

Simulations with MPS/MPO

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Model

► **Hamiltonian:** Transverse Ising Model

$$H = J \sum_i^{N-1} \sigma_i \sigma_{i+1} + h \sum_i^N \sigma_i \quad (1)$$

► **Parameters** Physics parameters:

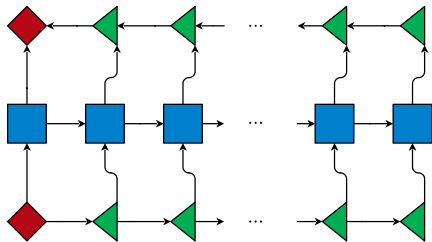
$$J = 1.0, \quad h = 0.5, \quad N = 12 \quad (2)$$

Numerical parameters:

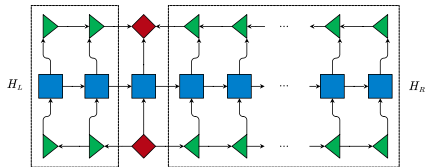
$$d = 2, \quad D_{MPO} = 3, \quad D_{MPS} = 128 \quad (3)$$

DMRG

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

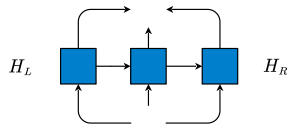


- Sweep at two direction (right - left - right - ...)
- Calculate the left/right environment H_L/H_R .

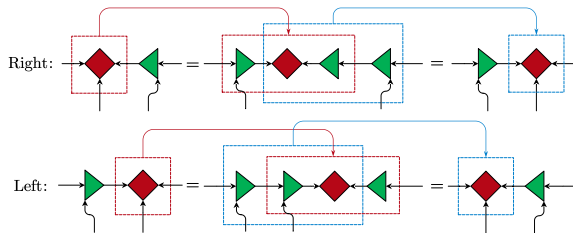


DMRG

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

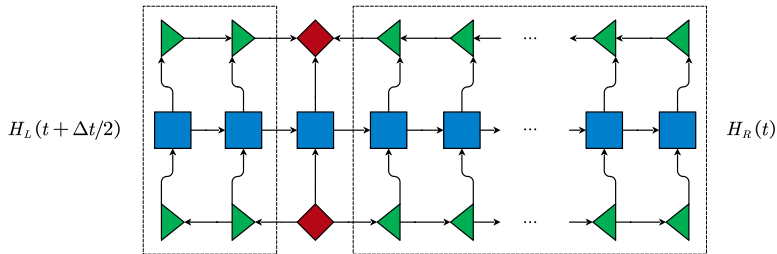


- ▶ OrientSVD and move the center to next site.



TDVP

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



TDVP

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

