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Tensor Network and Cold Atoms Methods for Lattice Gauge Theories

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Quantum simulation and tensor networks are two many-body physics approaches rooted in quantum information science, which have been widely used recently, especially in condensed matter contexts, proving to be very useful. The first suggests to use controllable quantum systems as simulators of others, which might be otherwise inaccessible or hard to solve; the latter allows one to efficiently construct and study (analytically and numerically) physically relevant many body states with arbitrary symmetries. More recently, these methods have been generalized and applied to high energy physics problems as well, and in particular to gauge theories. In my talk I will discuss the application of those methods for the study of lattice gauge theories, focusing on the work carried out at the theory group at MPQ: first, quantum simulation of lattice gauge theories with ultracold atoms in optical lattices – suggesting to observe non-perturbative elementary particle physics in atomic simulators; and finally, gauged fermionic PEPS – a particular tensor network construction of gauge invariant states, involving dynamical gauge fields and fermionic matter, allowing one to use the efficient tensor network toolbox for the study of gauge theories, and extend it, thanks to the presence of gauge fields, to numerical studies in $(2+1)$-d and more.

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