

Title: Quantum Matter Lecture (230412)

Speakers: Ganapathy Baskaran

Collection: Quantum Matter (2022/2023)

Date: April 12, 2023 - 10:15 AM

URL: <https://pirsa.org/23040010>

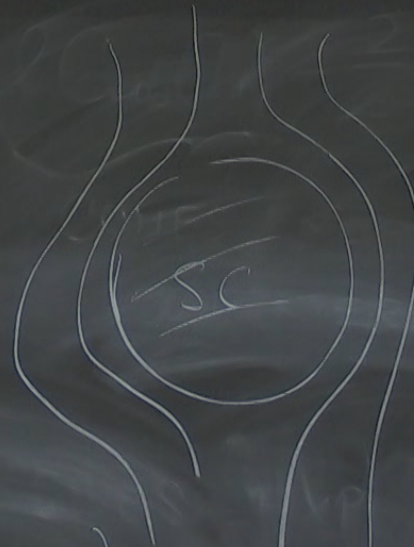
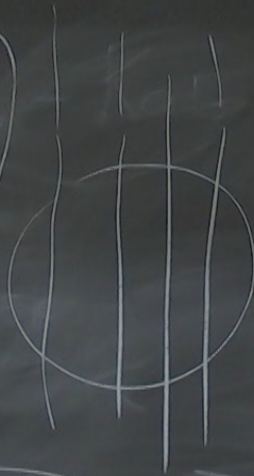
1911

Zero Resistance

Messner

1958 - BCS

Felix & Quaintance



$$T_c \sim k_B e^{-\frac{1}{5\lambda}}$$

$$\vec{j}(\vec{r}) \propto \vec{A}(\vec{r})$$

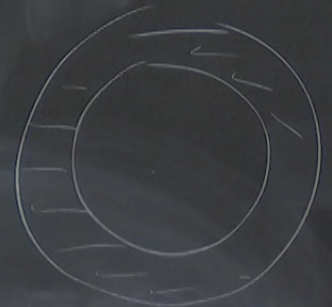
$$\frac{hc}{2e}$$

$$\frac{hc}{e} = \Phi_0$$

$$T_c \sim \frac{1}{\sqrt{M}}$$

Isotope effect

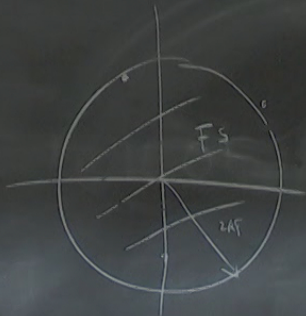
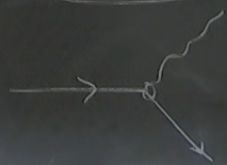
$\lambda_L$  - London Penetration length



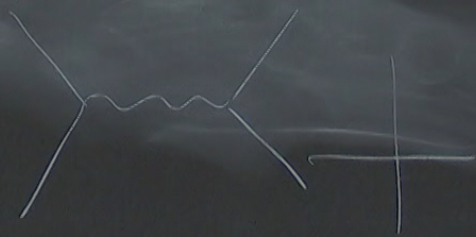
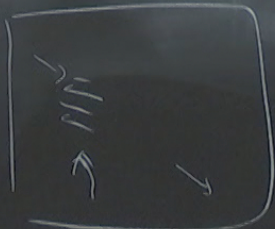
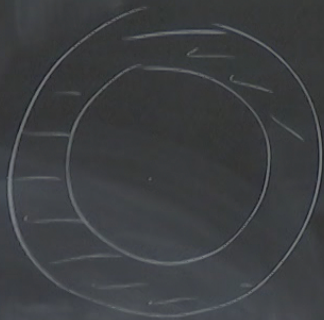
$$T_c \sim \hbar \omega_p e^{-\frac{1}{s, \lambda}}$$

