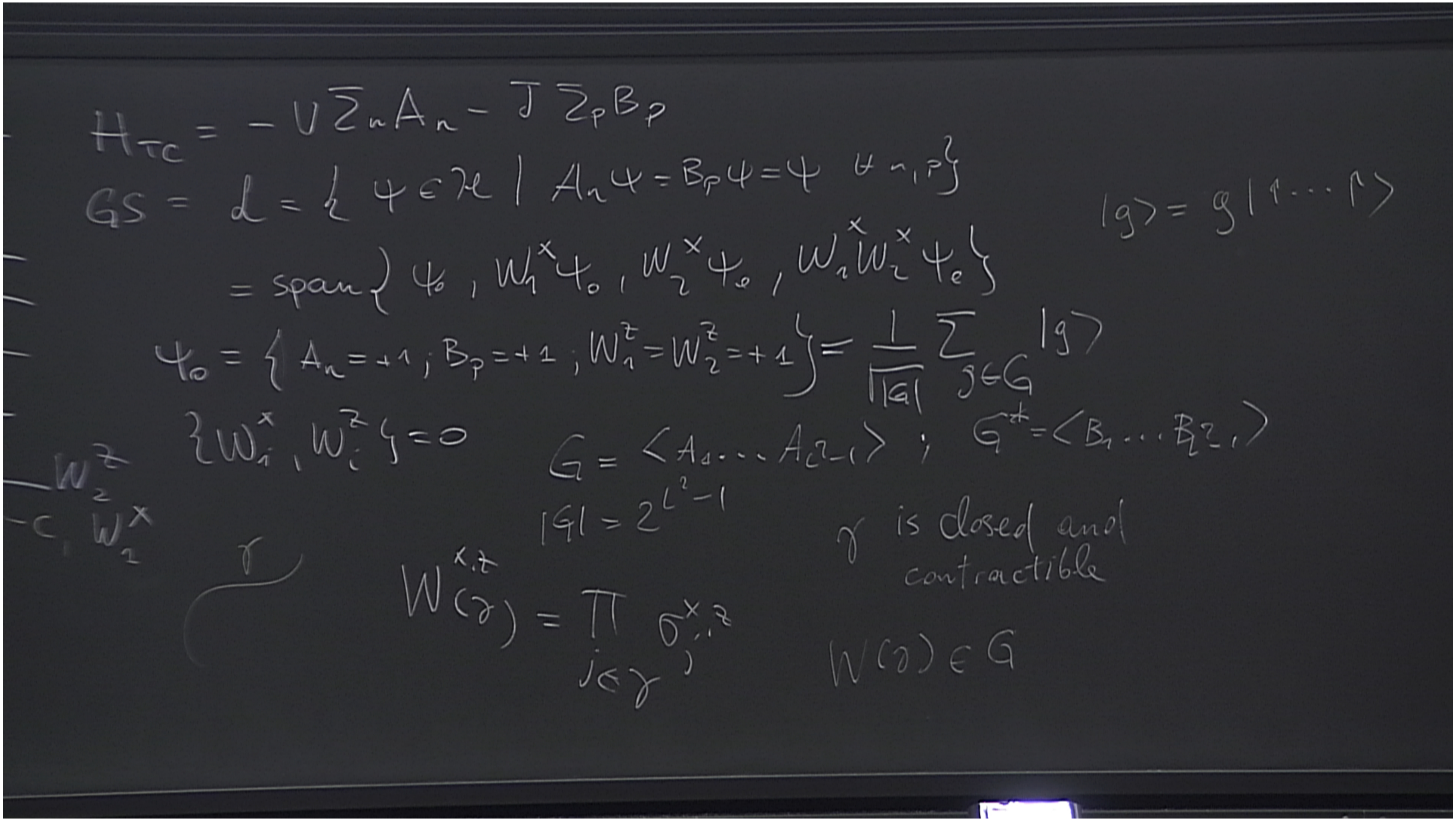
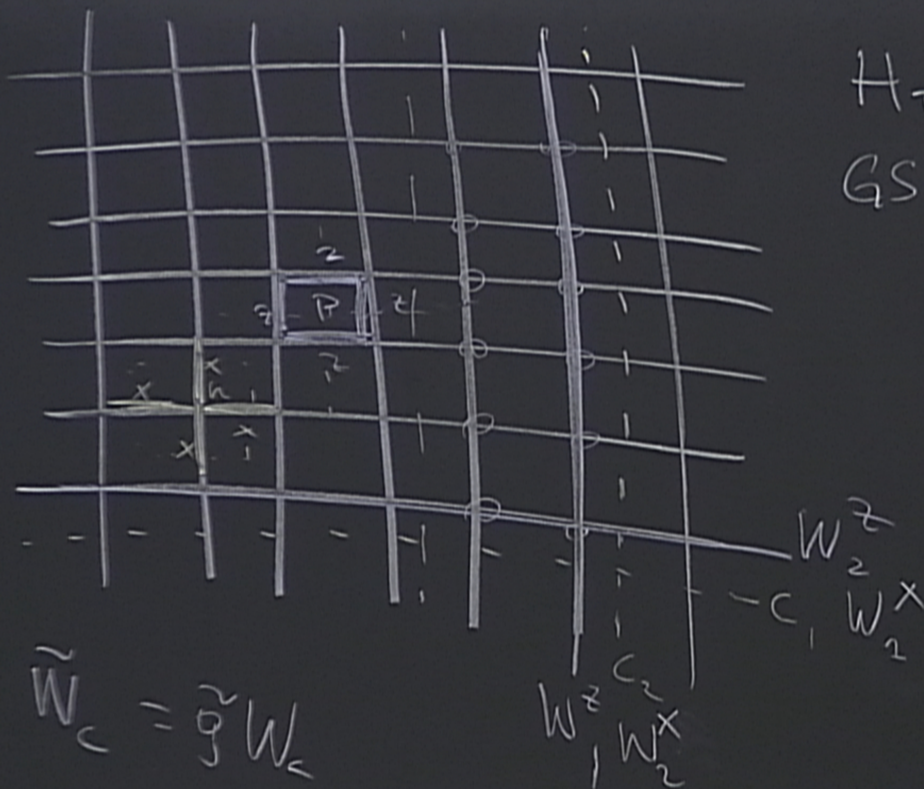
Title: Condensed Matter Review-11

Date: Feb 09, 2015 09:00 AM

URL: http://pirsa.org/15020008

Abstract:


