Theory of Solids, Qi Yang

wsr

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Contents

-2 Math

-2.1 Fourier Transform

Gu Qiao, MMP

$f(x)$	$\mathcal{F}(\omega)$
$\delta(x-x_0)$	$\mathrm{e}^{\mathrm{i}\,\omega x_0}$
$\delta(x)$	1
1	$2\pi\delta(\omega)$
$\frac{\mathrm{d}}{\mathrm{d}x}f(x)$	$\mathrm{i}\,\omega\mathcal{F}$
$\frac{\mathrm{d}^n}{\mathrm{d}x^n}f(x)$	$(\mathrm{i}\,\omega)^n\mathcal{F}$
$xf(x)$	$\mathrm{i}\,\frac{\mathrm{d}}{\mathrm{d}\omega}\mathcal{F}$
$\int_{x_0}^{x} f(x)\mathrm{d}x$	$\frac{\mathcal{F}}{\mathrm{i}\,\omega}$
$f(x+\xi)$	$\mathrm{e}^{\mathrm{i}\,\omega\xi}\,\mathcal{F}$

-1 Solid State Physics

-1.1 Reciprocal Lattice

$$\mathbf{a}_i \cdot \mathbf{b}_j = 2\pi\delta_{ij} \tag{-1.1}$$

$$\mathbf{b}_1 = \frac{2\pi}{\Omega}\mathbf{a}_2 \times \mathbf{a}_3 \tag{-1.2}$$

$$\Omega\Omega^* = (2\pi)^3 \tag{-1.3}$$

$$\mathbf{K}_n \cdot \mathbf{R}_l = 2\pi \sum_{i=1}^{3} n_i l_i \tag{-1.4}$$

0 Intro

Wed 2:00-3:00pm, hd Fri 3:00-4:00, jw S108

1 Second Quantization

有些问题用一次量子化更方便：Fractional Q Hall Effect: Laughlin wavefunction

2 Electron Interaction: Screening and Plasmons

Discussion session Apr11

PRB 77 220503

Discussion session May04

$$H = -t\sum_i (c_i^\dagger c_{i+1} + h.c.) + V\sum_i n_i n_{i+1} \tag{2.1}$$

order parameter: CDW (half-filled, 一个隔一个填充) 破坏平移对称性
$\langle n_i \rangle = n_0 + \delta n(-1)^i$

MF decomposition:

$$V\sum_i n_i n_{i+1} \Rightarrow V\sum_i (\langle n_i \rangle n_{i+1} + n_i \langle n_{i+1} \rangle - \langle n_i \rangle \langle n_{i+1} \rangle) \tag{2.2}$$

不考虑 DFT 已包含的相互作用和对称性不对的相互作用

$$\begin{aligned} R.H.S. &= V\sum_i \big((n_0 + \delta n(-1)^i) n_{i+1} + n_i(n_0 + \delta n(-1)^{i+1}) + E_0\big) \\ &= -2V\delta n \sum_i (-1)^i n_i \end{aligned} \tag{2.3}$$

能隙 $\Delta \equiv 2V\delta n$
do F.T.

$$\begin{aligned} H_{MF} &= -t(...) - \Delta \sum_i (-1)^i c_i^\dagger c_i + E_0 \\ &= \sum_k \xi_k c_k^\dagger c_k - \Delta \frac{1}{N} \sum_{k,k'} \sum_i \mathrm{e}^{\mathrm{i}\,Qx_i}\, c_k^\dagger c_{k'}\, \mathrm{e}^{\mathrm{i}\,kx_i}\, \mathrm{e}^{\mathrm{i}\,k'x_i} \\ &= ... - \Delta \sum_{k,k'} \mathrm{e}^{\mathrm{i}\,Qx_i}\, c_k^\dagger c_{k'} \frac{1}{N} \sum_i \mathrm{e}^{\mathrm{i}(k-k'+Q)} \\ &= \sum_k \xi_k c_k^\dagger c_k - \Delta \sum_k c_{k+Q}^\dagger c_k \end{aligned} \tag{2.4}$$

$$H = \sum_{k=0}^{\pi} \begin{pmatrix} c_k^\dagger & c_{k+Q} \end{pmatrix} \begin{pmatrix} \xi_k & -\Delta \\ -\Delta & \xi_{k+Q} \end{pmatrix} \begin{pmatrix} c_k^\dagger \\ c_{k+Q} \end{pmatrix} \tag{2.5}$$