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Direct calculation of parton distribution functions with time evolved tensor network states

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Parton distribution functions (PDFs) describe universal properties of hadrons. They provide insights into the non-perturbative internal structure of bound states in high energy physics, and are highly significant for experiments. Calculating PDFs involves evaluating matrix elements with a Wilson line in a light-cone direction. This poses significant challenges for Monte Carlo methods in Euclidean formulation of lattice gauge theory, where the light cone cannot be directly accessed. In contrast, the PDF can, in principle, be calculated directly from light-cone matrix elements in the Hamiltonian formalism. This seems particularly appealing since recent developments in quantum computing and tensor network approaches allow for an efficient representation and time evolution of states in Hilbert space. Using a tensor network ansatz, we introduce a new strategy to obtain the PDFs directly in the Minkowski formalism, and apply it to the Schwinger model. We present the PDF for different fermion masses and study systematic errors. Our work demonstrates the feasibility of tensor networks for dynamical calculations in gauge theories and represents a first step towards such computations for QCD.

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