$H_{TC} = -U \sum_n A_n - J \sum_p B_p$
$GS = \mathcal{L} = \{ \psi \in \mathcal{H} \mid A_n \psi = B_p \psi = \psi \ \forall n, p \}$
$|g\rangle = g|\uparrow \cdots \uparrow\rangle$
$= \mathrm{span}\{ \psi_0, W_1^x \psi_0, W_2^x \psi_0, W_1^x W_2^x \psi_0 \}$
$\psi_0 = \{ A_n = +1; B_p = +1; W_1^z = W_2^z = +1 \} = \frac{1}{\sqrt{|G|}} \sum_{g \in G} |g\rangle$
$\{ W_i^x, W_i^z \} = 0$
$G = \langle A_1 \dots A_{L^2-1} \rangle$; $G^* = \langle B_1 \dots B_{L^2-1} \rangle$
$|G| = 2^{L^2-1}$
W_2^z
W_2^x
γ
γ is closed and contractible
$W^{x,z}(\gamma) = \prod_{j \in \gamma} \sigma_j^{x,z}$
$W(\gamma) \in G$



$$\tilde{W}_c = \tilde{g}\, W_c$$

$$H_{TC} = -U \sum_n A_n - J \sum_p B_p$$

$$GS = \mathcal{L} = \{ \psi \in \mathcal{H} \mid A_n \psi = B_p \psi = \psi \ \forall$$

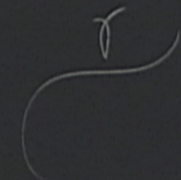
$$= \mathrm{span}\{ \psi_0,\ W_1^x \psi_0,\ W_2^x \psi_0,\ W_1^x W$$

$$\psi_0 = \{ A_n = +1;\ B_p = +1;\ W_1^z = W_2^z = +1 \} =$$

$$\{ W_i^x, W_i^z \} = 0$$

$$G = \langle A_1 \dots A_{L^2-1} \rangle$$

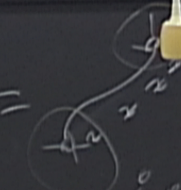
$$|G| = 2^{L^2-1}$$

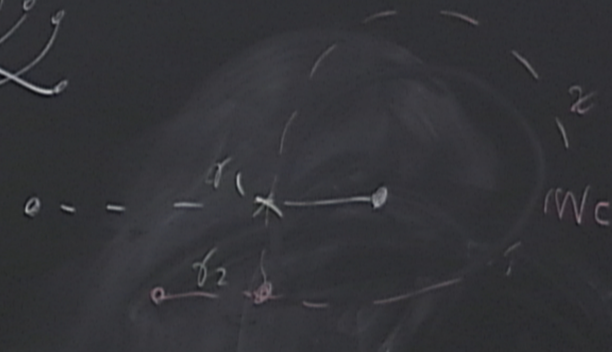


$$W^{x,z}(\gamma) = \prod_{j \in \gamma} \sigma_j^{x,z}$$

γ

W(

When γ is open $W_\gamma^{x,z}|\psi_0\rangle =$  $|\psi_0\rangle = \int_x^x \frac{1}{\sqrt{|G|}} \bar{z}_g |g\rangle$



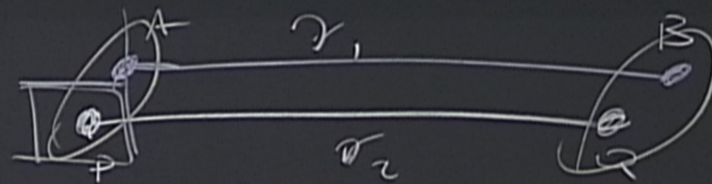
$$\psi^{in} = W_{PQ}\,\psi_0$$

$$\psi^{out} = W_C\, W_{PQ}\,\psi_0 = W_{PQ}\,\underbrace{W_C\,\psi_0}_{\psi_0} = \psi^{in}$$

$$\psi^{in} = W_{\gamma_1} W_{\gamma_2}\,\psi_0$$

$$\psi^{out} = W_C\, W_{\gamma_1} W_{\gamma_2}\,\psi_0 = -\,W_{\gamma_1} W_{\gamma_2}\,\psi_0 = -\psi^{in}$$

