

Title: PSI 17/18 - Condensed Matter - Lecture 6

Date: Jan 10, 2018 11:30 AM

URL: <http://pirsa.org/18010039>

Abstract:

Locality in Quantum Physics

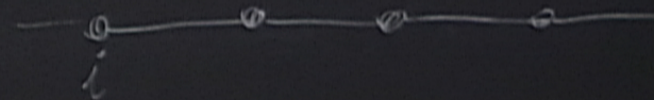
$$\mathcal{H}_\Lambda = \bigotimes_{i \in \Lambda} \mathcal{H}_i$$

$$\mathcal{H}_X = \bigotimes_{i \in X} \mathcal{H}_i$$

$$H = \sum_{X \subset \Lambda} \Phi_X$$

$$|X| \leq \sigma$$

$$\text{diam } X \leq R$$



$\mathcal{H}_{X_4}$

Locality in Quantum Physics

$$\mathcal{H}_\Lambda = \bigotimes_{i \in \Lambda} \mathcal{H}_i$$

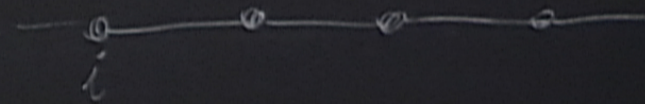
$$\mathcal{H}_X = \bigotimes_{i \in X} \mathcal{H}_i$$

$$\mathcal{H}_{X^c}$$

$$H = \sum_{X \subset \Lambda} \Phi_X$$

$$|X| \leq \sigma$$

$$\text{diam } X \leq R$$





$$\delta \int R \sqrt{g} d^4x = \int d^4x \sqrt{g} G_{ab} \delta g^{ab} + \int d^3x \sqrt{g} (\nabla_n \delta g - n_a \nabla_b \delta g^{ab})$$

Locality in Quantum Physics

$$\mathcal{H}_\Lambda = \bigotimes_{i \in \Lambda} \mathcal{H}_i \quad \mathcal{H}_X = \bigotimes_{i \in X} \mathcal{H}_i$$

$$H = \sum_{X \subset \Lambda} \Phi_X$$

$$|X| \leq \sigma$$

$$\text{diam } X \leq R$$

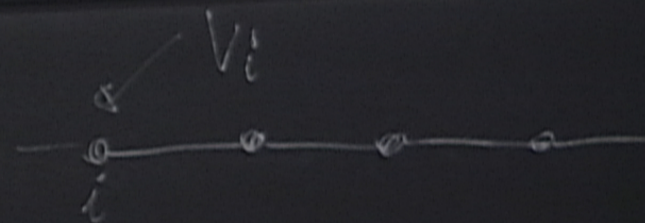
$$\|\Phi_X\| < \hbar$$

$$H_{XY}$$

$$t = t_0$$

$$\rightarrow H_{XY} + V_i$$

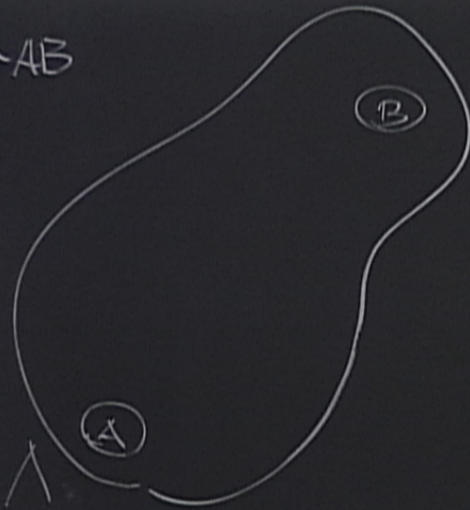
$$t' > t_0$$



$$|\psi_0^{XY}\rangle$$

$$|\psi(t)\rangle = e^{-iH(t-t_0)} |\psi_0^{XY}\rangle$$

d_{AB}



$$[A, B] = 0$$

$$A \rightarrow \dot{A}(t) = e^{iHt} A e^{-iHt}$$

$$f'(t) = [\dot{A}(t), B] = i [[H, A(t)], B]$$

$$[H, U]$$

$$B] \rangle \sim e^{k(\sigma t - d)}$$

$$f'(t) = [\dot{A}(t), B] = i [[H, A(t)], B] = i [U^\dagger [H, A] U, B]$$

$$[H, U] = 0$$

$$t \rightarrow d) \quad H = U^\dagger H U$$

$$f'(t) = [\dot{A}(t), B] = i [[H, A(t)], B] = i [U^\dagger [H, A] U, B]$$

$$[H, U] = 0$$

$$H = U^\dagger H U$$

$$= i \sum_{x_1 \in \mathbb{Z}_1} [U^\dagger [\Phi_{x_1}, A] U, B]$$

$$= i \sum_{x_1} [[\Phi_{x_1}(t), A(t)], B]$$

$t \rightarrow a$

$$\cap A \neq \emptyset$$

$$f' = L_0 f + G(t)$$

$$\gamma_t : f(0) \xrightarrow{\gamma} f(t) = \gamma_t f(0)$$

$$f(t) = \gamma_t \left[f(0) + \int_0^t \gamma_{s_1}^{-1} (G(s_1)) ds_1 \right]$$

