Time-Evolution of Tensor Networks in Quantum Electrodynamcis

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Due to high intensities and small wavelengths in modern light sources such as free electron lasers, a non-pertubative and beyond-dipole description of the coupling of electrons and photons is necessary.
To describe the dynamics in such coupled systems, time-dependent density functional theory was recently extended to include quantum-electrodynamical effects (QEDFT) [1].
Like all density-functional approaches, this description is formally exact. However, for current approximate QEDFT-functionals, no error bars for the deviation from the exact solution of the Schrödinger equation are known. In order to develop such error bars, we construct systematically improvable approximations for the wavefunction of lattice quantum-electrodynamics. Expanding the many-body wavefunction in terms of a tensor network, we express the wave function in a way that regards the geometry induced by the entanglement of the states. Using the Lanczos algorithm, we consider the dynamics of the system by exploiting the symmetries of the Hamiltonian and of the initial state. Ultimately, only a few possible states have to be regarded to describe the whole dynamics of the system. We analyze the entanglement of these states and compare our approach to QEDFT.

[1] M. Ruggenthaler et.al., Phys. Rev. A **90**, 012508 (2014).

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