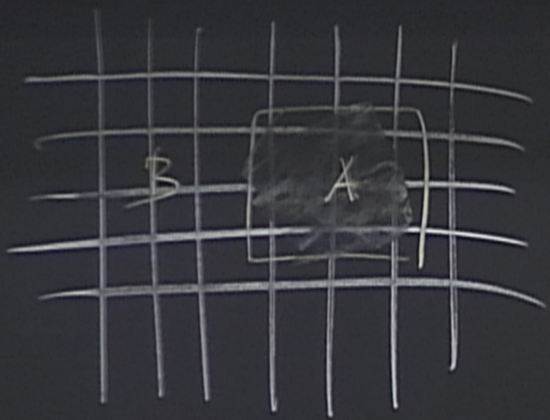
EXERCISE



$$\psi^{in} = W^{z}_{\gamma_1(AB)} W^{x}_{\gamma_2(PQ)} \psi_0$$

$$\psi^{out}(\text{after sweep}) = -\psi^{in}$$

$$\langle \psi_0 | \sigma^z_i \sigma^z_j | \psi_0 \rangle = 0$$

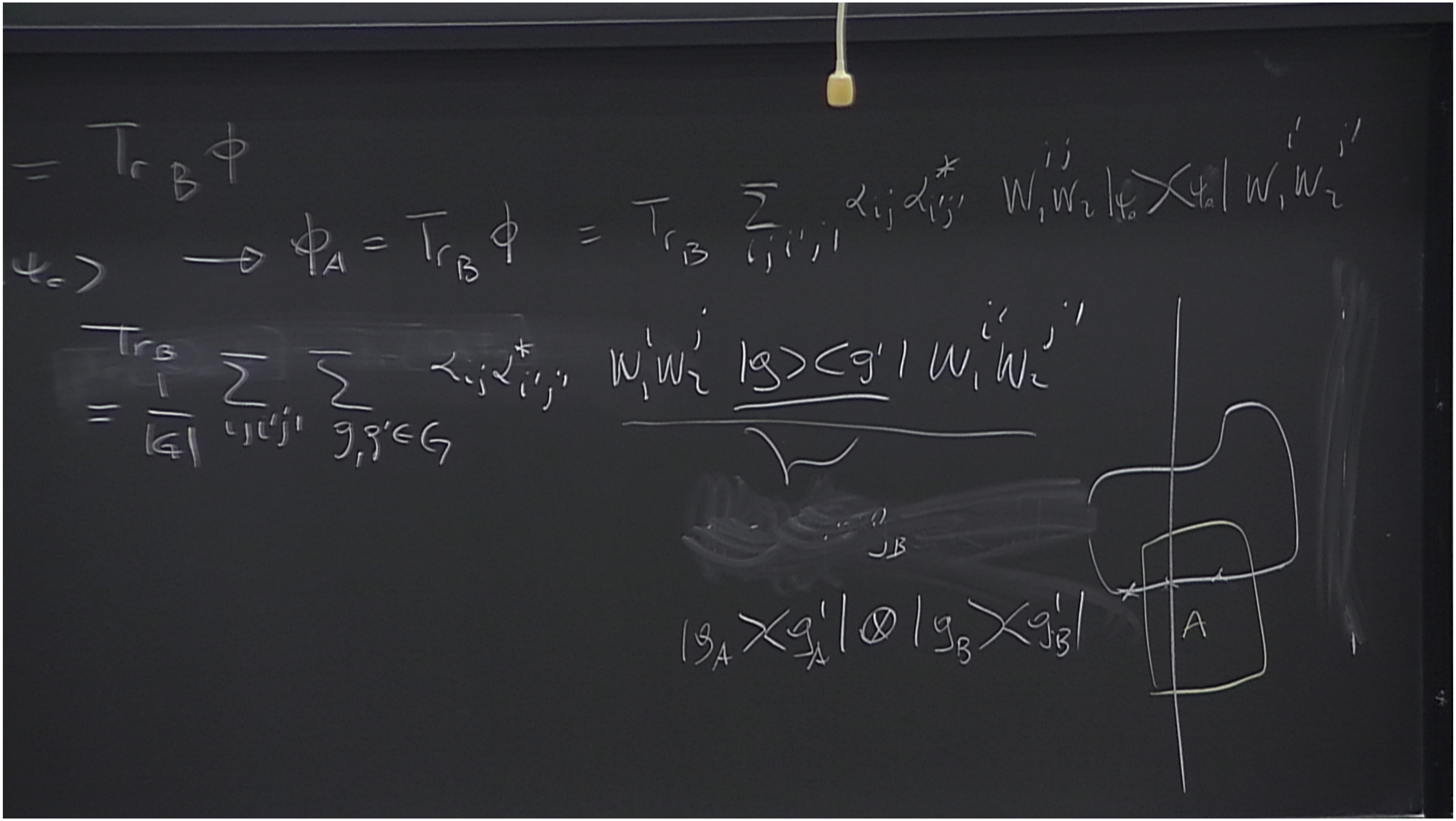


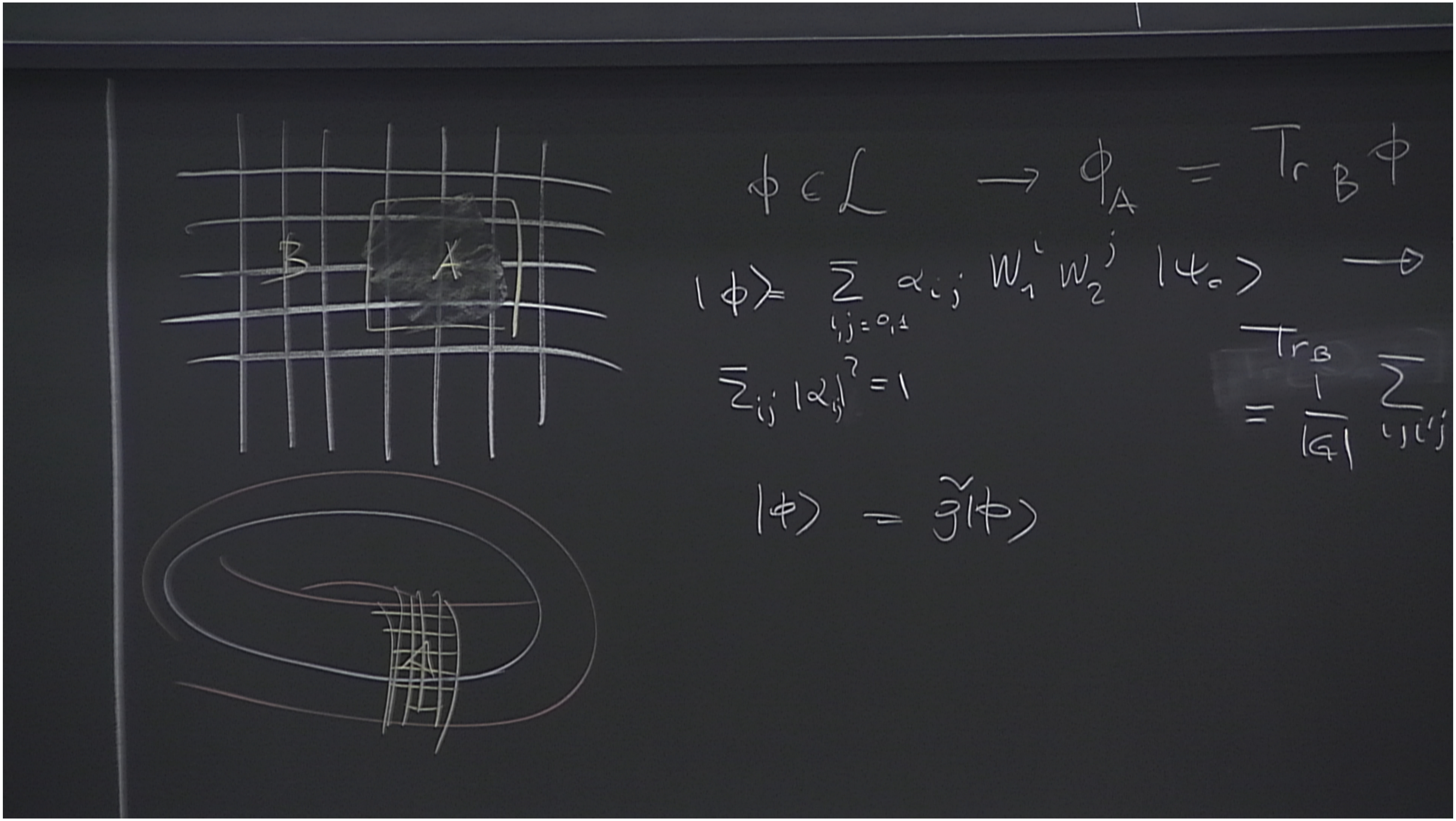
$\phi \in \mathcal{L} \rightarrow \phi_A = Tr_B \phi$

