Abstract
We consider the matrix product state formalism for the simulation of Hamiltonian lattice gauge theories. To this end, we define matrix product states which are manifestly gauge invariant. As an application, we study 1+1 dimensional one flavor quantum electrodynamics, also known as the massive Schwinger model. For the first time we simulate the full quantum non-equilibrium dynamics induced by a quench in the form of a uniform background electric field (i.e. the Schwinger pair creation mechanism). We are able to determine one-particle excitations in the continuum limit. Furthermore we study the effects of charge screening and confinement in the vacuum. (Reference: arxiv:1312.6654)

Content
In the last decade the tensor network state (TNS) formalism has emerged as a new numerical method for the simulation of quantum many body systems. As a Hamiltonian variational method, the TNS framework can tackle dynamical non-equilibrium phenomena and regimes with finite fermionic densities. And it therefore presents a promising complementary approach to the Monte-Carlo Euclidean lattice simulations.

As a first step towards the development of the TNS framework for general gauge theories, we have studied the 1+1 dimensional case. Specifically, we have used MPS to study 1+1 dimensional one flavor QED (a.k.a. the Schwinger model) . This is an interesting toy model for QCD as it also exhibits charge confinement. Part of the results that we want to present in this talk can be found in arXiv:1312:6654, but we also want to present some new work. Notice that in contrast to previous MPS studies our approach is manifestly gauge invariant, which allows us to work directly in the thermodynamic limit, keeping the relevant global symmetries exact.

To benchmark our method we have first calculated the static properties of the model: the ground state energy and the one-particle excitations in the continuum limit. For the lowest lying excitations our results confirm previous numerical studies, but we also uncover a novel particle excitation in the form of a heavy vector boson, compatible with the strong coupling expansion. Moreover, by working in the thermodynamic limit, we recovered the Lorentz dispersion relation for small momenta.

As a dynamical application we have simulated for the first time the full quantum non-equilibrium dynamics induced by a quench in the form of a uniform background electric field (i.e. the Schwinger pair creation mechanism). This process is also relevant for QCD as the analogous mechanism is believed to play an important role in heavy ion collisions. Furthermore, we have studied the string formation and breaking for heavy test charges.

Finally, we will also comment on the challenges that lie ahead in taking our approach to higher dimensions and non-abelian gauge theories.