Title: PSI 2019/2020 - Quantum Matter Part 1 - Lecture 15

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Collection: PSI 2019/2020 - Quantum Matter Part 1

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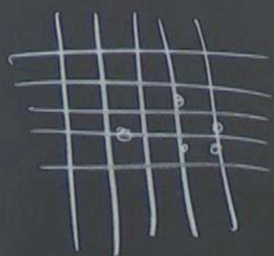
$H_{TC} = -U\sum_n A_n - J\sum_p B_p$

$$\big| \overset{L^2-1}{\{A_n\}} \overset{L^2-1}{\{B_p\}} \overset{1}{W^1} \overset{1}{W^2} \big\rangle \quad \text{eigenstates}$$

$|\psi_0\rangle \in \mathcal{L}_{GS} \Leftrightarrow$

$\dim \mathcal{H}_{TOT} = 2^{2L^2}$

$X_i^a \, |\psi_0\rangle$



$\mathcal{H}_{TOT} \simeq \mathbb{C}^{2 \otimes 2L^2}$

$$\mathcal{H}_{TOT} \simeq \bigotimes_{\ell \in \Lambda} \mathcal{H}_\ell$$

$$\simeq \bigotimes_n \mathcal{H}_n^{(A)} \bigotimes_p \mathcal{H}_p^{(B)} \otimes \mathcal{H}_{W_1} \otimes \mathcal{H}_{W_2}$$

$|\psi_0\rangle \in \mathcal{H}_{GS} \iff A_n|\psi_0\rangle = B_p|\psi_0\rangle = |\psi_0\rangle \quad \forall\, n, p$

$G = \langle A_1, \dots, A_n \rangle$ associate the group

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

$P_n = \frac{\mathbb{1} + A_n}{2}$

$|0\rangle^{\otimes N} \equiv |\tilde{0}\rangle$

for all p, $B_p|\tilde{0}\rangle = |\tilde{0}\rangle$

$|\psi_0\rangle = \prod_n P_n |\tilde{0}\rangle$

$|\psi_0\rangle = N \prod_n (\mathbb{1} + A_n)|\tilde{0}\rangle = N\left(\mathbb{1} + \sum_n A_n + \sum_{nn'} A_n A_{n'} + \sum_{nn'n''} A_n A_{n'} A_{n''} \dots\right)|\tilde{0}\rangle$

$\tilde{g} \in G \quad \tilde{g}|\psi_0\rangle = \frac{1}{\sqrt{|G|}}\sum_{g\in G}|g\tilde{g}\rangle = |\psi_0\rangle$

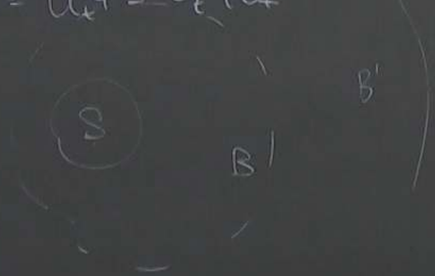
$= \frac{1}{\sqrt{|G|}}\sum_{g\in G} g|\tilde{0}\rangle \equiv \frac{1}{\sqrt{|G|}}\sum_{g\in G}|g\rangle$

$\mathcal{H}$ $\quad H = \sum_n E_n P_n = \sum_{n,\alpha} E_n |E_{n\alpha}\rangle\langle E_{n\alpha}|$ $\quad \alpha = 1$

