Kinetic energy

$$\hat{T} = \sum_{i=1}^{N} \frac{\hat{\vec{p}}_i^{\,2}}{2m} = \sum_{i=1}^{N} \left(-\frac{\hbar^2}{2m} \vec{\nabla}_i^{\,2}\right)$$

one particle base $\{|\alpha\rangle = |j\rangle\}$

↑ localized Wannier state

$$\hat{\psi}(\vec{r}) = \sum_j \phi_j(\vec{r})\, \hat{a}_j$$

$$\hat{T} = \int d^3r \; \hat{\psi}^{+}(\vec{r}) \left(-\frac{\hbar^2}{2m} \vec{\nabla}^2\right) \psi(\vec{r}) =$$

$$= \sum_{jj'} \int d^3r \; \phi_j^{*}(\vec{r}) \left(-\frac{\hbar^2}{2m} \vec{\nabla}^2\right) \phi_{j'}(\vec{r})\; a_j^{+} a_{j'} =$$

$$= \sum_{jj'} t_{jj'}\, a_j^{+} a_{j'}$$

↑ hopping

Warning!

$$t_{ij} = \int d^3r \; \phi_i^{*}(\vec{r}) \left[-\frac{\hbar^2}{2m} \vec{\nabla}^2 + U(\vec{r})\right] \phi_j(\vec{r})$$

periodic
$U(\vec{r} + \vec{e}_\alpha) = U(\vec{r})$