Determining topological order with tensor networks

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Exotic phases of matter beyond the Landau paradigm gained much attention in the recent years due to their experimental realizations as well as the development of powerful numerical methods like tensor networks. Among those exotic phases there are topologically ordered phases, the analysis of which is especially hard due to degeneracy of the ground state and no local order parameter. Topological order gained recognition after it was realized, thanks to Alexei Kitaev, that quantum computational models can be written in the language of condensed matter systems [1]. However apart from few exactly solvable models [1,2,3] the analysis of lattice Hamiltonians for the occurance of topological order was considered a very hard problem.

In my presentation I will describe the numerical methods to determine both Abelian and non-Abelian topological order starting from a lattice Hamiltonian [4,5]. The key idea is to find the topological S and T matrices, which (in most known cases) can be considered as a nonlocal order parameter of topologically ordered phases, in the sense that they give us unambiguous information about the model along with its excitations and their statistics. With the 2D tensor network – *Projected Entangled Pair States*, the method allows to analyze states which were not achievable by the state-of-the-art 2D DMRG algorithms due to long correlation length and it is immune to any small perturbations of the tensors, which had been a long feared problem due to numerical inaccuracies which may arise during the ground state optimization. Furthermore our construction enables an elegant description [6] of the model in terms of the mathematical structure underlying the topologically ordered phases of matter – *modular tensor category.*

References:

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