$$\vec{j}(\vec{r}) \propto \vec{A}(\vec{r})$$

Polaron



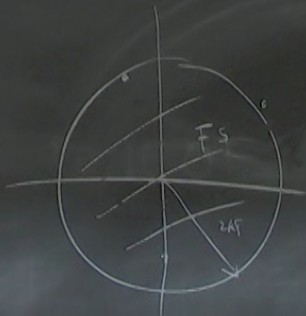
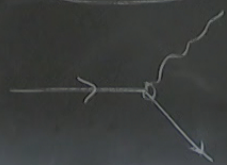
$$H = \sum_k \hbar \omega_k (b_k^\dagger b_k + \frac{1}{2}) + \sum_k C_k C_{k\sigma}^\dagger C_{k\sigma} - \sum_{\vec{D}_1} C_k^\dagger C_{k-\vec{D}_1} (b_{\vec{D}_1}^\dagger + b_{\vec{D}_1})$$



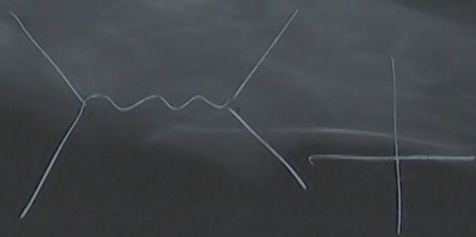
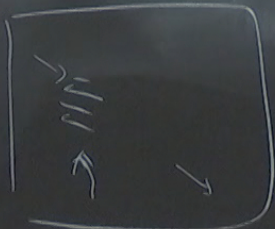
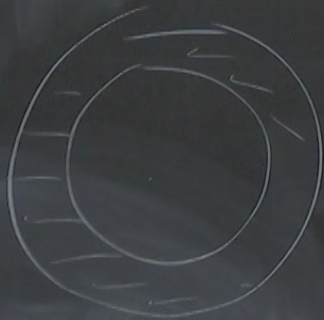
$$T_c \sim \hbar \omega_p e^{-\frac{1}{s\lambda}}$$

$$\vec{j}(\vec{r}) \propto \vec{A}(\vec{r})$$

Polaron



$$H = \sum_k \hbar \omega_k (b_k^\dagger b_k + \frac{1}{2}) + \sum_k C_k C_{k\sigma}^\dagger C_{k\sigma} - \sum_k (D_k) C_k^\dagger C_{k-\sigma} (b_k^\dagger + b_k)$$



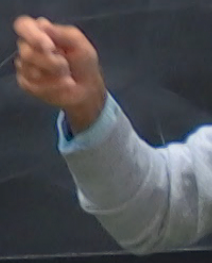
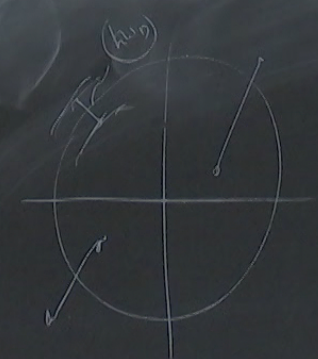
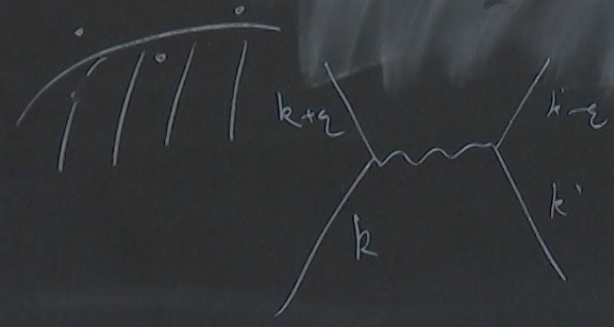
$$\tilde{H} = e^S H e^{-S}$$

ON LEFT SIDE THIS CORRESPONDS TO  
 FIVE POINT DECONTINEMENT DT.

