ENTANGLEMENT PROPERTIES OF LATTICE BOSONS FROM A VARIATIONAL WAVE FUNCTION

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INTRODUCTION

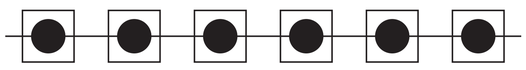
State of a N-spin $\frac{1}{2}$ system: $|\psi\rangle = \sum_{\vec{\sigma}} C(\vec{\sigma})\,|\vec{\sigma}\rangle$

$$\rightarrow 2^N \text{ variables}$$

Through gradient algorithm, find $|\psi\rangle$ which minimizes $\langle\psi|H|\psi\rangle$, with the assumption

$$|\psi\rangle = \sum_{\vec{\sigma}} \left(\prod_P C_P(\vec{\sigma}_P) \right) |\vec{\sigma}\rangle$$

EPS ALGORITHM

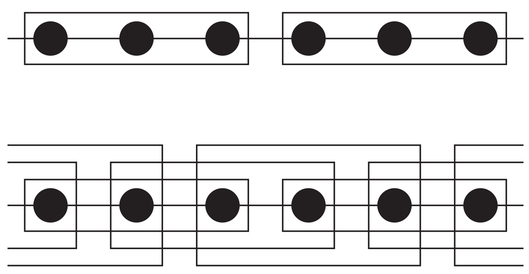


Mean field

$$\rightarrow 2N \text{ variables}$$

But:

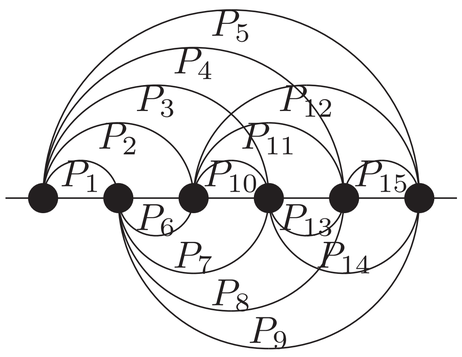
$$\langle S_i^z S_j^z \rangle - \langle S_i^z \rangle \langle S_j^z \rangle = \begin{cases} \frac{1}{4} - \langle S_i^z \rangle^2 & \text{if } i = j \\ 0 & \text{if not} \end{cases}$$



EPS with plaquettes of size 3

$$\rightarrow 2^3 N \text{ variables}$$

EPS DELOCALIZED



EPS with delocalized plaquettes of size 2

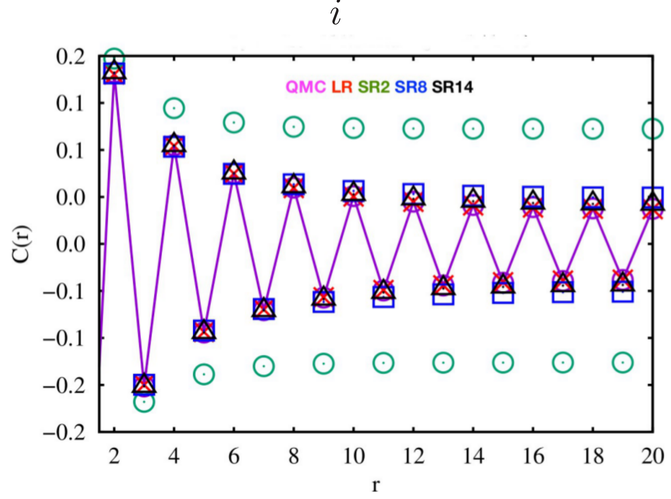
$$\rightarrow N^2 \text{ variables}$$

Reduced with considerations on symetries.

