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Tensor Networks and their use for Lattice Gauge Theories

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The term Tensor Network States (TNS) has become a common one in the context of numerical studies of quantum many-body problems. It refers to a number of families that represent different ansatzes for the efficient description of the state of a quantum many-body system. The first of these families, Matrix Product States (MPS), lies at the basis of Density Matrix Renormalization Group methods, which have become the most precise tool for the study of one dimensional quantum many-body systems. Their natural generalization to two or higher dimensions, the Projected Entanglement Pair States (PEPS) are good candidates to describe the physics of higher dimensional lattices. Another TNS ansatz, the MERA, has recently been connected to a discrete realization of the AdS/CFT correspondence.

TNS can be used to study equilibrium properties, as ground and and thermal states, but also dynamics. Quantum information gives us some tools to understand why these families are expected to be good ansatzes for the physically relevant states, and some of the limitations connected to the simulation algorithms.

Lattice Gauge Theories, in their Hamiltonian version, offer a challenging scenario for these techniques. While the dimensions and sizes of the systems amenable to TNS studies are still far from those achievable by Monte Carlo simulations, Tensor Networks can be readily used for problems which more standard techniques cannot easily tackle, such as the presence of a chemical potential, or out-of-equilibrium dynamics.

The last years have seen an increasing interest in this particular application of Tensor Network methods. In this talk I will present some of the recent work in this area. In particular, using the Schwinger model as a testbench, we have shown that Matrix Product States (MPS) are suitable to approximate low energy states precisely enough to allow for accurate finite size and continuum limit extrapolations of ground state properties, mass gaps and temperature dependent quantities. The feasibility of the method has already been tested also for non-Abelian models, out-of-equilibrium scenarios, and non-vanishing chemical potential.

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