RIGHT SIDE  
 ST. Q

$$H_{int}^{e.e} = D^2 \sum \left( \frac{\omega_q}{(q_k - q_{k'})^2 - k\omega_k} \right) e^{i q_{k+2} C_{k+2} + i q_{k'} C_{k'} - i q_{k-2} C_{k-2} - i q_k C_k}$$

$$- \lambda \sum C_k C_{k-2} C_{k'} C_{k+2}$$



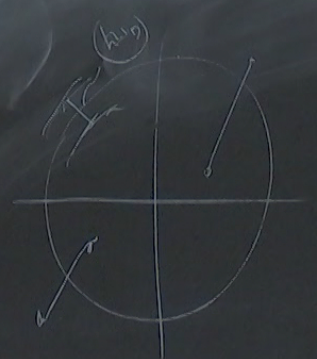
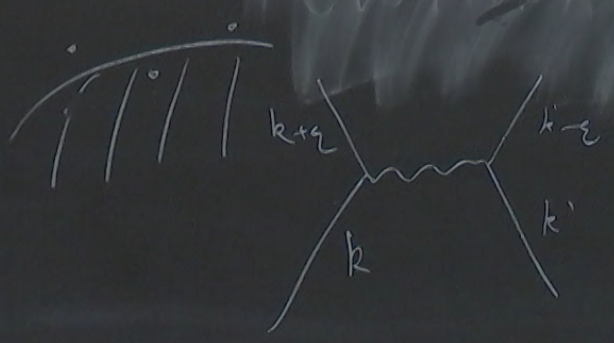
ON THE OTHER SIDE THIS CORRESPONDS TO

BY SPRING

CONFINEMENT / DECONFINEMENT DT

$$H_{int}^{e.o} = D^2 \sum \left( \frac{\omega_q}{(q_k - q_{k'})^2 - \omega_q^2} \right) e^{i q_k x} c_k^\dagger c_{k'}^\dagger S_{k-k'}^\dagger c_k c_{k'}$$

$$-\lambda \sum c_k^\dagger c_{k-\epsilon} c_k c_{k+\epsilon}$$



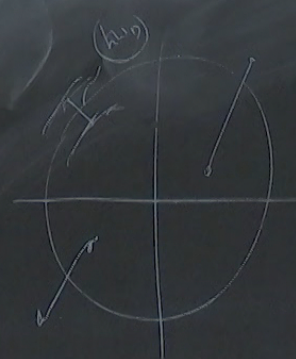
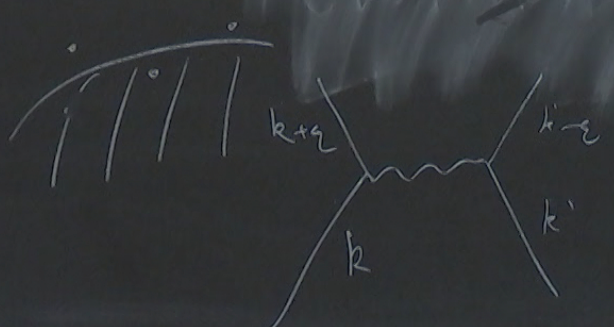
ON THE OTHER SIDE THIS CORRESPONDS TO

WAVELENGTH

THE DIFFERENCE OF COMPONENTS DT

$$H_{int}^{(e)} = D^2 \sum \left( \frac{\omega_q}{(G_k - G_{k+q})^2 - \hbar^2 \omega_q^2} \right) e^{iG_{k+q} \cdot r} c_{k'}^\dagger c_{k-q}^\dagger c_k$$

