Tensor network methods with automatic differentiation

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Tensor network algorithms have been widely applied to many aspects of the condensed matter physics. Recently, the combination of tensor networks with automatic differentiation, a widely used method for training the neural networks of machine learning, was firstly proposed by Liao et al. [1]. This method largely reduces the effort needed for preparing the ground state ansatz. Despite the success for the ground states, on the other hand, properties of quasiparticle excitations are still cumbersome to compute. The key bottleneck for this computation lies on the summation of many tensor diagrams. The way we solve this problem is to represent the tensor diagram summations as a suitably defined generating function [2] for the tensor network, as demonstrated in Figure 1. This is possible due to locality of many-body systems and the fact that low-energy excitations only contain one or few quasiparticles. Taking a physically motivated form for excited states, we show that relevant objects in determining excitations can be expressed as derivatives of a single tensor diagram and thus can be efficiently computed [3]. With excited states available, dynamical correlations can also be conveniently obtained. We hope that, through the adoption of tensor network generating functions, many physical properties can be more easily obtained with the tensor network algorithm.

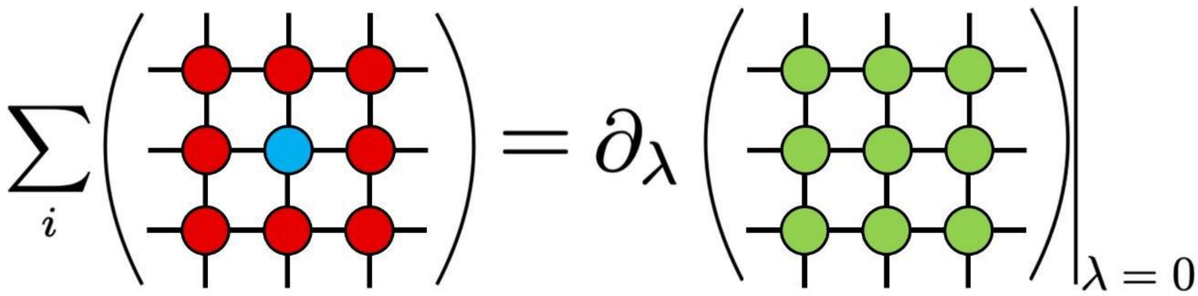

Figure 1: Demonstrative diagram for the tensor network generating function in two dimensions.

References

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