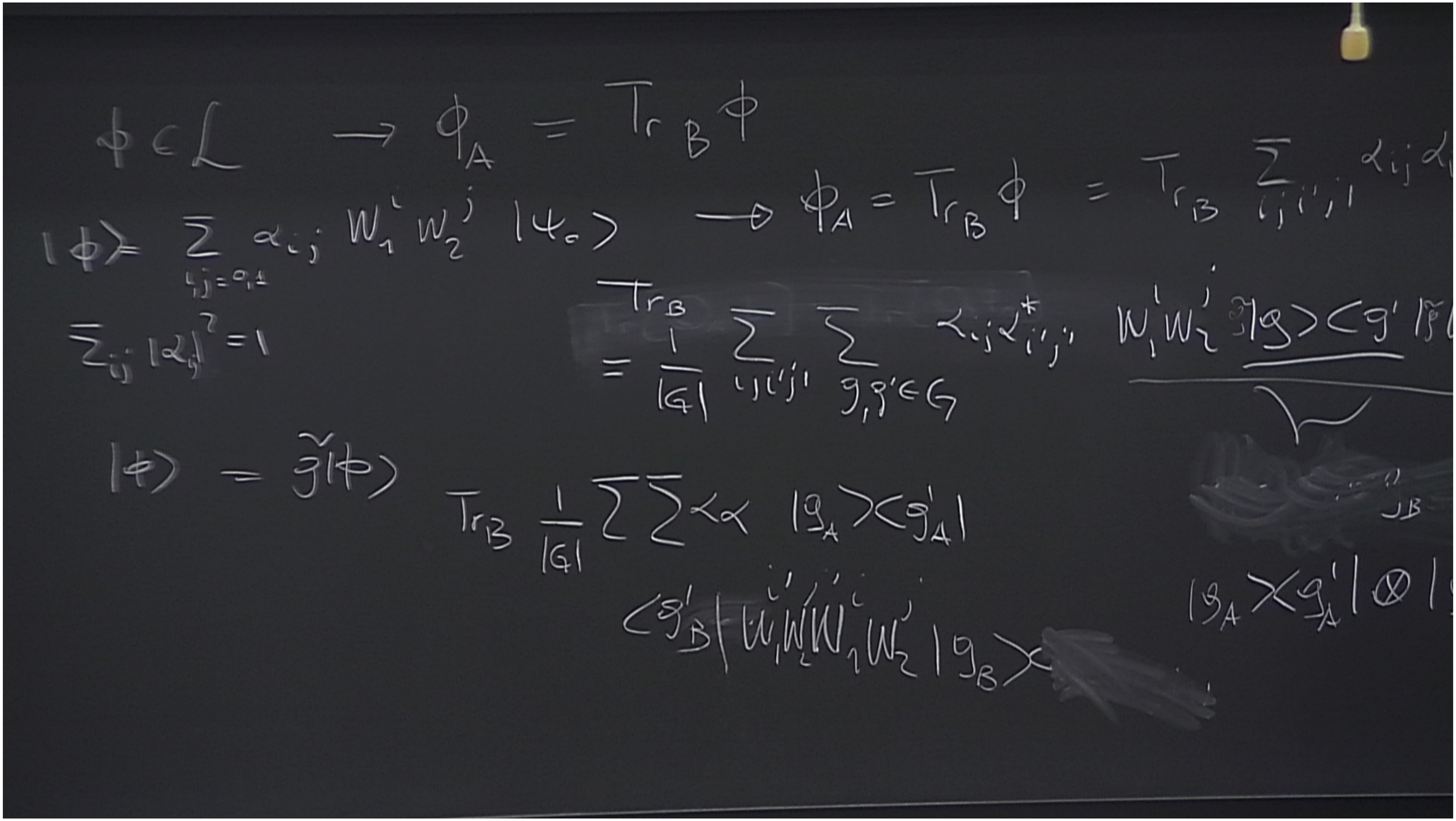
$\phi = \sum_{i,j=0,1} \alpha_{ij} W_1^i W_2^j |\psi_0\rangle \rightarrow \phi_A = Tr_B \phi$

$\sum_{ij} |\alpha_{ij}|^2 = 1$

$Tr[O_A \phi] = Tr[O_A \phi_A]$


$= \mathrm{Tr}_B \phi$
$|\psi_0\rangle \longrightarrow \phi_A = \mathrm{Tr}_B \phi = \mathrm{Tr}_B \sum_{i,j,i',j'} \alpha_{ij} \alpha^*_{i'j'} W_1^i W_2^j |\psi_0\rangle\langle\psi_0| W_1^{i'} W_2^{j'}$
$= \frac{1}{|G|} \sum_{i,j,i',j'} \sum_{g,g' \in G} \alpha_{ij} \alpha^*_{i'j'} W_1^i W_2^j |g\rangle\langle g'| W_1^{i'} W_2^{j'}$
$|g_A\rangle\langle g'_A| \otimes |g_B\rangle\langle g'_B|$
A


B
A
$\phi \in \mathcal{L} \rightarrow \phi_A = \mathrm{Tr}_B\, \phi$
$|\phi\rangle = \sum_{i,j=0,1} \alpha_{ij} W_1^i W_2^j |\psi_0\rangle \rightarrow$
$\sum_{ij} |\alpha_{ij}|^2 = 1$
Tr_B
$= \frac{1}{|G|} \sum$
$|\phi\rangle = \tilde{g}|\phi\rangle$



$\phi \in \mathcal{L} \rightarrow \phi_A = Tr_B \phi$
$|\phi\rangle = \sum_{i,j=0,1} \alpha_{ij} W_1^i W_2^j |\psi_0\rangle \rightarrow \phi_A = Tr_B \phi = Tr_B \sum_{i,j,i',j'} \alpha_{ij} \alpha$
$\sum_{ij} |\alpha_{ij}|^2 = 1$
Tr_B
$= \frac{1}{|G|} \sum_{i,j,i',j'} \sum_{g,g' \in G} \alpha_{ij} \alpha^*_{i'j'} W_1^i W_2^j |g\rangle\langle g'|$
$|\phi\rangle = \tilde{g}|\phi\rangle$
$Tr_B \frac{1}{|G|} \sum \sum \alpha \alpha |g_A\rangle\langle g'_A|$
$\langle g'_B| W_1^{i'} W_2^{j'} W_1^i W_2^j |g_B\rangle$
$|g_A\rangle\langle g'_A| \otimes |$

$$\phi \in \mathcal{L} \longrightarrow \phi_A = \mathrm{Tr}_B \, \phi$$

$$|\phi\rangle = \sum_{i,j=0,1} \alpha_{ij} W_1^i W_2^j |\psi_0\rangle \longrightarrow \phi_A = \mathrm{Tr}_B \, \phi = \mathrm{Tr}_B \sum_{i,j,i',j'} \alpha_{ij} \alpha_{i'j'}^*$$

$$\sum_{ij} |\alpha_{ij}|^2 = 1$$

$$\mathrm{Tr}_B \; = \frac{1}{|G|} \sum_{i,j,i',j'} \sum_{g,g' \in G} \alpha_{ij} \alpha^*_{i'j'} W_1^i W_2^j |g\rangle\langle g'| \ldots$$

$$\phi_A = \frac{1}{|G|} \sum_g |g_A\rangle\langle g'_A| \, \langle g'_B | g_B\rangle$$