$$- \lambda \sum c_n^\dagger c_{n+q}^\dagger c_k c_{k+q}$$

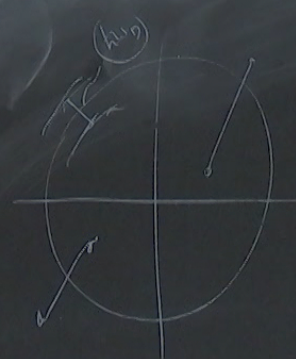
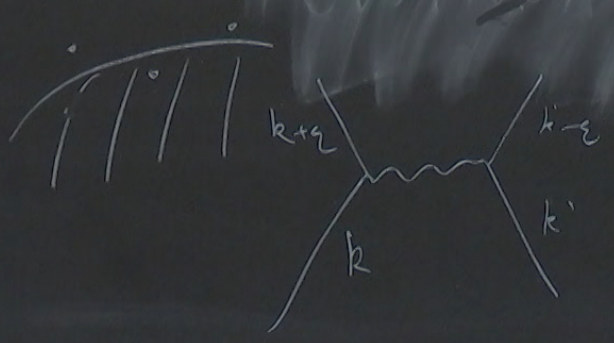


ON THE OTHER SIDE THIS CORRESPONDS TO

OF STRING

CONTRIBUTOR OF COMPLEMENT DT

$$H_{int} = D^2 \sum \left( \frac{\omega_q}{(G_k - G_{k+v})^2 - (k\omega_q)^2} \right) e^{i G_{k+v} C_k' - i G_{k-v} C_k} - \lambda \sum C_k^+ C_{k+v} C_k C_{k+v}$$



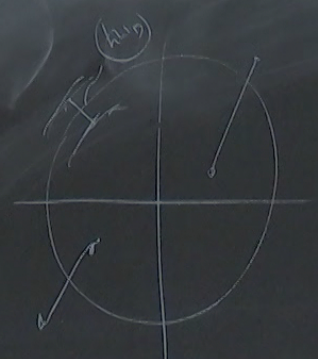
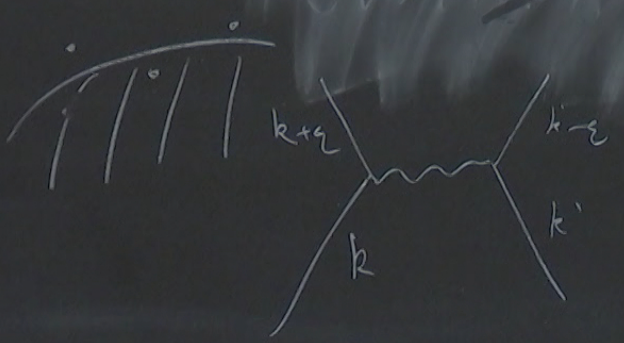


ON THE LEFT SIDE THIS CORRESPONDS TO

OF STRING THEORY

CONTINUED FRACTION DECOMPOSITION DT

$$H_{int} = D^2 \sum \left( \frac{w_q}{(G_k - G_{k+1})^2 - k^2 \omega_q^2} \right) e^{i k_1 x} C_{k_1}^+ C_{k_2}^- C_{k_3}^+ C_{k_4}^- \dots - \lambda \sum C_n^+ C_{n-1}^- C_n^+ C_{n+1}^-$$



