
Classical Simulation of Quantum Systems

Lectures 5 & 6



Frank Verstraete, University of Vienna

University of British Columbia, July 28, 2010



$$\sum_{\beta} X_{\alpha\beta} Y_{\beta\gamma} \equiv Z_{\alpha\gamma}$$

$$\sum_{i,j} |i\rangle\langle j| \dots$$



$$\sum_{\beta\gamma} A_{\alpha\beta}^i A_{\beta\gamma}^j A_{\gamma\delta}^k \rightarrow \sum_{i,j,k} \text{Tr}(A^i A^j A^k) \begin{pmatrix} + \\ - \end{pmatrix}^i \begin{pmatrix} + \\ - \end{pmatrix}^j \begin{pmatrix} + \\ - \end{pmatrix}^k - |\Omega\rangle$$

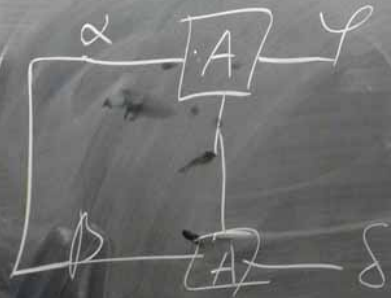
A^0, A^1

A diagram showing a horizontal line with five circles representing energy levels. Below it, a rectangular box is divided into four vertical sections labeled D_1, D_2, D_3, D_4 . The first section is labeled ψ_0 and the last section is labeled ψ_4 . An arrow points from the box to a square labeled D .

$$e_{z+1} = \sum A_i e_i(A_i)^\dagger$$

$$\langle \psi | \psi \rangle = \sum_{n=0}^{n_1} \frac{1}{2} (A^{n+1} A^{n+2} - A^{n+2} A^{n+1}) \frac{1}{2} (A^{n+1} - A^{n+2}) | X^{n+1} \rangle$$

$$\langle \psi | X^{n+1} | \psi \rangle$$



recep

ΣA
 $\beta \gamma$ $\epsilon \beta$ \bar{A}
 $\beta \delta$

certif

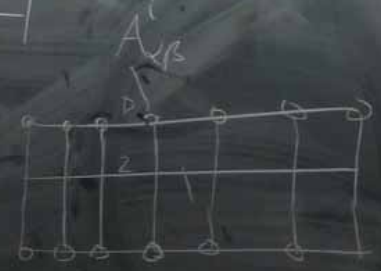


DMRG

Hamiltonian, transfer matrix \rightarrow MPO



$$\min_{|\psi\rangle} \frac{\langle \psi | \hat{O} | \psi \rangle}{\langle \psi | \psi \rangle}$$



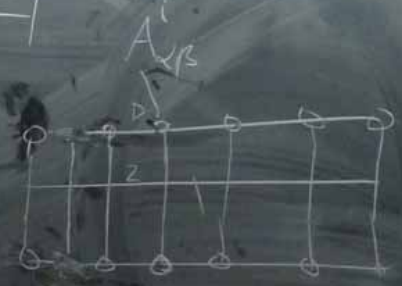


DMRG

Hamiltonian, Transfer matrix \rightarrow MPO



$\langle \psi | \hat{O} | \psi \rangle$
 $\langle \psi | \psi \rangle$



$$|\psi(t)\rangle = e^{iHt} |\psi(0)\rangle$$

$$\rightarrow H = H_1 + H_2$$

$$\exp(iHt) = \exp(iH_1 t) \exp(iH_2 t)$$

$$H_2 = \dots$$

$$\exp(i(A+B)) \approx \exp(iA) \exp(iB) \exp(iA) + \dots$$



$$\min_{|\chi\rangle} \|\hat{0}|\psi\rangle - |\chi\rangle\| \rightarrow \delta$$

$$\langle \chi | \chi \rangle - 2 \langle \chi | \hat{0} | \psi \rangle + \langle \hat{0} | \psi \rangle \langle \hat{0} | \psi \rangle$$

$$\langle \chi | A \rangle = \langle B | \chi \rangle$$





$$H = \sum_{i=1}^N \sum_{j=1}^N \bar{S}_i S_j$$