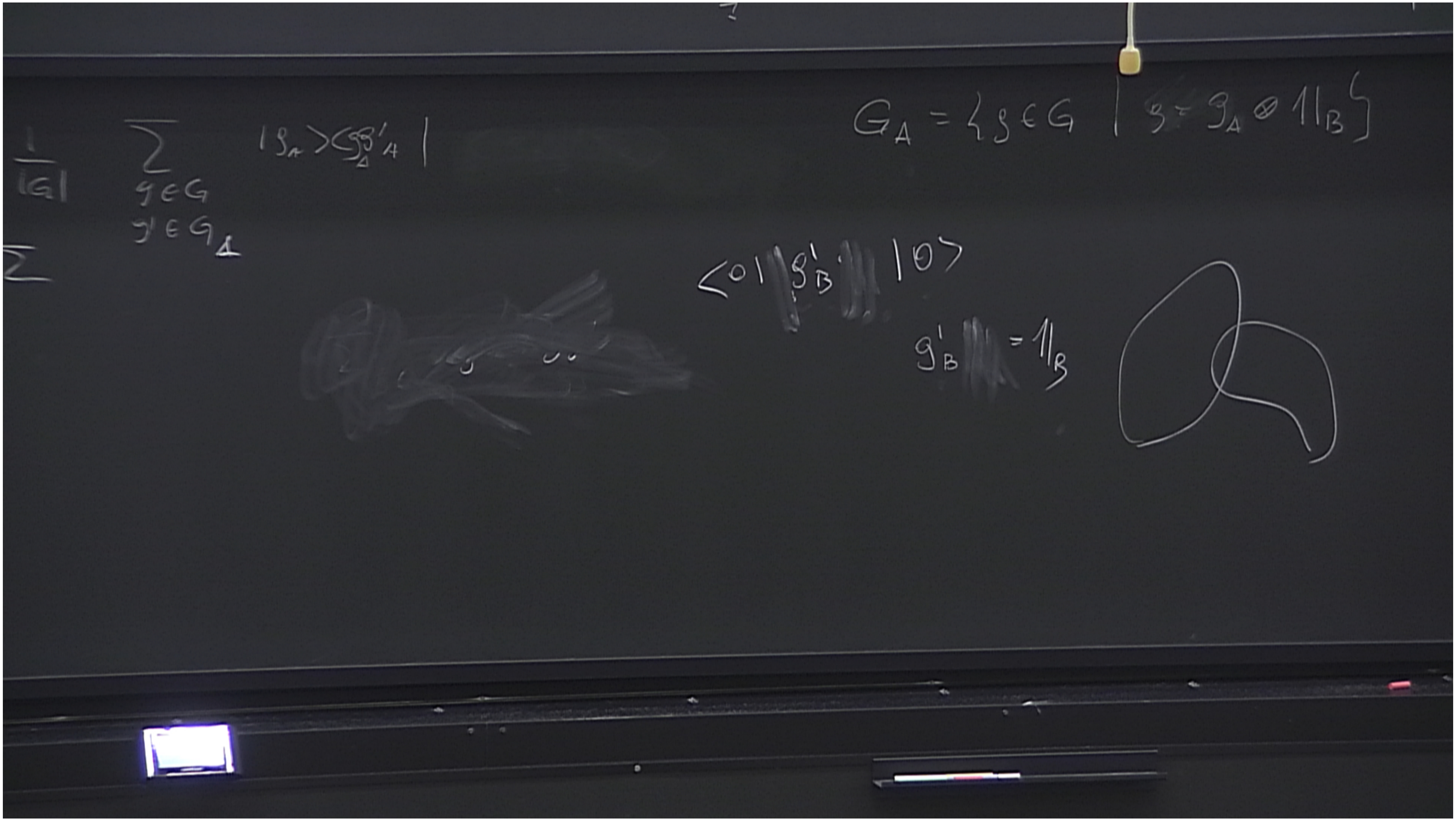
$$\langle g'_B | W_1 W_2 W_1 W_2 | g_B \rangle$$

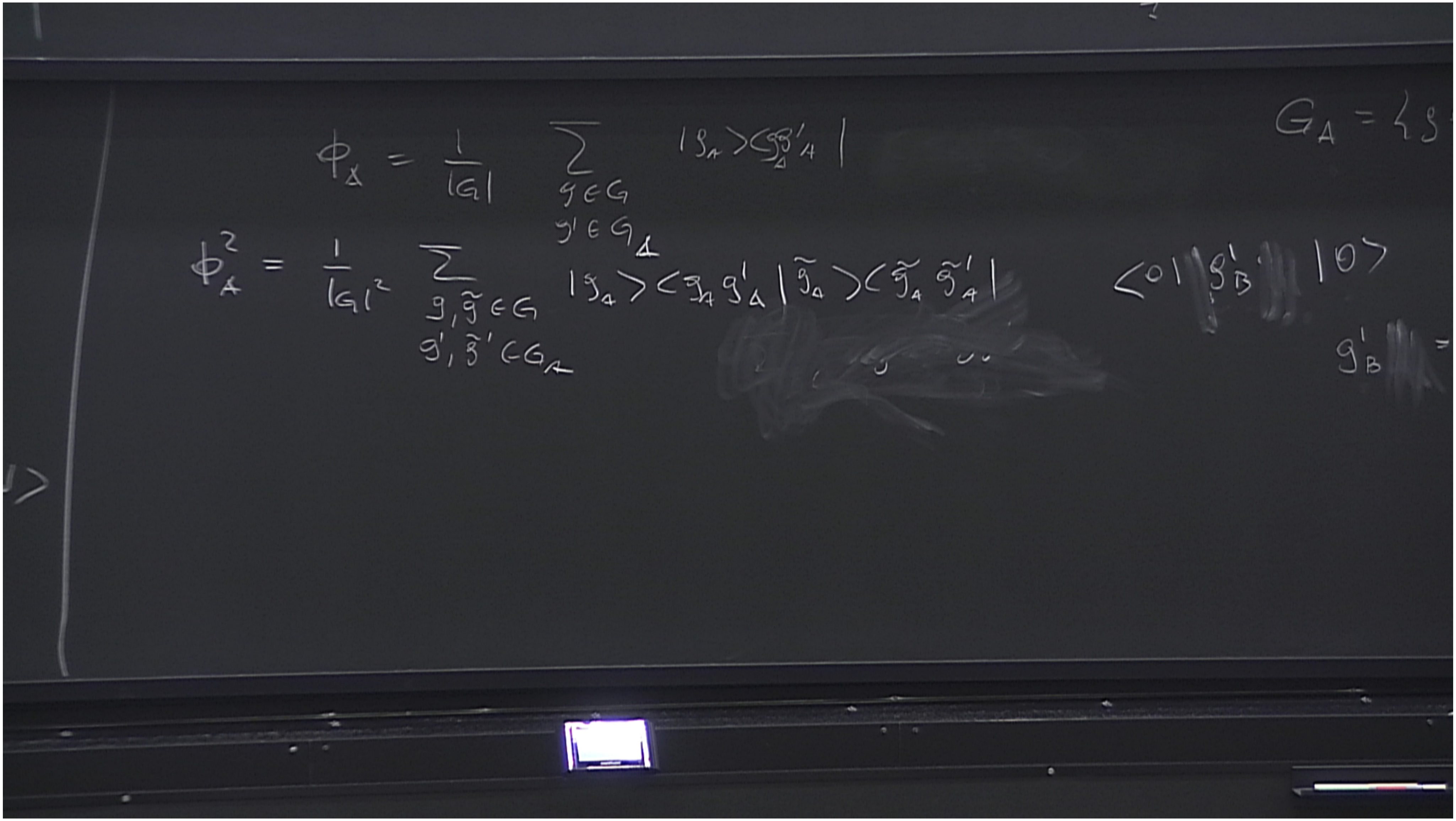
$$|g_A\rangle\langle g'_A| \otimes | \ldots$$