$X_t = \mathcal{U}_t X = U_t^\dagger X U_t$ $\quad U_t = e^{-iHt}$

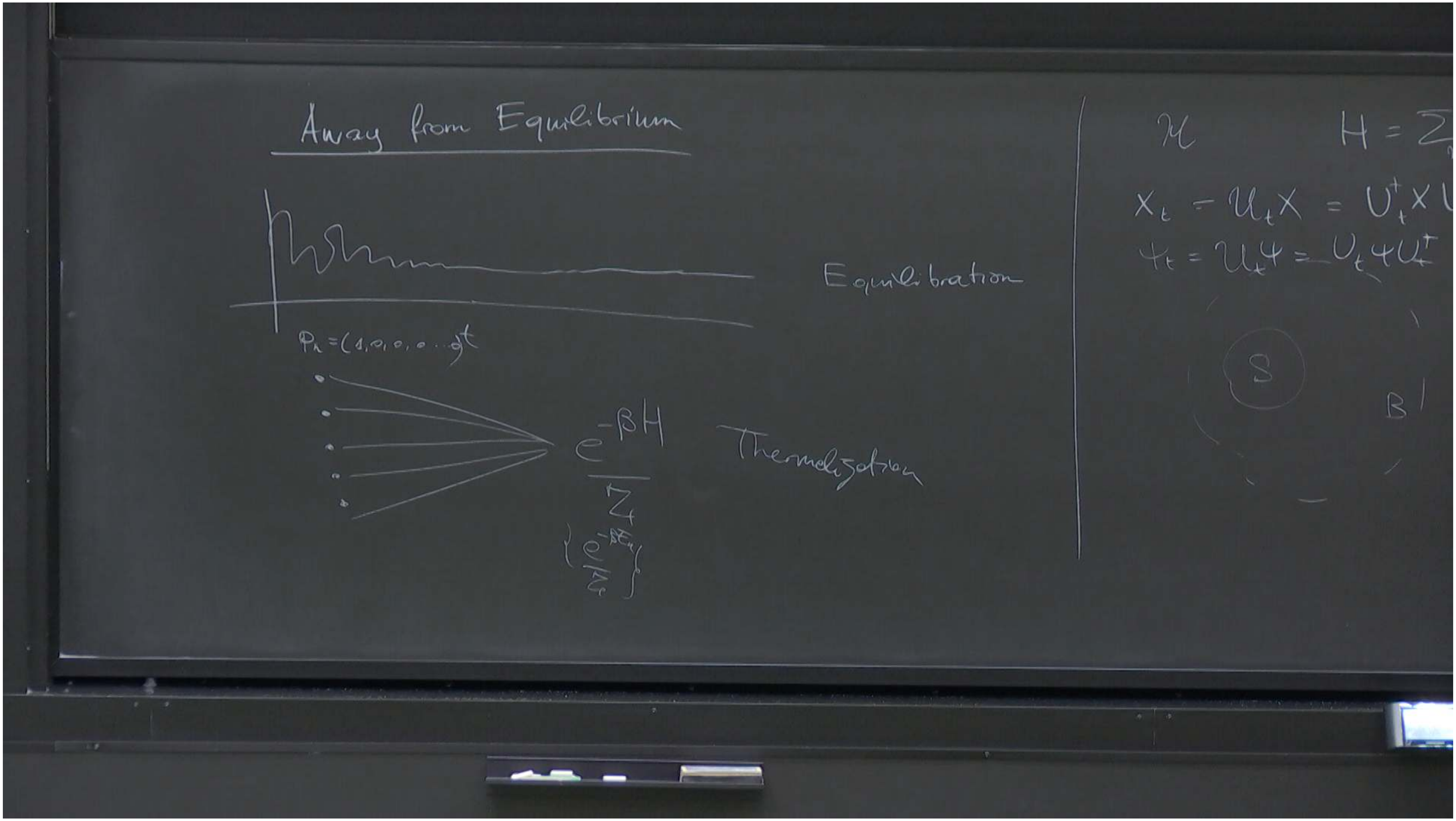
$\psi_t = \mathcal{U}_t \psi = U_t \psi U_t^\dagger$

II Law $\quad S(\psi_t) = S(U \psi U^\dagger) = S(U \sum_n p_n \Pi_n U^\dagger)$



$$S_\alpha(\phi) = \frac{1}{1-\alpha} \log \mathrm{Tr}\, \phi^\alpha$$

$\alpha \to 1 \quad S_1(\phi) = -\sum_n p_n \log p_n$


Away from Equilibrium
Equilibration
$\rho_h = (1,0,0,0,\ldots 0)^t$
$\frac{e^{-\beta H}}{Z_t}$
Thermalization
$\mathcal{H}$
$H = \Sigma$
$X_t = \mathcal{U}_t X = U_t^\dagger X U$
$\psi_t = \mathcal{U}_t \psi = U_t \psi U_t^\dagger$
S
B

Equilibration

$\phi \xrightarrow{t} \phi_t \xrightarrow{t>t^*} \phi_{eq}$

$\mathcal{U}(\phi_{eq}) = \phi_{eq}$ fixed point

$\phi = \phi_{eq}$

ϕ

ϕ is steady

$\Updownarrow$

$[\phi, H] = 0$

$= |\psi_0\rangle$

...tion

$$0 = \lim_{t\to\infty} \|\phi_t - \phi_{eq}\| = \lim_{t\to\infty} \|\mathcal{U}\phi - \mathcal{U}\phi_{eq}\| = \lim_{t\to\infty} \|\mathcal{U}(\phi - \phi_{eq})\| = \|\phi - \phi_{eq}\|$$

$\rightarrow \phi = \phi_{eq}$

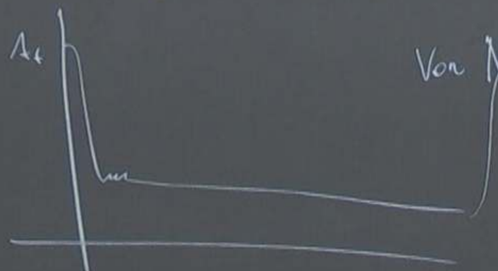
...nt

$$A_t = tr[A_t \phi] = tr[A \phi_t]$$

ϕ is steady

$\Updownarrow$

$, H] = 0$



Von Neumann A_t is quasi-periodic

$$\|A_{T_\epsilon} - A_0\| \leq \epsilon$$

Eq in prob. $\rightarrow \sigma$ is small

$\sigma^2 \equiv \Delta A^2 = \overline{(A-\bar{A})^2}$ temporal fluctuations

$\Pr\{\,|A_t - \bar{A}| > k\,\} < \frac{\sigma}{k}$ Chebyshev inequality