Simulations with MPS

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September 4, 2024

Model

- **Hamiltonian:** Transverse Ising Model

$$H = J \sum_{i}^{N-1} \sigma_i \sigma_{i+1} + h \sum_{i}^{N} \sigma_i \tag{1}$$

- **Parameters** Physics parameters:

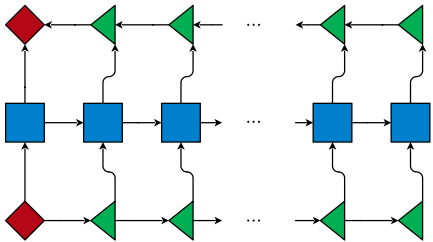
$$J = 1.0, \quad h = 0.5, \quad N = 12 \tag{2}$$

Numerical parameters:

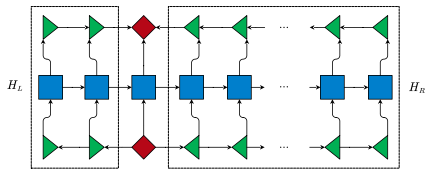
$$d = 2, \quad D_{MPO} = 3, \quad D_{MPS} = 128 \tag{3}$$

DMRG

- Initialize MPS with diagonalization center at $i = 1$.

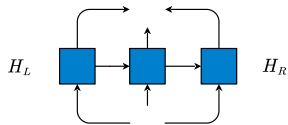


- Sweep at two direction (right - left - right - ...)
  - Calculate the left/right environment H_L/H_R.

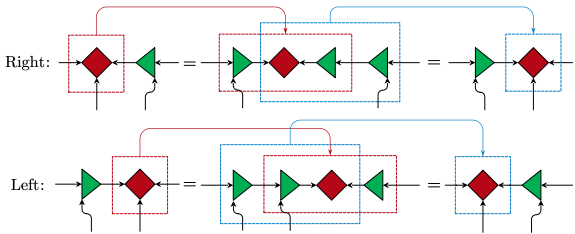


DMRG

- Sweep at two direction (right - left - right - ...)
  - Calculate the effective Hamiltonian $H_{eff} = H_L H_i H_R$

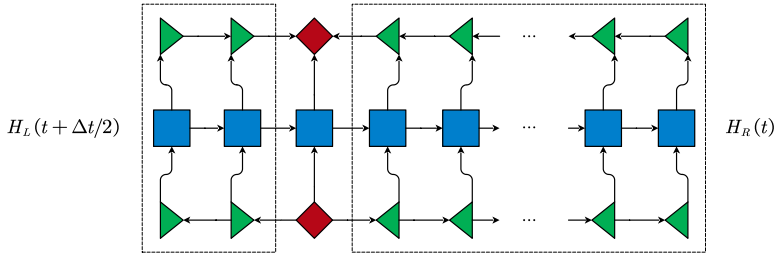


  - OrientSVD and move the center to next site.



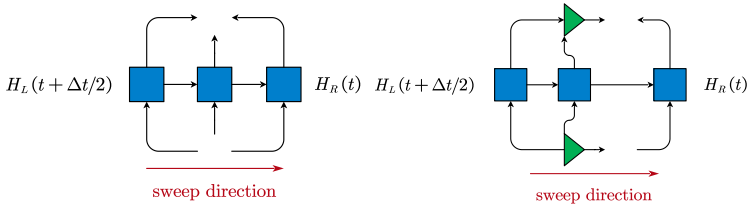
TDVP: 1-site integration

- Initialize MPS with diagonalization center at $i = 1$.
- Sweep at two direction (right - left - right - ...)
  - Calculate the left/right environment $H_L(t + \Delta t/2)/H_R(t)$.



TDVP: 1-site integration

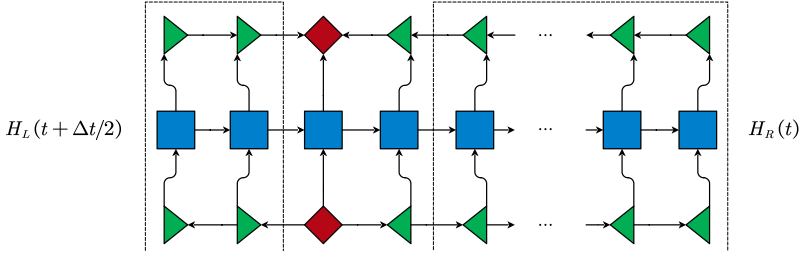
- Sweep at two direction (right - left - right - ...)
  - Calculate the effective Hamiltonian $H_{eff}^{(1)}$
  - Time evolution $A_i(t+\Delta t/2) = \exp\left(-iH_{eff}^{(1)}\Delta t/2\right)A_i(t)$
  - OrientSVD and calculate the center with inverse evolution $C_i(t) = \exp\left(iH_{eff}^{(0)}\Delta t/2\right)C_i(t+\Delta t/2)$, then absorb it into nextsite.



TDVP: 2-site integration

Sweep schemes

- Calculate the left/right environment $H_L(t + \Delta t/2)/H_R(t)$.



TDVP: 2-site integration

Sweep schemes

- Calculate the effective Hamiltonian $H^{(2)}_{eff}$
- Time evolution $A_i A_{i+1}(t + \Delta t/2) = \exp\left(-iH^{(2)}_{eff}\Delta t/2\right) A_i A_{i+1}(t)$
- OrientSVD and calculate the center with inverse evolution $A_{i+1}(t) = \exp\left(iH^{(1)}_{eff}\Delta t/2\right) A_{i+1}(t + \Delta t/2)$, then regard it as nextsite.