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Infinite-dimensional-matrix product states

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Infinite-dimensional-matrix product states (iMPS), in which the finite dimensional matrices in normal matrix product states (MPS) are replaced by infinite dimensional operators coming, e.g., from conformal field theories [1], turn out to have properties that are very different from normal MPS [1-3]. While some of the structure lying behind MPS is preserved, the area law no longer limits the amount of entanglement entropy in the states, and there are states for which the entanglement entropy grows logarithmically or even as a power law with the size of the considered subsystem and for which correlations decay as a power law or do not decay with distance [2]. These properties make the states particularly suited for describing critical systems. Furthermore, there are several cases in which explicit, and surprisingly simple, analytical expressions can be found for the wave functions.

In addition to discussing the construction and properties of iMPS, we propose a method using null vectors in conformal field theories to derive quantum spin chain Hamiltonians, whose ground states are iMPS [3]. We demonstrate the approach by constructing a family of Hamiltonians, whose ground states are the chiral correlators of the $SU(2)_k$ WZW model, where k is a positive integer. For $k = 1$, we obtain a generalization of the Haldane-Shastry model, and we also analyze models for $k = 2$. The null vectors furthermore lead to a set of simple, algebraic, linear equations relating different n-point spin correlation functions within each model. For $k = 1$, these equations allow us to obtain several analytical and semi-analytical results forvspin correlation functions.

[1] J. I. Cirac and G. Sierra, Phys. Rev. B 81, 104431 (2010).

[2] A. E. B. Nielsen, G. Sierra, and J. I. Cirac, Phys. Rev. A 83, 053807 (2011).

[3] A. E. B. Nielsen, J. I. Cirac, and G. Sierra, Quantum spin Hamiltonians for the $SU(2)_k$ WZW model, in preparation.

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