Contents

1 Equations

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$$\hat{H} = \hat{K} + g\hat{V} \tag{1}$$

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$$\hat{H} = \sum_{x} \sum_{p,p'} h^{p}_{p'}(x) \hat{e}^{p}_{p'}(x) + g \sum_{x \neq y} \sum_{p,p',q,q'} V^{pq}_{p'q'}(x,y) \hat{e}^{p}_{p'}(x) \hat{e}^{q}_{q'}(y) \tag{2}$$

$$\equiv \sum_{x} \sum_{p,p'} \hat{h}^{p}_{p'}(x) + g \sum_{x \neq y} \sum_{p,p',q,q'} \hat{V}^{pq}_{p'q'}(x,y) \tag{3}$$

$$\tag{4}$$

$$\hat{e}^{p}_{p'}(x) = |p\rangle \langle p'| (x) \tag{5}$$

$$\hat{e}(x) = (cos(\varphi), sin(\varphi)) \tag{6}$$

$$\hat{H} = \sum_{i=1}^{N} \hat{h}_i + g \sum_{i=1}^{N-1} [\hat{e}_i \hat{e}_{i+1} + g(1 - 3\cos\gamma)(\hat{e}_i \hat{r})(\hat{e}_{i+1} \hat{r})] \tag{7}$$

$$\langle p, q | \hat{V} | p', q' \rangle \tag{8}$$

$$|p - q| = |p' - q'| = 1 \tag{9}$$

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$$\dim(\hat{H}) = N \times N \tag{10}$$

$$N = \text{state}^{\text{site}} \tag{11}$$

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$$M_{dense}(state^{site}) = \frac{8\left(\text{state}^{\text{site}}\right)^2}{1024^3} \tag{12}$$

$$M_{sparse}(state^{site}) = \frac{24(2state-2)^2 state^{site-2}}{1024^3} \tag{13}$$

$$M_{dense}(state^{site}) \approx state^{2\times site} \tag{14}$$

$$M_{sparse}(state^{site}) \approx state^{site-2} \tag{15}$$

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$$\phi : M \longrightarrow P, \qquad \phi(m) = \begin{cases} 2|\text{m } +1| \ +1, & m < 0 \\ 2\text{m}, & m \geq 0 \end{cases} \tag{16}$$

$$M = \{-n, \ldots, n\}, \quad P = \{0, \ldots, 2n\} \text{ (so } N = 2n) \tag{17}$$

$$\langle \lambda, p', \mu | h | \lambda, p, \mu \rangle = \hat{h}^p_{p'} \tag{18}$$

$$\langle \lambda, p', \nu, q', \mu | V | \lambda, p, \nu, q, \mu \rangle = \hat{V}^{pq}_{p'q'} \tag{19}$$

$$\tag{20}$$

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$$\hat{H} = \sum_x \sum_{p,p'} h^p_{p'}(x) \hat{e}^p_{p'}(x) + g \sum_{x \neq y} \sum_{p,p',q,q'} V^{pq}_{p'q'}(x,y) \hat{e}^p_{p'}(x) \hat{e}^q_{q'}(y) \tag{21}$$

$$\equiv \sum_x \sum_{p,p'} \hat{h}^p_{p'}(x) + g \sum_{x \neq y} \sum_{p,p',q,q'} \hat{V}^{pq}_{p'q'}(x,y) \tag{22}$$

$$\tag{23}$$

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$$\hat{D}_1 = D^p_{p'} = \sum_{\lambda,\mu} C^*_{(\lambda,p,\mu)} C_{(\lambda,p',\mu)} \tag{24}$$

$$\hat{D}_1 \boldsymbol{\psi}_i = N_i \boldsymbol{\psi}_i, \qquad 0 \leq N_i \leq 1 \tag{25}$$

$$f : \mathbb{R} \longrightarrow \mathbb{R}, \qquad f(x) = x^2 \tag{26}$$

$$U_{NO} = \left[\boldsymbol{\psi}_1 \ \boldsymbol{\psi}_2 \ \cdots \ \boldsymbol{\psi}_n \right] \tag{27}$$

