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Spectral Tensor Networks

The spectral tensor network by Ferris [Phys. Rev. Lett. 113; 010401 (2014)] is based on a quantum circuit which implements a fast Fourier transform (FFT) of fermionic modes and hence diagonalizes the Hamiltonian of free fermions in case of periodic boundary conditions, making it possible to represent such systems in an exact and efficient way. Using FFT-like algorithms for other spectral transformations, it is possible to generalize the network to make it applicable to systems with non-periodic boundary conditions. This procedure is explicitly shown for the case of open boundary conditions. Based on the algebraic theory of signal processing a discrete sine transform of the first kind (DST-I) is decomposed into small unitary operations. Using a diagrammatic language, this algorithm is then second-quantized to obtain a quantum circuit and a tensor network which implements the DST-I for fermionic modes on a lattice. This method can be used as a systematic approach to generalize Ferris' spectral tensor network for non-trivial boundary conditions.