Transfer Matrices and Excitations with Matrix Product States

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We investigate the relation between the dispersion relation of low energy excitations and static correlation functions in the ground state of local quantum many-body Hamiltonians in the context of tensor networks. As a central object in obtaining static correlations we relate the Matrix Product State Transfer Matrix (MPS-TM) to the Quantum Transfer Matrix (QTM) at zero temperature and show that it contains important information about the location and magnitude of the dispersion relation's minima. We elaborate on the peculiar structure of the MPS-TM's eigenspectrum and give several arguments as to how it affects the structure of the low energy spectrum of the system as well as the form of static correlation functions. We further derive a bound for the decay of momentum-resolved static correlation functions as a function of the dispersion relation. Lastly we establish a relation between the exact QTM and a finite bond dimension MPS approximation of the ground state using renormalization group arguments. We present supporting numerical data for one-dimensional lattice and continuum models as well as two-dimensional lattice models on a cylinder.