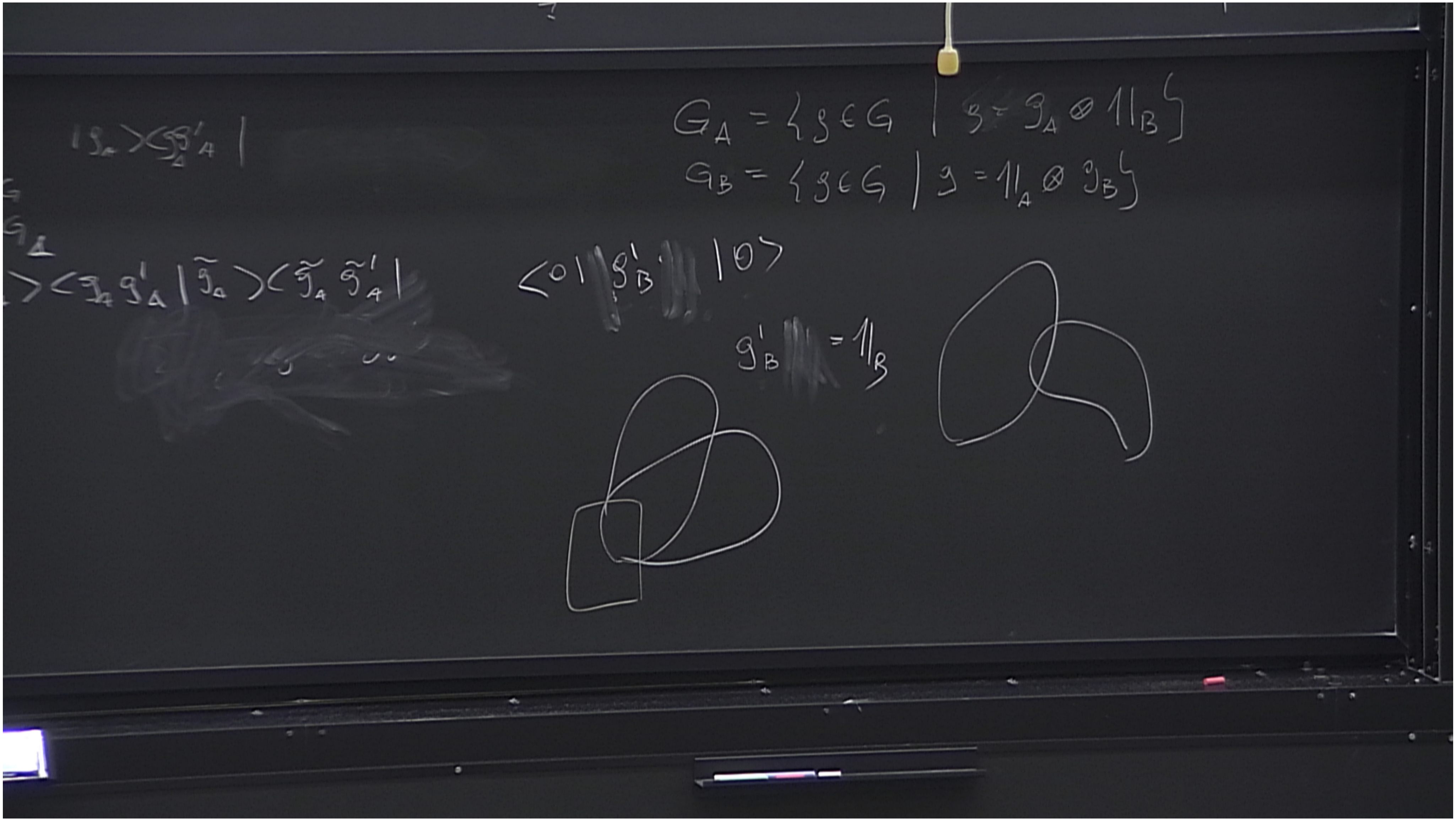
$$\frac{1}{\sqrt{2}}\left(|\uparrow\uparrow\uparrow\cdots\uparrow\rangle + |\downarrow\downarrow\cdots\downarrow\rangle\right)$$

$$\frac{1}{\sqrt{2}}\left(|\uparrow\uparrow\cdots\uparrow\rangle - |\downarrow\downarrow\cdots\downarrow\rangle\right)$$