$$\propto N \text{ variables}$$

HEISENBERG CHAIN

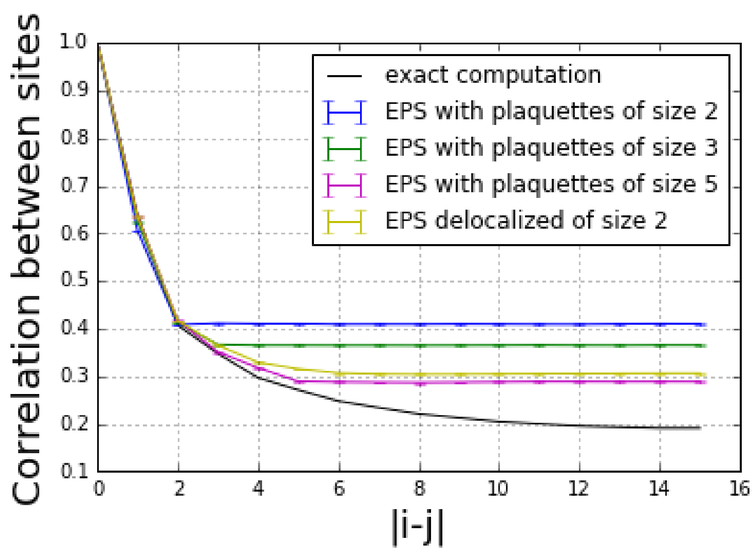
$$H = J_1 \sum_i \vec{S}_i \cdot \vec{S}_{i+1}$$



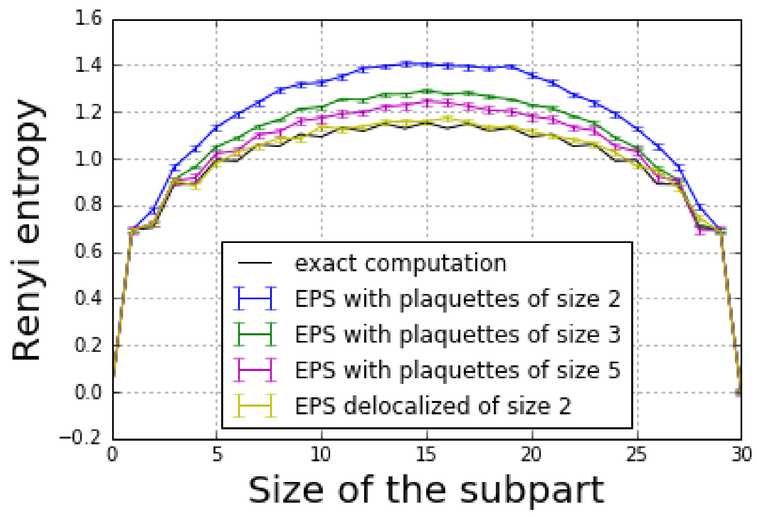
Correlation function between sites i and j of a system of size 40

XX-CHAIN

$$H = J \sum_i (S_{i+1}^x S_i^x + S_{i+1}^y S_i^y)$$



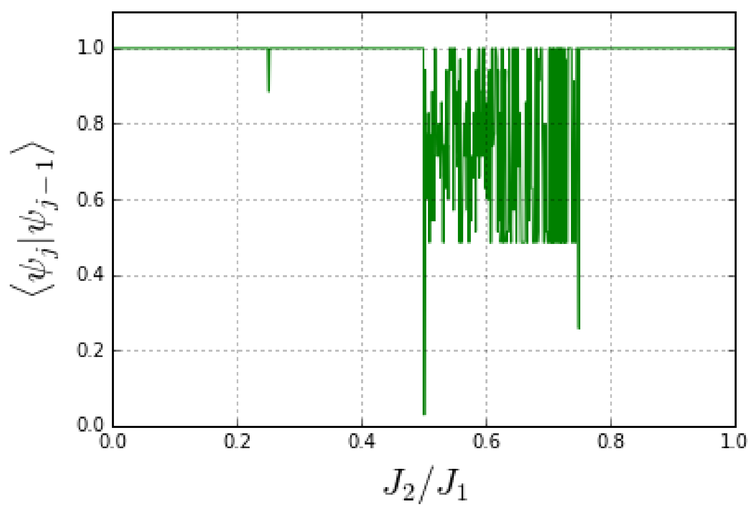
Correlation function along x axis between sites i and j of a system of size 30