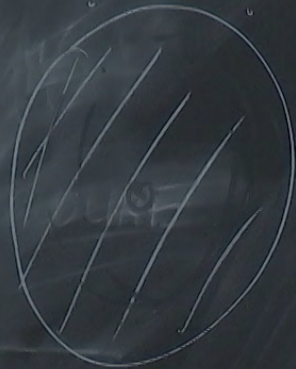
$O_{gg}$

# STRING MOTIVATIONS FOR ADS/CFT

DT,  $\lambda \delta(\tau)$

$$-\lambda \sum_k C_k C_{k-1} C_k C_{k+1}$$

Cooper



Ogg

$$\Delta(\lambda) \sim e^{-\frac{1}{\lambda}}$$

STATISTICAL STRINGS & HETERO

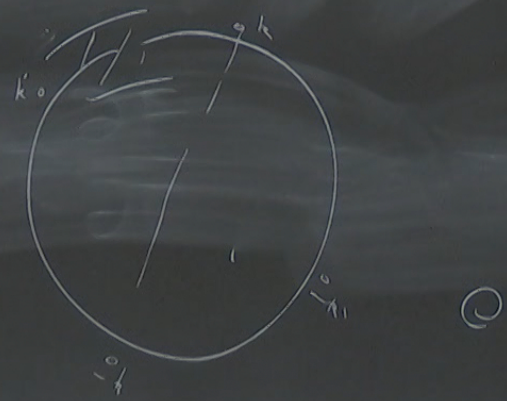
Wise Advice

Smart PDF

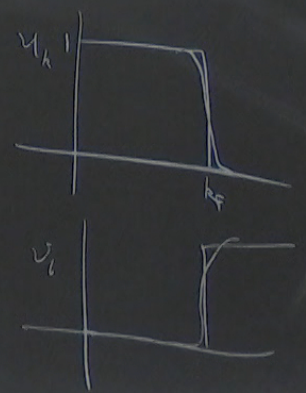
LAST WEEK ... ARE THE MATHEMATICAL OBJECTS

$$H = \sum_{\mathbf{k}} \epsilon_{\mathbf{k}} c_{\mathbf{k}\uparrow}^\dagger c_{\mathbf{k}\uparrow} + \sum_{\mathbf{k}} \epsilon_{\mathbf{k}} c_{\mathbf{k}\downarrow}^\dagger c_{\mathbf{k}\downarrow} - \lambda \sum_{\mathbf{k}, \mathbf{k}' \in \text{shell}} c_{\mathbf{k}\uparrow}^\dagger c_{\mathbf{k}'\downarrow}^\dagger c_{\mathbf{k}'\uparrow} c_{\mathbf{k}\downarrow}$$

$$\langle a_0^\dagger | e^{-\alpha \sum_{\mathbf{k}} \varphi_{\mathbf{k}} c_{\mathbf{k}\uparrow}^\dagger c_{\mathbf{k}\downarrow}} | 0 \rangle = \prod_{\mathbf{k}} (u_{\mathbf{k}})$$



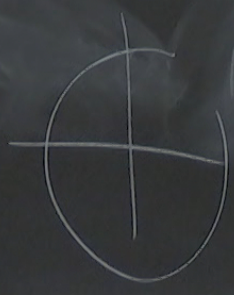
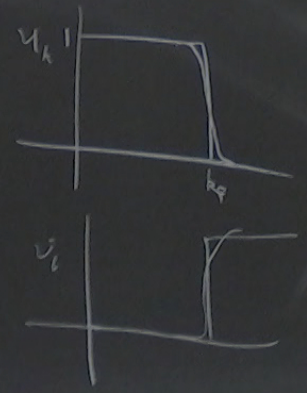
$$a_0^\dagger = \left( \sum_{\mathbf{k}} \varphi_{\mathbf{k}} c_{\mathbf{k}\uparrow}^\dagger c_{\mathbf{k}\downarrow}^\dagger \right) \varphi(r_{ij})$$



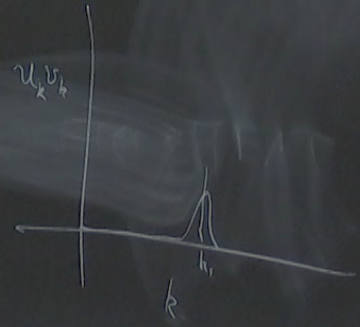
THE OBJECTS

EXERCISE FACTOR

$$|0\rangle = \prod_k (u_k + v_k c_{k\uparrow}^\dagger c_{k\downarrow}^\dagger)$$



$$\prod_{|k| < k_F} (u_k + v_k c_{k\uparrow}^\dagger c_{k\downarrow}^\dagger) |0\rangle$$



$$|\alpha\rangle = \sum_n \frac{|\alpha\rangle^n}{\sqrt{n!}} |n\rangle$$