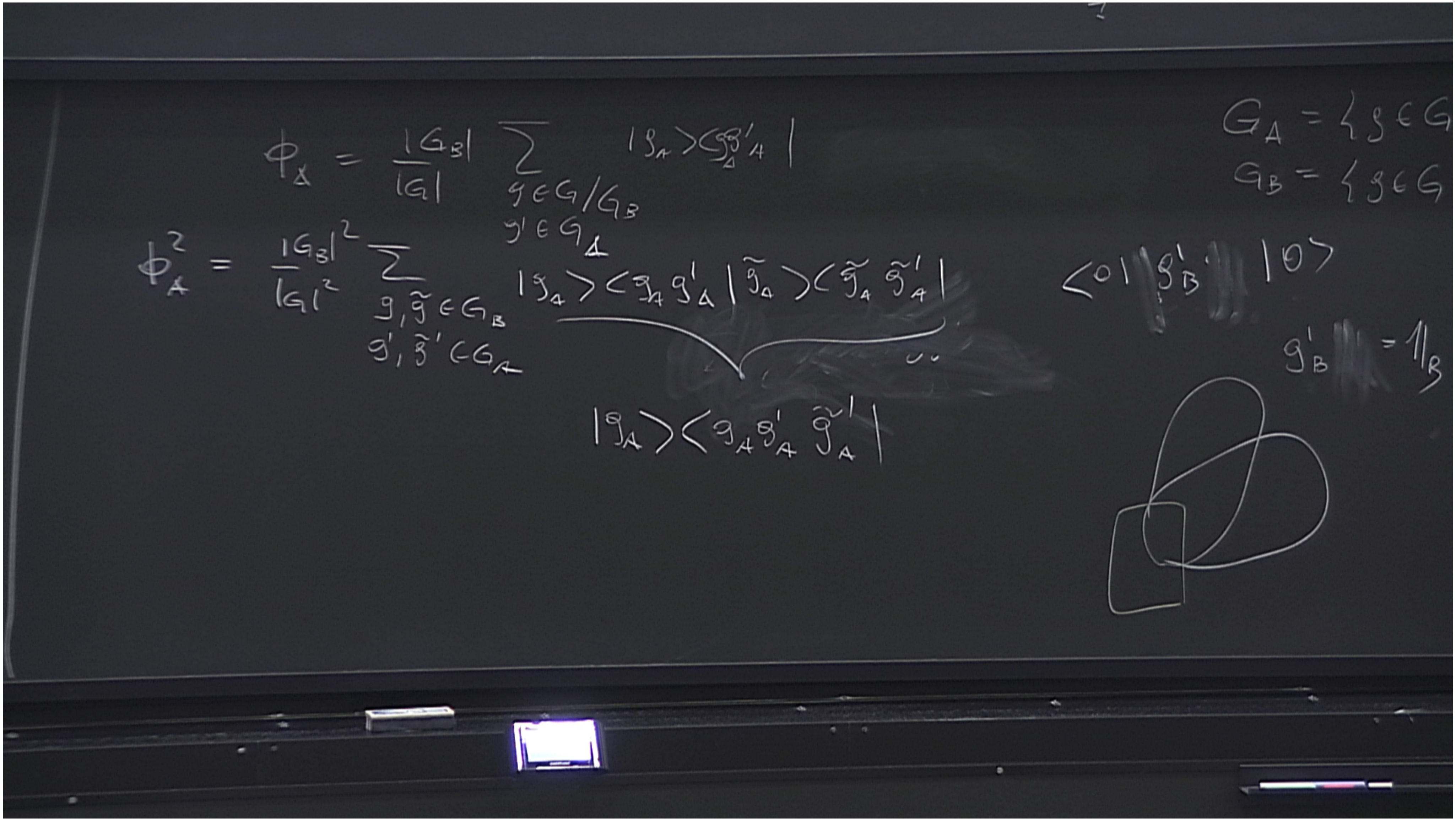
$$|\uparrow\uparrow\uparrow\cdots\uparrow\rangle \qquad |\downarrow\downarrow\downarrow\cdots\downarrow\rangle$$


$G_A = \{ g \in G \mid g = g_A \otimes 1_B \}$
$\frac{1}{|G|} \sum_{g \in G, g' \in G_A} |g_A\rangle\langle g'_A|$
$\langle 0 | g'_B | 0 \rangle$
$g'_B = 1_B$


$\phi_A = \frac{1}{|G|} \sum_{g \in G,\ g' \in G_A} |g_A\rangle\langle g g'_A|$
$G_A = \{g$
$\phi_A^2 = \frac{1}{|G|^2} \sum_{g,\tilde{g} \in G,\ g',\tilde{g}' \in G_A} |g_A\rangle\langle g_A g'_A|\tilde{g}_A\rangle\langle \tilde{g}_A \tilde{g}'_A|$
$\langle 0| g'_B |0\rangle$
$g'_B =$



G_A = { g ∈ G | g = g_A ⊗ 1_B }
G_B = { g ∈ G | g = 1_A ⊗ g_B }
<0| g'_B |0>
g'_B = 1_B


$\phi_A = \frac{|G_B|}{|G|} \sum_{g \in G/G_B, g' \in G_A} |g_A\rangle\langle g g'_A|$
$\phi_A^2 = \frac{|G_B|^2}{|G|^2} \sum_{g,\tilde{g} \in G_B, g',\tilde{g}' \in G_A} |g_A\rangle\langle g_A g'_A|\tilde{g}_A\rangle\langle \tilde{g}_A \tilde{g}'_A|$
$|g_A\rangle\langle g_A g'_A \tilde{g}'_A|$
$G_A = \{ g \in G$
$G_B = \{ g \in G$
$\langle 0| g'_B |0\rangle$
$g'_B = 1\!\!1_B$

$$\phi_A = \frac{|G_B|}{|G|} \sum_{\substack{g \in G/G_B \\ g' \in G_A}} |g_A\rangle\langle g g'_A|$$

$$\phi_A^2 = \frac{|G_B|^2}{|G|^2} \sum_{\substack{g, \tilde{g} \in G_B \\ g', \tilde{g}' \in G_A}} |g_A\rangle\langle g_A g'_A | \tilde{g}_A\rangle\langle \tilde{g}_A \tilde{g}'_A|$$

$$\frac{|G|}{|G_B|} \frac{|G_B|^2 |G_A|}{|G|^2} \sum |g_A\rangle\langle g_A \underbrace{g'_A \tilde{g}'_A}_{g^*_A}| = \frac{|G_A||G_B|}{|G|} \phi_A$$