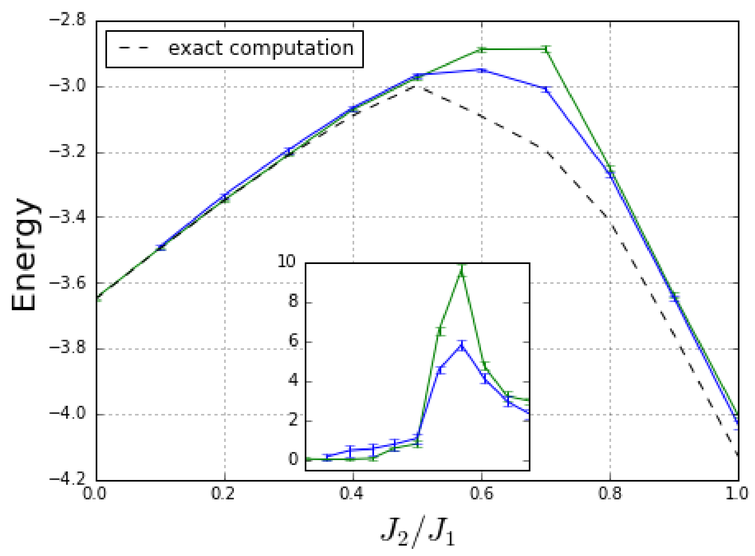
Entanglement entropy as a function of the size of the subsystem of a system of size 30

$J_1 J_2$ CHAIN

$$H = J_1 \sum_i \vec{S}_i \cdot \vec{S}_{i+1} + J_2 \sum_i \vec{S}_i \cdot \vec{S}_{i+2}$$



Sign structure



Energy as a function of the parameter J_2/J_1

CONCLUSION

- EPS algorithm with short range plaquettes reproduces well short range correlations but fails to reproduce long range
- EPS algorithm with delocalized plaquettes better reproduces the overall shape of the curve, but costs more calculation time.

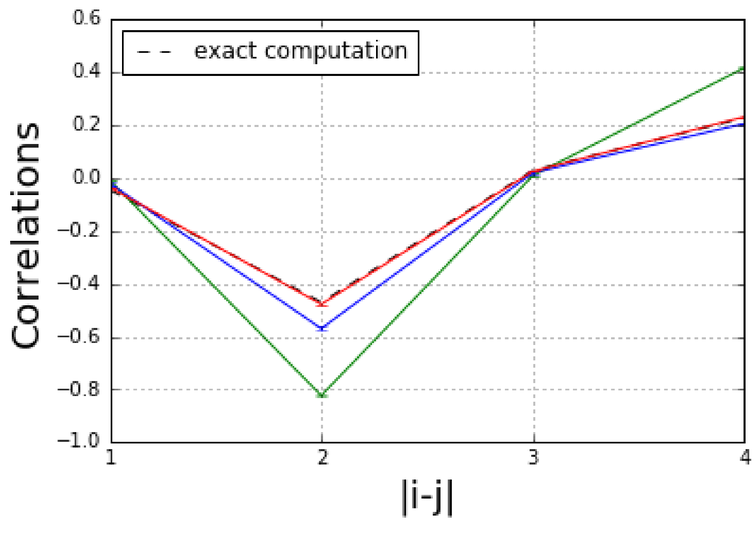
  Using symetries seems to be a good compromise, but how to choose the symetries we consider in the Ansatz ?
- The sign structure influences the convergence of the algorithm.
- Is it possible to find the sign structure of a system with this algorithm ?

REFERENCES

→ F. Mezzacapo, N. Schuch, M. Boninsegni and J.I. Cirac, "Ground-state properties of quantum many-body systems: entangled-plaquette states and variational Monte Carlo", *New journal of Physics*, **11**(2009).

→ M.E.J. Newman, G.T. Barkema, *Monte Carlo Methods in Statistical Physics*, Oxford University Press (1999).

CORRELATIONS WITH $J_2 = J_1$



Correlation function between sites i and j of a system of size 8