Mapping Multiple States

$$\left\langle \mathbf{n}' \middle| \hat{a}_i^\dagger \hat{a}_j \middle| \mathbf{n} \right\rangle = \delta_{n_i, n_i'+1} \; \delta_{n_j, n_j'-1} \prod_{p=i+1}^{j-1} (-1)^{n_p} \prod_{q \neq i,j} \delta_{n_q, n_q'}$$

raising lowering book-keeping

This is the direct product of 2x2 matrices for each dof!

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For example, for degree of freedom *i*, the matrix is:

$$\begin{array}{c} \\ \langle n_i = 1| \\ \langle n_i = 0| \end{array} \begin{array}{c} |n_i = 1\rangle \quad |n_i = 0\rangle \\ \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix} \end{array}$$