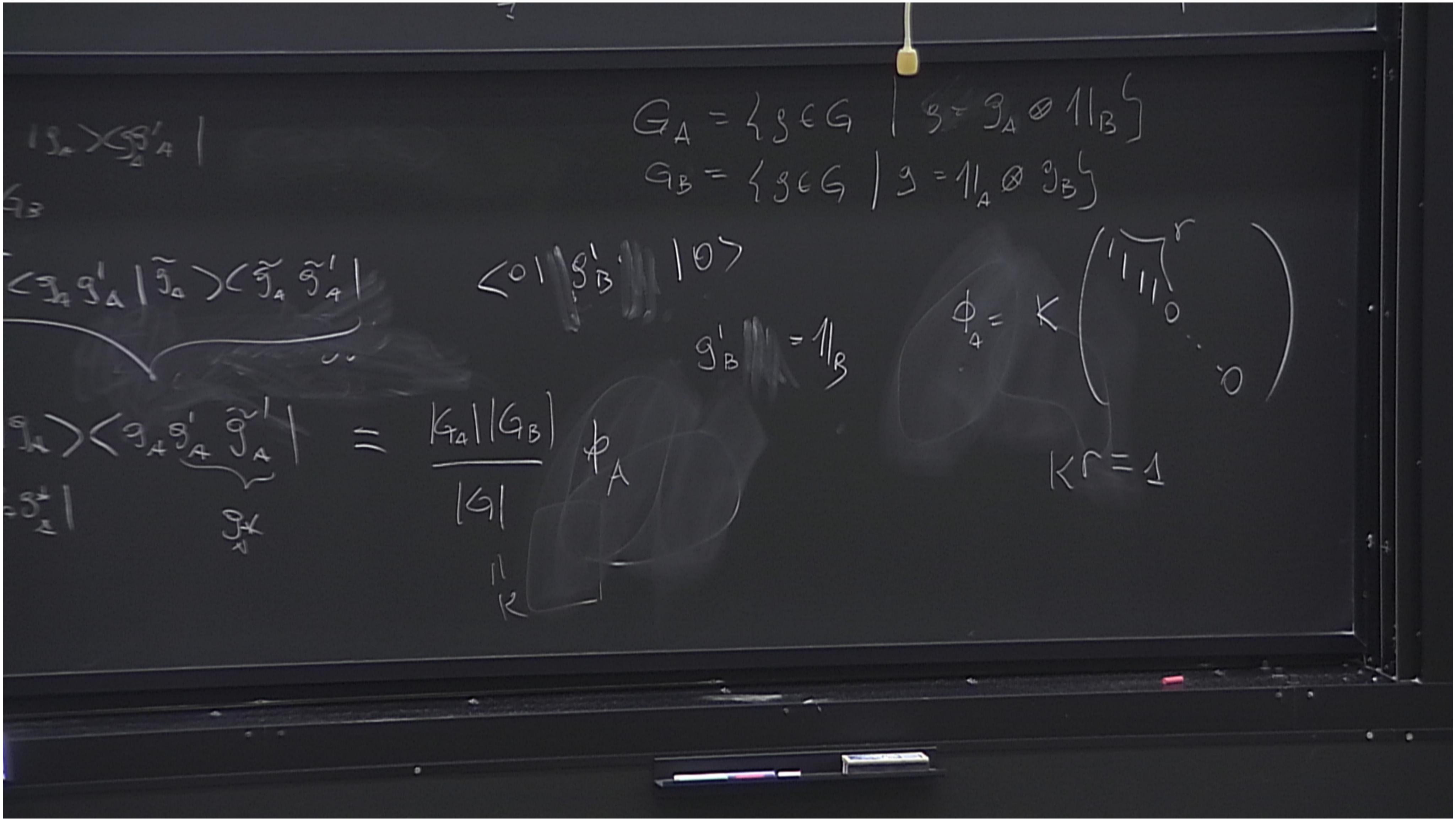
$$\sum_{g, g^*} |g_A\rangle\langle g_A g^*_A|$$

$G_A = \{ g \in G$

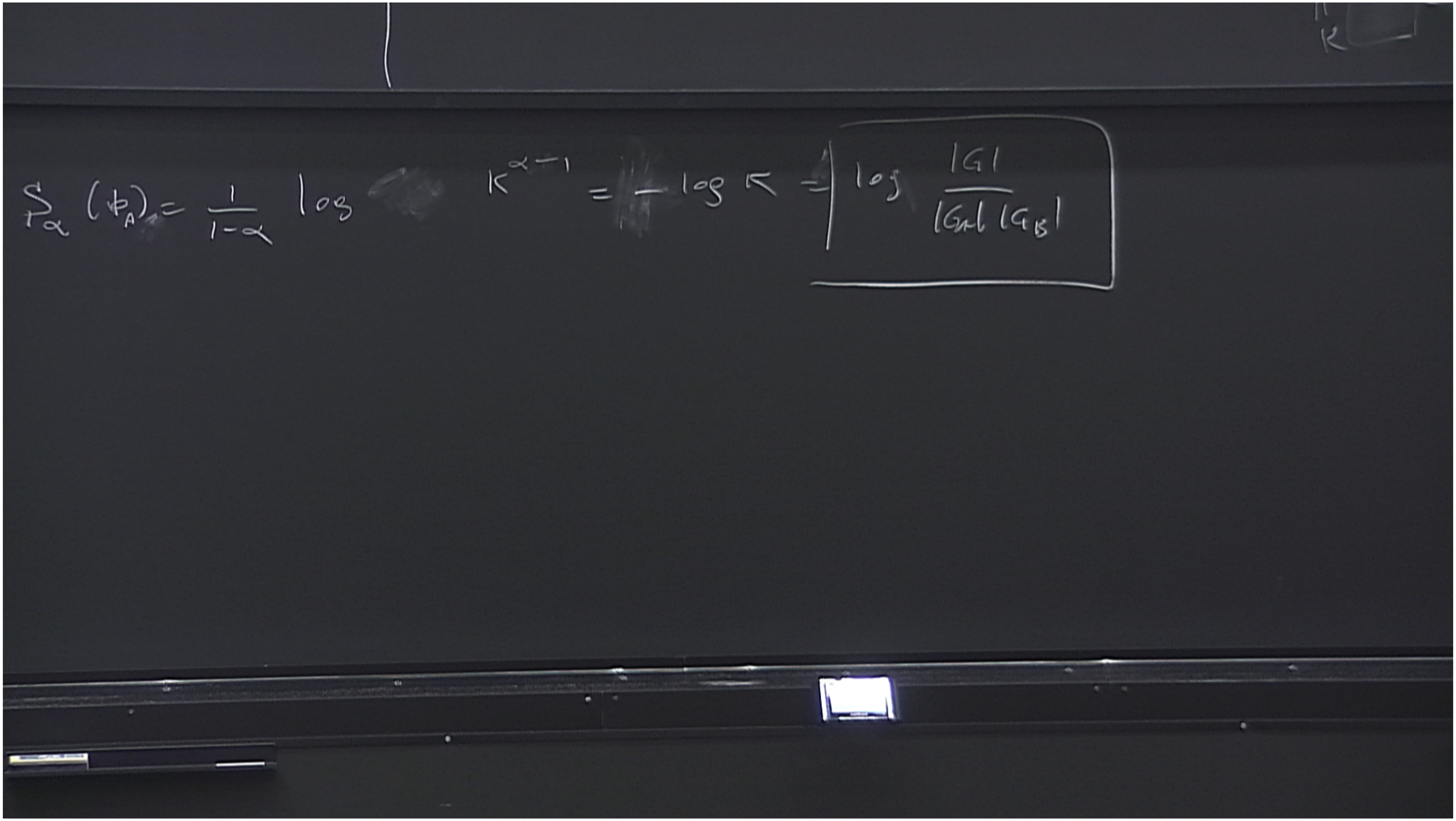
$G_B = \{ g \in G$

$\langle 0 | g'_B | 0 \rangle$

$g'_B = 1_B$


G_A = { g ∈ G | g = g_A ⊗ 1_B }
G_B = { g ∈ G | g = 1_A ⊗ g_B }
<0| g'_B |0>
g'_B = 1_B
φ_A = K
Kr = 1
|G_A||G_B| / |G|
φ_A

$$S_\alpha(\rho_A) = \frac{1}{1-\alpha}\log \quad K^{\alpha+1} = -\log K = \log \frac{|G|}{|G_A|\,|G_B|}$$


$S_\alpha(\rho_A) = \frac{1}{1-\alpha} \log K^{\alpha-1} = \log K = \log \frac{|G|}{|G_A||G_B|}$