$$\|f(t)\| \leq \|f(0)\| + \int_0^t \sum_{X_1} \| [A(u), [\Phi_{X_1}(u), B]] \|$$

$$[H, U] = 0$$

$$H = U^\dagger H U$$

$$K(t-d)$$

e

$$X \cap A \neq \emptyset$$

$$= i \sum_{x_1 \in \mathbb{Z}_1} [U^\dagger [\Phi_{x_1}, A] U, B]$$

$$= i \sum_{x_1} [[\Phi_{x_1}(t), A(t)], B] =$$

$$= i \sum_{x_1} \left\{ [\underbrace{\Phi_{x_1}, [B, A(t)]}_{f(t)}] + [A(t), [\Phi_{x_1}(t), B]] \right\}$$

$$X_1 \neq \emptyset, X_1 \in \mathcal{Z}_1$$

$$\begin{aligned} \|f(t)\| &\leq \|f(0)\| + \int_0^t \sum_{X_1} \| [A(s), [\Phi_{X_1}(s), B]] \| \\ &\leq \|f(0)\| + \int_0^t \sum_{X_1} 2\|A\| \underbrace{\|[\Phi_{X_1}(s), B]\|}_{f_1(s)} ds \end{aligned}$$

$$f_1' = i \sum_{X \in \mathcal{Z}_2} [[\Phi_{X_1}, \Phi_X], B] = -i \sum_{X_2} \left(\begin{aligned} &[\Phi_{X_2}(s), [\Phi_{X_1}(s), B]] \\ &+ [\Phi_{X_1}(s), [B, \Phi_{X_2}(s)]] \end{aligned} \right)$$

$$\|f_1(s_1)\| \leq \|f_1(0)\| + \int_0^{s_1} ds_2 \, 2 \|\Phi_{x_1}(s_2)\| \sum_{x_2} \|[\beta_1 \Phi_{x_2}(s_2)]\|$$

$$\|f_1(s_1)\| \leq \|f_1(0)\| + \int_0^{s_1} ds_2 \, 2 \|\Phi_{X_1}(s_2)\| \sum_{X_2} \|[B_1 \Phi_{X_2}(s_2)]\|$$

$$\|f(t)\| \leq \|f(0)\| + \int_0^t ds_1 \, 2 \|A\| \sum_{X_1} \left(\|f_1(0)\| + \int_0^{s_1} ds_2 \, 2 \|\Phi_{X_1}(s_2)\| \right) \|A\|$$

$$X_1 \cap A \neq \emptyset$$

$$X_i \cap X_{i+1} \neq \emptyset$$

$$X_n \cap B \neq \emptyset$$

$$\|f(t)\| \leq \sum_{\text{paths}(A,B)}$$

$$\Sigma(n) \leq$$

$$d_{AB} > nR$$

$$d_{AB} < nR$$

$$\Sigma(n) = 0$$

$$\Sigma$$

$$\Sigma(n) \leq$$

$$\alpha > 1$$

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$$d_{AB} > nR$$

$$\Sigma(n) = 0$$

$$d_{AB} < nR$$

$$\Sigma(n) \leq \sigma^n e^{\alpha(nR - d_{AB})}$$

$\rightarrow 1$

$$\|f(t)\| = \sum_{n=0}^{\infty} \frac{\alpha^n e^{\alpha(nR-d_{AB})} 2^n n!}{\sigma^n} \frac{1}{t^n}$$

$\alpha(nR-d_{AB})$

$$= e^{\alpha \left(\frac{\sigma e^{\alpha R 2h}}{\alpha} t - d_{AB} \right) n!} = e^{\alpha (v_{LR} t - d_{AB})} = e^{\frac{\alpha}{a} (v_{LR} t - d_{AB})}$$

$$da = l \quad v_{LR} = \frac{d}{t} = \frac{l}{at} = \frac{1}{a} \tilde{v}$$

v_{LT}