Hamiltonian learning from a projected entangled pair state

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Given a tensor network state, how can we determine conserved operators (including Hamiltonians) for which the state is an eigenstate? We answer this question by presenting a method to extract geometrically k-local conserved operators that have the given infinite projected entangled pair state (iPEPS) in 2D as an (approximate) eigenstate. The key ingredient is the evaluation of the static structure factors of multi-site operators through differentiating the generating function. Despite the approximation errors, we show that our method is still able to extract from exact or variational iPEPS to good precision both frustration-free and non-frustration-free parent Hamiltonians that are beyond the standard construction and obtain better locality. In particular, we find a 4-site-plaquette local Hamiltonian that approximately has the short-range RVB state as the ground state. Moreover, we find a Hamiltonian that has the deformed toric code state at any string tension as excited eigenstates at the same energy, which might be potential candidates for quantum many-body scars.

References:

[1] Wen-Tao Xu, Miguel Frías Pérez, Mingru Yang*, https://arxiv.org/abs/2511.20619
[2] Mingru Yang, Bram Vanhecke, Norbert Schuch, Phys. Rev. Lett. 131, 036505 (2023)