Mo Tu We Th Fr Sa Su

Memo No.
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4.4 Two Particles

Two particle 2nd quantized operator:

$$\hat{A} = \sum_{\alpha\beta\gamma\delta} A_{\alpha\beta\gamma\delta}\, a_\alpha^\dagger a_\beta^\dagger a_\gamma a_\delta$$

$$A_{\alpha\beta\gamma\delta} = \langle \alpha, \beta | \hat{A} | \gamma, \delta \rangle .$$

$$\hat{V} = \frac{1}{2}\int d^3x\, d^3y\, \psi^\dagger(x)\psi^\dagger(y) V(x,y)\psi(y)\psi(x) .$$

we put creation on left so that

$\langle 0|\hat{V}|0\rangle = 0$. If it were the other way, then $\langle 0|\hat{V}|0\rangle \neq 0$ and could be infinite.

It also prevents self energies. See Ex 4.9!

Now we expand in momentum modes:

$$\hat{V} = \frac{1}{2}\int d^3x\, d^3y\, \psi^\dagger(x)\psi^\dagger(y)V(x,y)\psi(x)\psi(y)$$

$$= \frac{1}{2V^2}\int d^3x\, d^3y \sum_{p_1p_2p_3p_4} e^{i(-p_1\cdot x - p_2\cdot y + p_3\cdot y + p_4\cdot x)}\, a^\dagger_{p_1} a^\dagger_{p_2} V(x-y)\, a_{p_3} a_{p_4}$$

Ex 4.10

$z = x - y$

$$= \frac{1}{2V^2}\sum_{p_1p_2p_3p_4} a^\dagger_{p_1} a^\dagger_{p_2} a_{p_3} a_{p_4} \int d^3z\, V(z)\, e^{i(p_4-p_1)\cdot z} \int d^3y\, e^{i(-p_1-p_2+p_3+p_4)\cdot y}.$$

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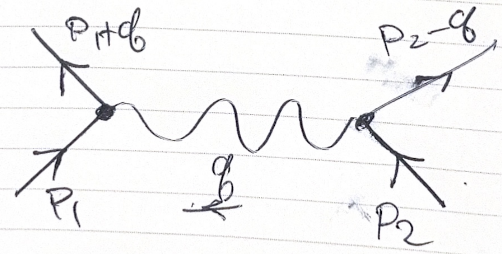
$$\cancel{\hat{V} = \frac{1}{2}\sum_{p_1p_2q}\tilde{V}_q a^\dagger_{p_1} a^\dagger_{p_2} a}$$

$$\hat{V} = \frac{1}{2}\sum_{p_1p_2q}\tilde{V}_q\, a^\dagger_{p_1+q}\, a^\dagger_{p_2-q}\, a_{p_2}\, a_{p_1}$$



4.5 The Hu

$\hat{H} = \sum_{ij}$

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$\Rightarrow \hat{H} = \sum_{ij\sigma}$

Hubbard's Model
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is a con

Then $\hat{H} = \sum_{ij}$

This looks