$$\hat{\boldsymbol{h}} = U^\dagger_{NO} \cdot \hat{V} \cdot U_{NO} \tag{28}$$

$$\hat{\boldsymbol{V}} = (U_{NO} \otimes U_{NO})^\dagger \cdot \hat{V} \cdot (U_{NO} \otimes U_{NO}) \tag{29}$$

$$\hat{\boldsymbol{H}} = \sum_x \sum_{p,p'} \hat{\boldsymbol{h}}^p_{p'}(x) + g \sum_{x<y} \sum_{p,p',q,q'} \hat{\boldsymbol{V}}^{pq}_{p'q'}(x,y) \tag{30}$$

$$\tag{31}$$

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$$\hat{D}_1 = D^p_{p'} = \sum_{\lambda,\mu} C^*_{(\lambda,p,\mu)} C_{(\lambda,p',\mu)} \tag{32}$$

$$\lambda_1, \lambda_2 \approx 0.495081, 0.495081 \tag{33}$$

$$\mathbf{v}_1 = \begin{pmatrix} -9.770 \times 10^{-1} \\ 0 \\ 0 \\ 1.507 \times 10^{-1} \\ 1.507 \times 10^{-1} \\ 0 \\ 0 \\ -1.727 \times 10^{-3} \\ -1.727 \times 10^{-3} \\ 0 \\ 0 \end{pmatrix}, \quad \mathbf{v}_2 = \begin{pmatrix} 0 \\ -8.765 \times 10^{-4} \\ 8.765 \times 10^{-4} \\ 0 \\ 0 \\ 3.192 \times 10^{-5} \\ -3.192 \times 10^{-5} \\ 0 \\ 0 \\ -1.509 \times 10^{-7} \\ 1.509 \times 10^{-7} \end{pmatrix}. \tag{34}$$

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$$(-1)\frac{d}{d\tau} |\Psi(\tau)\rangle = \hat{H} |\Psi(\tau)\rangle \tag{35}$$

$$|\Psi(\tau)\rangle = e^{\hat{T}(\tau)} |0\rangle \tag{36}$$

$$(-1)\frac{dt_\lambda}{d\tau} = R_\lambda \tag{37}$$

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$$\hat{h}^p_{p'}(0) = \hat{h}^p_{p'}(x) \qquad 0 \le x \le N_{sites} \tag{38}$$

$$\hat{V}^{pq}_{p'q'}(0,1) = \hat{V}^{pq}_{p'q'}(x, x+1) \qquad 0 \le x \le N_{sites} - 1 \tag{39}$$

$$\hat{V}^{pq}_{p'q'}(x,y) = \hat{V}^{pq}_{p'q'}(y,x) \qquad 0 \le x, y \le N_{sites}, |x-y| = 1 \tag{40}$$

$$\tag{41}$$

$$Rt^{ab}_{ij}(x<y) = Rs^{ab}_{ij}(x<y) + Rn^{ab}_{ij}(x,y) + Rn^{ab}_{ij}(y,x) \tag{42}$$

$$= Rs^{ab}_{ij}(x<y) + 2 \times Rn^{ab}_{ij}(x,y) \tag{43}$$

$$\tag{44}$$

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$$D(\text{state}, \text{site}) = \frac{E_{\text{state}}}{E_{\text{site}}} = \frac{\text{site}}{\ln(\text{state})}. \tag{45}$$

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$$A^a_p(x)\, A^b_q(y)\, V^{pq}_{cd}(x,y)\, t^{cd}_{ij}(x,y) \;\longrightarrow\; A^a_p(x)\, A^b_q(y)\, V^{pq}_{cd}(x,y)\, t^{cd}_{\cdot\cdot}(x,y) \;\longrightarrow\; AA^{B=ab}_{Q=pq}(x,y)\, V^Q_C(x,y)\, t^C_{\cdot}(x,y)$$