Exact volume-law entangled eigenstates in a large class of spin models

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Exact solutions for excited states in non-integrable quantum Hamiltonians have revealed novel dynamical phenomena that can occur in quantum many-body systems. This work proposes a method to analytically construct a specific set of volume-law-entangled exact excited eigenstates in a large class of spin Hamiltonians. In particular, we show that all spin chains that satisfy a simple set of conditions host exact volume-law eigenstates in the middle of their spectra. Examples of physically relevant spin chains of this type include the transverse-field Ising model, PXP model, spin-S XY model, and spin-S Kitaev chain. Although these eigenstates are highly atypical in their structure, they are thermal with respect to local observables. Our framework also unifies many recent constructions of volume-law entangled eigenstates in the literature. Finally, we show that a similar construction also generalizes to spin models on graphs in arbitrary dimensions.

[1] S. Mohapatra and Ajit C. Balram, Exact volume-law entangled eigenstates in a large class of spin models, arXiv:2410.22773.