$$\begin{split} \left[\hat{\mathbf{c}}_{l,\sigma}, \hat{\mathbf{c}}_{l',\sigma'} \right] &= \left[\hat{\mathbf{c}}_{l,\sigma}^{\dagger}, \hat{\mathbf{c}}_{l',\sigma'}^{\dagger} \right] = 0 \\ \left[\hat{\mathbf{c}}_{l,\sigma}, \hat{\mathbf{c}}_{l',\sigma'}^{\dagger} \right] &= \delta(l,l') \cdot \delta(\sigma,\sigma') \end{split}$$

$$\hat{\mathbf{c}}_{l,\uparrow}^{(\dagger)} \leftrightarrow \hat{\mathbf{c}}_{l}^{(\dagger)} \qquad \qquad \hat{\mathbf{c}}_{l,\downarrow}^{(\dagger)} \leftrightarrow \hat{\mathbf{d}}_{l}^{(\dagger)}$$

$$\begin{split} \mathcal{H}_0 &= U \cdot \sum_l \hat{\mathbf{c}}_l^\dagger \hat{\mathbf{c}}_l \hat{\mathbf{d}}_l^\dagger \hat{\mathbf{d}}_l + \sum_l \varepsilon_l \hat{\mathbf{c}}_l^\dagger \hat{\mathbf{c}}_l \sum_l \varepsilon_l \hat{\mathbf{d}}_l^\dagger \hat{\mathbf{d}}_l \\ \hat{\mathbf{V}} &= -J \cdot \sum_{\langle l,m \rangle} \left(\hat{\mathbf{c}}_l^\dagger \hat{\mathbf{c}}_m + \hat{\mathbf{c}}_m^\dagger \hat{\mathbf{c}}_l + \hat{\mathbf{d}}_l^\dagger \hat{\mathbf{d}}_m + \hat{\mathbf{d}}_m^\dagger \hat{\mathbf{d}}_l \right) \end{split}$$